Harpur Hill, Buxton
Derbyshire, SK17 9JN
T: +44 (0)1298 218000
F: +44 (0)1298 218590
W: www.hsl.gov.uk

HEALTH & SAFETY LABORATORY

Summary Report On Additional Work Carried Out On The Monitoring Of Chrysotile Containing Textured Decorative Coatings

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Project Leader: **Garry Burdett**

Author(s): **Garry Burdett and Graham Revell**

Science Group: **5**

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EXECUTIVE SUMMARY

Objectives

The objectives of the research were to carry out further site monitoring to determine:

1. Airborne fibre concentrations releases during the removal of textured decorative coatings (TDCs) from a wider range of surfaces to those reported in an earlier survey (see IF2005/03);

2. Change in the personal airborne asbestos fibre concentrations inside the enclosed area during the removal of TDCs, if no air extraction is used to keep a reduced pressure inside the enclosure; and

3. Effectiveness of the clearance, following removal of TDCs, based on a visual assessment alone.

In addition as the work progressed sampling was also carried out to address three additional questions raised by the Asbestos Removal Contractors Association (ARCA):

4. What are the likely airborne releases from poorly controlled removal of TDCs?

5. What is the airborne concentration outside the enclosure during removal of TDCs, if no air extraction is used?

6. What are the airborne exposures that will be experienced by persons reoccupying a building, following the removal of TDCs?

Method

Notifications for licensed removal of TDCs from four Health and Safety Executive (HSE) regional offices were used to select sites where TDCs were being scraped or removed from resistant surfaces. The asbestos removal contractors at the candidate sites were contacted by staff from the Health and Safety Laboratories (HSL) and the proposed sampling work discussed. If agreement for sampling was given, HSL then arranged for the appropriate waivers and contacted the main contractor and owners.

HSL sampling personnel in liaison with the contractors attend sites during the removal to sample the following:

- personal fibre concentrations of operatives during peak removal and cleaning activities;

- personal gravimetric dust exposure of operatives during peak removal and cleaning activities;

- static fibre concentration in the airlock during removal, and

- static fibre concentration inside the enclosure during disturbance sampling of dust and debris.

The high airborne dust concentrations encountered, meant that the collection filters would become overloaded and unusable for microscopy analysis if personal samples of 240 litres of air over a four-hour period were collected, as required for compliance monitoring. In most cases it was only possible to sample for some 10 – 30 minutes at flow rates of ≤1 litre per minute before the filters became too overloaded for microscopy analysis.

The filters collected during the site sampling were analysed by HSL using UKAS accredited procedures for fibre counting and analysis. Fibre count analysis was carried out on a portion of the filter using light microscopy at X500 magnification with phase contrast optics (PCM) to count the number of visible fibres (particles that were >5 µm long, < 3µm wide and had a length to breadth ratio >3:1).

Variable amounts of calcium sulphate fibres can be released from the TDC and from underlying plasterboard or plaster. These fibres cannot be distinguished from asbestos fibres when samples are counted by using a light microscope. The number of calcium sulphate fibres, which are released may be many times greater than the number of asbestos fibres released. To remove this interference, part of the filters were water wicked to dissolve the calcium sulphate fibres.

Only PCM counts on water–wicked samples have been included in this summary of the site sampling data. Similarly, only results using the World Health Organisation (WHO) counting rules have been used in this summary report, unless it is expressly stated otherwise. Although the PCM concentration of non-soluble fibres will not give a direct measure of the asbestos fibres, as other non-asbestos fibres will still remain, it gives an initial upper estimate of what the asbestos fibre concentration could be.

A limited number of samples were also analysed by analytical transmission electron microscopy (TEM), which uses electron diffraction and energy dispersive x-ray analysis to identify individual fibres to determine whether they are asbestos or non-asbestos. Fibres of a size, which would have been visible and met the PCM counting criteria (fibres >5 µm long, > 0.2 - 3 µm wide and with an aspect ratio >3:1), were analysed. This allowed PCM equivalent (PCME) airborne asbestos fibre concentrations to be calculated as detailed in the International Standards Organisation method ISO 10312:95 for asbestos in ambient air.

Total and respirable dust concentrations were determined, in accordance with MDHS14, by weighing filters from inhalable and cyclone personal samplers, which were collected in addition to the asbestos samples.

As it was only possible to sample small volumes of air to avoid overloading the filters, this meant that fewer fibres were counted which reduced the precision of the result and few individual samples exceeded the limit of quantification (LOQ).

Results and Main Findings

Airborne releases from the removal of TDCs from a wider range of surfaces

Five sites containing TDCs were monitored; four of which contained asbestos containing textured decorative plaster and one that contained an asbestos containing paint. The asbestos type present was chrysotile (white) asbestos. The removal methods and the underlying substrates included:

- Hand scraping TDC from concrete (one site) and hard finishing plaster (two sites);
- Removing plaster and TDC from brickwork with a hammer and chisel (one site);

- Removing a chrysotile containing paint on pebbledash from brickwork with a Kango powered chisel;

- Demolition and removal of TDC and the under laying plasterboard using a hammer and crowbar.

The average individual personal PCM fibre exposures for the asbestos removal operatives at the five sites are summarised in table S1. The calculated limits of detection (LOD) and limit of quantifications (LOQ) for the average volumes of air sampled are also shown. The high concentrations of airborne dust release made sampling problematical and compromised the sensitivity of the analysis and only short-term peak concentrations are presented. Although the average PCM fibre concentration was above 0.08 f/ml at three of the sites (B, D&Y) the high concentrations of dust produced at these sites limited the sampled volumes so that at only one (site D) of these three sites exceeded the LOQ. It is important to recognise that these averages include samples taken when there was no extraction from the enclosure and dry scraping with no dust suppression was taking place, also at site Y power tools were used. [Note: For PCM analysis LOD is defined in Annex 1 of HSG 248 as a count of 6.5 fibres in 200 fields of view and the LOQ as a count of 20 fibres in 200 fields of view based on background counts on blank filter samples and statistical confidence limits.]

The gravimetric data showed that the average personal dust concentrations were nearly three times higher than the COSHH exposure limit at sites B and Y and at site D it was close to the exposure limit. The sites giving the higher PCM fibre concentrations were also the sites, which had poor control of dust emissions and the high PCM counts were more to do with the low volume of air sampled and the resultant LODs and LOQs, than high fibre counts. It was a surprise that site D gave significant PCM fibre concentrations as this type of site, involving the ‘careful’ removal of plasterboard with the TDC attached, was monitored specifically because in the previous survey this removal method gave no detectable release of asbestos. It should be noted that the TEM analysis did not find any PCME asbestos fibres in the two samples with the highest PCM fibre concentration from this site.

Samples from site D contained a large number of calcium sulphate fibres and other types of non-asbestos fibres, that did not dissolve during water-wicking. It was noted that a few samples from other sites, retained significant numbers of calcium sulphate fibres after water wicking. In general, the individual samples with high PCM counts were from samples where the calcium sulphate, may not have been efficiently dissolved during the wet wicking.

Table S1: Summary of the site average of the personal PCM fibre concentration for non-soluble fibres and the calculated average LOD and LOQ.

Site	N^{o} of personal samples	Average volume sampled (L)	PCM WHO fibre concentration for non-soluble fibres. (f/ml)	LOD	LOQ
B	14	23.00	0.13	0.07	0.22
D	11	18.00	0.29	0.09	0.28
R	8	84.25	0.065	0.02	0.06
S	24	38.60	0.057	0.04	0.13
Y	16	8.76	0.26	0.19	0.57

At least two samples with the highest PCM fibre counts were selected from each site for TEM analysis. Although the limited volume of air sampled made it difficult to achieve the desired analytical sensitivity, the TEM count was continued until the analytical sensitivity was at least below 0.08 f/ml. The TEM results were divided into two groups: those that used some control at source and those that used uncontrolled dry removal (see table S2). Nearly all the TEM samples analysed were collected with no air extraction from the enclosure. None of the selected individual personal samples, which used some method to control the release at source, were found to have PCME asbestos concentrations above 0.08 f/ml when analysed using TEM. This result is in line with previous site sampling results of TDC removal [IF2005/03 and IF2005/13] and supports the use of 0.08 f/ml as an upper estimate of the average exposure for the risk assessment in the consultative document (CD 205).

Table S2: Summary of the TEM analysis of personal samples

Site	Sample Number	PCM fibre concentration (f/ml)	PCME chrysotile fibres	
			(f/ml)	(N^{o}.)
Removal with controls				
B	00458/06	0.58	<0.07	(ND)
	00474/06	0.34	<0.08	(ND)
D	00156/06	0.41	<0.07	(ND)
	00164/06	0.46	<0.07	(ND)
R	11671/05*	0.06	<0.01	(ND)
	11675/05*	0.07	0.02	2
S	00326/06	0.05	0.06	3
Removal with no controls				
S	00321/06*	0.05	0.21	7
R	11641/05*	0.03	0.02	3
	11643/05*	0.04	<0.01	(ND)
	11656/05*	0.06	0.01	11
	11661/05*	0.05	0.02	2
	11667/05*$^{+}$	0.11	0.18	8
	11668/05*$^{+}$	0.09	0.12	5
Y	00360/06	0.34	<0.05	(ND)
	00368/06	0.54	<0.08	(ND)
ND = non detected *NPU off, $^{+}$dry				

The highest personal PCM samples collected during uncontrolled dry removal gave short term peak exposures ranging from not detected to 0.21 f/ml. Given the type of activities involved and the difficulty in dry scraping surfaces it was unlikely that the four hour control limit would be exceeded. Also this type of activity was not compliant with the control of asbestos at work (CAW) regulations. All the TEM samples had low asbestos fibre counts and hence poor precision.

The change in the personal airborne asbestos fibre concentrations inside the enclosed area if no air extraction is used.

It was found that on average when doing similar work, the personal PCM fibre concentrations at these sites were increased by some 23% when the extraction was switched off. This was in line with the result from a simulation in a HSL test chamber (see IF2005/13).

The effectiveness of the clearance, based on a visual assessment alone.

The low amounts of fibres released from TDCs means that visual clearance of dust and debris is more than adequate to ensure that PCM fibre concentrations will remain below the clearance indicator.

The likely airborne releases from poorly controlled removal

The PCM results showed no clear pattern of reduction between dry and wet removal of TDCs at the two sites sampled. This is in complete contrast to effective wet removal of other licensed ACMs, where uncontrolled dry removal produces a two to three order of magnitude increase in airborne fibre exposures.

The airborne concentration outside the enclosure if no air extraction is used

As most of the sites had one or more rooms as the enclosure, it was not possible to sample outside the enclosure in a meaningful way. The only place where escape of airborne dust was likely was at the "airlock" exit from the enclosure but as these were generally situated outside the building it was again thought to be of little use to sample around the exit in ambient air. It is a current requirement that licensed removal sites use at least a three stage entry and exit "airlock" for person entering and exiting the enclosure with an inward flow of air. In the draft guidance a two stage "airlock" without any inward airflow has been suggested as sufficient. To test the effectiveness of the two arrangements air monitoring was carried out inside the airlock two flaps away from the source in the enclosure, which is equivalent to the second airlock chamber.

The results showed that although the PCM airborne fibre concentrations inside the airlocks were lower with the negative pressure unit (NPU) on and drawing air into the enclosure, when switched off the increased concentration was still relatively low. Site S was sampled with the NPU off when the removal activity was directly over the entrance of the airlock and surrounding area and when only one flap was in position. This might be considered a worst-case situation and the measured value was at the LOQ.

Although it is hard to draw a conclusion from only two sites and when low wind speeds were present outside of the airlock, it would appear that any airborne fibre concentrations outside the airlock would be low and readily diluted.

The airlock flap system at these sites was designed to allow the ingress of air with a NPU running and there are more effective ways of producing a much more airtight seal to produce a true "airlock" entry if no NPU was in use.

Taking into account that measurements were made inside the airlock, it is unlikely that PCM fibre releases from the enclosure would exceed 0.01 f/ml in the area surrounding the airlock entry.

The airborne exposures that will be experienced by persons reoccupying the building

The airborne asbestos fibre concentrations inside enclosures during active removal were low, therefore there is unlikely to be a significant exposure to airborne fibres if the enclosure has been thoroughly cleaned and the area inspected for visible debris before the enclosure is taken down.

Measurements made inside enclosures demonstrated that a PCM fibre concentration of around the LOQ ~0.01 f/ml was produced from disturbance/ clearance type sampling: when sweeping several grams of visible debris and dust with a broom for at least 5 minutes and sampling for a period of 1 hour. This would be a one off peak (i.e. a poor clean up had been carried out by a contractor in breach of CAW) and where and the re-occupier or maintenance personnel had to sweep up the majority of the TDC debris left behind. After the first clean up, it is unlikely that the small amount of TDC dust and debris remaining would act as a significant future source of airborne asbestos fibre emission.

In order to investigate with greater precision, the potential airborne release from the disturbance of debris remaining following removal of TDC, a simulation was carried out in the HSL 9 m^3 dust chamber (see IF/2006/01). This used about 100g of dry, friable dust and debris recovered from the dry removal of the TDC at site R. With an air exchange rate of 2.4 room volumes per hour, 30 minutes walking over the debris produced personal PCM airborne fibre concentrations of ~0.014 f/ml (for all fibres, no wet-wicking was used). Given that the amount of debris was more than two orders of magnitude higher than what would be easily seen in a visually clean area and the likelihood of disturbance of such a small amount of remaining debris is much lower: it is unlikely that any remaining dust and debris following removal of TDCs would contribute significantly measurable airborne fibre concentrations to the indoor environment.

The contribution to the airborne asbestos fibre concentration of small amounts of dust and debris after the site was visually cleared are expected to be below 0.0005 f/ml.

Implications for the risk assessment

For epidemiology and risk assessment the statistic used to represent exposure and dose is the arithmetic average of the annual exposure, which is used to derive the cumulative dose in f/ml/years.

As nearly all measurements are based on short-term peak concentrations, it is extremely unlikely that removal of TDC could give rise to cumulative exposures for PCME chrysotile fibres above 0.08 f/ml per year.

Furthermore, it is not expected that PCME chrysotile fibre concentrations would exceed the proposed control limit of 0.1 f/ml over a 4-hour measurement period.

Using HSE figures of the current rate of licensed removal of TDCs, it is only theoretically possible for ~83 workers per annum, to disturb TDCs in a way that could approach the level of activity needed to generate the 0.08 f/ml average exposure for an entire year, as assumed in the risk assessment.

The small increase in airborne concentration when comparing licensed controlled removal with uncontrolled dry removal, shows that unlike other licensed ACMs, there is a limited amount of additional release that poor practice will generate, when compared to the existing regimes used by licensed asbestos removal contractors.

The difficulty in releasing fibres from TDCs mean that if any debris is left behind as a result of poor clean up, the contribution to the exposure of the occupants will be small. Once the initial clean up of debris and dust has been carried out, it is unlikely to be measurably higher than the ambient background in buildings containing ACMs. The additional work in this report supports the risk assessments in CD205, that if CAW regulations and control procedures are applied, there will be no predicted premature deaths from asbestos related diseases arising from work with TDCs.

Conclusions

For risk assessment purposes, 0.08 f/ml provides a high upper estimate for the average annual PCM airborne asbestos fibre exposure of asbestos workers removing TDCs. It is important to note that a very conservative risk estimate would be obtained based on this figure, particularly as it does not take account of any respiratory protective equipment worn by those undertaking TDC removal work.

The upper estimate of 0.08 f/ml is applicable to all TDC removal work meeting the CAW regulations.

Abbreviations and units

µm:	micrometer	L:	litre
ACMs:	asbestos containing materials	LOD:	limit of detection
AIB:	asbestos insulation board	LOQ:	limit of quantification
ALPIs:	Asbestos Licensing Principal Inspectors (HSE)	m:	metre
ARCA:	Asbestos Removal Contractors Association	MDHS:	Methods of Determination of Hazardous Materials (HSE)
ASLIC:	Asbestos Licensing Regulations	mg:	milligramme
AWPD:	Asbestos Worker Protection Directive	mm:	millimetre
CAW(R):	Control of Asbestos at Work (regulations)	ND:	not detected
CD:	consultative document	N^{o}:	number
ERM:	European Regulatory Method	NPU:	negative pressure unit
EU:	European Union	PCM:	phase contrast microscopy
f/ml:	Fibre / millilitre	PCME:	phase contrast microscopy equivalent
FOD:	Field Operations Directorate (HSE)	QA:	quality assurance
FSSU:	Field Scientific Support Unit (HSL)	RICE:	Regular Inter-laboratory Counting Exchange
HEPA:	High efficiency particulate air (refers to high efficiency air filters)	TDC:	textured decorative coating
HSE:	Health and Safety Executive	TDP:	textured decorative plaster
HSE/IC:	Health and Safety Executive / Insurance Companies	TEM:	transmission electron microscope
HSG:	Health and Safety Guidance	TWA:	time weighted average
HSL:	Health and Safety Laboratory	UK:	United Kingdom
ISO:	International Standards Organisation	UKAS:	United Kingdom Accreditation Service
IF:	Inorganics and Fibres (HSL Section name)	WHO:	World Health Organisation

1 INTRODUCTION

1.1 BACKGROUND

The implementation of the amended EU asbestos worker protection directive (AWPD, 2003) means that changes have to be made to the existing control of asbestos at work (CAW) regulations (2002). The Health and Safety Commission is also taking this opportunity to propose changes to asbestos licensing and prohibition regulations. The current asbestos (licensing) regulations (ASLIC) as amended in 1999, prescribe that work with certain of types of asbestos containing products must be undertaken by a licensed asbestos removal contractor, if more than a total of two hours work is to be carried out. It is proposed that this is to be amended in revised CAW regulations (2006), as amendments to the EU AWPD directive have introduced a new concept of, "Sporadic and low intensity exposure", to determine whether the work is notified to the responsible authority. In Great Britain, notification is normally required for licensed asbestos containing materials (ACMs) and it is proposed in future to fully align notification and licensing using the "Sporadic and low intensity exposure" cut off.

The amended EU AWPD specifically allows member states, along with their social partners, to lay down practical guidelines for, "Sporadic and low intensity exposure". The practical approach proposed in the consultation document (CD205) to define sporadic and low intensity exposure, would mean that there will be a further reduction in the time (currently 2 hours) that high risk materials such as thermal insulation, spray coatings and lagging can be worked on. In general, these materials contain both a high proportion of asbestos and the higher risk crocidolite and amosite (blue and brown) asbestos. Also, these materials can readily release airborne asbestos fibres, especially if worked on without the use of controlled removal methods. However, one group of currently licensed material known as textured decorative coatings (TDC), only contain the lower risk chrysotile (white) asbestos (see figure 1) and it is present in a much lower percentage than in other licensed (see figure 2) materials. As the chrysotile in TDCs is more tightly bound in a resistant matrix, compared to other licensed asbestos products, it does not readily release airborne asbestos fibres when worked on. These characteristics separate TDC from other licensed asbestos materials in that it represents a much lower level of asbestos exposure and risk to workers compared with other licensed materials (see figure 3). As part of the consultation it was proposed that TDCs are removed from the licensing regime but will continue to come under the same set of stringent control requirements detailed in the CAW regulations and which apply to work with all asbestos containing materials (ACMs).

A number of changes to the practical control measures for removal of TDCs included in the approved Code of Practice and guidance have also been proposed:

- use of 2-stage instead of a 3 stage entry/exit "airlock";
- decontamination in the airlock;
- use of visual inspection without air sampling to ensure that the site is ready for re-occupation.

HSE, in response to early comments received during the consultation, commissioned HSL to carry out further measurements of airborne fibre concentrations during the removal of TDCs, to further assess the effects of the proposed changes in the control regime.

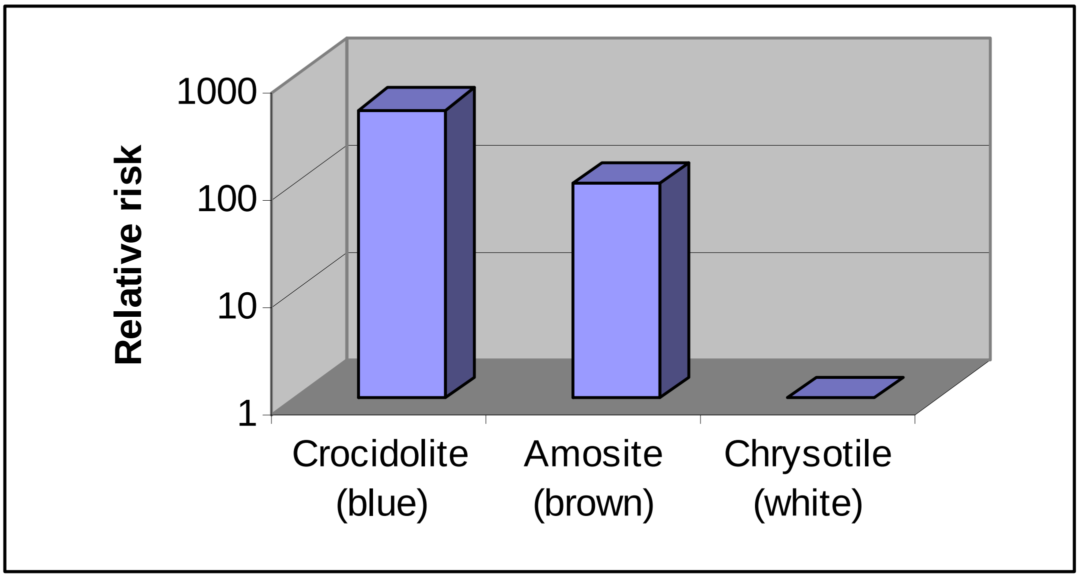


Figure 1: Relative risk (Logarithmic scale) by asbestos type, as assessed by Hodgson and Darnton (2000).

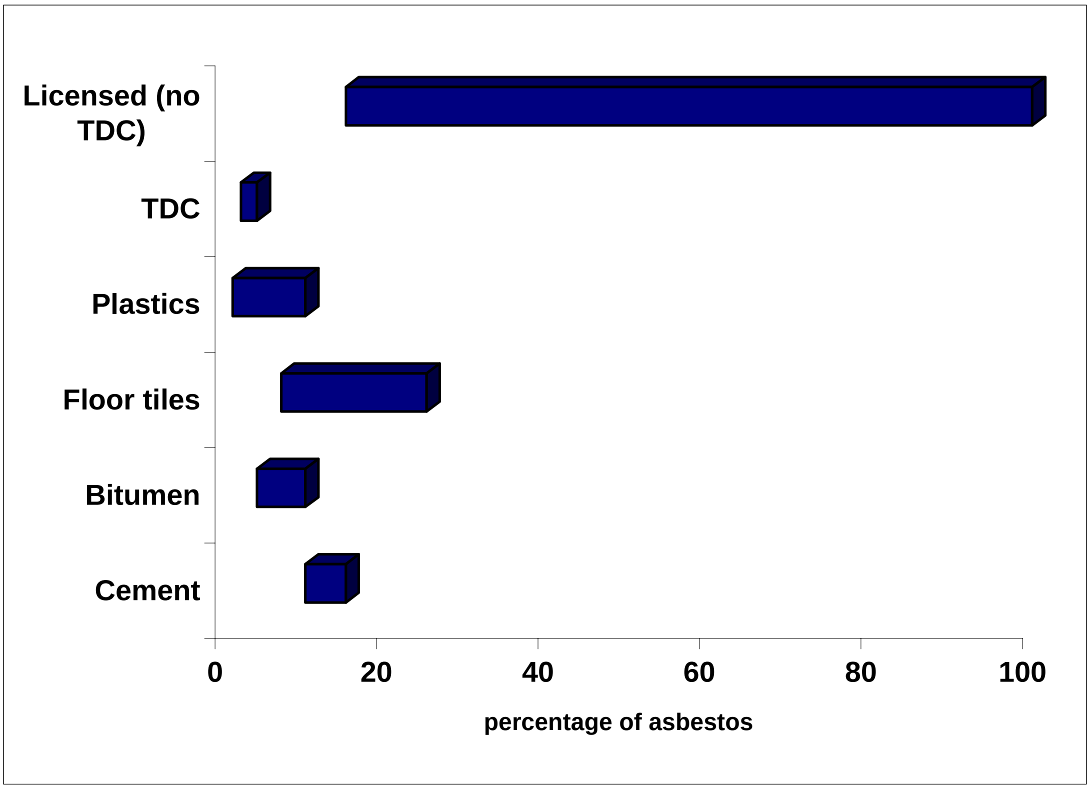


Figure 2: Typical weight percentages of asbestos in licensed and non-licensed asbestos products.

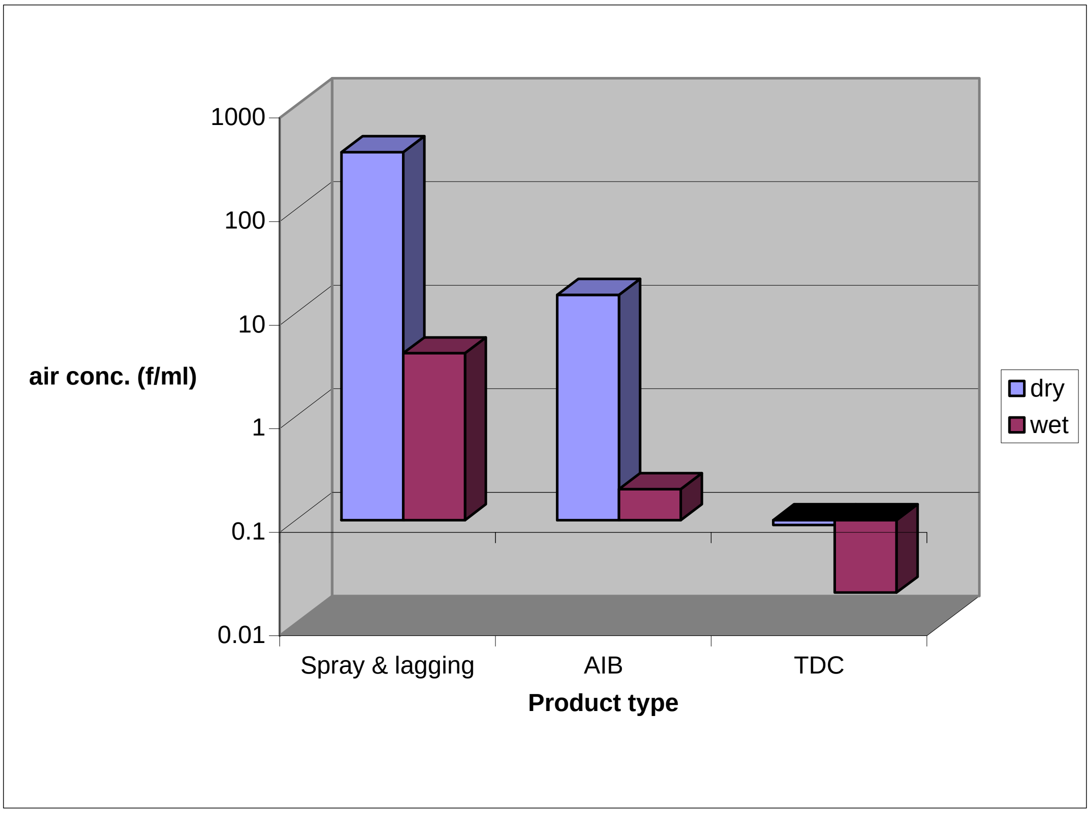


Figure 3: Typical airborne personal exposure concentrations monitored at licensed asbestos removal sites for wet and dry removal of various licensed asbestos products: Logarithmic scale with the axis adjusted to the proposed 0.1 f/ml control limit

1.2 OBJECTIVES

The objectives of the work were to determine the:

1. Airborne fibre concentrations releases during the removal of textured decorative coatings (TDCs) from a wider range of surfaces to those reported in an earlier survey (see IF2005/03);

2. Change in the personal airborne asbestos fibre concentrations inside the enclosed area during the removal of TDCs, if no air extraction is used to keep a reduced pressure inside the enclosure; and

3. Effectiveness of the clearance, following removal of TDCs, based on a visual assessment alone.

A draft sampling and analysis protocol was developed and sent to HSE for comment. The draft protocol was also distributed to the Asbestos Removal Contractors Association (ARCA) for comment and co-operation in carrying out this additional work, some of which they had requested. The protocol is given in annex 1 and the response from ARCA is given in annex 2.

ARCA's response and further points raised by HSE lead to, some additional questions being addressed by the research. These included:

4. What are the likely airborne releases from poorly controlled removal of TDCs?

5. What is the airborne concentration outside the enclosure during removal of TDCs, if no air extraction is used?

6. What are the airborne exposures that will be experienced by persons reoccupying a building, following the removal of TDCs?

This report summarises the results from the additional work carried out to meet the objectives and answer the questions listed above. The more detailed individual site reports are referenced.

2 SITE SELECTION AND STRATEGY

2.1 SITE SELECTION AND ARRANGEMENTS

HSL contacted HSE Asbestos Licensing Principle Inspectors (ALPI's) in three of the HSE's Field Operations Directorate (FOD) regions. The request was first to locate sites at which TDCs had been notified for removal and secondly to establish the way in which an appropriate waiver could be issued so that variations from normal licensing conditions could take place. HSE personnel at several regional offices were then asked to send any notification for TDC removal to HSL, who assessed the site for its relevance to the objectives of the work. Possible sites were then discussed with the supervising HSE Inspector and ALPI and if agreed the asbestos removal contractor was contacted by HSL staff. The purpose of the research was then discussed with the asbestos removal contractor and a copy of the protocol was sent. Following further discussion, HSL asked the contractor whether they could sample and then secured the co-operation of the main contractor and site owner.

Sites of interest were those where asbestos was being scraped or removed in some other way from a resistant surface (e.g. from concrete, hard finishing plaster, pebbledash and brickwork). One site was also visited where it was reported that careful removal of plasterboard from a ceiling was taking place. In the previous survey, funded jointly by the HSE and some insurance companies (referred to as HSE/IC study, IF2005/03) it was found that at the three sites that had reported careful removal of the TDC, no measurable chrysotile asbestos was found in the samples analysed by TEM and further confirmation of this was sought. Only one removal from concrete was present in the notifications received and conversations with removal contractors confirmed that removal of TDC from this type of substrate was relatively rare.

2.2 SITE SELECTION AND SAMPLING BIASES

The previous HSE/IC survey of TDC removal had been arranged so that no involvement of HSE or HSL was apparent to the asbestos contractor (only three of the 35 sites were monitored by HSL's FSSU staff for QA purposes). The only difference from normal was that instead of the laboratory representative arriving near the end of the job to "clear the site" and issue a certificate of re-occupation, they arrived earlier in order to conduct personal monitoring of the workers carrying out the removal inside the enclosure. Personal monitoring is a requirement of the assessment process and would be a familiar occurrence to asbestos operatives. The absence of HSE and HSL staff was intended to ensure that workers carried out their work in an unbiased way, whilst personal sampling was being carried out.

In this study, it was necessary for HSL staff to go onto site to sample and to make detailed arrangements with both HSE and the contractor to arrange a waiver. Although, no HSE personnel visited the site or contacted the site supervisor and operatives directly, the purpose of the sampling and involvement of HSL was known to all site operatives. This might be expected to promote the use of best practice but at all the sites sampled, for various reasons, the operatives were up against tight deadlines and the pace of the work observed was usually fast with additional operatives being used. It could equally be argued that the knowledge that the sampling was being carried out specifically to investigate a proposal to remove TDCs from licensing could provide an incentive for the licensed asbestos removal contractor, to ensure high concentrations of asbestos fibres. Although some of the HSL requests for sampling were refused by asbestos removal contractors, a number of suitable sites were found and sampled. It is not verifiable whether the non-participation at some sites produced a biased sample set but as intended, the sites selected covered a range of different substrates.

3 SAMPLING AND ANALYSIS METHOD AND ISSUES

3.1 SAMPLING METHOD

The sampling method is outlined in Annex 1 and more detailed information is given in the individual site reports (see reference section). The main purpose of the sampling was to collect the airborne dust on 25-mm diameter membrane filters (0.8 µm pore size mixed esters of cellulose) to determine airborne fibre concentrations. Fibre sampling was carried out using conductive-cowled cassettes, with flow rates set at between 0.5 – 10 L/minute based on field conditions. The sampling was carried out in accordance with MDHS 39/4 (the current method) and also HSG 248 annex 1 (the new revised method).

Additional sampling of the mass concentration of airborne particulates (inhalable and/or respirable) was also carried out using a 15-mm entry diameter inhalable sampler and / or respirable size-selecting cyclone, operating at 2.0 and 2.2 L/minute respectively.

3.2 ANALYTICAL METHOD

Airborne fibre concentrations were determined in accordance with MDHS 39/4 and HSG248 using both the current European Reference Method (ERM) and the WHO counting rules. The WHO counting rules are scheduled to replace the ERM counting rules in 2006. Quarter filters were prepared in the normal way and counted using both sets of counting rules. The counting rules were applied to the same fields of view, so the poor precision associated with fibre counting did not mask differences. A second set of quarter filters was also prepared and placed on wet blotting paper in a Petri dish to remove any soluble particles / fibres. After wicking for approximately one hour and then leaving to dry, the filters were prepared and counted by PCM using both sets of counting rules.

All four of the PCM analyses on each filter were carried out using light microscopy at X500 magnification with phase contrast optics (PCM) to count the number of visible fibres (i.e. particles that are >5 µm long, < 3µm wide and with a length to breadth ratio >3:1). There are two main differences between the ERM and WHO counting rules. One is the way in which fibres that attached to, or covered by particles, are counted. The current method (also see annex 1 of the AWPD, 1983) only counts a fibres or a fibre bundles meeting the size requirements if they are not attached to other greater than 3 µm in diameter (i.e. respirable fibres only). The newer World Health Organisation (WHO) method counts all fibres meeting the size criteria regardless of other particles.

The second major change introduced by the WHO method, is to allow for fibre identification / discrimination to take place once the initial PCM count has been made. Previously for regulatory determination of the control limit it was required to accept the PCM count as a measure of the actual asbestos fibre concentration. While this was broadly correct for sampling exposure during manufacturing of ACMs, it has been recognised that there are many sources of non-asbestos fibres which can be released during maintenance and removal work.

Previous experience has shown that many of the particles released from the disturbance and removal of TDCs are calcium sulphate. In particular, texture decorative plaster such as “Artex” contains 2-4% chrysotile asbestos with calcium sulphate as filler. Plastered surfaces and plasterboard, onto which TDCs are commonly applied, are also largely made from calcium sulphate. Unfortunately, calcium sulphate (gypsum) particles regularly occur in a fibrous form with dimensions that meet the PCM fibre counting criteria.

This means that most of the PCM fibre counts for TDC removal work are calcium sulphate fibres and asbestos fibres usually represent only a small and variable percentage of the fibres counted. The variability will also depend on the amount of the underlying plaster that is disturbed.

HSL has pioneered two methods of discrimination:

- A method based on dissolving the calcium sulphate fibres and particle before analysis to remove them from the count. The PCM count is then one for non-soluble fibres.

- For selected samples the use of an additional analysis based on analytical transmission electron microscopy, with water dissolution if necessary;

Both methods have been applied to a selection of the samples to help determine the asbestos fibre concentration. The units of measurement are directly relevant for the risk estimation and are based on historical counting conventions for asbestos in industrial manufacture going back to the 1960s.

The additional analysis by analytical transmission electron microscopy (TEM) uses electron diffraction and energy dispersive x-ray analysis to identify the individual fibres and the type of asbestos. A third quarter filter was prepared for the TEM counting, sizing and identification. Fibres of a size, which would have been visible and counted by PCM (fibres >5 µm long, > 0.2 - 3 µm wide and with an aspect ratio >3:1), were analysed. This allowed PCM equivalent (PCME) airborne asbestos fibre concentrations to be calculated as detailed in the international standards Organisation method ISO 10312:95 for asbestos in ambient air.

The United Kingdom Accreditation Service (UKAS) accredits HSL for all the fibre analyses mentioned above (except the wet-wicking preparation).

The total and respirable dust concentrations were determined by weighing the filters in accordance with MDHS14. The cyclones were fitted with membrane filters suitable for PCM analysis and these filters were also analysed for their PCM fibre count.

3.3 PCM SAMPLING AND ANALYSIS ISSUES

Previous experience has shown that sampling of TDCs is extremely difficult, as many sites produce high concentrations of airborne dust. This is partly the result of poor dust control at source and the difficulty to effectively wetting both the TDC and the underlying substrate (e.g. plaster or plaster board). The effect of high airborne dust release is to readily overload the membrane filters with particles in relatively short sampling times. This means that not only must multiple sequential samples be collected to try and measure the 4-hour exposures required for comparison to the control limit but also each individual filter has a low sample volume (usually between 5L and 100 L during work activity) and consequently a reduced analytical sensitivity. This problem is illustrated using the results from the previous survey shown in figure 4 (see IF/2005/05). The limit of detection (L0D) and limit of quantification (LOQ) used was derived from several thousand filter blank counts carried out for the UK “RICE” PCM fibre counting proficiency testing scheme (See Annex 2 of HSG248).

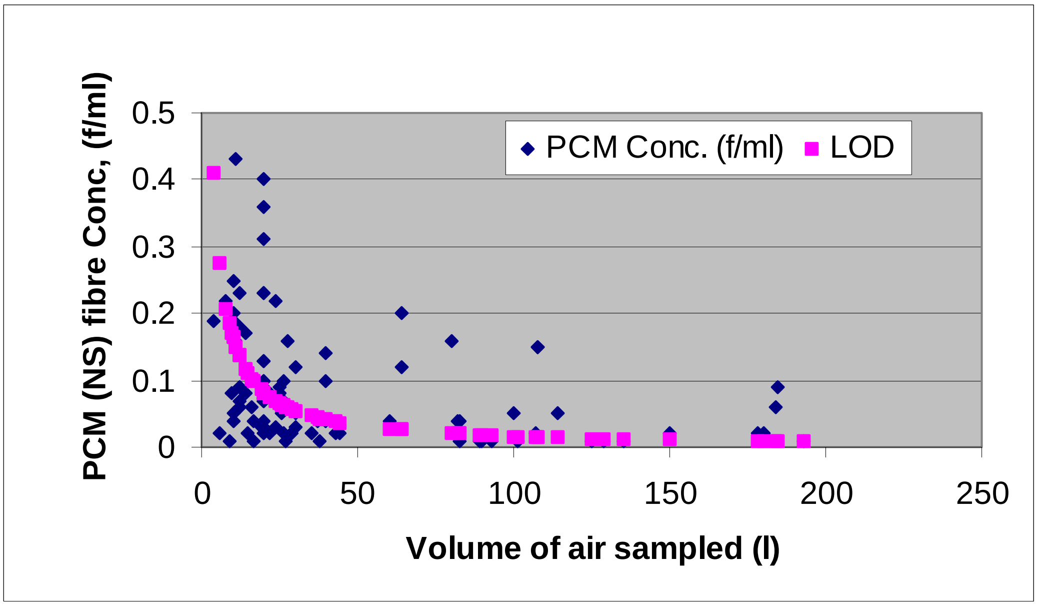


Figure 4: PCM fibre concentrations of treated samples from the HSE/IC study superimposed against the calculated limit of detection (LOD) v volume of air sampled,

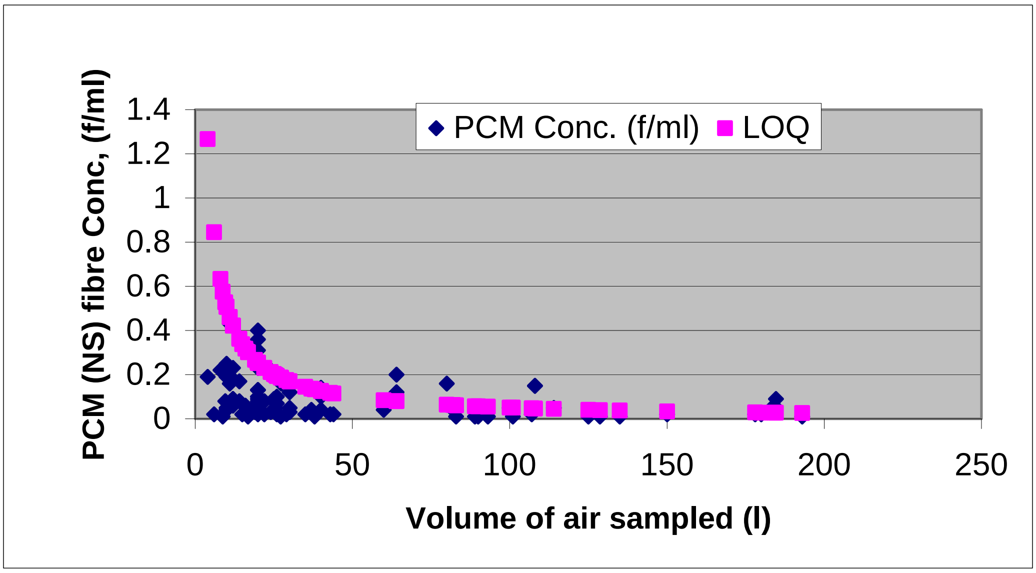


Figure 5: PCM fibre concentrations of treated samples from the HSE/IC study superimposed against the calculated limit of quantification (LOQ) v volume of air sampled.

The fact that blank filters have PCM fibre counts is in itself a problem. Although the counts are low the poor precision of counting means that a blank filter fibre concentration above the new control limit of 0.1 PCM f/ml can be produced (upper 95% confidence limit) if volumes of less than 16 litres are sampled. This means that there is limited confidence and very poor precision around the 0.1 f/ml control limit if low volumes or air are sampled. The volumes of air for samples, which were judged too dense to count by PCM, without pre-treatment (water-wicked) from the previous HSE/IC study, are illustrated in figure 6.

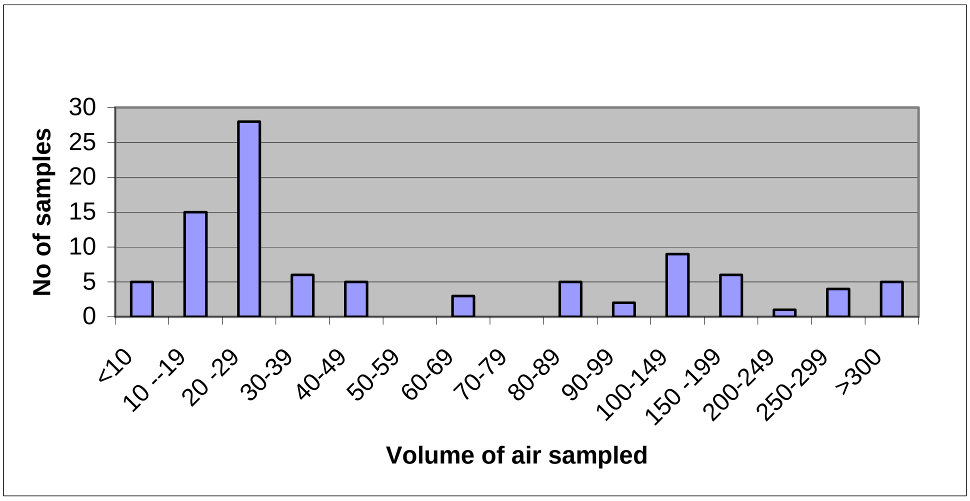


Figure 6: Distribution of sampled air volumes used for PCM counting in the HSE/IC study: requiring pre-treatment before counting was possible.

Clearly, with poor control at source and hence high dust concentrations, and simplistic assessment of the results of short term low volume samples can lead to biased averages and seemingly high airborne fibre concentrations at or above the control limit. However, the statistical relevance and precision of the results renders such interpretations suspect, especially when the control limit is defined over a 4-hour time weighted average (TWA) (N.B. it is an 8–hour TWA in the AWPD directive). In short, peak short-term results based on low volumes of sampled air are likely to produce much higher results than those, which would be obtained during the regulatory 4-hour control limit.

Both the ERM and WHO PCM methods recommend that 240 litres of air is filtered to measure personal exposure. Site conditions meant that this was only possible for ~ 12% of samples in the previous TDC survey, usually when low dust activities were being carried out (e.g. final clean up).

3.4 DETERMINATION OF THE ASBESTOS CONCENTRATION

At best, wet wicking PCM samples before analysis will remove most of the readily soluble fibres and particles (e.g. calcium sulphate) but there is no certainty that the remaining non-soluble fibres will be asbestos. To assess the asbestos concentration it is necessary to use analytical electron microscopy to count, size and identify fibres of the equivalent size. These are referred to as PCM equivalent (PCME) asbestos fibres. TEM analysis as set out in ISO 10312:95 takes a lot longer than simple PCM counting as higher magnification are used (X5, 000 – 11,500. In practice, at the magnifications used by HSL the area of the filter scanned by the PCM (200 fields of view) is equivalent to ~20,000 fields of view in the TEM at the magnification (11,500X) used for sizing. Therefore the TEM identification of the asbestos is used selectively and does not achieve the same analytical sensitivity as the PCM. Due to the high dust concentrations at some of the sites and the very low volumes of air sampled, meant that the TEM analysis was extended at most sites until an analytical sensitivity of < 0.1 f/ml was achieved. This means the results have poor precision.

4 RESULTS AND DISCUSSION

Variable amounts of calcium sulphate fibres can be produced depending on how much the plasterboard or plaster is being scraped. As this may change over time, only the water wicked samples giving counts excluding easily soluble fibres have been included in this summary report. Similarly only results using the WHO counting rules, which will be used from 2006 onwards, have been given, unless expressly stated otherwise. Although the PCM concentration of soluble fibres will not give a direct measure of the asbestos fibres, it gives an upper estimate of what the asbestos fibre concentration could be.

A limited number of TEM analysis of PCME asbestos fibres have also been reported for each site. As can be seen in figure 7 it was only possible to sample low volumes of air before the filter became overloaded. Few individual samples exceeded the LOQ and these results should be reported as <the calculated LOQ. However, it was felt that reporting many of the results as less than the LOQ based on a statistical expectations, would be unhelpful and would mask any trends in the data. Therefore, even though the statistical precision was poor, the actual number of fibres seen was used to calculate the fibre concentration, regardless as to whether this was above the LOQ or LOD.

4.1 THE AIRBORNE RELEASES FROM THE REMOVAL OF TDC FROM A WIDER RANGE OF SURFACES

HSL report IF2005/13 summarised the exposure information known to HSL for removal of TDCs from a variety of surfaces and substrates using a number of different removal methods. However, the study was criticised for having a limited sample set, especially with respect to the lack of sites where removal by scraping from a resilient under layer (e.g. concrete, plaster and brickwork) had taken place as it was considered that, "hard surfaces have the potential for generating significantly higher airborne asbestos fibre concentrations". The additional sites summarised in this report are described in table 1. Site Y offered a rare opportunity to monitor powered chisels removal of textured decorative paint from the outside substrate of a building.

Table 1: Description of activity at the additional sites monitored

Site reference	Description and controls
B	Scraping painted TDC from finishing plaster on walls and the use of a hammer and bolster to remove painted TDC and plaster from a chimneybreast. X-Tex gel was used to soften the TDC being applied on the previous day and at the start of work.
D	A hammer was used to punch holes in TDC on a plasterboard ceiling and a crowbar was used to remove plasterboard in large pieces. Occasional hand spraying of the plasterboard to reduce dust concentration.
R	Scraping TDC from underside of a ceiling both (dry) and using steam removal.
S	Scraping TDC from concrete ceilings sprayed with softener/remover. Day 1: Wet and dry scraping. Day 2: Wet scraping only.
Y	Use of a "Kango" powered chisel to remove TDC paint on the pebbledash on the outside of a building (no controls).

4.1.1 PCM results

PCM personal airborne fibre concentrations are given in table 2, which includes the calculated LOD and LOQ for the average volume sampled. The high concentration of airborne dust at some of the sites meant that the sampled air volumes were, of necessity, very low to prevent overloading the filter (see figure 7). At site Y, where powered chisels were used, the maximum air volume that could be sampled was <10 litres, some 24 times lower than recommended in HSG248. Consequently the average airborne fibre concentration was barely above the LOD at this site, as defined from blank filter counts and the seemingly high concentration have no statistical significance. Sites B and S also gave average PCM fibre concentrations between the LOD and LOQ and the statistical relevance of these results are also questionable. Only at sites D and R were the average site PCM concentrations marginally above LOQs, based on the average volume of air sampled. Site D had the highest PCM fibre concentration and contained much higher concentrations of calcium sulphate and other non-asbestos fibres than those from the other sites sampled. This was surprising in that this was meant to be gentle removal of the TDC and substrate, using a method, which had previously given low PCM counts and no detectable asbestos fibres, by TEM. At site B, one relatively high PCM fibre concentration (0.58 f/ml) had a large influence on the PCM average.

Table 2: Summary of the site average of the personal PCM fibre concentration for non-soluble fibres and the calculated average LOD and LOQ.

Site	N^o of personal samples	Average volume sampled (L)	Concentration of non-soluble PCM WHO fibres (f/ml)	LOD	LOQ
B	14	23.00	0.13	0.07	0.22
D	11	18.00	0.29	0.09	0.28
R	8	84.25	0.065	0.02	0.06
S	24	38.60	0.057	0.04	0.13
Y	16	8.76	0.26	0.19	0.57

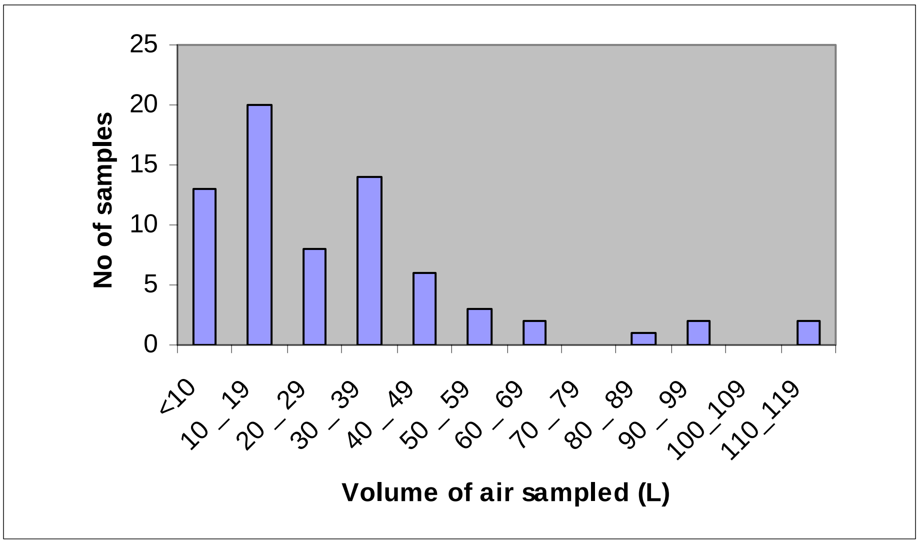


Figure 7: Distribution of sampled air volumes for personal samples counted by PCM.

4.1.2 TEM results

The TEM data for personal and clearance samples are given in table 3. The samples that gave the highest count of non-soluble PCM fibres were chosen for TEM analysis. The table has been divided into samples where some attempt to control dust releases were taken and into uncontrolled dry removal. The TEM analysis of site D, which gave the highest PCM fibre concentrations, did not detect any PCME chrysotile fibres in the 40 – 50 grid openings analysed (4,000 – 5,000 fields of view) and the samples are reported as <0.07 f/ml. A sample from site B, which gave the highest PCM fibre concentration (0.58 f/ml) for any site also had no PCME chrysotile fibres found in the filter area analysed, representing a concentration of <0.07 f/ml but did contain some calcium sulphate fibres. This suggested that the wet wicking on some filters is not always successful and it was observed that a few filters did not wet properly in the washer.

Samples collected during dry removal with no controls and generally with no extraction gave values ranging from not detected to 0.21 f/ml for PCME asbestos fibres. The highest value was from an attempt to remove the asbestos from the concrete dry but this was abandoned, as it was so difficult to remove. It was found to be much faster and easier to use a removal agent to soften the coating. Although short term peak values may exceed 0.1 f/ml this is only achievable when carrying out uncontrolled dry removal and sweeping which is non-compliant with CAW. It is important to note that the uncontrolled removal gives values around 0.1 f/ml and even bad practice barely exceeds this value. The difficulty of removing the coating by dry scraping suggests that this practice would not be continued for more than a short time before a more effective removal method was sought. Therefore it is considered unlikely than the proposed 4-hour control limit would be exceeded.

Table 3: Results of TEM analysis of PCME asbestos fibres on selected personal samples with high PCM fibre counts from each site.

Site	Sample Number	PCM fibre concentration (f/ml)	PCME chrysotile fibres	
			(f/ml)	(N^{o}.)
Removal with controls				
B	00458/06	0.58	<0.07	(ND)
	00474/06	0.34	<0.08	(ND)
D	00156/06	0.41	<0.07	(ND)
	00164/06	0.46	<0.07	(ND)
R	11671/05*	0.06	<0.01	(ND)
	11675/05*	0.07	0.02	2
S	00326/06	0.05	0.06	3
Removal with no controls				
S	00321/06*	0.05	0.21	7
R	11641/05*	0.03	0.02	3
	11643/05*	0.04	<0.01	(ND)
	11656/05*	0.06	0.01	11
	11661/05*	0.05	0.02	2
	11667/05*$^{+}$	0.11	0.18	8
	11668/05*$^{+}$	0.09	0.12	5
Y	00360/06	0.34	<0.05	(ND)
	00368/06	0.54	<0.08	(ND)
ND = non detected *NPU off, $^{+}$dry				

4.1.3 Gravimetric dust concentrations

The average airborne dust concentrations at the sites are summarised in table 4. Usually at a given site either the inhalable or respirable dust concentrations were monitored. It can be seen that there was a direct relationship between dust concentration and the average time of sampling for the fibre concentration, with sites B and Y exceeding the COSHH exposure level (4 mg/m^3 for respirable dust and 10 mg/m^3 for inhalable dust).

Table 4: Summary of average gravimetric airborne dust concentrations.

Site	Average inhalable dust concentration (mg/m^3)	Average respirable dust concentration (mg/m^3)
B	28.2	-
D	-	3.1
R	2.24	0.45
S	2.66	-
Y	-	11.4

4.1.4 Summary of site data

Overall, only two of the five sites, gave statistically relevant (>LOQ) average PCM fibre counts for insoluble fibres. Only one of these was higher than the overall average for individual personal samples from the HSE/IC survey (0.09 f/ml). The samples from this site (D) contained many non-asbestos fibres and TEM counts to date show that low numbers of chrysotile fibres were present in them. It should be noted that the data includes periods of dry removal and periods where the NPU was switched off. Site Y, which used Kango chisels to remove a chrysotile containing paint and substrate, was particularly difficult to monitor, as was site B where a hammer and bolster was used to remove both the TDC and the underlying material from the chimneybreast.

Although the analytical sensitivity of the TEM analysis was very limited by the low volume of air sampled, analysis of selected samples with high PCM fibre counts showed that low concentrations of PCME asbestos fibres were present and these were below 0.08 f/ml.

4.2 CHANGE IN THE PERSONAL AIRBORNE ASBESTOS FIBRE CONCENTRATIONS INSIDE THE ENCLOSED AREA IF NO AIR EXTRACTION IS USED TO KEEP A REDUCED PRESSURE INSIDE THE ENCLOSURE

The use of air extraction is primarily to prevent spread of airborne fibres from the enclosure to adjoining areas. Its effectiveness in lowering personal exposures will be both limited and variable. Personal exposures are usually multiple times higher than static exposures as the airborne fibres and dust is generated by the actions of the removal operative, usually in close proximity to their respiratory region. The sampling protocol called for measurements to take place with the filtered air extraction, also referred to as negative pressure units (NPU), both on and off. As far as possible this was done for similar work and levels of disturbance during both regimes, to allow direct comparison between the two.

The average for the five sites listed in table 5 show that overall, the personal concentrations were some 23% greater with the NPU switched off. This was similar to that reported for laboratory simulations (see IF2005/13). Although the increase is well within the 95% confidence interval, this was a consistent trend for 4 of the 5 sites and was an average for many samples, so this is taken to be broadly representative of the expected average increase in personal exposure.

Table 5: PCM WHO fibre concentration (f/ml) for non-soluble fibres with air extraction on and off at the 5 sites sampled.

Site	NPU on (f/ml)	NPU off (f/ml)	Difference (%)
B	0.14	0.1	71
D	0.67	0.96	143
R	0.04	0.06	150
S	0.05	0.05	100
Y	0.26	0.26	100
Average	0.232	0.286	123

4.3 EFFECTIVENESS OF SITE CLEARANCE, BASED ON A VISUAL ASSESSMENT ALONE.

The PCM results from the site clearance monitoring are given in table 6. The disturbance air tests were all carried out with visible debris and dust on the floor, with the aim to replicate the likely maximum concentrations that could be generated if a partial or improper clean up was performed, and the occupants were left to clean up the mess. The disturbance method used was sweeping surfaces vigorously with a broom, starting with those surfaces from which the asbestos had been removed, before sweeping horizontal dust traps and finally the floor. At some sites, a second disturbance was carried out around the mid-point of the sampling (after about 30 minutes) and the debris was swept into small piles, photographed and collected for weighing.

The amount of debris and dust remaining and the level of disturbance meant that some filters had a high loading of particulate. Overall, the PCM fibre counts showed that dry sweeping with a broom, on surfaces that had been poorly cleaned and which contained visible debris, produced airborne PCM concentrations of around 0.01 f/ml. At site S the material from the piles of debris swept up was collected and weighed. In one of the rooms about 8g of dust and debris was collected from a floor area of about 14 m^2.

Some clearance samples were also analysed by TEM and the asbestos concentrations are given in table 7. The results were similar to the PCM results and showed that PCME asbestos fibre concentrations around the clearance level (0.01 f/ml) can be generated when significant visible debris and dust remain and are vigorously disturbed.

All the sites, where HSL staff carried out disturbance air monitoring, would have failed any form of visual assessment, as debris was readily visible on the floor. All three sites where HSL staff was still present failed the visual assessment during the formal certificate of reoccupation inspection and required further (sometimes extensive) cleaning.

It was also noted that the degree of disturbance used by HSL staff to carry out the disturbance air monitoring, was far greater than that used by the commercial laboratories. In one case the analyst simulated disturbance activity using a nail brush/ small scrubbing brush, to disturb the area. Only marginal contact with the surface was being made during some of the time. The current guidance was set up with the intention to simulate a typical work activity that may take place at the site after removal of the enclosure with an intention that all the removed and horizontal surfaces should be disturbed. This includes simulating activities such as dry sweeping with a broom or sweeping up with a dustpan and brush. Failure to adequately disturb surfaces will result in low fibre and dust concentrations in the air and renders the clearance air testing of little value.

Overall, there was no doubt that a reasonable clean up, which leaves no easily visible dust and debris will not give rise to airborne chrysotile concentrations above the clearance indicator even when a valid disturbance air test is carried out. The low amounts of fibres released from TDCs means that visual clearance of dust and debris is more than adequate to ensure that fibre concentrations will remain below the clearance indicator. One-site analysts stated that he had not had to fail a TDC removal site on the initial clearance air test concentration for some 50 sites.

Ultimately the low fibre release from this material means that removal sites are unlikely to exceed the clearance indicator unless a very poor clean up has been done. The requirement in the CAW regulations is for the area to be thoroughly cleaned before taking down the enclosure. If after the enclosure is removed small amounts of dust and debris remain these will not give rise to high concentration of airborne fibres and can be cleaned up by the contractor using a HEPA vacuum or wet wiping with minimal exposure.

Table 6: Summary of PCM results for clearance samples using different preparation methods and counting rules.

Description of clearance and activity	PCM (f/ml)
Site B: Room swept for 5 minutes with broom on walls and floor, visible debris easily swept into small piles. The external laboratory carrying out certificate of re-occupation monitoring swept the room (a small scrubbing brush) for a further 5 minutes after about 40 minutes of sampling. (Samples with many particles).	0.004 0.005 0.011
Site D: Two separate rooms swept with broom for 5 minutes at the start of the sampling period, visible debris was visible on the floor during sweeping. Additional clean up ordered by independent analyst attending site later.	0.005 0.010
Site S: Four individual rooms swept for 5 minutes from ceiling downwards at start of sampling and for a further 2.5 minute after ~30 minutes of sampling (samples with many particles). All four rooms had significant visible debris.	0.009 0.010 0.013 0.014
Site Y: Inside enclosure (outside building) visible debris	0.004

Table 7: TEM results from disturbance air sampling.

Site	Sample Number	PCM fibre concentration (f/ml)	PCME chrysotile fibres	
			(f/ml)#	N°.
D	00167/06*+	0.01	0.002	1
S	00355/06*+	0.009	0.0099	5
	00356/06*+	0.010	0.012	6
*NPU off; +dry sweeping				

4.4 THE LIKELY AIRBORNE RELEASES FROM POORLY CONTROLLED REMOVAL

The control of emission at source is a key requirement of all health and safety legislation in reducing personal exposure. Effective wetting the material being worked upon is the key method to reducing dust emission. Other secondary containment methods such as local exhaust collection and barrier methods such as wrap and cut and glove bags are also used.

4.4.1 PCM results from site monitoring

The effectiveness of the control measures in use was tested at two of the sites where scraping was taking place and by carrying out part of the removal with no attempt at dust suppression (e.g. dry). The PCM results are given in table 8.

Table 8: Comparison of PCM WHO airborne concentrations of non-soluble fibres for wet and dry removal

Site (suppression method)	PCM WHO airborne concentrations of non-soluble fibres (f/ml)			
	Dry with NPU off	Wet with NPU off	Dry with NPU on	Wet with NPU on
S (sprayed solvent)	0.05	0.03	0.05	0.05
	0.12		0.04	0.07
R (Steam removal)	0.06	0.06	0.03	Not done
	0.06	0.07	0.04	Not done

It can be seen that the PCM results showed no clear pattern of reduction between dry and wet removal of TDCs at these two sites. This is in complete contrast to effective wet removal of other licensed ACMs, where wetting produces a two to three orders of magnitude reduction in airborne fibre exposures.

The explanation for this lack of variation is that the material is not effectively wetted or controlled at source and in reality TDC is often removed partially dry. Site observations and the measured gravimetric dust concentration show that most of the removal, where the material is scraped from the surface, is effectively done with the contact between the wet/dry surface interface, where the TDC has not been wetted. Unless the sprayed solvents, brush applied gels and steam softening penetrate through the entire layer of the TDC the scraper meets resistance where the dry layer begins. Although the build up of softened material on the end of the scraper may have some effect in suppressing airborne release, the difference between dry and suppressed removal for both scraping and demolition of TDC seems to be small.

Overall it would be expected that scraping a dry surface would disturb a greater area of TDC than cracking it into smaller pieces and pulverising small areas where the hammer hits during demolition. However, completely dry scraping is particularly difficult to do unless the TDC is attached to a substrate has a weaker layer that easily detaches (see site R). Therefore some aid to removal is needed for scraping, which softens the TDC and partially suppresses the airborne release from the dry surface along which the scraper runs.

As the control at source during scraping appears only to be partially effective and some treatment is necessary to scrape TDC from most substrates, it is not possible for an unlicensed removal contractor, if complying with the CAW regulations, to produce fibre concentrations significantly above that measured at licensed removal sites. The chemical applications used to soften the TDC are useful in that they permit easier removal of the coating. It is far preferable to use something that increases the speed and ease which the TDC can be removed, and it is likely these chemical softeners will continue to be used. A similar argument appears to apply for localised steam softening and removal. While it is possible that more energetic methods such as powered tools, powered sanders and dry grit blasting could be used, their use will almost certainly result in a breach of the CAW regulations.

4.4.2 TEM results from site R during uncontrolled dry removal and steam removal

Site R gave an opportunity to monitor in detail the airborne fibre concentrations produced by uncontrolled dry scraping. The TDC had been applied to a distempered plaster ceiling and the friability of the paint layer meant that the TDC layer was poorly adhered and could readily be scraped away even when dry. The PCM and TEM results for personal samples are given in table 9. The activity carried out was intended to be an example of poor practice where uncontrolled dry removal took place with no extract air inside the enclosure. It can be seen that chrysotile asbestos PCME fibre concentrations were above 0.1 f/ml during the peak removal and sweeping activity. Although the airborne fibre concentrations were calculated from the small numbers of PCME chrysotile fibres that were found (0 – 11), this gives poor precision, but shows that short term peak concentrations of around 0.1 f/ml can be produced by uncontrolled dry removal or sweeping of friable material. These activities, which are not allowed under the CAW regulations and did not exceed the proposed 10-minute limit (0.6 f/ml).

The airborne PCME asbestos concentrations for controlled removal using steam to soften and wet the coating were lower than the uncontrolled dry removal but the low numbers of fibres counted make it difficult to show whether this was statistically significant in terms of 95% confidence intervals. All the PCME asbestos fibres found were identified as chrysotile.

Table 9: TEM PCME airborne asbestos fibre concentrations at site R during uncontrolled dry removal

Sample Number	Activity	No of asbestos fibres	TEM /PCME chrysotile concentration (f/ml)	PCM fibre concentration (f/ml)
11641/05	R: dry scrape*	3	0.019	0.03
11643/05	M: dry scrape*	0	0.000	0.04
11656/05	R: dry scrape	11	0.115	0.06
11661/05	M: dry scrape	2	0.019	0.06
11667/05	M: cleaning and dry sweeping	8	0.184	0.11
11668/05	R: cleaning and dry sweeping	5	0.124	0.09
11671/05	R: steam scrape	0	0.000	0.06
11675/05	M: steam scrape	2	0.019	0.07
Total / average		31	0.060	0.065
* NPU was on only for these samples				

4.5 THE AIRBORNE CONCENTRATION OUTSIDE THE ENCLOSURE IF NO AIR EXTRACTION IS USED

The two sites where sampling outside the enclosure was carried out both had entry airlocks situated on the outside of the building and it was not thought to be a reasonable assessment to sample airborne fibre concentrations near the exit to the airlock in ambient air. Instead, sampling was carried out in the area that was one chamber (two flaps) away from the inside of the enclosure. In the two-stage airlock proposed in the ACoP this would equate to the concentrations in the second chamber. Dilution effects and an additional flap to further reduce circulation mean that this will give an overestimate of the airborne fibre concentration around the airlock exit. However, it was noted that at the sites sampled there was often a lot of activity in the airlock chamber nearest to the enclosure, and at both sites the inside flap was propped open for prolonged periods. The reasons for this were due to: operatives trying to communicate with the supervisor (outside the enclosure), waiting for further supplies and inappropriate placement of equipment and bags at the entrance to the airlock. It was also the area were the operatives were active double bagging asbestos waste etc. Therefore for some of the sampling time, a single flap was all that separated the middle chamber from the enclosure.

The PCM results of the static sampling carried out inside the airlock with the NPU on and the NPU off are summarised in table 10.

Table 10: Results of the static monitoring of the PCM WHO airborne fibre concentrations of untreated fibres inside the airlock and the enclosure at two sites.

Sample details	Volume of air sampled (litre)	PCM fibre concentration (f/ml)
Site S: During removal in 2nd bag airlock, NPU on*	1124	0.001
Site S: During removal in 3rd stage of airlock, NPU on*	264	0.004
Site S: During removal, with activity very close to airlock: 2nd stage of airlock with NPU off. (Note: an operative was standing in the first stage and holding a flap open during most of the sampling period).	90	0.05
Site B: During removal NPU on	95	0.018
During removal NPU on	188	0.001
During removal NPU off	560	0.002
During removal NPU off	240	0.007
*Removal activity was far from airlock and low airborne fibres in the vicinity of the airlock.		

The sampling evidence available showed that PCM airborne fibre concentrations inside the airlocks were low when the NPU are switched off. Site S was sampled with the NPU off when the removal activity was directly over the entrance of the airlock and surrounding area and when only one flap was in position. The measured airborne fibre concentration in what might be considered a worst-case situation was at the LOQ. Although it is hard to draw conclusion from only two sites, both sampled in relatively still air / low wind speed conditions on the outside of the airlock, it would appear that airborne concentrations in the area around the exit of the airlock would be relatively low. The airlock flap system at these sites was designed to allow the ingress of air with a NPU running and there are much more effective ways of producing an airtight seal to produce a true “airlock” entry, if no NPU was in use. Using the existing design and taking into account that measurements were made inside the airlock it is unlikely that PCM fibre releases from the enclosure would exceed 0.01 f/ml in the area close to where the airlock entry was situated.

4.6 THE AIRBORNE EXPOSURES THAT WILL BE EXPERIENCED BY PERSONS REOCCUPYING THE BUILDING.

As the airborne asbestos fibre concentrations inside enclosures during active removal are low then there is unlikely to be a significant exposure to airborne fibres if the enclosure has been thoroughly cleaned and the area inspected for visible debris before it is taken down. Measurements inside enclosures, which had visible debris, and dust demonstrated that a clearance level is produced (~0.01 f/ml) when sweeping with a broom for 5 minutes. This would be a one off peak if poor clean up had been carried out by the contractor (in breach of CAW regulations) and the re-occupier or maintenance personnel had to sweep up the TDC debris left behind. After the first clean up, it is likely that little asbestos containing material will be left to act as a significant source of airborne emission.

Inspecting sites for the spread of debris outside the enclosure is relatively easy. If operatives carrying out the work leave the enclosure and airlock still wearing contaminated footwear and overalls, it is possible to spread debris outside of the work area. At the sites visited there was some evidence of debris spreading inside the airlock and reducing the airlock from three to two chambers will increase the potential for debris to spread outside the airlock. However, as we are unable to assess the difference between the two and three stage airlocks in this current study we have INSTEAD looked at the potential effect that any debris will have on the airborne exposures.

In order to investigate the potential airborne release from the disturbance of debris left following a removal of TDC with greater precision, a simulation was carried out in the HSL 9 m3 dust chamber (see IF/2006/02). This used over 100g of dry and friable dust and debris gathered from site R, where dry removal of the TDC had been carried out. With an air exchange rate of 2.4 room volumes per hour, 30 minutes walking over the debris gave personal PCM airborne fibre concentrations of ~0.014 f/ml (for all fibres, no wet-wicking was used). Given that the amount of debris was more than two orders of magnitude higher than what would be easily seen in a visually clean area and the likelihood of disturbance of such a small amount of remaining debris is much lower: it is unlikely that any remaining dust and debris would contribute significantly measurable airborne fibre concentrations to the indoor environment. The contribution to the airborne concentration of small amounts of dust and debris after the site was visually cleared are expected to be below 0.0005 f/ml.

5 IMPLICATIONS FOR RISK ASSESSMENT.

5.1 THE AIRBORNE RELEASES FROM THE REMOVAL OF TDCS

A misconception has arisen that the HSE/HSL exposure risk assessment was based only on data from one study, known as the HSE/IC study (IF2005/03). The risk assessment was based on the data summarised in IF2005/13. The data included a variety of disturbance and removal methods used on a range of surfaces (e.g. concrete, metal, plaster and lathe, plasterboard and wood). The data in IF/2005/13 was used to estimate the annual average exposure for a person carrying out exclusive removal of TDCs. The average exposure was estimated at 0.08 f/ml for PCM chrysotile fibres, based on working exclusively with TDC removal averaged over some 240 days per year for 8 hours per day. This figure was chosen to be representative of an upper limit of the average exposure from TDC removal that any single person would be likely to achieve over the working year. For epidemiology and risk assessment the statistic used to represent exposure and dose is the arithmetic average of the annual exposure, which is used to derive the cumulative dose in f/ml/years. It can be seen that in numerical terms that time weighted averages of PCME chrysotile fibres above 0.08 f/ml are extremely unlikely over a 4- hour period, let alone over the full 1920 hours assumed in the risk assessment.

5.2 THEORETICAL MAXIMUM NUMBER OF PERSON EXPOSED AT THE HIGH ESTIMATE OF THE EXPOSURE CONCENTRATION

The data available from HSE licensed removal database showed that the current number of job days per year spent on TDC work is ~20,000 with approximately 47,000 worker days per year. Assuming, as above, a person was working on TDC for 8 hours a day for 240 days a year, it would only be possible for 196 people to be exposed in this way before all licensed TDC removal is accounted for. Even then this is a substantial overestimate of the time spent actually physically disturbing /removing the material as a variety of non- or low exposure activities are also carried out (e.g. travel to site, site set up, changing and decontamination, application of wetting agents, final clean up, enclosure tear down, equipment maintenance etc). It is estimated that depending on the size of the jobs, that over a year only something between one third and one half of the time could realistically be spent physically disturbing the TDC (i.e. ~42% if midpoint is used). Therefore the actual exposure of 0.08 f/ml could only theoretically take place for a maximum of 83 people, if they spent their entire time carrying out peak removal and clean up activities. In practice, it is difficult to see how even exposure of more than a few of the theoretical number of 196 full time TDC removal workers (who would be exposed to concentrations two to three times lower than the conservative average of 0.08 f/ml) could be realised, and a larger number of workers will be exposed for a shorter time.

5.3 VALIDITY OF THE AVERAGE EXPOSURE FOR RISK ASSESSMENT

For the arithmetic average to be an unbiased estimate the measured exposures, the data must be normally distributed, broadly representative of the activities taking place and based on the substance of concern. Unfortunately, all of the above do not apply to the TDC data.

Removal of TDCs gives rise to low airborne exposures of PCM fibres, which are often close to the LOD and LOQ, even if 240 litres of air can be sampled. Also the filter blanks give measurable background counts, which contribute to the measured PCM concentration. Failure to adequately control dust emissions at source makes the situation far worse in that the LOD and LOQ approach or even exceed the value of the control limit. Therefore the distribution of the individual samples is constrained and biased and is no longer a normal distribution. Although no corrections for the bias has been made, nor for the fact that the PCM counts of soluble fibres is an overestimate of the asbestos fibre concentration, it is clear that the PCM average is likely to be an overestimate of the peak short term concentrations.

The current and updated EU AWPD directives, define the exposure limit over an 8-hour working period. UK practice has been to use a 4- hour time weighted average for the control limit, which already provides a more stringent control limit of up to twice that required by the directive, if work is undertaken over a 4-hour period.

5.4 MEASURED CONCENTRATIONS FROM THE ADDITIONAL SITES

Taking into account the sampling and analytical limitations, and the statistical precision and relevance of results below the limit of quantification, there is no evidence from the additional monitoring of the short term peak concentration, carried out on surfaces where the TDC is being scraped and/or chiselled off, that the estimated average of 0.08 f/ml for the annual exposure, will be exceeded by any worker over a period of a year engaged in TDC removal, provided the CAW regulations are applied.

6 APPENDICES

6.1 PROPOSED PROJECT TO MONITOR PERSONAL FIBRE CONCENTRATIONS OF WORKERS INVOLVED IN THE REMOVAL AND RENOVATION OF TEXTURED DECORATIVE COATINGS PHASE 2.

AIM

The aim of this work is to collect data on fibre emission from work with asbestos containing textured decorative coatings removed under licensed and unlicensed conditions. It is intended to build on the experience of phase 1.

PURPOSE

The results will be used to inform further the consultation by HSE on whether decorative coatings should continue to be a licensed asbestos material.

INTRODUCTION

The work in phase 1 showed that very high dust concentrations were produced by licensed removal contractors during the removal of chrysotile containing textured decorative coatings. A number of sampling and analytical strategies were developed for and during phase 1 to try to get countable samples, which were not overloaded. This however, meant that very short sampling times and low volumes of air had to be collected, that often reduced the limit of quantification to above the proposed control limit of 0.1 f/ml. This required pooling of several samples to characterise the fibre concentration. Also in the later samples using much lower flow rates 0.2 – 0.5 L/min it was decided to monitor for longer periods

The release of calcium sulphate particles and fibres from the underlying plaster was also a problem. This caused the PCM fibre count to include calcium sulphate fibres and to overestimate the asbestos content. A procedure was developed to remove the calcium sulphate before the PCM analysis and was shown to be effective in removing some of the particulate matter. This made some overloaded filters countable, reduced fibre undercounting due to obscuration and/or the touching particle rule and reduced the count of non-asbestos fibres.

The same principles are to be extended to this further work and a generic project design has been produced below. As sites will be different it is expected that variations will have to be made to accommodate the types of work taking place and local conditions.

PROJECT DESIGN

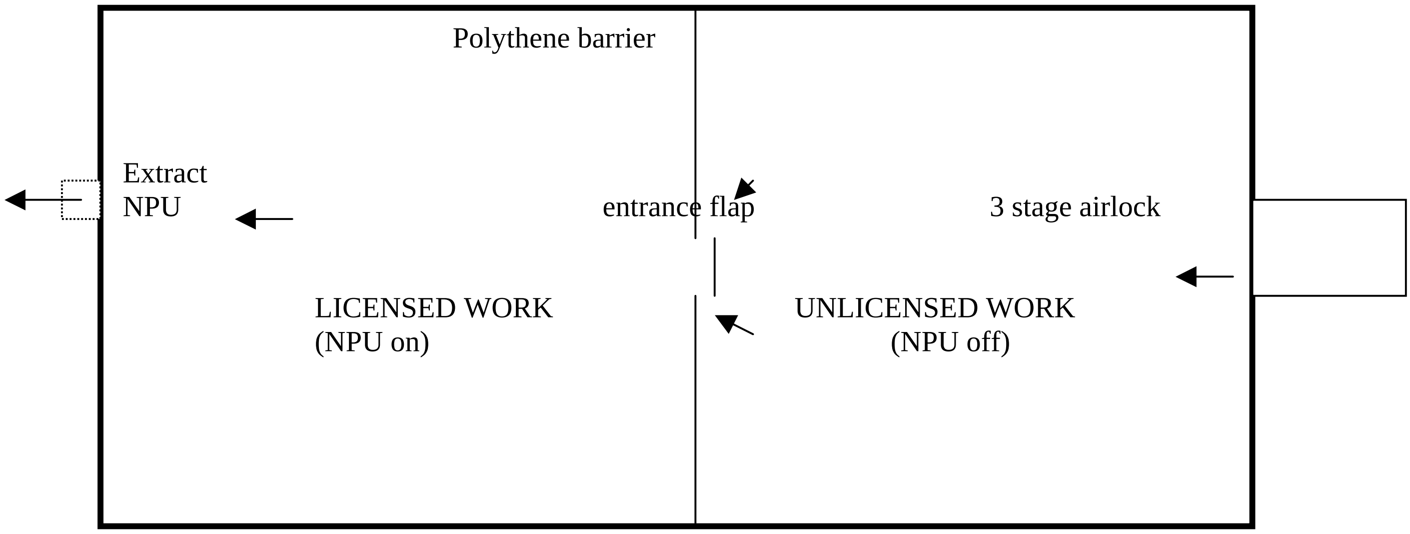
The proposed project is designed to:

- Collect personnel exposure data (fibre and mass concentration) during the repair, renovation or removal of damaged ceilings or walls coated with asbestos containing textured decorative coatings;
- Compare the personal exposures from licensed and simulated unlicensed work with appropriate controls as required by CAWR and the proposed ACoP;
- Compare the clearance levels from licensed and unlicensed removal;

To achieve this, where possible, the full enclosure built for licensed removal will be divided into two halves (one for licensed removal and the other for unlicensed type removal) with a temporary plastic barrier in between with a doorway entrance flap cut to allow persons and air to pass through but can be sealed up later to limit the dust spread (see below). The licensed removal type work will be carried out first, in the half with the NPU) with the NPU unit on and dust suppression techniques used as normal. Both the removal and clean up should be completed so the Contractor is happy with the area passing a visual assessment.

Then turn off the NPU and tape up the entrance to the middle barrier to seal the area and carry out removal and clean up in the unlicensed area. This will mean no extraction or ventilation in most cases but normally the use of water sprays, gel removers and steam units etc. should be used, as we would expect these control measures to be used by anybody who removes asbestos under CAWR.

If separation into two areas with a physical barrier is not possible, the sampling with NPU on and NPU off should be arranged with a lunch break or overnight gap between.



SAMPLING STRATEGY DURING WORK

Use up to 3 samplers per person 1 for mass concentration and 2 for fibre concentration (depends on number of workers). The sampling personnel will have to apply a judgement on what sampling rate and time of sampling to use, based on the expected amount of airborne dust.

Sample the two main work phases (removal and clean-up) separately by:

- Use a cowled sampler head with 0.8 µm pore size filter sampling set at between 0.2 – 0.5 litres/minute for entire period of removal and then change head for entire period of clean up.

- Use a cowled sampler with 0.8 um pore size filter sampling at 1 litres/minute and change cowl every 10 minutes during dusty periods, or if lower concentration leave for longer. (The sampling person will have to judge this as best they can).

- Measure respirable dust on at least 1 person using a cyclone sampler at the appropriate rate (e.g. 2.2 L/min) for removal period and then change over for the clean up. (The cyclone can be fitted with a 1.2 µm pore size membrane filter to allow for PCM counting after reweighing).

- Measure total dust on 1 person using IOM inhalable sampler operating at 2 L/min for removal period and then change over for the clean-up period.

SAMPLING STRATEGY DURING CLEARANCE

The Contractor should thoroughly clean the area after the work as required by CAWR and carry out their own visual clearance. Once this has been done and the Contractor is satisfied, HSL personnel will carry out stage 2 and 3 of the four-stage clearance test as documented in HSG 248 in each part of the enclosure (licensed and unlicensed) individually.

For each separate part:

- The stage 2 visual clearance will note whether dust and debris are visible inside the work area. The Contractor will not be asked to carry out further clean-up if not found to be adequately cleaned, in either section but a detailed note and photographs) will be made of the amount and location of the debris seen.

- The stage 3 disturbance sampling (using a new broom) will be carried out separately (as detailed in HSG 248) in each half of the enclosure when dry to collect 480 litres of air onto static membrane filter samplers.

- The licensed area should be cleared first (with NPU off).

The full 4-stage procedure for a certificate of reoccupation will be carried as usual by another laboratory, after the HSL clearance. Results to be forwarded to HSL.

ANALYSIS

Quarter filter should be mounted for PCM analysis and counted by WHO rules (200 fovs examined).

Quarter filters should be carefully wicked in water to remove calcium sulphate particles and when dry (left overnight) mounted for PCM analysis and counted by WHO rules (200 fovs examined).

Quarter filters should be prepared for TEM analysis and counted by ISO method for PCME fibres (asbestos and non-asbestos fibres identified). If lots of calcium sulphate present grids can be placed in a water washer for 60 minutes to dissolve fibres, (see appendix H ISO 10312:95).

A quarter filter should be retained and stored.

Mass concentration filters should be weighed before and after sampling with 3 control blank filters.

REPORTING

Individual site reports detailing the work and results will be produced by HSL.

6.2 RESPONSE FROM ARCA

Dear Gary

Please find below the ARCA Technical Committee comments on the proposed further trials to determine the appropriateness of the proposed method of removing asbestos containing textured coatings.

The sites should be large enough so that removal of textured coating can take place during the entire air-sampling period. This will allow the measurement data from the study to be assessed in terms of actual airborne fibre concentrations rather than in terms of time-weighted average airborne fibre concentrations.

The range of textured coatings removed during the first study was too limited to permit a full assessment of the likely risks associated with textured coating removal. Any conclusions derived from the study results can therefore only be applied to the coating types and removal techniques observed. All sites during further trials should include proper removal from concrete not removal of plasterboard/lathe and plaster that happens to have Artex on it

No measurements were made during the first study to determine whether there had been spread of asbestos contamination to outside the enclosures and no measurements were made of airborne asbestos fibre concentrations at the location of demolished enclosures. Robin Howies method of micro vacuuming to identify fibres that have left the enclosure and settled on surfaces should be employed after completion of jobs during further trials to assess whether any fibres are present.

The failure to address the potential for asbestos contamination generated by the removal of textured decorative coatings to spread into areas occupied by unprotected adults and/or children is a critical omission from the first study and should be addressed this time.

All work during the first study, including enclosure construction, was carried out by experienced trained and licensed contractors which will bias the results “towards best practice”. The proposal is to allow the work to be carried out by unlicensed contractors, therefore the further trials should assess the new proposal by using unlicensed contractors.

HSL were on site during the first study to manage the work which will have ensured better than normal practice. This will have biased the results “towards best practice” and this casts doubt on the validity of the measurement results obtained as being representative of likely real-world exposures. This will also apply to the second series of tests.

Permission for HSL to carry out further studies on removal sites will require the permission of the client therefore we would recommend that HSL contact our members directly in order to obtain sites at which to carry out further studies. A list of ARCA members can be found at http://www.arcaweb.org.uk/ARCA_members1024.asp

Finally, will the necessity to carry out the further trials result in the need to extend the consultation period?

Regards

Steve Sadley

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