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**Airborne fibre concentration during the removal
of asbestos containing textured decorative
plasters and paints and the risk to workers**

Report Number IFS/05/13

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EXECUTIVE SUMMARY

Objectives

This report details the available measurements of airborne fibre concentrations released during the maintenance and removal of chrysotile containing textured decorative plasters and paints. This survey was initially carried out to obtain information on the level of exposure to workers for use in the regulatory impact assessment for the new CAW (2006) regulations. The report also includes a broader assessment of the risks for various groups and whether the definition in the EU directive for 'sporadic and low intensity exposure,' applies and whether it is necessary to retain this type of asbestos containing material within the licensing regime.

Main Findings

All asbestos removal is controlled under CAW (2002) and a requirement to reduce exposure to as low as reasonably practicable, applies to all work activities whether licensed or unlicensed. Low intensity exposures should generally be below the control limits, which are due to be further lowered to 0.1 f/ml over 4 hours of sampling and 0.6 f/ml over a 10 minute peak exposure for all regulated asbestos types.

The monitoring summarised in this report shows that there are two basic types of removal taking place. When the textured decorative plaster finish has been applied to a low resistance surface (e.g. plaster board or a lathe and gypsum plaster surface on the ceiling and walls) the underlying surface and finish will often both be removed. When the textured decorative plaster has been applied directly to a resistant (e.g. concrete) surface, the layer is removed from the underlying surface (but it is sometimes scraped from plaster and plasterboard surfaces).

The airborne asbestos fibre emissions are low because a relatively small proportion (up to 4%) of chrysotile (white) asbestos is present in the product and the fibres are firmly bonded within the matrix making them difficult to release. The dust released from the product in many removals often makes up only a small proportion of the total dust generated from the substrate.

Removal work with textured decorative plasters and paints can give rise to high concentrations of airborne dust, much of it comes from the underlying plaster and from disturbance of settled dust layers on top of ceilings.

The combination of high dust concentration and low fibre concentration can make the sampling and analysis very difficult. Ideally, measurements of a low fibre concentration requires a high flow rate and / or a long sampling time, in order to obtain a sufficient fibres on the filter for good precision. However, if the density of non-fibrous dust on the filter is too high, some fibres may be obscured by dust particles and the fibre concentration is an underestimate. This can only be avoided by using a low flow rate and /or a short sampling time. In practice, the sampling conditions usually have to be an awkward compromise between the conflicting requirements. This meant that for many short period samples, the measured fibre concentration is often not much above the limit of detection and may exceed the control limit based on the background/blank fibre count. Pooling counts from a number of filters from the same activity and /or the use of short-term 10-minute samples was the only way to compare exposure to the control limits.

A further difficulty is that in the standard phase contrast microscopy (PCM) method of analysis used to determine airborne fibre concentrations, all fibres meeting the size definition are counted and a large proportion of these may not be asbestos. In particular, gypsum particles from the plaster may be $> 5 \mu\text{m}$ long and have aspect ratios $> 3:1$ and so come within the definition of a 'regulated' fibre under the PCM counting rules.

Analytical electron microscopy is the most reliable way to determine the airborne concentration of 'regulated' asbestos fibres (known as PCM equivalent (PCME) asbestos fibres) and the several hundreds of PCM results reviewed may considerably overestimate the actual asbestos fibre concentration. The proposed introduction of the WHO method for the PCM analysis of fibres in the new CAWR regulations, allows for further analysis and fibre discrimination to take place so that the asbestos fibre concentration is obtained, rather than just including all fibres that meet the regulatory size definition.

Airborne fibre concentrations

Small scale disturbance due to maintenance type activities produced airborne fibre levels well below 0.1 f/ml, the proposed control limit and easily come within the definition in the new directive for 'sporadic and low intensity exposure'.

Many removals appeared to be of relatively short duration and involve the repair or replacement of a damaged ceiling in one or two rooms of houses and flats due to water ingress or fire damage. All but one of the PCM samples taken for short periods 10-20 minutes gave airborne fibre levels below the proposed short term control limit of 0.6 f/ml. The one high sample was heavily loaded and had to be prepared by an indirect method that overestimates the airborne fibre concentration.

Due to the high numbers of non-asbestos calcium sulphate fibres released, it is known that the PCM fibre count overestimates the asbestos levels. Using a method to remove calcium sulphate particles and fibres from a selected set of high concentration samples gave an of 0.09 f/ml. However, as many were short term peak release samples these represent an upper estimate and the 4-hour time weighted average used for the control limit will be substantially lower. The value includes all non-soluble fibres.

A sub-set of samples chosen predominantly because of their high PCM fibre counts and analysed by analytical TEM for their equivalent PCM asbestos fibre content, gave a average value of 0.07 f/ml for personal samples. This set had many high biases and would represent an overestimate of the average. Again conversion of the short term samples into a representative 4 hour time weighted average for comparison to the control limit would substantially reduce this figure.

Therefore if CAW is complied with, average exposures during removal of textured decorative finishes will be below the control limits.

The results available show that average value of 0.08 f/ml used for the risk assessment for the regulatory impact assessment, is likely to be an upper estimate of the average airborne asbestos fibre exposures to removal workers.

Only chrysotile asbestos was found in the TEM analysis.

Uncontrolled vigorous scraping at one site with no controls gave PCME chrysotile asbestos concentrations equivalent to 0.09 f/ml over one hour of peak activity.

Worst-case simulations suggest PCME counts of asbestos fibres of around 0.1 – 0.3 f/ml can be generated by uncontrolled dry removal and ~1 f/ml by the use of uncontrolled dry abrasive methods (e.g. power chisel and sanding). Uncontrolled, dry removal and the use of abrasive methods are however, specifically excluded by the CAW regulations.

Other observations

Arguably, due to the high dust levels generated at many of the removal sites (and therefore giving rise to the difficult monitoring situations encountered) many licensed asbestos removers did not control emissions at source and did not meet the requirements of either the CAW or COSHH regulations.

Most removal contractors relied on controlled wetting using hand pumped water sprays or the use of chemical gel softeners to control dust emissions when the material was removed along with the substrate. Only one site was reported as using a wet-injection method. Therefore there is unlikely to be any significant difference in the technology used for the control of release at source between unlicensed and licensed contractors for combined substrate and coating removal.

Removal of textured decorative plasters from concrete does require more effort and other techniques have been sought exposing workers to a wider range of risks (e.g. high pressure jets etc).

Fibre concentrations well-below the control limits can be achieved when textured decorative plaster finishes are abated or removed using “controlled removal” methods. Methods that result in limited disturbance to the material (e.g. removal of plasterboard as intact as possible) or that effectively wet and suppress airborne fibre emissions gave low dust and fibre levels. Dry scraping and dropping ceilings produces a high level of disturbance and very high dust levels, which made sampling and measurement of the fibre concentration very difficult and offers little or no control at source.

Risk

The risk assessment for licensed removal work, based on continuous work on removal of textured decorative finishes for 1920 hours per year for 5 years from the age of 30, without use of any respiratory protection, gave an annual risk of death of 0.67 per million.

This annual risk of death with RPE (assuming a X10 reduction in exposure) was calculated as 0.02 per million. The HSE TOR approach considers annual risks of death of <1 per million to be the divide between “broadly acceptable” and tolerable.

Most removals are likely to have TWA’s below the 4 hour control limit and are unlikely to exceed the 10 minute control limit regardless of whether they are licensed or unlicensed provide CAWR is applied.

It is not expected that any increased exposures due to the de-licensing textured decorative plasters and paints will cause the risk to workers to rise above a 1 per million annual risk of death.

The four-stage clearance required for licensed work will not be mandatory but there is no reason why this could not be done.

It is not anticipated that a lower level of clearance (e.g. thoroughly cleaned by the contractor and examined to be visually clean) would give rise to any non-work related deaths among building occupants.

Recommendations

There is a strong case to consult on and recommend the removal of textured decorative plasters and paints from the licensing regulations.

It should be emphasised that all asbestos removal is controlled by the CAW regulations and the requirement to reduce exposure to as low as reasonably practicable applies to all work activities whether licensed or unlicensed.

The high levels of dust generated during removal of ceilings and floors shows that more attention to controlled removal is needed by contractors and improvements in current work practices are required.

1 INTRODUCTION

This report lists the available measurements of airborne fibre concentrations released during the removal of chrysotile containing textured decorative plasters and paints. This was carried out to inform the debate on the exposures and risks to asbestos removal workers and the likely effects on a proposal to consult on whether it is necessary to retain this type of asbestos containing material within the licensing regime.

1.1 LEGISLATION AND REQUIREMENTS

Currently any material that contains any asbestos is regarded as asbestos containing and work with this material is subject to the Control of Asbestos at Work regulations (CAW, 2002) and two approved codes of practice (L27 & L28). Since Asbestos (Licensing) Amended Regulations (ASLIC, 1983) and after their amendment in 1998: three categories of asbestos products were recognised as being of particular concern, and any work taking longer than 2 hours on these products was restricted to contractors who had received a licence from HSE. The three 'licensed' categories were asbestos insulation, asbestos coatings and asbestos insulation board. These three groups of asbestos containing materials (ACMs) were considered to present a higher risk to workers who repaired and removed them. Work with these materials was therefore subject to greater controls, these include: at least 14 days advanced notification to HSE before starting work, isolation of the work in a 'negative pressure' enclosures, better facilities for decontamination of the workers, higher standards of protective equipment, more sophisticated methods for control of emissions and a more comprehensive clearance procedure.

Categories of asbestos products which were 'unlicensed' include: asbestos cement, materials of plastic, resins or rubber which contain asbestos, the thermal and acoustic properties of which are incidental to its main purpose.

According to ASLIC, asbestos coatings describe the various mixes containing asbestos that were widely used as a surface coating for fire protection purposes or as both heat and sound insulation. However, the term asbestos coating was also applied to decorative and textured finishes containing asbestos, which range from paints and ceiling plasters to coatings used to produce special finishes. It is not clear why two very distinct categories of materials with different functions and purposes were included under the same coating category. The presence of asbestos in these products and paints was prohibited at the end of 1992 by the Asbestos (Prohibition) Regulations.

The Environment Agency classes any material containing more than 0.1 % asbestos by weight as a hazardous waste (HWR, 2005). This has implications for the transport, disposal, tracking of waste materials and the cost.

2 PRODUCT DESCRIPTION

2.1 TEXTURE DECORATIVE FINISHES AND PAINTS

Asbestos containing texture decorative plasters and paints were frequently applied as a finishing coat to interior ceilings and walls of gypsum plaster, plasterboard, other building boards and even cement. In terms of area, this is probably the most widely occurring asbestos containing material in domestic housing. The product offers a durable textured finish, which is usually painted so the fibres are both encapsulated and held within a durable matrix. When applied to new surfaces it provides a means of caulking plasterboard joints but has also been widely applied to existing older ceilings and walls to cover up cracks and blemishes. Although often referred to by the most familiar trade name Artex, other trade products include: Wondertex, Marblecoat, Suretex, Newtex and Pebblecoat. Asbestos was also sometimes added to paints and bitumen-based sealers to give improved flexibility and resilience in harsh environments (e.g. external paints and sealers).

The plaster finishes are usually a proprietary formulation of water dispersible binders combined with inert fillers, pigments and a fungicide. The main fillers and majority of the product is chalk (calcium carbonate) and gypsum plaster (calcium sulphate). Typically the dry powdered mix for trade use Artex contained about 3.8% w/w of chrysotile asbestos and the ready mixed DIY product (known as W14) contained somewhat less 1.8% and also contained an emulsion binder (Derricott, 1979). The asbestos was specifically added to control the water and rheology of the product but the presence of asbestos within a matrix would also provide a degree of reinforcement and aid other performance characteristics. Since 1976 Artex has offered both products in asbestos-free form (Derricott, 1979). Production of asbestos-containing Artex in the UK is said to have ceased around mid 1984 but use of chrysotile in other similar products (or older batches of material) may have continued until its use was prohibited in 1992.

The asbestos content of the texture decorative finishes and paints are lower than many unlicensed materials (e.g. asbestos cement 10%, asbestos containing PVC floor tiles 7 %, asbestos containing thermoplastic floor tiles up to 25%, roofing felt 8%, brake and clutch linings 20-25%, other reinforced plastics and composites 1- 10%). Also the asbestos is encapsulated in a resilient semi-flexible matrix that does not readily release fibres. Nearly all textured coats are painted, encapsulating the asbestos containing matrix behind a non-asbestos paint layer. It is important to note that only chrysotile asbestos was added by the manufacturers and this has a lower risk than other types of regulated asbestos, Hodgson and Darnton (2000).

3 METHODS FOR ASSESSING EXPOSURE

3.1 SAMPLING AND MEASUREMENT METHODS FOR AIRBORNE FIBRES AND ASBESTOS.

The current European reference method (ERM, see MDHS 39/4) used to evaluate asbestos exposure to workers, mandates that air is sampled through a 0.8 – 1.2 µm pore size filter held in a conductive cowl at a rate of 1 litre per minute. The filter is then prepared and analysed for countable fibres using X500 phase contrast light microscopy (PCM). All elongated particles that are >5 µm long and with an aspect ratio >3:1, and of <3 µm width are counted in the analyses, provided that they are not attached to particles of >3 µm diameter. All particles (regulated fibres) meeting these counting criteria are assumed to be asbestos and in many circumstances may overestimate the numbers and concentration of asbestos due to the presence of other types of fibres.

As the asbestos fibres are held in a resilient matrix they are not easily made airborne. Therefore measurements tend to be low and often below the control limit (currently 0.3 f/ml for chrysotile but due to fall to 0.1 f/ml) unless a high level of disturbance of the material is taking place (e.g. the use of power tools or highly abrasive methods such as sanding. The filters used for the analyses also have a low background of fibre-like objects, which may also give countable fibres in the PCM analysis. This means that the limit of detection and quantification are increased due to the need to be sure that the counts are above the background. It is common to have a count of 20 fibres in 200 fields of view as the limit of quantification (LOQ) during clearance monitoring but this is aimed at giving a reasonable degree of confidence in the clearance. Depending on the volume of air sampled this will set the limit of quantification in terms of the fibre concentration (e.g. <0.01 f/ml if > 480 litres of air are sampled on a 380 mm² exposed filter area). The limit of detection (LOD) based on counts of blank filters is about 3 times lower than the LOQ (~0.003 f/ml for 480 L of air sampled). However from the actual numbers of fibres present, it is always possible to calculate the fibre concentration albeit with very poor precision, based on the actual fibre count, the volume of air sampled and the area of the filter examined. For various data sources all the above have been used for reporting of the concentration.

As the textured decorative finish is often covering a conventional wall plaster or plasterboard surface, this may also release fibres of calcium sulphate, which will give increased fibre counts by the current regulatory method. The backing plaster behind the finish is usually difficult to wet and can give rise to high dust levels well in excess of the nuisance dust limits. This means sampling times and volumes can be very limited and the limit of detection can be at or above the control limit. Therefore when reviewing results great care needs to be taken that the results have exceeded the limit of quantification of the PCM method. A less than symbol (<) is used to signify that the limit of quantification (or in some cases the LOD) was not exceed. Recent work carried out by HSL has pooled the individual samples from a large survey of 35 textured decorative plaster removals in order to get a more accurate estimate of the mean airborne concentrations and to overcome some of the sampling difficulties due to the limited sampling times and air volumes collected arising from the high dust levels generated. All results are given in terms of fibres per millilitre of air (f/ml).

When high dust concentrations are present, in order to avoid possible overloading of the filter for PCM analysis, lower volumes of air are sampled and the precision and accuracy of the counts are reduced. In some circumstances short term sequential sampling, where the filter is changed frequently to reduce overloading may allow a time weighted average to be calculated

over a longer period by pooling the individual filter results together to give a longer representative sampling period. However, this requires much more analytical effort and also examines a larger area of filter material which increases the background count.

The updated EU directive will introduce new WHO counting rules. Firstly, it will (for all samples) allow the fibre type to be discriminated and the fibre concentration results to be based on the asbestos content alone. Secondly, it no longer excludes fibres that are attached to non-respirable particles from the count. In the case of asbestos containing decorative finishes, the fibres emitted are often still attached to the binders and matrix and HSL data suggest that this change in counting rules will increase the fibre count by up to a factor of 2 but this increased count will be offset by the use of fibre discrimination.

Discrimination is usually carried out using analytical electron microscopy instead of light microscopy. The PCM microscopy measures an index of exposure based on the $>5 \mu\text{m}$ long (optically visible) fibres, the better resolution of electron microscopes show that many thinner and shorter chrysotile fibres are also present. As these fibres have always been present in industrial exposures, only electron microscopy data which has been carried out to count the same size of fibres as the PCM light microscope has been evaluated in this report. These are known as PCM equivalent fibres (PCME).

4 WORK WITH TEXTURED DECORATIVE FINISHES

4.1 MAINTENANCE WORK

The widespread use of textured decorative finishes means that the coating may need to be worked on to install new pipes and cables or to replace wall and lighting fittings. These are relatively short periods of work, where a few holes will be drilled and procedures for this are set out in the Asbestos Essentials guidance. By taking simple precautions exposures can be kept low. Repainting existing textured decorative finishes textured decorative finishes may involve washing and wiping of the previously painted surface with surfactants but this will not give rise to any significant airborne release due to the use of wet wiping, and the protection afforded by the paint layer (non-asbestos) to the plaster beneath. However, if the old surface is sanded to remove the paint or reduce the textured effect, significant disturbance will take place and this type of work should not be carried out. Whether painters and decorators and DIY enthusiasts are sufficiently aware of this is a key point and some exposure undoubtedly occurs due to these activities. Some small-scale work to repair and replace ceilings by general builders, painters and decorators is also likely to be carried out. Although up to a maximum of two hours work is currently permitted on a licensed material, it is likely that this type of activity does take place without awareness that they are working with an ACM. However, the duty to manage regulations in CAW (2002), which came into force in 2004, should reduce such events.

4.2 REMOVAL WORK

The extent of the removal can vary from a small area of water damaged ceiling to large scale removal of texture decorative finishes on the walls and ceilings of a large block of flats or housing schemes. The removal is often both difficult and costly. Usually if applied to a conventional plastered wall or ceiling it is not possible to remove without taking off the plaster as well. Similarly for plasterboard substrates, it is not possible to remove the finish without significant damage to the board and removing both is usually the only option. On more resistant surfaces (i.e. concrete) the texture decorative finish has to be physically separated using energetic techniques from the underlying concrete layer and in some system built housing and flats this can require substantial efforts to remove and leave a clean surface. There is some debate as to how clean it is possible to get a concrete surface unless there is some abrasion of the concrete itself.

As coatings are usually painted with emulsion paint this provides a semi-waterproof layer of protection and it is hard to adequately wet the thin layer of textured decorative coating by the use of simple water sprays even with added wetting agents. The difficulty to wet the finish and the underlying material creates significant emissions of airborne dust, which can make sampling for any length of time difficult due to overloading of the filter.

Other methods that have been used to remove texture decorative finishes from the underlying substrate include:

- Use of steam to soften the coating and hand scraping;
- Gel chemical treatment with hand scraping;
- “Eco”Solvent treatment with hand scraping;
- High-pressure water jetting;
- Other abrasive methods (e.g. grit blasting, wet grit removal etc.).

The last two methods should only be used for residual material as HSE only recommends use of controlled removal, as the potential for dust release and difficulty of containment of the debris rapidly increase with the more aggressive treatment. However, all the removal methods introduce other hazards due to steam and chemical burns, cuts from scrapers, solvent exposure, and damage to limbs, hearing and eyes. Therefore, there are other risks than asbestos exposure that have to be taken into account.

5 AIRBORNE FIBRE EXPOSURES FROM WORK WITH CHRYBOTILE CONTAINING TEXTURED DECORATIVE PLASTER FINISHES AND PAINTS

The currently available airborne PCM fibre concentration data from work with textured decorative plaster finishes has been summarised in tables 1-3.

Table 1 gives the PCM airborne concentrations results for maintenance type work where smaller amounts of the materials are being disturbed; it also includes some simulation data where the finish has been disturbed in a test chamber.

Table 2 gives the PCM airborne concentrations during licensed asbestos removal work with textured decorative plaster finishes, various removal methods are being monitored.

Table 3 gives the PCM airborne concentrations of releases monitored when the finish and substrate are removed together.

5.1 PCM FIBRE CONCENTRATIONS FOR MAINTENANCE TYPE ACTIVITIES AND SIMULATIONS FROM VARIOUS STUDIES

Table 1: Measured airborne PCM fibre concentrations during maintenance work.	
Sampling Details	Fibre concentration by PCM (f/ml)
<i>Activities 1-3⁺* from data supplied by a, Consultant, Dublin.</i>	
1)	
Screwdriver scraping textured decorative plaster for 15 minutes	
Personal - 1	<0.01
Personal - 2	<0.01
Static – 1	<0.01
Static – 1	<0.01
Pooled	0.002
2) Wire brushing textured decorative plaster for 15 minutes	
Personal - 1	0.02
Personal - 2	0.02
Static – 1	<0.01
Static – 1	<0.01
Pooled	0.006
3) Drilling and grinding cement 5 + 5 minutes	
Personal - 1	0.04
Personal - 2	0.05
Static – 1	0.06
Static – 1	0.04

Pooled	0.045
<i>Activities 4 –9* from data supplied by Building contractor.</i>	
4) Fitting smoke detector to textured decorative plaster ceiling	
Background	0.004
Personal	0.024
Reassurance	0.004
5) Removing ceiling rose from textured decorative plaster ceiling	
Background	0.003
Personal	0.024
Reassurance	0.003
6) Remove surface mounted fluorescent lighting unit from textured decorative plaster ceiling.	
Background	0.003
Personal	0.003
Reassurance	0.002
7) Drilling holes of 25 –50 mm at fast speed through textured decorative plaster ceiling	
Background	0.001
Personal	0.024
Reassurance	0.004
8) Strip textured decorative plaster ceiling for 90 minutes	
Background	0.004
Personal	Overloaded
Reassurance	0.004
9) Remove strip of damaged (water?) ceiling (~6 in by 10 ft) with textured plaster	
Background	0.003
Personal	0.012
Reassurance	0.009
Drilling removal of light fittings and drilling 17 holes in ceiling walls with textured decorative plaster finish to install lighting: sample duration 83 minutes. (<i>Baird, Invest NI, 2004</i>)	
Personal exposure removal and drilling	<0.003
Personal removal and vacuuming	<0.003
Short-term work on walls with textured decorative plaster finishes (<i>Adams Envir. In Stacey, 2001</i>)	
Removal of fittings from wall - wet suppression, hand tools	<0.01 - <0.03
Drilling (domestic premises) **	0.16
Ripping off architrave, gouging walls (simulated vandalism)	<0.01
+ Pooled values calculated from supplied data by HSL *Values calculated from actual fibre counts and not based on the LOQ of 20 fibres. ** Reported result may include many non-asbestos fibres.	

5.2 PCM FIBRE CONCENTRATIONS FOR REMOVAL OF TEXTURED DECORATIVE COATINGS AND PAINTS FROM THE UNDERLYING SURFACE.

Table 2: Measured PCM airborne fibre concentrations during the removal of textured decorative coatings and paints from the underlying surface.	
Sampling Details	Fibre concentration by PCM (f/ml)
<i>(1) High-pressure water jet</i> ‘Artex’ coating was being removed from the ceilings of council flats. Debris and water were collected by vacuum cleaner and filtered through a mesh but the filtering was inefficient and wet debris was splashed on the floor. Personal sampling of workers impossible in the wet conditions. Stacey (2000) - Visit 2	
Environmental (4 samples)	<0.01 <0.01 0.02 0.016
Personal (HSL scientist taking samples)	0.02
Disturbance test in flat declared cleared	0.19 (PCME asbestos fibres by TEM)
<i>(2) Hand chisels after glycol ether/ethanol gel application</i> Decorative coating was removed from the kitchen ceiling and wall of a house. The gel was applied 1½ hours before work began. The workmen hand-chiseled the coating off and swept the debris into plastic bags. The gel did not penetrate the coating fully and the underneath side was dry. Part of the ceiling was dropped as neither the coating nor the plaster could be removed. Stacey (2000) - Visit 3	
Personal - scraping ceiling and sweeping	0.07
Personal - scraping, dropping ceiling and sweeping	0.04
Static at end of room under dropped ceiling	0.09
Static in middle of enclosure (2 samples)	0.14 0.09
Static between outside door and airlock	0.03
<i>(3) Hand scrapers after wetting with gel solution</i> ‘Artex’ was removed from the ceilings of corridors and rooms in a former nursing home. At intervals, the debris was swept into a plastic bag and a vacuum cleaner used to clean the plastic covering the floor. The coating peeled off as strips whose underside appeared to be dry. Stacey (2000) - Visit 4	
Personal - scraping and applying gel	0.01
Personal - scraping and applying gel	0.03
Personal – scraping	0.01
Personal - scraping and vacuuming	<0.01
Personal - HSL scientist taking samples	0.01
Environmental	0.01
<i>(4) ‘Steam-master’ and scraper</i>	

Decorative coating was being removed from the kitchen ceiling of a fire-damaged flat (windows boarded up). PVA was sprayed on the ceiling before the coating was removed. Stacey (2000) - Visit 5	
Personal	<0.01
<i>(5) Dry coating removed with power chisels⁺</i> Coating was stripped from the walls of the hallway and landing of an empty flat. [Powered respirators worn]. Stacey (2000) - Visit 6	
Personal - using power chisel Worker A (2 samples on successive days)	1.17 0.52
Personal - using power chisel Worker B (2 samples on successive days)	0.68 0.27
Personal - using power chisel Worker C	0.41
⁺ Samples were too dense to count and were ultrasonically resuspend in water which would have released fibres from the matrix and split bundles giving a significant overestimate of the original airborne fibre concentration.	
<i>(6) Removal by sanding wet,</i> Painter removing asbestos-containing paint. <i>EVALUTIL No 400</i>	
Not stated whether personal or ambient (3 measurements)	Mean 0.17 Minimum 0.12 Maximum 0.22
<i>(7) High-pressure cleaning wet</i> Specialist asbestos-removal worker high-pressure cleaning bituminous paint on sluice gate or paddle of [canal] lock <i>EVALUTIL No 1711</i>	
Personal (20-60min) (3 measurements)	Mean not quoted Minimum <0.056 Maximum 0.018
Ambient (60 min)	<0.033

5.3 PCM FIBRE CONCENTRATIONS FOR DEMOLITION AND REMOVAL BY HAND OF TEXTURED DECORATIVE PLASTER FINISHES AND THE UNDERLYING SUBSTRATE.

Field monitoring results of fibres releases during hand scraping from and or demolition of the underlying substrate are given in table 3. The demolition of these materials in place releases other fibres from the substrate and in particular gypsum (calcium sulphate) fibres, which are counted in the PCM. This usually results in a significant overestimate. In the recent HSL work a method to remove the calcium sulphate fibres before counting by dissolving them in place on the filter was used. The remaining non-soluble fibre concentrations were analysed by PCM.

5.3.1 Field data

Table 3: Measured PCM airborne fibre concentrations (f/ml) from removal of textured decorative coatings and the substrate together.	
Short-term work on walls with textured decorative plaster finishes (Adams Envir. In Stacey, 2001)	
Knocking down walls, shovelling rubble into sacks - hand tools, wet.	<0.13 - <0.21
Processing waste from walls	<0.12 - <0.21
Peak exposures from short term single samples during the licensed removal of textured decorative plaster finishes from 35 domestic sites (Revell , 2005)	
Untreated samples includes calcium sulphate fibres (86 samples)	Average 0.28 median 0.04
Treated to remove calcium sulphate fibres (106 samples)	Average 0.09, median 0.04

The large number of sites visited and the number of PCM samples analysed (194 samples) in the HSE/ABI study add significantly to the knowledge base for the small scale demolition of textured plaster finishes. This data is presented in more detail.

5.3.2 Short term peak exposures from HSE/ABI study

Fifty short term (10-minute) TWAs were calculated for treated samples from sixteen jobs. To increase the number of comparisons TWAs were calculated for all treated samples whose duration was less than twenty minutes.

The arithmetic average of the short term TWA's was 0.13 f/ml, about one fifth the proposed 0.6 f/ml control limit and one seventh of the current short term control limit for chrysotile. Only one short-term sample (1.22 f/ml) exceeded these values and this was due to fibres released from an indirect preparation, which is likely to be a substantial overestimate.

Table 4: Summary of short term (10-20-minute samples) TWA's – treated samples.			
Job N ^o .	N ^o . of samples	Average TWA (f/ml)	Highest value TWA (f/ml)
Job02	7	0.09	0.25
Job06	1	0.40	0.40
Job10	10	0.23	1.22
Job11	4	0.14	0.23
Job13	1	0.08	0.12
Job16	1	0.08	0.08
Job19	2	0.06	0.10
Job22	4	0.17	0.31
Job26	4	0.10	0.13
Job27	1	0.06	0.06
Job28	3	0.06	0.09
Job29	3	0.05	0.19
Job30	1	0.03	0.03
Job34	3	0.22	0.36
Job41	3	0.10	0.13
Job43	2	0.01	0.20
All	50	0.13	1.22

5.3.3 Estimated and calculated 4 hour exposures from HSE/ABI study

Four-hour TWAs for treated samples were calculated (table 5) using the pooled averages and the maximum duration as defined by the start of personal sampling to the start of the clearance sampling. In order to estimate the highest possible level of exposure the largest individual airborne fibre concentrations recorded during the removal was also used to make calculations over the same duration. For both these TWA determinations it was assumed that if the removal and clean up took less than 4 hours in total there would be no airborne fibre exposure to the removal workers while clearance was taking place.

The use of the single highest airborne fibre values gives an upper limit to the four-hour TWA and in effect assumes that throughout the full removal airborne fibre levels remain at the highest level recorded during the period. Clearly this will be a marked overestimation of the TWA. Nevertheless at only four of eighteen sites did the four-hour TWA exceed 0.1 f/ml. At one of these the very high TWA (0.72 f/ml) was the result of the short-term indirect sample discussed in 5.3.2. above. Individual PCM results for the data set are given in appendix 1.

Job No.	Airborne fibre concentration (f/ml)*		4-hourTWA (f/ml) Treated samples	
	Pooled average	Maximum	Average	Maximum
Job02	0.12	0.25	0.083	0.172
Job04	0.03	0.05	0.014	0.023
Job06	0.24	0.40	0.085	0.142
Job07				
Job09				
Job10	0.19	1.22	0.112	0.724
Job11	0.14	0.23	0.088	0.144
Job12	0.03	0.14		
Job13	<0.16	0.12	<0.08	0.060
Job14	<0.06	0.04	<0.023	0.015
Job15	<0.08	0.04	<0.075	0.038
Job16	<0.22	0.08	<0.083	0.030
Job18				
Job19	<0.09	0.10	<0.046	0.051
Job20				
Job22	0.07	0.31		
Job23	0.15	0.16	0.06	0.064
Job24	0.03	0.10	0.006	0.019
Job26	0.10	0.13	0.056	0.071
Job27	0.01	0.06		
Job28	0.03	0.09	0.021	0.064
Job29	<0.06	0.19		
Job30	<0.25	0.03		
Job31	0.02	0.07	0.015	0.053
Job32	0.02	0.04		
Job33	<0.24	0.04		
Job34	0.22	0.36	0.046	0.075
Job37	0.02	0.06	0.014	0.041

Job No.	Airborne fibre concentration (f/ml)*		4-hourTWA (f/ml) Treated samples	
	Pooled average	Maximum	Average	Maximum
Job39				
Job40	<0.04	0.01	<0.0525	0.013
Job41	0.02	0.13		
Job42	0.01	0.02		
Job43	0.11	0.20		

5.4 TEM DATA FROM FIELD STUDIES

Analytical TEM using energy dispersive x-ray analysis and selective area electron diffraction (see ISO method 10312:95) can be used to positively identify the different asbestos fibre types and to discriminate between asbestos and non-asbestos fibres. TEM analysis is usually carried out at a higher magnification ~5,000 – 20,000 magnification to accurately size the fibre length and width. All asbestos fibres can be seen but ISO rules count three fibre size categories: fibres > 0.5µm long with an aspect ratio of >3:1; fibres >5µm long with an aspect ratio of >3:1 and fibres > 5µm long, >0.2 µm wide and with an aspect ratio of >5:1. The latter is to represent PCM optical fibre counts which are known as PCM equivalent (PCME) fibres and this was the metric of interest for the survey and risk analysis (note: a 3:1 aspect ratio was used to mirror the EU/UK fibre definitions).

The TEM analysis carried out on most samples usually examine between 20 - 40 EM grid openings, which with HSL's current EM grids represents an area of 0.18 – 0.36 mm². This represents several thousands of fields of view at the higher magnifications used. However, this is less than the area examined in the PCM (0.75 mm²), where 100 fields of view using the Walton-Becket graticule at 500 magnification was used for compliance sampling (see MDHS 39/4). However, PCM counts on blank filters are not zero and the limit of detection (LOD) and limit of quantification (LOQ) are based on counts of 5 and 20 fibres respectively. As filters do not have measurable TEM asbestos fibre backgrounds the LOQ is based on a count of three fibres compared to twenty on the PCM. This means that the LOQ of the TEM analysis are broadly equivalent to the PCM analysis.

5.4.1 HSE/ABI study

The HSE/ABI study was the largest TEM data set available and was being collected and analysed during the writing of the RIA. A summary of the available results for PCME asbestos fibres from analytical TEM analysis of selected samples is shown in table 6 (Revell, 2005). For comparison purposes, the untreated and treated MDHS39/4 fibre concentrations have been included in the table. Only asbestos fibres with a chrysotile composition were identified in the TEM analysis. Most samples contained higher numbers of thinner (<0.2 µm wide) and shorter (< 5µm long) chrysotile fibres but these are not countable as regulated fibres for the assessment of exposure and risk and as such are present in all chrysotile aerosols.

Table 6: Results TEM analyses of samples from the HSE/ABI survey with high PCM counts.
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Sample N°	PCME – Airborne fibre conc. (f/ml)		Ratio NA: A	N°. of (TEM) asbestos fibre*	Code	Job	PCM – Airborne fibre concentration. (f/ml).		Air volume (litre)
	Asbestos	Non Asbestos					Treated	Untreated	
08613/04	<0.12	0.55	4.68	2.99 (0)	##	Job06	0.4		20
08463/04	<0.48	0.48	1.00	2.99 (0)	##	Job11	0.09	1.55	12
08464-04	<0.46	3.54	7.69	2.99 (0)	##	Job11	0.07	1.47	12
08466-04	<0.77	6.14	8.02	4.74 (1)	##	Job11	0.18	1.44	12
08468-04	<0.60	2.83	4.68	2.99 (0)	##	Job11	0.23	0.67	12
08611/04	<0.08	0.42	5.35	2.99 (0)	##	Job14	0.04		82
08617/04	<0.58	0.97	1.67	2.99 (0)	##	Job26	0.126	0.847	20
08672/04	0.13	0.03	0.44	9	##	Job40	0.01	0.008	128.7
<u>Average</u>	<u>0.40</u>	<u>1.87</u>	<u>4.19</u>	<u>10</u>	<u>##</u>		<u>0.14</u>	<u>1.00</u>	<u>37.34</u>
08614/04	0.07	0.14	2.00	4	A3	Job04	0.05	0.021	114
08467-04	<1.53	4.85	3.16	4.74 (1)	A3	Job10	0.02	0.56	6
08469-04	<0.92	0.92	1.00	2.99 (0)	A3	Job10	0.08	0.48	9.6
08470-04	<0.60	3.23	5.35	2.99 (0)	A3	Job10		0.32	6
08472-04	<0.28	3.62	13.04	2.99 (0)	A3	Job10		0.24	9.6
08656/04	<0.10	0.06	1.00	4.74 (1)	A3	Job27	0.01	0.001	93
08612/04	0.54	0.98	1.80	5	A3	Job9		0.392	19.8
<u>Average</u>	<u>0.58</u>	<u>1.97</u>	<u>3.91</u>	<u>11</u>	<u>A3</u>		<u>0.04</u>	<u>0.29</u>	<u>36.86</u>
08625/04	<0.26	2.39	9.03	2.99 (0)	AR	Job22	0.16	-	27.4
08683/04	0.11	0.03	0.42	12	AR	Job37	0.06		184
<u>Average</u>	<u>0.19</u>	<u>1.21</u>	<u>4.72</u>	<u>12</u>	<u>AR</u>		<u>0.11</u>	<u>-</u>	<u>105.70</u>
08471-04	<0.29	3.97	13.71	2.99 (0)	B2	Job16		0.427	20
08620/04	<0.22	1.57	7.02	2.99 (0)	C2	Job22	0.31	0.192	20
08622/04	<0.19	1.10	5.69	2.99 (0)	C2	Job22	0.22	0.07	24
<u>Average</u>	<u>0.21</u>	<u>1.33</u>	<u>6.35</u>	<u>2.99 (0)</u>	<u>C2</u>		<u>0.27</u>	<u>0.13</u>	<u>22</u>
08673/04	0.67	0.22	0.55	11	C4	Job12	0.14	-	40
08597/04	<0.64	3.39	5.28	6.63 (2)	C5	Job02	0.225	-	20
08668/04	<0.03	0.02	1.05	4.74 (1)	CS4	Job41	0.01	-	263
<u>Average</u>	<u>0.16</u>	<u>0.14</u>	<u>2.02</u>	<u>7.75 (3)</u>	<u>D8</u>		<u>0.06</u>	<u>0.06</u>	<u>70</u>
08637/04	<0.13	0.13	1.00	2.99 (0)	D17	Job34	0.36	-	20
08659/04	<0.01	0.01	2.59	2.99 (0)	D8	Job27	0.02	0.003	107
08646/04	<0.08	0.10	2.11	4.74 (1)	D8	Job32	0.04	-	83
08671/04	<0.38	0.30	1.36	6.63 (2)	D8	Job41	0.13	0.12	20
<u>Average</u>	<u>0.16</u>	<u>0.14</u>	<u>2.02</u>	<u>7.75 (3)</u>	<u>D8</u>		<u>0.06</u>		<u>70</u>
08665/04	<0.04	0.06	2.71	6.63	s##	Job41			332
Pooled Mean	0.014	-	-				0.063	-	-
Average All	n/a	1.50	4.05	52*			0.13	0.49	61.33

*upper 95% confidence value. The upper 95% confidence values are used to calculate airborne fibre concentrations if the number of fibres counted are less than 4. The 95% confidence values are shown with the number of fibres actually counted shown in brackets. When the number of fibres counted exceeds three then just the numbers counted are shown.

Code A3 = manual scraping wet, AR = removal all activities, B2=Intact removal of substrate, C2 drop ceiling dry, C4-5= drop ceiling wet, D = various clean up activities e.g. D8 bagging wet rubble by hand.

It can be seen from data and the averages at the end of table 6 that this subset had higher PCM fibre counts on the untreated samples (or were too dense to count) but most of the TEM PCME chrysotile fibre concentrations were below the limit of quantification. This meant that the average could not be accurately calculated from the results of the individual samples and a pooled mean was calculated by combining all the PCME chrysotile fibre counts and sampled volumes. This analysis showed that the average PCME asbestos concentration was around an order of magnitude less than the simple average concentration of the treated and untreated PCM count samples.

5.4.1.1 Analytical limitations

Due to the large numbers of PCM samples taken it was only planned to analyse a sub-set of the samples by TEM, to determine the concentration of PCM asbestos and non-asbestos fibres. The selection of the subset for TEM analysis could have been done in a number of ways. Often when the TEM is used to determine which PCM fibres are asbestos and non-asbestos, it produces a ratio that can be applied to the rest of the samples from the same job or to a number of jobs using the same material. However, early samples analysed by TEM showed that large numbers of non-asbestos (mostly calcium sulphate) fibres were present in some samples. For instance one sample 08614 had 60 PCME calcium sulphate fibres counted in ten grid openings but no PCME asbestos fibres. This meant that much analytical effort and time could be spent on determining that most fibres were non-asbestos and counting very few asbestos fibres. This also meant that the few asbestos fibres counted would have poor precision so that the ratio of asbestos to non-asbestos fibres would also have poor precision. In some cases many hundreds of fibres would have need to be discriminated to find just a few asbestos fibres and the range of non-asbestos to asbestos fibre ratios were estimates to vary from around 3:1 – 200:1. The poor precision and large range between samples, even from the same job, meant that dividing all the PCM counts by a single ratio or even a single site ratio would not have been justifiable. It was found that the type of removal being conducted and more importantly how much of the underlying plaster was being disturbed, scraped or broken, would have a variable effect on the PCM fibre count due to numbers of additional calcium sulphate fibres produced. This meant that the only way a reliable estimate of the asbestos concentration could be obtained was to directly determine the actual concentration of PCME asbestos fibres on a sample.

To make TEM analysis practicable a number of additional sample preparation procedures, were taken in order to remove the calcium sulphate fibres from the samples.

Initially an indirect procedure was used on overloaded filters, where the filter was ashed in a low temperature asher and the ashed material resuspended in water with shaking and minimum ultrasonic treatment before filtering onto a membrane filter.

A direct procedure was used to prepare TEM grids (ISO 13032:95) but then to wick the prepared grids in a warm water washer to dissolve any soluble particles. This leaves a visible carbon replica of the particle, which is visible in the TEM but the lack of electron density shows that the particle has been removed. This procedure was developed at HSL some 15 years ago and is an optional procedure that has been incorporated in the ISO method. This greatly speeds up the analysis as it is only necessary to identify fibres, which appear as dark (electron dense) in the TEM.

Due to the overloading of many filters and the high PCM fibre counts of non-asbestos fibres a similar pre-treatment was introduced for the membrane filters by wicking the filter in a warm water washer before any preparation. This was found to be quite effective for removing soluble particles and allowed many previously overloaded filters to be counted by PCM and TEM with mainly all the calcium sulphate fibres being removed (some larger particles and fibres may not

always be completely dissolved). This meant that PCM counts of non-soluble fibres could be obtained removing much of the variability due to the level of disturbance of the backing plaster.

5.4.1.2 TEM analytical biases

The selection, preparation and analysis of the TEM sample sub-set, produce a number of biases compared to the PCM data set from which they were chosen.

The samples analysed by TEM were intentionally selected in a way that would give a high biased sub-set. Initially some samples for TEM analysis were selected because the filters were overloaded with particles and were judged to be too dense to prepare and count by PCM. However, once a method for treating the filters to remove the calcium sulphate particles before analysis was introduced most samples were selected based on there having high untreated PCM fibre counts (f/mm^2).

TEM counts of PCME asbestos fibres also have a high bias. Comparison between TEM PCME fibre counts and PCM counts on the same filter sample of an aerosols of asbestos fibres usually shows the TEM count to be significantly higher, and particularly so for chrysotile. This is in part due to the additional resolution and higher magnification being used but also the >0.2 μm width used in this study represents the situation for the high contrast amphibole fibres using a top of the range phase contrast microscope. In practice, the lower refractive index difference and lower contrast between the chrysotile fibres and the mount, results in reduced PCM fibre counts.

The TEM counts all PCME chrysotile fibres regardless of whether they were attached to or covered by other particles so the TEM count conforms with the WHO counting rules but overestimates the ERM result.

Due to the high amount of airborne dust produced by the licensed removal contractors during the work it was only possible to sample for a few minutes. This meant that many samples were peak emissions and had high LOQs due to the low volume of air sampled and analysed. This failure to control dust and asbestos emission at source (as required by COSHH and CAW) made exposure measurement extremely difficult and meant that only by pooling the results of several samples could enough air be analysed to achieve a limit of quantification below the control limit.

Low fibre counts have poor precision and the 95% confidence intervals have a large range and individual results are difficult to interpret. Most of the initial TEM analyses were made on examinations of 20 grid openings and most samples had less than 3 asbestos fibres counted with a total of 52 chrysotile PCME fibres being found in the 28 samples.

Eight of the samples were prepared using the indirect method of sample preparation (ashing and redispersion) of the original filter deposit. These eight samples (of the 28) accounted for 39 of the 52 (75%) PCME chrysotile fibres. The indirect preparation of chrysotile fibres is well known to give substantially increased TEM counts (Chesson and Hatfield, 1989). Although precautions were taken to limit the increase of chrysotile fibres, if the material is present in a soluble matrix this effect can be very significant and a minimum increase of a factor of 3 would be expected but could be many times higher. Although we cannot assume that the samples had the same asbestos loading, a quick comparison of the two preparation methods show that the indirect preparation samples gave fibre levels some 7.5 times greater than the direct method (based on the number of samples collected).

5.4.1.3 Further analysis of HSE/ABI TEM samples

Due to the low number of asbestos fibres present in the TEM subset, further QA counts have subsequently been carried out on samples which had low chrysotile fibre counts, in order to increase the precision of the analysis and the estimated mean. Samples with zero chrysotile asbestos counts have not been recounted to date, so this is likely to introduce a high bias in the recalculated mean.

The subset of samples for TEM analysis, while chosen due to their high PCM fibre count, must also represent the typical stages of a job. Due to the limit sampling times of some of the stages this may not have balance the pooled means to the typical job. Also table 6 had a considerable number of uncoded (#) activities and the sampling records were examined to help determine from the time of sampling the most likely activity taking place. Therefore every # code was reassigned to a specific activity.

During the reanalysis it was found that two of the samples in the TEM sub-set were static samples and these had lowered the pooled mean for personal samples and were excluded from the reanalysis in table 7. For comparison the treated and untreated PCM counts are also given in the table. The categories for removing the finishes intact on the substrate (B) and dropping the ceiling (C) were also combined for this summary due to the low volume of air analysed and some of the sampling sheets being ambiguous in their description about which category of work was taking place (sometimes a mixture of both). However, category B did not have any PCME chrysotile fibres found and careful removal of the ceilings when possible looked to be the best work practice and obviously limited the amount of disturbance to the ACM. In contrast dropping the ceiling resulted in high dust levels and shortened sampling times giving a high PCME limit of quantification (~0.6 f/ml based on a count of 3 fibres in 20 grid openings on a 10 litre direct sample). However, this large difference in fibre releases was not supported by the PCM counts and a single 20 L indirectly prepared sample accounted for 14 of the 16 PCME chrysotile fibres found. The value of C was considerably lower (0.06 f/ml) if the sample was discounted.

Table 7: HSE/ABI TEM data recalculated by activity and with static samples excluded. (analysed PCM data sets are also given)

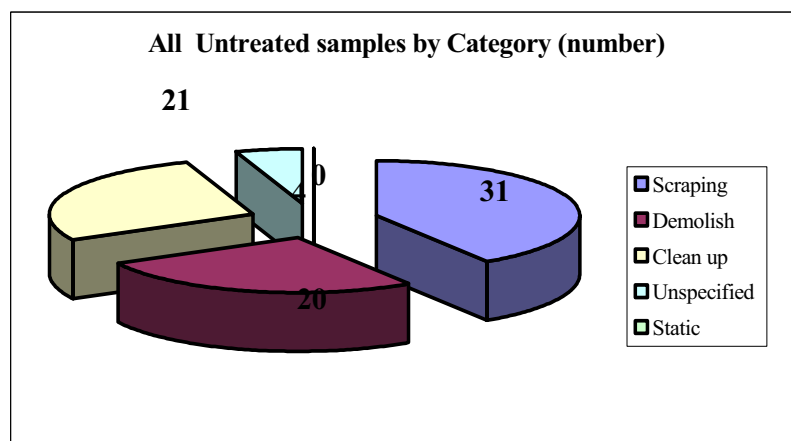
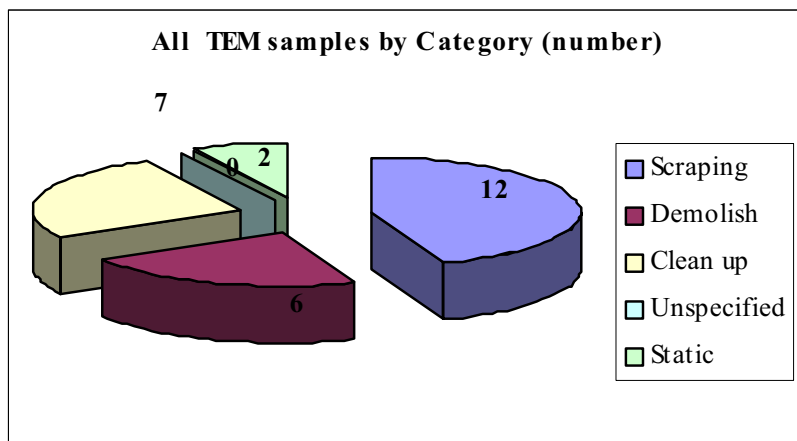
Activity	TEM data				PCM counts on treated samples (water wicked)				PCM counts on untreated samples (MDHS 39/4)			
	No	Ave f/ml	Time (min)	Vol (litre)	No	Ave f/ml	Time (min)	Vol (litre)	No	Ave f/ml	Time (min)	Vol (litre)
Scraping (A)	12	0.08	455	466.9	33	0.12	2145	3325.4	31	0.25	834	1622.8
Remove intact (B)	3	0.0000	102	122	3	0.06	102	121	11	0.43	841	4084.1
Drop ceiling (C)	4	0.15	72	84	23	0.10	777	1346	9	0.47	0	333
Remove intact / drop intact (B+C)	7	0.09	174	206	26	0.10	879	1467	20	0.45	841	4417.1
Clean up (D)	7	0.06	242	254.85	27	0.08	1153	1819.3	21	0.19	905	1412.3
Not Coded (#)					12	0.07	383	766	4	0.59	43	98
All personal	26	0.070	871.00	927.75	99	0.09	2489	7202.45	83	0.25	3125	9735.2
S	2	0.01	158.00	595.00	8	0.02	636	2532.75				

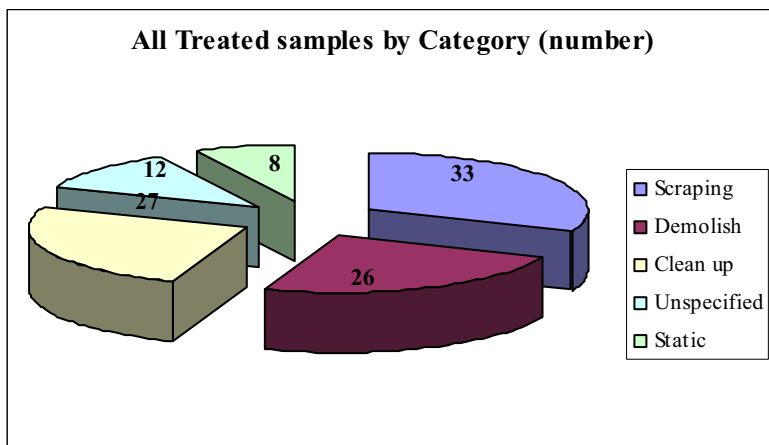
It is important to note that the number of PCME non-asbestos fibres was considerably greater than the PCME asbestos fibres present, even though the samples had been treated to remove calcium sulphate.

5.4.1.4 TEM sample selection biases

The largest selection bias is that most of the PCM and all the TEM samples represent peak worker exposures, often over just a few minutes sampling during ceiling dropping and sweeping etc. Giving the small average size of textured decorative removal jobs, it is unlikely that workers will be doing this type peak of disturbance for much more than a quarter of each removal. This means that their cumulative exposure, which determines their risk, is likely to be at least 5 times lower than the peak average, even assuming most jobs run reasonably back-to-back.

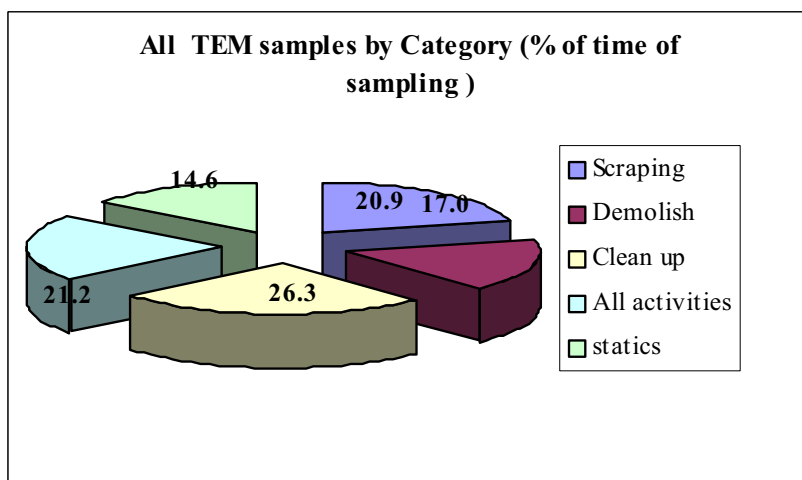
The distribution of activities amongst the samples selected for analysis were investigated in figures 1 a-c by sample number, using the data from table 7. It can be seen that the distribution of sample types was broadly similar.

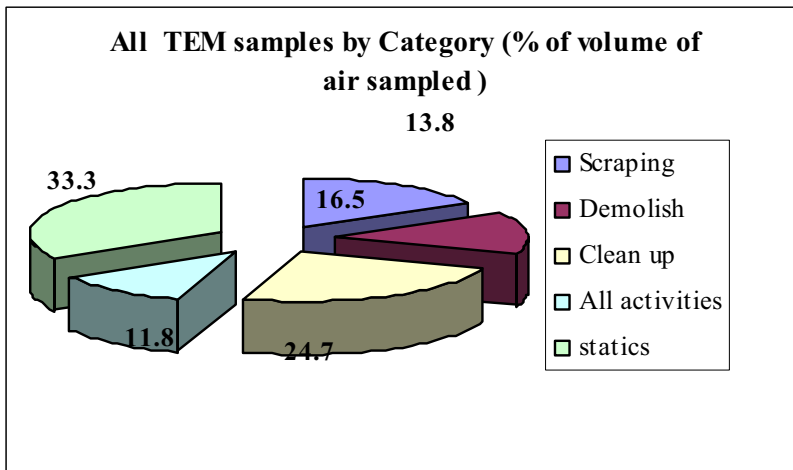




Figures 1a-c: Activity distribution in the different sample sets, by number of samples analysed.

Over half of the personal TEM samples measured, included the removal stage and at least one fifth measured or included the clean up, so all 3 sets would seem to broadly represent the activity in general. Dropping the ceilings was the most dusty activity and the most difficult to monitor and gave the highest chrysotile concentration but the many short term samples may have produced a high bias. This is shown by Figure 2 a-b where the TEM data is represented in terms of the time of sampling and the volume of air sampled. These have been plotted as a percentage and the influence of the two static samples (removed in table 7) is shown.





Figures 2a-b: Distribution of TEM samples by time of sampling and volume of air (with static's included).

Overall the TEM data from the HSL/ABI survey, which had many high biases within the data set, supported that the 0.08 f/ml average exposure used in the risk assessment is a conservative estimate of the average exposure to demolition workers (without RPE) and that for smaller removal and demolition jobs, the average exposures may be expected to be substantially lower.

5.4.2 Energetic removal of paint

Results of the removal of chrysotile containing paint using an energetic method are given in table 8.

Table 8: Results of TEM analysis of paint removal	
<i>(7) Sand-blasting</i>	
Building worker sand-blasting anti-corrosion coating on [canal] lock gates with lance ACM said to be enclosed but without extraction. <i>EVALUTIL No 1619 & 1620</i>	
Personal (1-34 min) (3 samples)	Mean not quoted Minimum 0.043 Maximum 1.7
Personal (1-34 min) (Same 3 samples) Chrysotile and ceramic fibres identified by TEM	Mean 0.31 Minimum 0.12 Maximum 0.6

5.5 TEM AND PCM DATA FROM SIMULATIONS WITH NO CONTROLS

Simulation of removal activity in a house was carried out (Burdett and Scott, 1988) table 9 but work was limited to 60 minutes to comply with the regulations. The textured finish was

relatively poorly adhered to the old ‘Carlite’ finishing plaster so that it could be stripped off quite easily in places, although some of the underlying plaster was removed as well. The test was done dry, with no extraction or enclosure with doors and windows closed to simulate conditions of poor control.

Table 9: Simulation of removal activity in a house			
Simulation activity and sampling period	PCM (f/ml)	TEM all>5µm long chrysotile (f/ml)	PCME* Chrysotile fibres (f/ml)
<i>Vigorous dry scraping for 60 minutes to remove textured decorative plaster from a wall (Burdett & Scott 1988*).</i>			
Personal sample	Not done	0.18	0.09
Static sample	Not done	0.02	0.01
Static sample	Not done	0.02	0.01
<i>Dry sweeping of floor debris after scraping (Burdett & Scott, 1988) *</i>			
Personal sample	Not done	Too dense ⁺	
Static sample	Not done	0.03	0.02
Static sample	Not done	0.04	0.03
* The figure is the approximate PCME fibre concentration based on the diameter distribution of the >5 µm long chrysotile fibres used to calculate the PCME fibre concentration. ⁺ Although the static samples indicate that dry sweeping would give rise to personal exposures above 0.1 f/ml the debris included a large amount of dust from a previous simulation using a belt sander to abrade the textured coating, this unfortunately overloaded the filters during the activity and no results could be reported.			

A series of simulations in a small volume (~9 m3) test cabin with no ventilation were also carried out by HSL (Burdett & Scott, 1988). Both PCM and TEM fibre concentrations were counted but again all fibres > 5 µm long were counted by the TEM and an approximate PCME equivalent fibre concentration has also been obtained for some samples by counting chrysotile fibres >0.2 µm in width. Due to the test conditions these results are likely to be significantly higher than would be found at most sites and demonstrate the likely upper levels airborne chrysotile fibres release from poor handling and removal of this type of product under the worst case conditions. Results from a range of worst-case simulated activities are given in table 10.

Table 10: TEM and PCM results from worst case simulation of exposure from various activities with textured decorative plasters			
Simulation activity and sampling period	PCM (f/ml)	TEM all>5µm long chrysotile (f/ml)	PCME Chrysotile fibres (f/ml)
<i>Mixing Artex powder for application (22 minutes) and applying (20 minutes) Test 1</i>			
Mixing (Personal sample)	Too dense	2.9	

Mixing / spreading (Personal sample)	0.4	0.8	
After mixing (Personal sample)	0.8	1.8	1.4
Static sample mixing	Too dense	1.8	
Static sample mixing/spreading	Too dense	0.6	
<i>Mixing Artex powder for application 11 minutes, sweeping up 10 minutes and applying 20 minutes. Test 2</i>			
Mixing and sweeping (Personal sample)	0.9	2.1	
Mixing only (Personal sample)	1.1	2.9	
Sweeping only (Personal sample)	Too dense	1.6	
Sweeping spreading (Personal sample)	Too dense	1.3	
Static sample mixing only	Too dense	1.8	
Static sample sweeping only	0.3	0.6	0.5
<i>10 minute TWA from mixing Artex powder Test 6</i>			
Personal sample during mixing	2.2	10.7	6.0
Personal sample during mixing	1.8	6.9	5.0
<i>(9) Laboratory simulation - scraping painted plaster Test 3 Paint scraper used [dry] to remove decorative coating covered by two coats of emulsion paint, on chipboard; 30 min duration; in small enclosed chamber and sampling after.</i>			
Personal during scraping (30 min sample)	0.13	0.95	
Personal during scraping (45 min sample)	0.12	0.82	
Static during scraping (30 min sample)	0.13	0.53 & 1.02	0.59
Static during and after scraping (127 min sample)	0.05	0.58	0.28
Static during and after scraping (127 min sample)	0.05	0.33	0.16
<i>Laboratory simulation - sanding painted plaster . Test 4 Light sanding (dry) by hand of decorative coating covered by two coats of emulsion paint, on chipboard; 30 min duration; in small enclosed chamber</i>			
Personal sample during sanding and 10 minutes after	Too dense	0.87	
Personal sample during sanding and 10 minutes after	Too dense	0.25	
Static sample sanding and 10 minutes after	Too dense	0.25	
<i>Laboratory simulation - sanding unpainted plaster Light sanding (dry) by hand of decorative coating on chipboard; 10 min duration; in small enclosed chamber- Test 5</i>			
Personal sample during sanding (10 min sample)	0.3	2.5	1.4
Personal sample during sanding (10 min sample)	0.3	1.1	
Two hour static sample during and after		0.20	
Two hour static sample during and after		0.20	
Two hour static sample during and after		0.22	

6 DISCUSSION

6.1 EXPOSURE FROM MAINTANCE WORK

Disturbances to textured decorative plasters from a variety of short term (sporadic) maintenance type activities have been shown to result in airborne fibre concentrations well below the proposed new control limits. The recent data from various sources in table 1, had sampling times of much less than 4 hours so represent peak releases and exposures, rather than 4 hour time weighted averages. Even so these peak values were usually well below the current control limits and all but one sample was below the proposed 0.1 f/ml 4-hour control limit. Improved assessment of the low concentrations present was obtained by calculating the fibre concentration based on the counted fibres and not on a LOQ based on a count of 20 fibres. Also when the data allows, sequential samples were used to calculate a pooled mean. Most maintenance activities will be of limited duration and if basic precautions are taken (e.g. see Asbestos Essentials) exposures to maintenance workers will be low.

6.2 EXPOSURE FROM REMOVAL OF TEXTURED DECORATIVE PLASTERS AND PAINTS FROM THE UNDERLYING SURFACE.

Fibre concentrations well below the control limit can be achieved when removing textured decorative plaster finishes by 'wet' methods or using sealant [(1)-(4), in Table 2] so long as there is good penetration into the coating. Bitumous paints reported in example (6) are harder to wet and sites (6&7 table 2) & (table 8) gave increased fibre levels but the increase is also due to the highly energetic dust producing removal methods employed. High pressure water jetting appears at first to be the most successful way to keep levels low but sampling in these situations is extremely difficult as water droplets and high humidity will quickly prevent airflow through the membrane filter. The results therefore do not relate to personal worker exposures and there also appears to be problems associated with anaging the waste water and clean up.

Dry removal, particularly if coupled with the use of energetic methods, will give releases above the control limit, as seen in site (5) of table 2. Simulations of dry removal with hand tools [Table 9] gave chrysotile concentrations below 0.1 f/ml but dry removal with power tools [table 10] gave fibre releases above the proposed 0.1 f/ml control limit but the levels were increased by the method of sample preparation. These results show that HSE's guidance on the use of controlled wet removal and avoidance of power tools and other energetic methods, applies equally to paints and plasters, as well as other ACMs. However, it is recognised that in some situations, more aggressive removal methods may be necessary to remove residual ACM from a resistant difficult to clean surface (e.g. concrete).

6.3 EXPOSURES FROM HAND REMOVAL OF THE FINISH AND THE UNDERLYING SUBSTRATE

Tables 3,4 & 5 gives results from smaller licensed removals by hand where the substrate is mostly removed along with the textured decorative plaster. This method has a disadvantage in that it is most likely to be used with lathe and plaster surfaces or some plasterboard, where controlled removal without damage to the underlying surface is difficult and it is often more cost effective to drop the ceiling and to remove the underlying gypsum plaster. However, this

means that a great deal of airborne dust may be generated and it will contain many gypsum fibres that will be of a size that will be counted in the PCM analysis. To an extent, the smaller scale of this type of job and the use of hand tools for the removal plus some attempt at wetting, will usually limit the concentration of asbestos fibres to <0.1 f/ml for most jobs. However, if large areas of textured plaster are being removed in an uncontrolled fashion high general dust levels in breach of COSHH will result and chrysotile levels may possibly approach or exceed 0.1 f/ml, if it were possible to measure the level with any precision in such circumstances. The peak short-term releases for this type of job (table 4) are consistently below the proposed 0.6 f/ml 10-minute control limit. Although this was rarely observed, more careful removal of ceiling plaster boards more or less intact can also be carried out and should produce less dust than the faster 'drop' method and disturb much less of the asbestos containing material, resulting in low airborne concentrations (table 7).

6.4 TEM RESULTS

The change to the WHO method for PCM analysis in the EU directive 2003/18/EC and the Control of Asbestos at Work Regulations (CAW), means that it is no longer necessary to assume all the fibres counted are asbestos. While the lack of discrimination could be justified for monitoring the asbestos production industry, for maintenance and removal work other sources of non-asbestos fibres are more likely to be present and may add to the PCM fibre count. The release of gypsum fibres from the gypsum wall plaster, is an example where high non-asbestos fibres levels may also be generated.

The use of analytical transmission electron microscopy to count, size and identify the fibres allows the asbestos fibres to be discriminated from other fibres. Although the TEM analyses were carried out on only a sub-set of samples that had the higher PCM fibre counts, it was found that the proportion of PCM fibres that were actually asbestos was much lower than the normal PCM fibre count and was below the 0.08 f/ml average used for the risk assessment even though many high biases were present in the data set.

TEM results from an uncontrolled simulation in a house (table 9) showed that the airborne concentration to the person carrying out dry scraping were just below 0.1 f/ml and would not have exceeded the control limits. A further set of simulations in a small-enclosed chamber (table 10) showed that mixing of the product in its bulk dry powder form, gave fibre concentrations above the control limit. Also sanding of the unpainted product could also give fibre concentrations above the control limit but these were very much worst-case situations where very high levels of dust release were taking place in a small area with little or no dilution.

It is important to note that the index of exposure and the control limits are based on PCM fibre counts at x500 magnification of visible particles > 5 um long, < 3 um wide and with an aspect ratio >3:1. The TEM has much better resolution and fibres which are much thinner can be seen and some of the TEM counts were based on all >5 um long fibres rather than limiting the width to 0.2 um, the approximate lower fibre width that may be visible by PCM under ideal conditions.

7 RISK ESTIMATES

7.1 ESTIMATION OF THE MEAN EXPOSURE FOR THE CALCULATION OF WORKER RELATED RISK

Given the difficulties of sampling and analysis, the range of circumstances and the large number of results reviewed, it is difficult to calculate a single time weighted average to represent the personal exposure during the removal of textured decorative plasters and paints. The general pattern of the exposure data is what would be expected: that the higher the amount of disturbance to the material, the higher the level of airborne dust produced and the higher the fibre concentration. The reviewed results show that maintenance work which disturbs a small area of textured decorative finishes will be well below the control limits and only sanding down of textured surface is likely to give rise to levels which may approach or exceed the proposed new control limits.

A series of smaller domestic removals at 35 sites did give some higher PCM fibre concentrations when very short term samples were taken in order to prevent filter overloading from the high dust concentrations being produced. For a 10 minute sample of 10 litres the LOD for 200 fields of view counted is 0.16 f/ml and the LOQ is 0.51 f/ml so there is considerable problems with getting good statistical data around the control limit, especially if there is poor control of the dust emission. Averaging and pooling of data from several samples was undertaken, as well as TEM analysis of a subset of high PCM fibre concentration samples, to measure the actual number of PCME chrysotile fibres present.

Regulatory counts of PCM fibres treated to remove soluble fibres gave a median value of 0.04 f/ml and an average of 0.09 f/ml for the individual samples and an average of 0.13 f/ml for the selected subset, which were also analysed by TEM. The TEM analysis which contained a number of high biases showed that many of the PCME fibres were non-asbestos and this was an overestimate of the peak concentration. Worst-case simulations in an enclosed space suggest PCM counts of around 0.1 – 0.3 f/ml can be generated by vigorous dry removal and perhaps ~1 f/ml by the use of dry abrasive methods (e.g. power chisel and sandpaper). Dry removal and the use of abrasive methods are however, specifically excluded by the CAW regulations. Overall the balance of results for peak removal activities showed that asbestos exposures were likely to be below the control limits and the figure of 0.08 f/ml used as the average exposure level for the assessment of the risk from removal of textured decorative finishes in the RIA analysis was a conservative figure for use in the risk assessment.

7.2 RELATIVE RISKS FOR LICENSED ASBESTOS MATERIALS

As part of the RIA, HSE for the first time was able to undertake a detailed assessment of the risks due to the removal of licensed materials. As a by-product of this work it was possible to assess what the various licensed materials contributed the relative percentage of risk. The results of this assessment (table 11) the initial driver for asking the question in the forthcoming CD, whether HSE should continue to keep textured decorative coatings within the licensing regime. The material along with all other ACMs will continue to be covered by CAW.

The risk assessment section of the RIA in the CD, has described in detail the quality of data available from the asbestos licensing unit database of notified licensed removal work and the

detailed procedures and additional research undertaken by HSL to calculate the relative risks, for each category of licensed removal work. The results of the relative risks from the RIA analysis are summarised below:

Table 11: Relative risk to licensed asbestos workers by type of ACM	
Licensed material	Relative risk for all licensed removal (%)
Asbestos coatings (AC) only*	16.4
Asbestos coatings +AIB + AI*	45.7
Asbestos insulating board (AIB)	3.2
Asbestos insulation (AI)	28.9
Asbestos insulation (AI) + AIB	2.6
Other mixtures not specified	3.1
Textured decorative finishes	0.0006

* Excludes textured decorative finishes

It was found that although only some 15% of the notifications for licensed removal were for textured decorative finishes; this represents ~0.001% of the actual risk to licensed asbestos removal workers.

The risk assessment were based on the Hodgson and Darnton (2000) human epidemiology assessment that chrysotile has a much lower risk than amosite (1/100) and crocidolite (1/500) asbestos. This risk model has been supported by subsequent work (Berman and Crump, 2003) and Bernstien at al.(2003, 2005) using data drawn mostly from animal inhalation experiments. The airborne levels inside the enclosure were taken from actual measurements from controlled wet removal inside enclosures as monitored by HSL some years previously. These values may not reflect some of the improvements in compliance and practice but as they are themselves a low-biased set of results – as HSL and other sampling personnel were present monitoring the exposure - it was considered these older data are probably reasonably representative of exposures to licensed removal workers. The types of materials being removed and time spent inside the enclosure from the database was used to calculate the average exposures to the licensed worker population by asbestos type.

7.3 CALCULATED RISK TO REMOVAL WORKERS AS A LICENSED MATERIAL

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 finishes 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. It is extremely unlikely that any person would be removing textured finishes every working day for 8 hours for 5 years continuously at 0.08 f/ml, so the risk estimates are likely to be overestimates.

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 workers assuming 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.

The actual number of deaths predicted from licensed work with textured decorative coatings over the next 50 years is <1, regardless of whether respiratory protection is worn. There are some negatives to keeping a low risk material within the licensing regime. Removal workers may well become more lax in their work procedures for a “low risk” material if the controls applied seem unnecessary and this may continue over to the other types of ACM, exposing them to a far greater risk.

7.4 RISK TO WORKERS IF UNLICENSED

Consideration of whether to take some or all of textured decorative plasters and paint removal outside of the licensing regime is a function of the, “sporadic and low intensity” considerations introduced by the EU directive and the associated low level of risk derived from the risk assessment. The introduction of “sporadic and low intensity” will in fact reduce the amount of work that be carried out outside the licensing regime with the more hazardous types of asbestos and ACMs. However, as any perceived relaxation of the licensing regime could be controversial, as it can be portrayed in isolation, as a weakening of controls on asbestos and allowing an increased risk to workers. This means it is also necessary to estimate any increased risk to workers if the material becomes unlicensed. There is at present limited information on unlicensed removal but it is possible to assess what differences are likely to occur and the effect on exposure levels.

7.4.1 Differences in the control of emissions at source

As all asbestos removal is controlled under CAW, 2002 the requirement to reduce exposure to as low as reasonably practicable applies to all work activities whether licensed or unlicensed. Therefore there is no difference to the overarching requirement to control emission at source and in practice it is unlikely that there would be any substantial differences in the effectiveness or sophistication of the control methods. The monitoring summarised in this report shows that there are two main types of removal taking place based partly on whether the textured decorative plaster is applied to a plaster board or gypsum plaster surface on the ceiling and walls, or where it is applied directly to a concrete surface. The former is typical of low-rise housing and the latter to multi-storey flats.

Removal of textured coatings from gypsum plaster and plasterboard is often more easily and quickly carried out by removing the underlying material to which the coating is attached but scraping is also carried out. The method of dust suppression used by licensed contractors at the sites sampled was often hand pumped water sprays or gel chemical treatments to soften before scraping. These are readily available and their use would be required under CAW for any asbestos removal. During use by the licensed contractors there seemed little consistency as to whether they attempted to wet the underlying material before removal or just the surface of the textured decorative coating (usually painted and ineffective). Most contractors relied on spraying as the material was removed/exposed when the ceiling was being demolished and only one site was reported as using an injection method. Therefore there is unlikely to be any significant difference in the technology used to control of release at source between unlicensed and licensed contractors for substrate removal. Arguably due to the high dust levels generated dust emission levels were far too high and better control of dust emission at source is required to

meet the COSHH regulations. More controlled removal of plasterboard is possible by removing it intact and minimising the disturbance to the ACM, is the simplest way to reduce dust and fibre emissions there are also specialist glove bags suitable for ceiling type removals, that would effectively isolate the worker from the dust produced and produce a much more control and containment of the dust and debris.

Removal of textured decorative plasters from concrete does require more specialist methods. The use of chemical solvents and gels can remove most of the coating with low fibre emissions but leave a thin film of material on the surfaces and in cracks and are not visibly clean, and additional cleaning may be required using aggressive methods. Some such as powered tools and grit blasting have poor dust suppression, others like high pressure water jetting and other wet blasting methods are more controlled but may pose significant other risks. Workers are exposed to a much wider range of risks e.g. hazardous chemicals and vapours, high-pressure jets and there are concerns that the removal of textured decorative finishes from large areas of concrete in building before demolition, is the best low risk option.

7.4.2 Differences in the control of spread during removal

Much of the licensing regime is aimed at reducing the spread of asbestos through the use of enclosures, entry airlocks, decontamination procedures, hygiene units and four-stage clearance. The exposure and risk assessment above shows that the airborne release from this type of product is much lower than from other types of licensed materials so the level of control of the spread could be less. There is little doubt that the dropping of ceiling is a very dusty operation and any contractor has to control the spread through a series of measures. Unless the building is being demolished, control of water used to suppress dust emission and the airborne dust passing to other rooms, is a high priority for the contractor to avoid more extensive areas to clean up and damage claims. Therefore systems to prevent spread of dust along the same lines as used for asbestos removal are likely to be employed and familiar to many non-licensed contractors but it would be expected that the licensed contractor would be more proficient in this area and the controls applied more effective. However, the reduction in worker exposure and spread would be relatively small if basic decontamination procedures were used – (e.g. the use of removal and cleanable of footwear (Wellington boots), removing or cleaning overalls and footwear before leaving the enclosure, and the use of sealable plastic enclosures designed to reduce the spread of dust.

7.4.3 Differences in worker exposure

Other than control at source, the two main differences in the licensing regime, that are likely to reduce worker exposure and risk, are the level of personal protective equipment (PPE) and the use of extraction units to keep the enclosure under reduced pressure. Respiratory protection is selected on the basis of the risk assessment and in the risk assessment showed that even with no respiratory protection 5 years of continuous exposure from removal work from age 30 would give an annual risk of <1 per million. Due to the high dust levels generated it is very much a practical necessity to use a respirator and it would be expected that a negative pressure respirator with an APF of 20 would be used in such conditions. A licensed contractor may well adopt the same approach or use their higher specification positive pressure respirators, however the actual increased risk to workers from the use of higher specification respirators is unlikely to be significant.

The extraction of air from an enclosure is primarily designed to reduce the spread and at the rates specified makes little difference to the personal exposure of workers involved in active removal. It is well proven that personal exposures are much higher than area exposures as the worker's breathing zone is much closer to the exposure source. To illustrate this in a recent simulation in a small volume (9m³) test chamber and carrying out the same activity at 0.6 air changes per hour and 13.2 air changes per hour was monitored. The concentration of fibres recorded on two personal inter-lapel samples reduced from 0.06 and 0.07 to 0.05 and 0.04 f/ml, a reduction of 31% in the personal exposure for a x22 increase in the extraction rate. As the extraction rates are unlikely to be much higher than 10 air changes per hour inside an asbestos enclosure, personal exposures due to reduced rates of extraction are unlikely to be more than about 25% higher.

7.4.4 Compliance levels

The current amount of textured decorative plasters and paints removed outside of the licensing regime is unknown. The percentage of jobs (15%) on the ALU database suggests that given the prevalence of this type of ACM in domestic housing, that significant proportion of textured decorative finishes could be removed outside of the licensed system. This may be due to ignorance that it is an ACM, or the desire to avoid the additional delays and costs arising from its licensed status and need to notify.

7.4.5 Estimated effect of exposure and risk from reduced controls

For the risk estimate for licensed workers a conservative estimate of exposure was used (0.08 f/ml) although where TEM results were available the evidence suggests that the chrysotile asbestos concentration is often much lower than the PCM fibre concentration. The airborne sampling carried out to date suggest that at many sites the method of dust control at source were relatively simple and it is not clear why the controls used (a water spray) cannot be employed just as easily by a non-licensed contractor. Therefore it is anticipated that there will be minimal changes from the control of source at most sites and the level of additional extraction from the enclosure is unlikely to increase personal exposures by more than around 20%.

The requirement is to try and maintain nuisance dust below the recommended levels (< 10 mg/m³) was often not achieved by licensed removal contractors, given the ease which samples were overloaded.

Most removals are likely to have TWAs below the 4 hour control limit and are unlikely to exceed the 10 minute control limit regardless of whether they are licensed or unlicensed provide CAWR is applied. Control of emissions at source and no use of power tools are fundamental to the removal of all ACMs in CAWR and the main issue is one of practicality and compliance. Other than standard of respiratory protection other elements of the licensing regime will have only a limited effect on the airborne exposure from the removal of textured decorative finishes.

In the risk assessment for licensed workers, even without use of a respirator and continuous work on removal of textured decorative finishes for 1920 hours per year for 5 years did not make the annual risk greater than 1 per million. It is extremely unlikely that the higher exposures due to changes in the control, PPE and containment will cause the risk to workers to rise above the 1 per million risk of annual death. Respiratory protection up to an APF of 20 will in most cases be worn and should ensure the annual risk remains well below 1 per million. In terms of the actual number of deaths avoided by retaining as a licensed material, there is currently some 47,000 days per year of notified removal work, some of this will be spread out

over a much larger potential workforce. Therefore very few individuals will have exposure durations of more than 30 days per year and it is not predicted that there will be any additional deaths from relaxing the licensing regime for the removal of asbestos-containing textured decorative finishes.

7.5 EXPOSURES DURING UNLICENSED REMOVAL WORK

At present there are no direct measurement of controlled removal inside an enclosure without extraction and airlocks. There is however worst case simulation data where no controls have been used. These results appear in tables 7 & 8. The measurements inside a room in a house where dry scraping was carried out for 60 minutes showed that the level of PCME chrysotile fibres was just below 0.1 f/ml over this monitoring period. As the finish was dry and was quite easy to remove as fine flakes with a scraper it was considered that this was typical of the peak exposure that would be produced by the absence of any controls to reduce dust emission.

The simulations in table 8 were meant to give the worst-case situation with no extraction and small room volume. The mixing of the loose powder where the asbestos is not bound in a matrix gave levels of ~ 2 f/ml and where high levels of attrition of unpainted surfaces took place fibres concentrations of 1 f/ml could be produced. Scraping dry from a surface gave airborne personal concentrations of ~0.12 f/ml over the duration of the activity.

Therefore the data is consistent that unless sanding and power tools are used, scraping textured decorative finishes from a surface will give peak releases of about 0.1 f/ml but will be unlikely to exceed the ten minute or four hour control limits in most circumstances (i.e. it is difficult to scrape at this rate for 4 hours).

7.6 RISKS FROM UNLICENSED REMOVAL WORK UNDER CAWR

The CAW regulations place much the same generic controls as are required for licensed asbestos removal work e.g. control of emissions at source, prevention of the spread of asbestos, safe disposal and decontamination etc. Therefore the exposure levels found in uncontrolled work and worst case simulations – with no controls- shows that the average exposure to chrysotile asbestos from work with textured decorative finishes is likely to be below 0.1 f/ml and the conservative average used for licensed removal of 0.08 f/ml is not unrealistic for the unlicensed exposure levels. To put this risk into context some additional calculations from the RIA are summarised in table 10 which compare the removal of textured decorative finishes to asbestos cement (unlicensed) removal. The average exposure for both unlicensed activities was 0.08 f/ml and the same contact times as used in the RIA were used. The calculated risk from textured decorative finishes, is less than for asbestos cement.

Table: 11 Calculated number of asbestos related deaths for removal/demolition of asbestos cement and textured decorative finishes based on an average exposure during the work of 0.08 f/ml of asbestos based on 10 years exposure at age 20.

	Chrysotile	Amosite	Crocidolite	Total
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Asbestos cement demolition based on a total of 50,000 demolition workers in a 50-year period (no RPE) with 10% exposure time.	0.66	0.14	0.94	1.74
Asbestos cement demolition for 10 years for a total of 500,000 general building workers in a 50-year period (no RPE) with 0.5 % exposure time.	0.67	0.14	0.97	1.78
Textured decorative plaster and paint removal / demolition for a total of 500,000 general building workers in a 50-year period (no RPE) with 0.5 % exposure time.	0.67			0.67

These estimates are based on 100,000 general building workers occasionally removing textured decorative finish (0.5% of time) with a total of 500,000 such workers of the next 50 years coming into contact. Assuming 240 working days per year this represents on average 1.2 days per year per worker and a total of 120,000 working days of removal per year some two and a half times greater than the previous level of licensed removal. It was not anticipated that maintenance worker exposures would change.

7.7 EXPOSURE AND RISKS TO OTHERS

Regulation 16, 17 & 18 of CAW 2006 are specific in the contractors responsibility to prevent the spread of asbestos and to ensure the premises are thoroughly cleaned after the work and to take measures to prevent others entering the work area. For licensed asbestos removal work there is a recent requirement under (CAW, 2002) to undergo a four-stage clearance procedure to issue a certificate of reoccupation. The purpose of the four-stage procedure is primarily to:

1. Check which ACMs should have been removed and from where;
2. Check that the ACMs have been complete removed and that the area is left clean of any debris and dust.
3. Carry out air monitoring to ensure it is safe to take down the enclosure;
4. Carry out a final check that the site is left clean

In practice, there is no reason why a four-stage clearance cannot continue to be employed for clearance, if the owner/client wants this take place. As always the issue is where to decide to place a realistic limit for where this requirement is no longer mandatory due to the low risk involved. At present it would be possible to carry out up to 2 hours work on any type of ACM without the issue of a certificate of reoccupation and for any length of work on an unlicensed ACM. The introduction of the 'sporadic and low intensity exposure' will give a more risk based approach to when licensed removal takes place and will increase the requirement for clearance of work with the higher risk insulation and spray coatings.

As it has been shown that the risk to workers is much lower from textured decorative finishes, it is questionable whether a full 4-stage clearance should be mandated. This depends on the additional risk that would be avoided by both maintenance workers and occupants for textured

decorative finishes. Based on the risk assessment for removal workers, even if small amounts of material are left in place or as debris these are unlikely to give rise to a substantial source of airborne fibres or be a significant risk to occupants. If the site is thoroughly cleaned after the work so that no visible debris or dust is present this risk is likely to be very low

Examination of the sampling logs and site information from the HSL/ABI survey showed that the clean-up and achieving clearance was not a problem and it appears that retesting was not required. This suggests it is relatively easy to clear the site.

The residual airborne levels after removal are expected to be well below the levels generated during removal and a background exposure of 0.0005 f/ml has been assumed for the risk estimate. Therefore based on :

- 10,000 households per year where removal of TCs carried out and
- 2 children per household exposed for 5 years from birth for 24 hours per day (conservative).
- This continues for the next 50 years - which results in 1 million children exposed in total.
- Exposure is to chrysotile only
- Exposure from birth for 5 years constitutes a risk 3 times greater than that for the same exposure from age 30
- .- To convert from work time only exposure to 24 hours, concentrations are multiplied by 2.

For a million children exposed in this way from birth to 5 years over the next 130 years (50 years of continuous removal with up to an 80 year lag time to develop a disease) this was estimated using a modified Hodgson and Darnton model to represent 2 lifetime deaths equivalent to an annual risk of death of around 0.02 per million. This estimate was based on some worst-case assumptions and linear interpolation from much higher worker exposures and in practice it is unlikely any deaths could be attributed to post removal exposures of occupants.

8 APPENDICES

Appendix 1: Individual PCM fibre concentration results from HSL survey of small-scale hand demolition of ceilings and walls with chrysotile containing textured decorative plaster finishes. (Revell. 2005)

Job N°.	Volume (litre)	f/ml (untreated)	10-min TWA (untreated)	Activity code	f/ml (treated)	4-hour TWA (treated)
Job02	20			C5	0.02	0.02
Job02	10			C5	0.04	0.02
Job02	20			C5	0.23	0.23
Job02	10			C5	0.25	0.13
Job02	10			D4	0.05	0.03
Job02	10			D4	0.19	0.10
Job02	10			D4	0.20	0.10
Job02	540	<0.01		RE		
Job02	540	<0.01		RE		
Job04	114	0.02		A3	0.05	
Job04	178	0.01		D8	0.02	
Job04	480	<0.01		E2		
Job04	480	<0.01		E2		
Job04	480	<0.01		E2		
Job04	480	<0.01		E2		
Job06	480	<0.01		E2		
Job06	480	<0.01		E2		
Job06	20			##	0.40	0.40
Job07	480	<0.01		E2		
Job07	480	<0.01		E2		
Job07	480	<0.01		E2		
Job07	480	<0.01		E2		
Job09	19.8	0.39	0.43	A3		
Job09	480	<0.01		E2		
Job09	480	<0.01		E2		
Job09	480	<0.01		E2		
Job09	480	<0.01		E2		
Job10	6	0.32	0.16	A3		
Job10	9.6	0.24	0.19	A3		
Job10	6	0.56	0.28	A3	0.02	0.01
Job10	9.6	0.48	0.38	A3	0.08	0.06
Job10	11	1.34	1.47	A3	0.16	0.18
Job10	8	1.01	0.81	A3	0.22	0.18
Job10	11	0.44	0.48	A3	0.43	0.47
Job10	8	0.48	0.38	A3	1.22	0.98
Job10	14			D1	0.08	0.11
Job10	16.8	0.11	0.15	D2	0.04	0.06
Job10	14			D2	0.17	0.24
Job10	16.8	0.09	0.12	D4	0.01	0.01
Job11	480	<0.01		##		
Job11	480	<0.01		##		

Appendix 1: Individual PCM fibre concentration results from HSL survey of small-scale hand demolition of ceilings and walls with chrysotile containing textured decorative plaster finishes. (Revell. 2005)

Job N°.	Volume (litre)	f/ml (untreated)	10-min TWA (untreated)	Activity code	f/ml (treated)	4-hour TWA (treated)
Job11	12	1.47	1.47	##	0.07	0.07
Job11	12	1.55	1.55	##	0.09	0.09
Job11	12	1.44	1.44	##	0.18	0.18
Job11	12	0.67	0.67	##	0.23	0.23
Job11	480	<0.01		E2		
Job12	544	0.00		BG		
Job12	537	0.00		BG		
Job12	40			C4	0.14	
Job12	250			CS4	0.02	
Job12	24	0.01		D8	0.03	
Job12	288			DS8	0.02	
Job13	30			##	0.12	0.18
Job13	480	<0.01		E2		
Job13	480	<0.01		E2		
Job14	82			##	0.04	
Job15	60			##	0.04	
Job15	480	<0.01		E2		
Job15	480	<0.01		E2		
Job16	20	0.43	0.43	B2		
Job16	22	0.22	0.24	D3	0.08	0.09
Job16	486	<0.01		E2		
Job16	486	<0.01		E2		
Job18	10			##		
Job18	10			D8		
Job18	10	0.05	0.03	E1		
Job18	480	<0.01		E2		
Job18	480	<0.01		E2		
Job19	515	<0.01		AT		
Job19	18.2			C1		
Job19	26	0.05	0.05	C1	0.02	0.02
Job19	31.2			D1		
Job19	26			D1	0.10	0.10
Job19	516	<0.01		E2		
Job19	516	<0.01		E2		
Job19	510	<0.01		E2		
Job19	534	<0.01		E2		
Job19	516	<0.01		RE		
Job20	5	1.37	0.69	B7		
Job20	5	2.00	1.00	B7		
Job22				##		
Job22	12			##	0.06	0.07
Job22	27.2	-		AR	0.01	
Job22	125			AR	0.01	
Job22	25.6	-		AR	0.05	
Job22	25			AR	0.08	

Appendix 1: Individual PCM fibre concentration results from HSL survey of small-scale hand demolition of ceilings and walls with chrysotile containing textured decorative plaster finishes. (Revell. 2005)

Job N°.	Volume (litre)	f/ml (untreated)	10-min TWA (untreated)	Activity code	f/ml (treated)	4-hour TWA (treated)
Job22	12			AR	0.09	
Job22	27.4	-		AR	0.16	
Job22	22	0.12	0.13	C2	0.02	0.02
Job22	24	0.07	0.08	C2	0.22	0.26
Job22	20	0.19	0.19	C2	0.31	0.31
Job22	24	<?		D2		
Job22	24	<?		D2		
Job23	108			##	0.15	
Job23	108			##	0.15	
Job23	160			##		no filter
Job23	80			AR	0.16	
Job24	204			D73	0.02	
Job24	40			D73	0.10	
Job26	20	0.01	0.01	##		
Job26	20	2.33	2.33	##	0.10	0.10
Job26	20	0.85	0.85	##	0.13	0.13
Job26	20	0.02	0.02	D8	0.07	0.07
Job26	20	0.28	0.28	D8	0.10	0.10
Job27	439			A3	0.00	
Job27	84	0.01		A3	0.00	
Job27	140	0.00		A3	0.00	
Job27	89	0.01		A3	0.01	
Job27	90	0.01		A3	0.01	
Job27	93	0.00		A3	0.01	
Job27	600			A3	0.01	
Job27	135	0.00		A3	0.01	
Job27	29	0.01		A3	0.02	
Job27	30	0.01		A3	0.03	
Job27	513	0.00		A3	0.03	
Job27	380			C4	0.00	
Job27	35	0.09		C4	0.02	
Job27	16	0.47	0.76	C4	0.06	0.10
Job27	203	0.00		D4	0.00	
Job27	236	0.00		D8	0.00	
Job27	107	0.00		D8	0.02	
Job27	569	0.01		H3		
Job27	569	0.01		H3		
Job28	180			##	0.02	
Job28	150			##	0.02	
Job28	20			##	0.03	0.03
Job28	20			##	0.07	0.07
Job28	20			##	0.09	0.09
Job29	36			C1		
Job29	4			C1	0.19	0.07
Job29	80			CS1		

Appendix 1: Individual PCM fibre concentration results from HSL survey of small-scale hand demolition of ceilings and walls with chrysotile containing textured decorative plaster finishes. (Revell. 2005)

Job N°.	Volume (litre)	f/ml (untreated)	10-min TWA (untreated)	Activity code	f/ml (treated)	4-hour TWA (treated)
Job29	44			CS1	0.02	0.03
Job29	30			CS1	0.05	0.06
Job30	19	0.04	0.04	A5		
Job30	19	0.08	0.08	A5		
Job30	19	0.05	0.05	A5		
Job30	19	0.05	0.05	A5		
Job30	19	0.03	0.03	A5		
Job30	19	0.03	0.03	A5		
Job30	19	0.03	0.03	D1		
Job30	19			D1	0.03	0.03
Job30	19	0.05	0.05	D3		
Job30	19	0.05	0.05	E1		
Job31	100	0.10		C1	0.05	
Job31	26	0.10		C1	0.07	
Job31	31	0.00		D3		
Job31	156	0.00		D34		
Job31	316			D7	0.01	
Job31	37	0.10		D7	0.04	
Job32	101			C1	0.01	
Job32	193			C1	0.01	
Job32	38	0.00	0.01	D49		
Job32	83			D8	0.04	
Job32	496	0.01		H3		
Job32	502	0.01		H3		
Job33	20	0.01	0.01	##		
Job33	20	<0.2		##		
Job33	20			AR	0.04	
Job33	20			AR	overloaded	
Job34	20			C2	0.23	0.23
Job34	20			D17	0.36	0.36
Job34	20	0.01	0.01	E1	0.08	0.08
Job37	184			AR	0.06	
Job37	684.75			AsR	0.01	
Job37	565.5	0.04		BG		
Job39	20	0.04	0.07	A3		
Job39	35	0.06		A3		
Job39	556	0.01		BG		
Job39	96	0.01		D8		
Job40	128.7	0.01		##	0.01	
Job40	1228.5	0.00		BG		
Job40	584.1	0.00		BG		
Job41	8.8	0.04	0.03	A3	0.01	0.01
Job41	15	0.01	0.01	A3	0.02	0.03
Job41	97			A3		overloaded
Job41	388			AS3	no filter	

Appendix 1: Individual PCM fibre concentration results from HSL survey of small-scale hand demolition of ceilings and walls with chrysotile containing textured decorative plaster finishes. (Revell, 2005)

Job N°.	Volume (litre)	f/ml (untreated)	10-min TWA (untreated)	Activity code	f/ml (treated)	4-hour TWA (treated)
Job41	83			C4	0.01	
Job41	43			C4	0.02	
Job41	25			C4	0.09	
Job41	263			CS4	0.01	
Job41	280			CS5	0.01	
Job41	20	0.12	0.24	D8	0.13	0.26
Job41	332			s##		overloaded
Job42	321.8			AR	0.02	
Job42	693			ASR	0.00	
Job42	693			ASR		
Job43	38	0.03	0.04	##	0.01	0.02
Job43	19	0.06	0.06	B1	0.00	0.00
Job43	64	3.00		C1	0.12	
Job43	64			C1	0.20	
Count	189	83	48	190	107	50
Average	184.6	0.28	0.37		0.09	0.14
Max	1228.5	3.00	2.33		1.22	0.98
Median	40.0	0.04	0.1		0.04	0.09

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