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Summary of fibre concentrations In CLASP construction schools containing asbestos.

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ACKNOWLEDGEMENTS

The data in this report were collected with the help and co-operation of a number of HSE inspectors, HSL staff, schools, local education authorities and contracted asbestos laboratories. As all data has been made non-attributable for this report, I am unable to name them but without the extensive help and co-operation provided this report would not have been possible.

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EXECUTIVE SUMMARY

Objectives

To prepare an initial assessment of the airborne fibre concentrations in type 4 and 4B CLASP construction schools during and after remediation.

Main Findings

Several hundred phase contrast microscopy (PCM) measurement of the airborne fibre concentration in over 20 schools have been compiled and assessed along with a much smaller number of electron microscopy measurements.

PCM counts are limited by the low volume of air sampled, background counts on blank filters and the inability to discriminate whether the fibres are asbestos or non-asbestos.

However, with such a large number of samples available it is possible to look at the distribution of results and pool the data to give a more precise picture of the airborne fibre concentrations.

The current PCM data available suggests that full sealing of the column is effective in reducing fibre release by at least one order of magnitude and probably by two orders of magnitude. Partial sealing of the vertical seams also appears to give a similar order of reduction.

The PCM data for all fibre counts (non-asbestos and asbestos) from the schools sampled are summarised in the table below.

	Activity Sampled					
Statistic	Normal occupation after remedial work	After remedial work with minimum activity	Disturbance & clearance testing of columns after remediation	During remediation / sealing	During disturbance testing (no remediation)	Inspection of ceiling area
Number of samples	96	44	95	12	31	20
Mean (f/ml)	0.005	0.002	0.005	0.004	0.094	0.004
Median (f/ml)	0.004	0.001	0.003	0.004	0.033	0.002
Largest value (f/ml)	0.022	0.008	0.058	0.006	0.441	0.019
Smallest value (f/ml)	0.001	<0.001	<0.001	0.001	0.001	0

A limited number of analytical electron microscopy (EM) results from disturbance testing of unsealed damaged columns showed that the fibres released were predominantly amosite asbestos. However, this is unlikely to be the case for PCM fibre counts after remediation during reoccupation, when several other sources of non-asbestos fibres may be present.

One set of high volume samples analysed by transmission electron microscopy (TEM) analysis available from an occupied school, gave an airborne asbestos concentration of <0.0004 PCME f/ml. This was sampled in a corridor between two sets of doors, which were mounted on the columns and were frequently used causing movement and vibration. The vertical seams of the column had been taped to cover visible separation of the casing. This result is below the average concentration of airborne PCM countable asbestos fibres that are commonly found in occupied buildings containing asbestos products and represented a two orders of magnitude reduction in the airborne asbestos concentration prior to improving the sealing.

The evidence available to date shows that the HSE's initial advice to check that column casings are intact and undamaged and to seal any gaps visible in the room, appears sufficient to reduce exposures in schools to the low background levels found in other asbestos containing buildings.

Recommendations

Further higher volume air sampling and analytical TEM analysis in CLASP 4 and 4B buildings is needed to confirm the findings in this report that the remediation was successful and leaves only background concentrations of airborne asbestos fibres in occupied school buildings.

Further work to assess releases into ceiling voids and the personal exposures to workers who enter or disturb the ceiling voids for inspection and maintenance purposes is needed.

1 INTRODUCTION

In late July 2006, after asbestos contractors had carried out some asbestos removal work at a school, they failed to obtain levels of asbestos fibre in air below 'clearance levels' when, as part of deliberate disturbance, they struck parts of the steel clad columns in the room. The measured concentrations inside the enclosure suggested a significant release of airborne fibres was present. A range of values was obtained using phase contrast microscopy (PCM) which is used to count all > 5 µm long fibres with aspect ratio >3:1 and <3 µm width 'regulatory sized fibres'. The PCM method counts all visible fibres meeting the size criteria and does not discriminate between whether they are asbestos or non-asbestos fibres.

The highest concentrations found under these simulation conditions in a sealed area was 0.42 f/ml on a personal sample and 0.44 f/ml on a static sample close by the source. This means that there is a potential for significant exposure to persons in the room from some (damaged or poorly sealed) columns, should the scale of mechanical disturbance to the column be reproduced. This information was reported to HSE in mid-September. An assessment of the cause of the release was undertaken and found to be due to damaged asbestos insulating board (AIB) and debris within the columns. This was exacerbated by a poor seal in some of the metal column casings, which was meant to enclose the AIB. Maintenance work on the columns to attach various items and in particular improper window replacement had all resulted in further breaches of the enclosing casing. After further field sampling work had confirmed the probable mechanisms for release (damaged and /or poor sealing) and that predominately amosite asbestos fibres were being released, advisory notes were prepared and circulated in mid-October. The advisory notes were circulated to the Directors of Education/Children's Services in England, Scotland and Wales and Governing Bodies of Foundation, Voluntary Aided and Independent schools, informing them of the potential for fibre release and requiring them to identify Mark 4 and 4B CLASP buildings; and to take action to seal gaps in the structure through which asbestos could escape to prevent any potential fibre release.

The recommended initial action to seal any gaps at room level in the metal casing, which enclosed the structural steel columns and the AIB, was a simple, cheap and fast way to improve the integrity of the enclosure in the occupied areas. However, the tops of the enclosure are open and can potentially release fibres into the suspended ceiling void and perhaps indirectly into the classroom. A full sealing of the column would also entail using a polyurethane foam or similar to seal the tops of the column casings. It is not known how much release would occur from the tops of the column and more data was needed to assess this.

HSL was asked to investigate the effectiveness of the sealing of the column casing seams and gaps visible in the rooms and corridors in reducing airborne fibre release; and to assess what additional problems and advantages may be derived from further sealing of the top and or bottom of the column. This report summarises the data gathered to date.

2 METHOD

2.1 STRATEGY

Given the short period since being requested to gather data: two approaches have been used:

- Obtain and assess any existing data;
- Carry out field measurements at suitable sites to generate additional data to research specific questions.

The types of airborne fibre measurements that are required to assess the situation are measurements of the fibre release from:

- Simulation of disturbance and cleaning activities in unoccupied rooms;
- Normally occupied rooms;
- During remediation of the columns' vertical seal;
- During remediation of the top of the columns;
- Simulated disturbance of the column at the various stages of remediation;
- Maintenance activities.

2.2 SAMPLING METHODS

Airborne samples are collected by drawing air through a membrane filter to trap particulates. This is usually done at a calibrated and measured flow rate for a known time so the sampled volume is known. The greater the volume of air that can be sampled the better the limit of detection (LOD) but as sampling proceeds many other particulates are collected and once the filter is covered with > 10% of particles microscopical analysis becomes increasingly difficult ,so the sampled volume is restricted by how much loading can be placed on the filter. Commonly the PCM method is used (see MDHS39/4 and HSG 248) in a specific way for either clearance sampling down to 0.01 f/ml or for assessing the exposure against the control limit (0.1 f/ml since 13/11/06) and the volumes collected are typically 480 and 240 litres of air respectively. For low level monitoring greater volumes of air need to be sampled and typically about 3000 litres can be sampled onto the standard 25 mm dia. membrane filter before microscopical analysis due to the particulate loading becomes a problem.

In some specifically dusty circumstances, size selective sampling may be necessary to exclude large non-respirable particles from the sampling device and various devices have been used (e.g. impactors, cyclones, foam separators (see MDHS 14) but their sampling and inlet characteristics are not well characterised for fibres and are not widely used. They do however, offer a chance to sample increased volumes of air for microscopical evaluation but will alter the fibre counts (e.g., either by possible loss of larger respirable asbestos fibres and structures or by the breaking up of fibre clumps and bundles due to high velocity shear flows as found in some impactors and cyclones). No data from specifically designed size selective samplers is included in this report.

2.3 ANALYTICAL METHODS

After sampling, parts of the filter are cut out, chemically treated and mounted for microscopical observation.

Most of the measurement carried out were analysed by light microscopy using a contrast enhancing method known as phase contrast microscopy (PCM). The standard method in MDHS 39/4 was used for the sampling and analysis of all the PCM counts in this report. The method counts all visible fibres, which are >5 µm long, < 3µm width and with an aspect ratio of >3:1and does not discriminate between fibre types (e.g. asbestos and non-asbestos).

Although some limited discrimination is possible using polarised light microscopy on the same sample, reliable discrimination of fibres can only be carried out using analytical electron microscopy, which uses energy dispersive X-ray analysis (EDXA) to determine the chemical composition of individual fibres. Transmission electron microscopy, as used by HSL in this report can also carry out electron diffraction to measure and determine the crystal and atomic structure of the fibre/mineral and give a full identification of the fibre type. An International Standard method ISO 10312:95 was used for the analysis. Some scanning electron microscopy (SEM) data with EDXA identification was also made available to HSL.

2.4 DATA ASSESMENT

The capabilities of measurement methods to measure down to the airborne low levels of asbestos present in most buildings during normal use means that an understanding of the underlying limitations of the measurement statistics and background counts are necessary.

2.4.1 Precision, limit of detection (LOD) and limit of quantification (LOQ)

Fibre counting has poor statistical precision. This means that individual results must be compared carefully to assess whether any differences are actually present. Particles sampled onto a filter at best have a random distribution. This means that the precision of the count is limited by the underlying ‘Poisson’ statistics. The precision is usually expressed in terms of the confidence interval, which defines the upper and lower limits expected for a defined percentage of repeat counts. For example 95% confidence limits mean that on average 19 of the 20 values from repeat counts would be within the upper and lower limits. For low counts the lower confidence limit is 0, so a one-sided upper 95% confidence interval is used. For a count of 0 it is 95% probable that the count is < 3 fibres.

The standard method for defining the limit of detection (LOD) and limit of quantification (LOQ) based on 3 and 10 standard deviations and from analysis of blank counts in the RICE (regular interlaboratory counting exchange) proficiency testing scheme, represent a fibre count in 200 fields of view on the PCM of 5.3 and 17.6 fibres, respectively. Although individual analyses may have counts below the LOQ and LOD where many similar samples are available it is possible to get a more precise picture based on pooling the samples together and also looking at the spread of the individual data points. This is the approach taken in this report to assess much of the existing data.

2.4.2 Blank counts

Where relatively few fibres are likely to be sampled, their evaluation is made more difficult if the blank filters, even without being used for sampling, may give small numbers of PCM fibre counts due to imperfections in their manufacture and /or subsequent contamination. The RICE quality control program has shown that blank membrane filter counts by PCM are low and that on average <1 fibre per 100 fields was counted. This gives an upper 95% confidence limit that <5 fibres will be counted in 100 fields and similarly <6.5 fibres in 200 fields. For a sample volume of 480 litres with 200 fields counted, this corresponds to a calculated result of 0.003 f/ml for the upper 95% confidence limit and it is highly likely that above this level, the fibres are from air. The average count of ~2 fibres corresponds to 0.001 f/ml.

It is now rare to find any blank membrane filters that have asbestos fibre contamination and if asbestos fibres are found by TEM sss they are likely to be from the sampled air.

3 RESULTS

Most of the data available relates to PCM data from static samples taken close to the vicinity of the disturbance. The analytical electron microscopy is summarised after the PCM data.

3.1 PCM RESULTS FROM SAMPLES TAKEN AFTER FULLY SEALING COLUMNS AND CLEANING THE AREA.

These data will tell how well the process of sealing the column is working. The vertical seam and the top of the column (also bottom if necessary) had been sealed to prevent any airborne release of fibres. Figure 1 summarises the results from 95 samples from a number of schools with CLASP 4 or 4B construction containing asbestos insulating board. The samples were almost always $\geq$ 480 l with 200 Walton-Becket graticules being counted by PCM.

The samples were collected during the clearance testing of the seal by carrying out a physical disturbance of the column and surrounding area by banging the casing hard with a fist several times and sitting on window seats, banging doors etc. This was normally carried out on a number of sealed columns in a single room or smaller enclosure with no extraction. The distribution of the counts is not log normal and shows that there is a tail to the distribution of higher counts, suggesting that a few columns are giving a small releases even after sealing has taken place. The level of release is still relatively low ~0.01 f/ml.

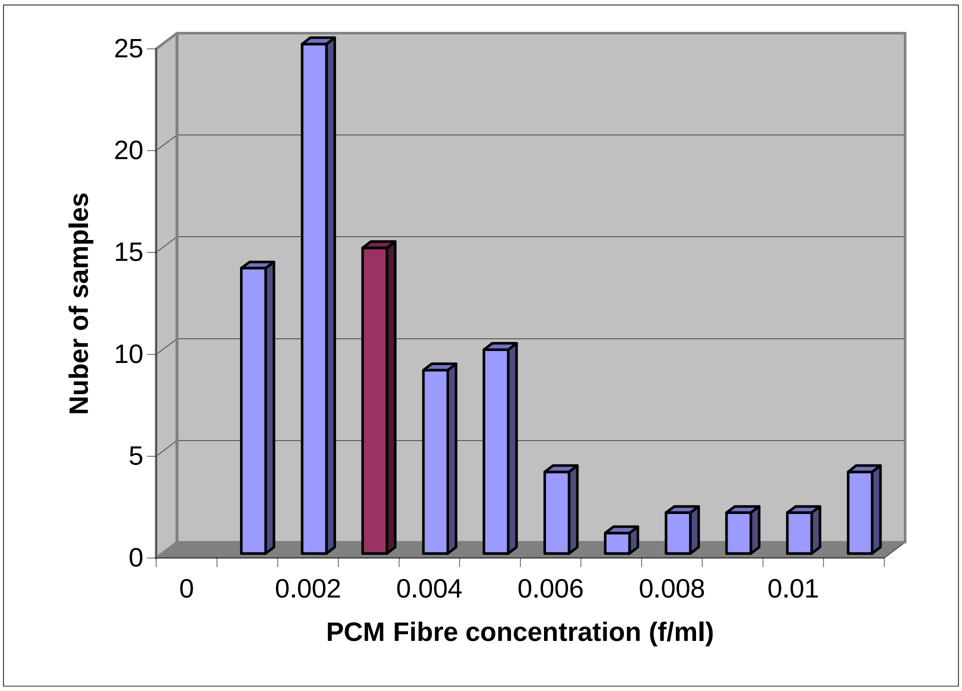

Figure 1: PCM results from disturbance testing of fully sealed columns after cleaning the room

(Nearly all volumes sampled were $\geq$ 480 l and 200 graticules counted, the different coloured column at 0.003 f/ml represents the upper 95% value expected for blank counts).

Figure 2 summarises 96 samples of PCM fibre concentrations measured after the classrooms were reoccupied and in normal use. Clearly there are some additional releases of airborne fibres but there are a number of sources of non-asbestos fibres (e.g. paper fibres, fine organic fibres) from the presence and activities of the occupants. These are compared in figure 3.

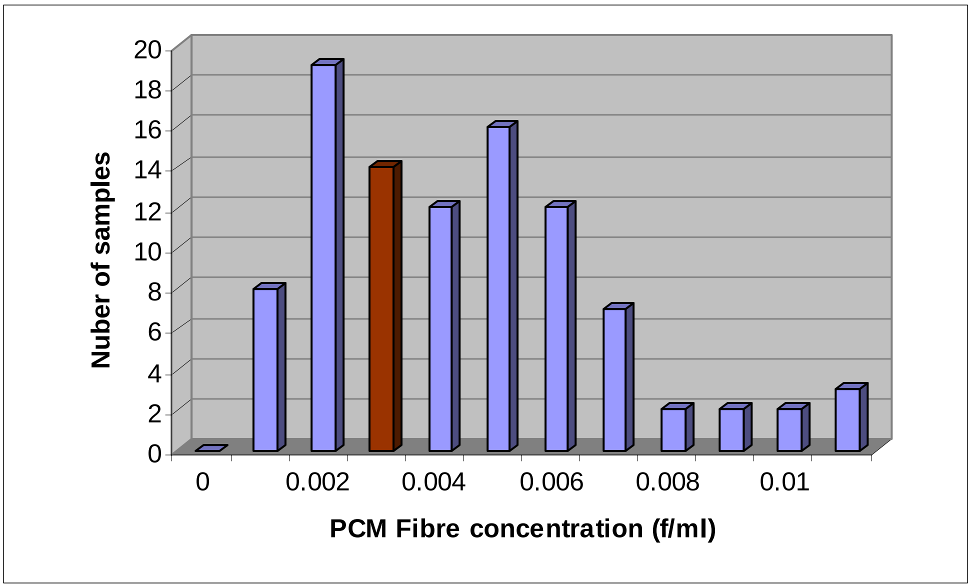

Figure 2: PCM fibre concentrations in reoccupied classrooms during normal use after remediation. (Nearly all volumes sampled were ≥ 480 l and 200 graticules counted, the different coloured column at 0.003 f/ml represents the upper 95% value expected for blank counts).

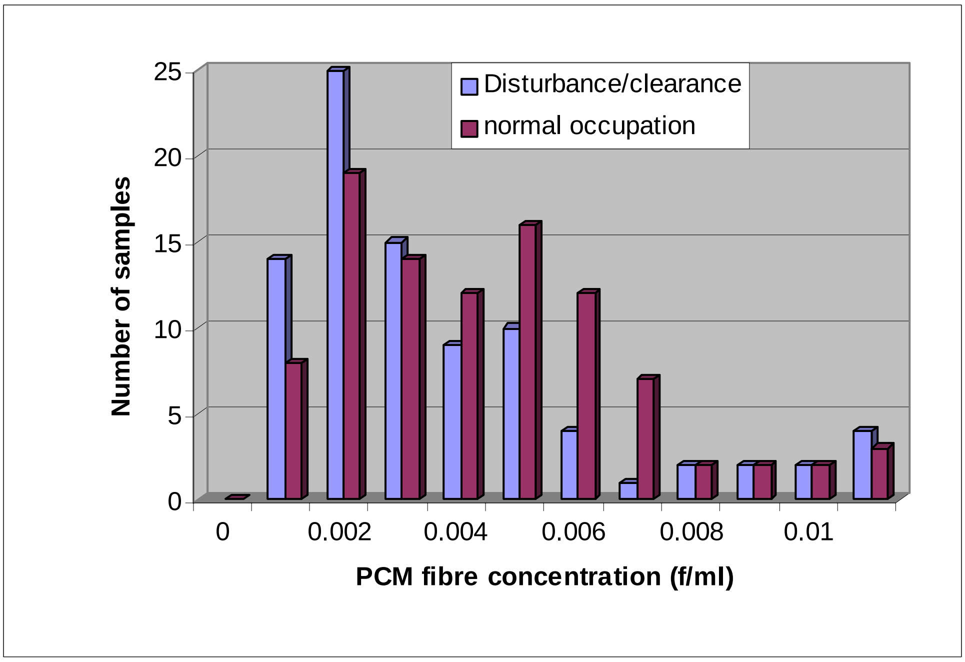

Figure 3: Comparison of PCM fibre concentrations between disturbance testing and reoccupied rooms after remediation.

A number of samples (44) were taken after the remediation but before reoccupation. Although some limited activity may have been present, figure 4 represents the best assessment estimate of the background level of fibre counts without known disturbance. This is compared to the normally occupied rooms in figure 5.

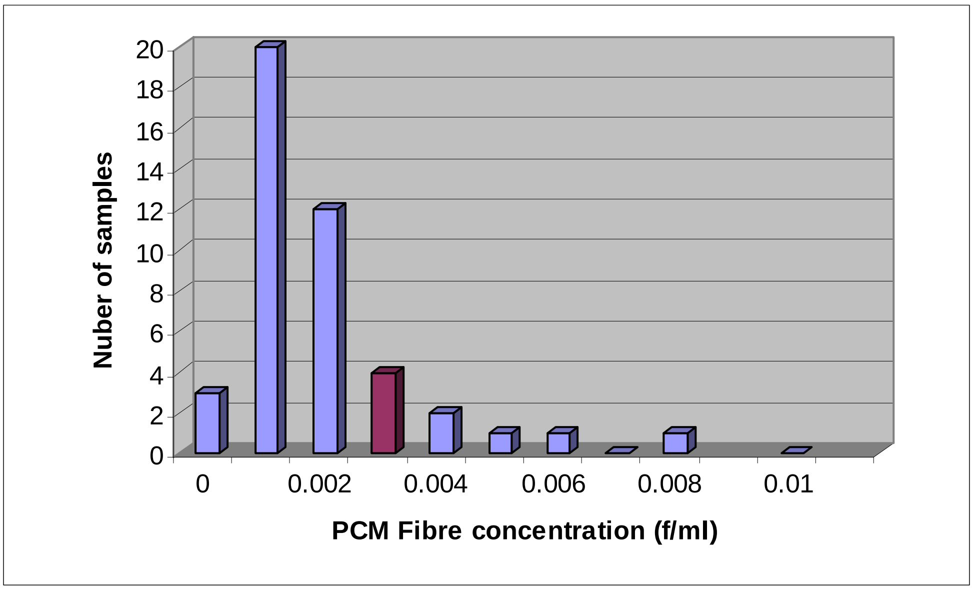

Figure 4: PCM fibre concentrations in unoccupied classrooms after remediation. (Nearly all volumes sampled were $\geq$ 480 l and 200 graticules counted, the different coloured column at 0.003 f/ml represents the upper 95% value expected for blank counts).

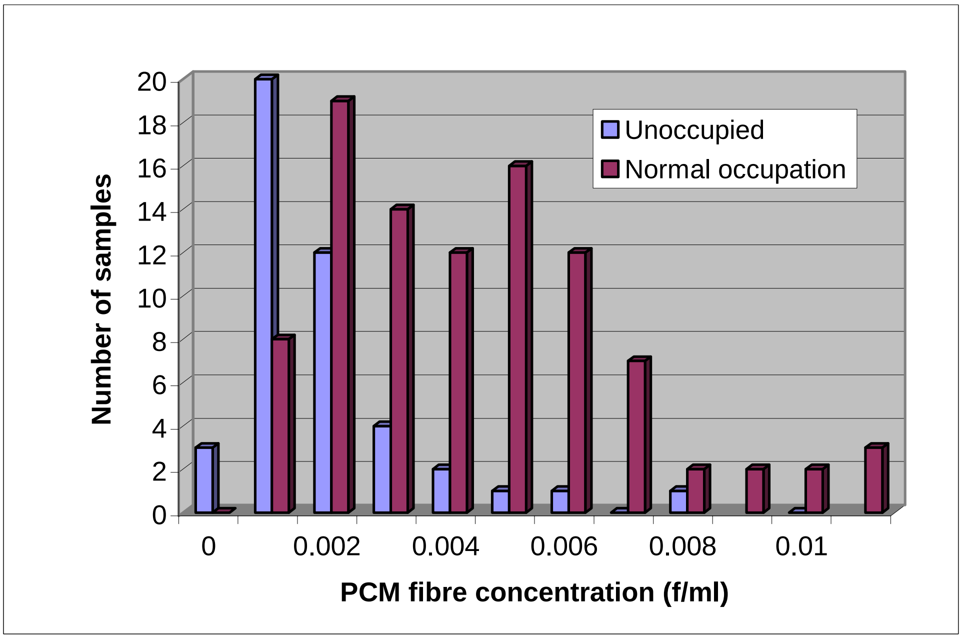

Figure 5: Comparison of PCM fibre concentrations between unoccupied and reoccupied rooms after remediation.

3.2 PCM RESULTS DURING WORK ON COLUMNS

Only a limited amount of data was available during the full remediation of columns and is compared with the results during the disturbance/ clearance testing in figure 6. However, HSE's interim advice was to seal the vertical seams of the column and to leave the sealing of the tops and bottoms to a later date. Although this advice was given for pragmatic reasons (e.g. speed and minimal disturbance) PCM results during this partial sealing are available and are summarised in figure 7.

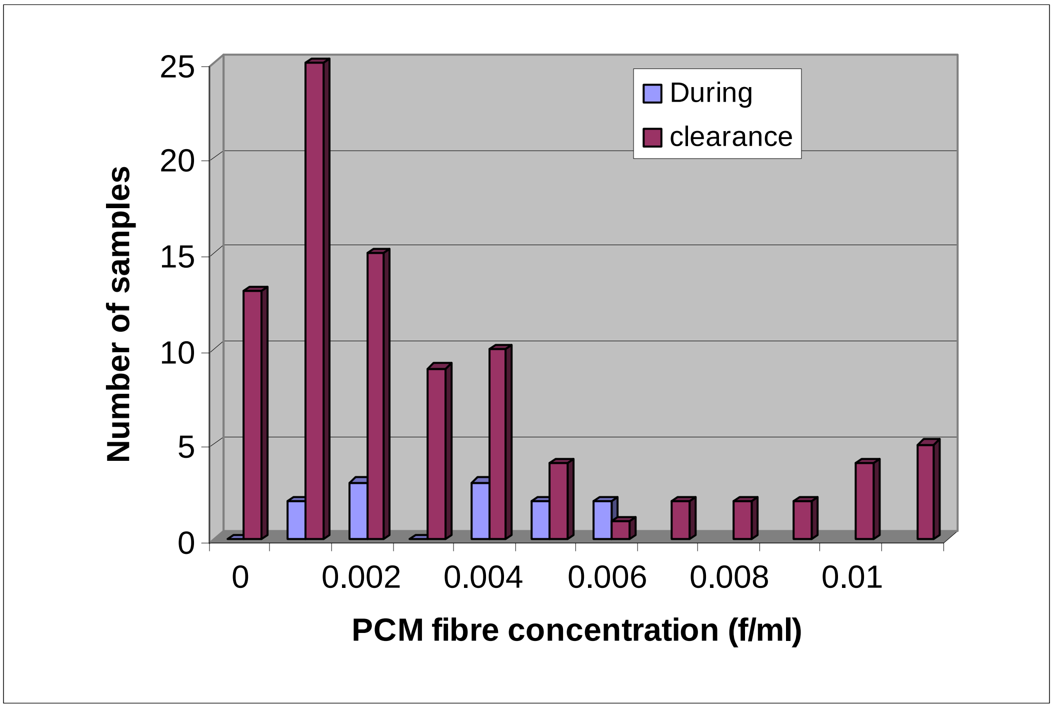

Figure 6: Comparison of PCM fibre concentrations during full remediation and sealing of the columns with disturbance/clearance testing.

The partial sealing involved taping of the seams only, so the column casing was being firmly pressed against, as the tape was unwound. This flexing of the casing would represent moderate normal contact with the columns such as leaning against them. The results in figure 7 are based on 188 individual PCM samples.

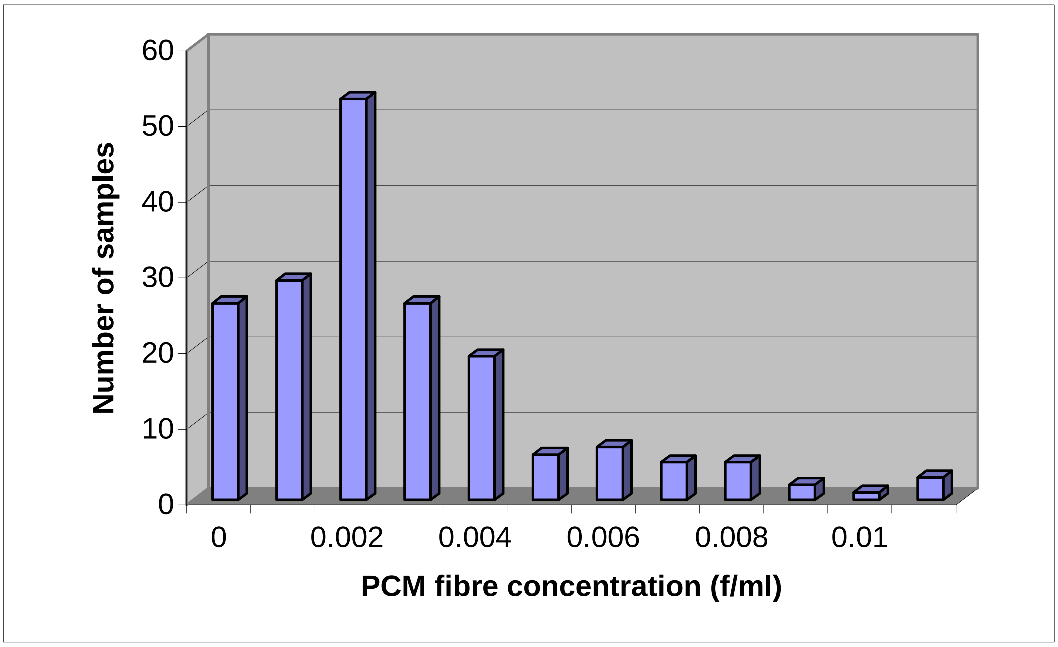

Figure 7: PCM air monitoring results from 188 samples taken during the taping of the vertical seams of the columns and surrounding joints.

3.3 PCM RESULTS FROM DISTURBANCE OF UNSEALED COLUMNS.

A number of columns have been subject to disturbance testing by striking the columns before any remedial action has been taken. Data from some 31air samples are summarised in figure 8.

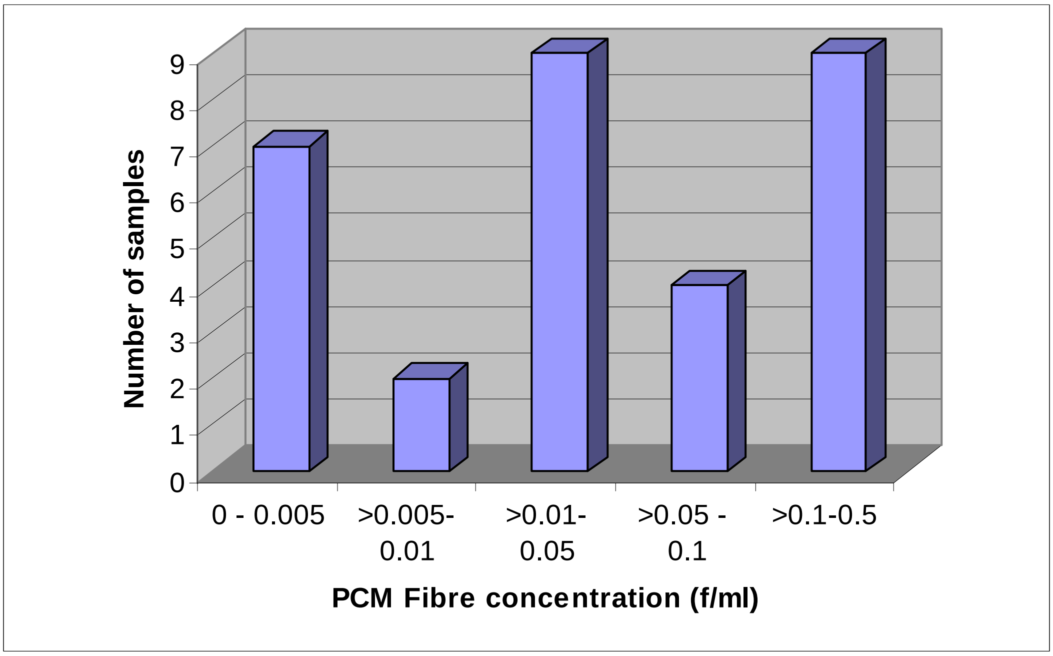

Figure 8: Distribution of PCM fibre concentrations from disturbing hitting the columns.

The columns selected for testing were generally chosen to represent a worst-case situation where there was visible damage to the casing (e.g. from installation of fire alarms) and /or obvious gaps were present. Columns adjacent to improperly or poorly replaced windows and with attached doors were also preferentially chosen to test, as the AIB would have been subject to greater damage. To induce movement and vibration, the columns were either banged directly with a fist a number of times or the attached / adjacent doors and windows were repeatedly slammed. In window sections the sills were also disturbed by sitting on them a number of times and the windows opened and banged shut. Some columns have been tested more than once or had more than one air sample collected.

The PCM results from 20 columns tested in this way in a number of schools before any remediation are summarised in table 1 with the comments on the condition and type of disturbance activity, if made. The results for the asbestos fibre concentration as determined by electron microscopy are also given, when this was carried out. The EM results showed that the majority of the fibres sampled close to source when disturbance activity was taking place, were amosite fibres, which implies that the PCM results for this source related activity may represent only a small overestimate of the amosite fibre concentrations. However, as the tests and sampling was usually conducted inside small enclosures erected around the column or directly adjacent to the column in sealed rooms, the absence of any significant ventilation will give an overestimate of the actual exposures that would have taken place under normal classroom conditions.

Table 1: Summary of close to source monitoring of airborne fibre concentrations by the disturbance testing poor condition columns in schools before remediation.

Code	Condition	Activity	PCM Conc. (f/ml)	Asbestos Conc. (f/ml)
AWP	Visible gaps on column / doorframe	Banging door	0.032	0.010
BWP		Banging door	0.0043	0.020
CWP		Banging door	0.001	0.004
DWP		Banging window	0.012	0.006
A2WP		Clear /Banging	0.032	0.018
EEG	No obvious gaps	Banging column	0.002	
FP	Poor condition, visible gaps window		0.17	
GP	Poor condition, visible gaps door		0.15	
HL	Poor condition		0.033	
IL			0.051	
JF	Condition not reported		0.033,0.036 0.02, 0.015	
KF	Condition not reported		0.003	
LF	Condition not reported		0.003	
MHE	Poor condition		0.069,0.108 0.441	

NG	Gaps	Doorway	0.001	
OG		Corridor	0.058	
PG		Door	0.005	
QH	Gaps	Window	0.058	
RH	Gaps	Door	0.010	
SM	Gaps and damage	Banging column	0.30, 0.30 0.29, 0.22	0.24
SM	Gaps and damage	Personal	0.42	
TM	Good condition	Banging column 43	0.04 0.01	
Mean			0.09	
Median			0.03	

3.4 PCM RESULT FOR INSPECTION AND MAINTENANCE WORK

Figure 9 gives the PCM results from 20 inspections of the site and ceiling area; two samples exceeded 0.01 f/ml showing that there are raised levels of fibres in some. Only two samples for simulated maintenance work above the ceiling are available to date (0.04 and 0.05 f/ml) and showed that there were measurable releases of PCM fibres.

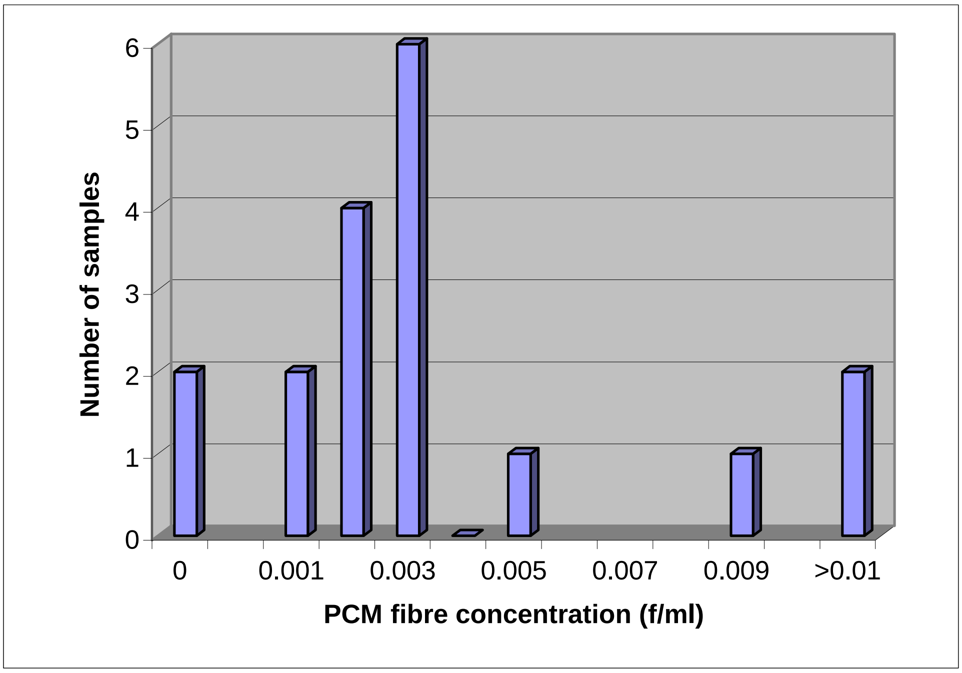

Figure 9: Distribution of PCM fibre concentrations from inspection of the site and ceiling voids.

3.5 SUMMARY OF PCM DATA

Table 2 summarises PCM data from schools for various activities. It should be noted that all data was recalculated based on the number of fibres and fields of view counted and the air volume sampled, assuming a 380 mm^2 exposed filter area and a graticule area of 0.0075 mm^2.

Table 2: Summary of the PCM data for schools.

	Activity Sampled					
Statistic	Normal occupation after remedial work	After remedial work with minimum activity	Disturbance & clearance testing of columns after remediation	During remediation / sealing	During disturbance testing (no remediation)	Inspection of ceiling area
Number of samples	96	44	95	12	31	20
Mean (f/ml)	0.005	0.002	0.005	0.004	0.094	0.004
Median (f/ml)	0.004	0.001	0.003	0.004	0.033	0.002
Largest value (f/ml)	0.022	0.008	0.058	0.006	0.441	0.019
Smallest value (f/ml)	0.001	<0.001	<0.001	0.001	0.001	0

3.6 ELECTRON MICROSCOPY RESULTS

Only a few electron microscopy results were available for this report. These were primarily taken to check whether the releases of the fibres from columns when disturbed were amosite fibres. These have generally confirmed that a high percentage of the fibres released when the columns were struck were amosite. The types of airborne fibres sampled in other situations have not been investigated yet. However, it is unlikely that a high percentage of the fibres sampled after remediation will be amosite and the PCM values overestimate the airborne amosite fibre concentrations.

One set of high volume samples have been taken for TEM analysis in a school where the vertical seams have been taped to cover visible separation of the casing. The samples were taken in a corridor between two sets of doors, which were mounted on the columns and were frequently used causing movement and vibration to the building structure. The combined pooled result from 3 samples found one amosite fibre, with dimensions large enough to be counted by PCM. This gave an analytical sensitivity of 0.0009 f/ml and was below the limit of detection, based on 95% confidence that the airborne concentration was <0.0004 f/ml.

This result is below the average airborne concentration of PCM equivalent asbestos fibres that are commonly found in buildings containing asbestos products and represented a two orders of magnitude reduction in the airborne concentration of asbestos fibres after partial remediation.

4 DISCUSSION

4.1 RELEASE MECHANISM FROM THE CLASP STRUCTURE

There is a significant amount of data that shows that amosite fibres can be released into the classroom air when some of the casings are struck or adjacent windows and doors are banged.

One of the key needs is to establish the main variables determining the magnitude of the airborne release of asbestos fibres into the room.

As with any asbestos containing material (ACM) the amount of airborne fibres released is usually a function of the:

1. Type of ACM;
2. Type of disturbance taking place;
3. Amount of disturbance and force applied;
4. The length of time the disturbance takes place;
5. The surface area or volume of the ACM being disturbed;
6. Any mitigating release factors (e.g. wet, enclosed, encapsulated etc);

The airborne concentration will depend on:

1. The environmental conditions where the release takes place (e.g. inside, outside, ventilation rate and direction etc.) and
2. Distance from the source of the release.

As the columns are enclosed, it is difficult to see or assess many of the above variables. Usually it is only possible to assess the casing for:

1. The presence of gaps and holes,
2. Visual damage and denting,
3. Looseness / amount of movement when pushed;
4. Signs of maintenance work after installation (e.g. fixtures attached to the casing or holes drilled into the casing).
5. Improper installation (e.g. when new windows installed)
6. Visible asbestos debris on the floor beneath.

Therefore the effectiveness of the enclosure is being judged with some assumptions on whether the asbestos insulating board (AIB) or other insulation materials may have been damaged (e.g. by screws and drill holes through the casing). Unless the casing is removed, it is difficult to assess what amount of damage has taken place. If the casing is well sealed and intact with little movement, there is no real mechanism for the generation and direct release of fibres into the room. Often the casing may not extend directly to the roof space or the floor above and may finish above the suspended ceiling, leaving the board applied to the column projecting above the casing. Although this board is unlikely to be directly disturbed, except be infrequent maintenance, the top of the column is unsealed and provides a possible route for airborne fibres to be released into the roof space / ceiling void. In many schools the level of interconnectivity and air change between these spaces is likely to be limited although it is possible that some ceiling voids are used as a return air plenum to ducted warm air heating systems. At present, the direct release into the room through gaps in the casing, appears to be the main release route but further work is needed to assess potential indirect releases via the ceiling void.

4.2 COLUMN CONSTRUCTION AND ASSESSMENT

Although these are detailed on the SCAPE web site, experience from the schools have shown that the type of insulation material (e.g. AIB, asbestos cement, sprayed asbestos, non –asbestos boards) and where it is used in the columns can vary considerably, sometimes in the same buildings. It has been found that AIB may be only attached to only the outside face of the column, two or more face of the column, to the casing itself, or even glued to the casing and then subsequently removed to leave a friable layer attached to patches of glue. Also it has been found that often no insulation materials have been used or sometimes a combination of two or more asbestos products were attached to the column or casing. In some cases there are just casings with no column inside (false columns) which may or may not contain insulation. The degree of variation across CLASP schools is unknown. It appears that the basic building system was supplied; local authority architects and the builders varied the insulation materials and when and where it should be. Although less than perfect information is available the higher release levels and amount of damage appears to be related to where the AIB has been stuck directly onto the casing or in some cases even screwed on, or there is a friable sprayed asbestos coating on the casing. Therefore there is a direct impact and disturbance to a large area of the AIB board/coating when the column is struck. It was also noted that some AIB board had cracked and screw holes has been enlarged when it was attached to the casing and (or with friable coatings) debris had fallen to the base of the column.

When the insulation material is attached to the rectangular cross section of the metal column, the casing is not directly in contact with the AIB, except for a few spacers that are sometimes found. These spacers were often made out of the material to hand and can be AIB, wood or plasterboard, which has been crudely cut up. It also seemed that some columns contained a lot of asbestos debris, possible left inside or even swept up and deposited inside during the initial construction or dislodged from friable coatings due to impacts over the years.

Looking down the gap between the column and the casing from the open tops in the ceiling and roof voids may be the most practical way to assess the construction of the columns / casings with minimal disturbance. It is recommended that an endoscope or small video camera is used to look down into the column to assess what materials have been used and if possible the amount of damage. Often the board material applied top the column extends above the casing but other insulation applied to the casing itself will not be visible without looking down into the column.

Figure 10: Example of a column casing with AIB attached to one side of the casing. The torch beam shows where the AIB has fractured due to a screw being placed into the casing. A hole is visible in the side of the casing and visible debris shows that friable material was present.

Figure 11: View of base of column from which the casing in figure 10 was removed. A large amount of friable AIB debris can be seen.

Figure 12: Example of a gap in the casing.

Figure 13: Example of asbestos debris from pieces of AIB that was glued onto the casing but had been torn off at some time. View down the column from above the suspended ceiling.

Figure 14: Example of casings removed from columns showing where AIB had been removed or left in place.

4.3 RELATIONSHIP BETWEEN COLUMN CONSTRUCTION AND AMOUNT OF DAMAGE TO THE FIBRE CONCENTRATION.

Much of the early investigation carried out was based on searching for the most visibly damaged casings and then to disturb them in a vigorous and reproducible way, while air sampling close to the column. The descriptions of the exact disturbance and the condition of the casing were not always recorded and the inner construction of the columns was unknown, so it is only possible to draw a tentative relationship between visible damage to the casing and the degree of containment it provided (i.e. the presence of gaps along seams, movement when hit, drill holes etc.).

At the present time it appears that the columns giving the highest values have the AIB stuck onto the casing rather than the column. The presence of holes and screws into the casing involves further levels of damage to the AIB attached in this way and any force or movement applied to the casing is directly transmitted to the AIB. Columns where the AIB is attached to the column are much more protected as there is usually a gap between the casing and the AIB with only a few spacers providing a direct mechanical contact. Therefore the AIB is subject to much less damage and disturbance and release lower levels of fibres. Some columns were found to contain considerable AIB debris, this may have been created and left inside the column during the installation and provides another source of asbestos fibres.

Due to the number of variables involved and the limited information to hand, the assessment for and sealing of gaps in the column casing and its surrounds, was judged to be the most effective measure to reduce and prevent direct airborne asbestos fibre emissions into rooms.

As with any asbestos survey, the factors that are most likely to give, rise to the higher levels of fibre release can be evaluated using an algorithm approach. However, the actual level of airborne release will be mitigated by the effectiveness of the seal provided by the casing.

4.4 EFFECTIVENESS OF REMEDIATION

As has been pointed out there are limitations in the PCM data used for this report. Much of the data collated was provided to HSE and this report has attempted to summarise the data in the best way possible to get an overview of the potential exposures that could occur from various activities.

As PCM fibre counts are the basic metric used for the assessment of workplace exposure and risk, this is obviously important data. However, samples collected when the schools are occupied are essentially non-occupational exposures (no one is working with the asbestos materials) and the presence of other fibre types will result in an overestimate of the actual exposure. Also, due to the limited volume of air sampled (around 480 litres) and that a few fibres will always be counted on a blank filter, there is a practical limit to the limit of detection that can be achieved for a single sample. The laboratories that carried out the work had reported many results as <0.01 f/ml, based on clearance sampling procedures where it is only required to establish whether the value is below 0.01 f/ml (usually based on a count of for <20 fibres in 200 fov's).

By recalculating the actual fibre concentration and grouping many samples of the same type together it was possible to calculate a mean of the distribution of values which is probably the best estimate of the PCM fibre exposure in CLASP 4 and 4B schools that can be obtained from the data. However, this mean value and any single count cannot be lower than the blank filter count, which was reported at ~2 fibres by some of the laboratories, which is the equivalent of 0.001 – 0.002 f/ml depending on whether 240 or 480 litres of air was sampled.

The mean PCM fibre concentration of 0.002 f/ml obtained after remediation but before reoccupation when little or no disturbance was taking place shows that levels of all PCM fibres were at or around the lowest level that could be monitored at the sampling volumes collected. Therefore it is more reasonable to view the PCM data using this as the datum. Therefore disturbance sampling for clearance of the classrooms, gave an average increase above background of only x2.5 based on a level of disturbance of the casing that is only rarely likely to be reproduced under normal occupation. The monitoring carried out after remediation and when in normal use showed a similar X2.5 increase but a significant proportion of the fibres were generally reported as appearing to be non-asbestos, although had to be counted as part of the PCM fibre count. An occupied classroom would have a number of potential sources of non-asbestos fibres (e.g. paper & clothing). Therefore while we cannot expect to remain at the unoccupied background during disturbance and reoccupation activity, the relatively modest increase shows that there is no evidence for high fibre emissions from the AIB due to direct impact of the casing or subsequent reoccupation.

With the limitations of the PCM method for measuring down to low airborne concentrations, it is only possible to say that both the mean and median values of the disturbance testing of the columns show that at least an order of magnitude reduction has been achieved by full sealing of the columns. The limited TEM data available at present showed that the taped only columns had at least a two orders of magnitude reduction in the asbestos fibres released and were below the average for asbestos containing buildings (HEI, 1991).

4.5 UPPER ESTIMATE OF POSSIBLE RELEASES

AIB can be quite friable and can be damaged relatively easily giving rise to airborne fibre concentrations of a few f/ml. During poor dry removal where AIB ceiling tiles are broken and dropped to the ground airborne concentrations of over 10 f/ml can be generated. Therefore there is a potential for higher fibre concentrations to be released if the casings are removed. The highest value found to date in schools from damaged casings and AIB when subject to disturbance banging was 0.44 f/ml.

In one non-school test building, where the casing had been removed and left dangling by a single screw so there was little or no sealing of the enclosure, a value of 2.37 f/ml was recorded when disturbance tested. The higher levels of release possible once the casing is detached or removed, underlines the current requirement (see Reg 4 of CAR, 2006) for the management of maintenance work and the routine checking of all ACMs in buildings for damage.

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