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

HEALTH & SAFETY LABORATORY

Airborne asbestos concentrations at Cwmcarn High School, Cwmcarn, Gwent.

AS/2012/14

EXECUTIVE SUMMARY

In recent years HSE has requested that HSL carry out a number of local research projects to add to HSE's existing data on the levels of airborne asbestos fibres in buildings. HSE arranged for asbestos testing at Cwmcarn High School (Chapel Farm, Cwmcarn, Gwent. NP11 7NG), to investigate the potential for airborne transfer of asbestos fibres from ceiling voids to the rooms below. The closure of Cwmcarn High School and the issues raised in the published Santia Asbestos Management report identified the school as suitable premises for this action. In the Santia report (available from the Caerphilly Country Borough Council website), it was suggested that asbestos debris in the ceiling voids was responsible for above average concentrations of airborne asbestos fibres in the classrooms.

Therefore, the main aim of the sampling and analysis in this HSL study was to measure the release and/or transfer of airborne asbestos fibres into the classrooms, which had been identified in the Santia Asbestos Management Ltd. report as giving rise to the greatest concern. Of particular interest were the first floor classrooms which contained fan-assisted warm air heaters in cupboards lined with asbestos insulating board (AIB), containing around 20-25% amosite asbestos. In some rooms where the AIB ceiling tiles had been replaced several years earlier, the ceiling inside the cupboards had been left open. Consequently the heater cupboards were connected directly to the ceiling void where AIB ceiling tile debris was present.

It is important that any estimate of the risk to pupils and teachers should be based on the exposure to airborne asbestos fibres. All of the airborne fibre concentrations being quoted in the Santia report were based on light microscopy counts using the phase contrast microscopy (PCM) method as set out in HSE guidance HSG248 (Annex 1). This method does not identify asbestos fibres; it counts all particles which meet the international definition of a fibre as set out by EU regulations and the World Health Organisation (WHO) method for fibres in air. There are many other sources of "fibres" in the school environment including paper fibres, machine made mineral fibres (MMMF), clothing fibres, skin cells, calcium sulphate fibres from plasterboard and school chalk and other varieties of mineral fibres (e.g. talc, rutile, calcium silicate etc.).

Furthermore PCM counts on new filters of the type used for monitoring, even when taken directly from the box with no air sampled onto them (blank filters) routinely give background counts of a few fibres. Therefore normal practice is not to make decisions on counts below the limit of quantification (LOQ) of the method as defined in HSG 248, without the use of additional analysis by an analytical method, which is capable of identifying whether asbestos fibres are present on the filter. All of the PCM results reported in the Santia report were below the LOQ. There was no supporting discriminatory analysis or field blank analysis.

The "gold standard" method for the identification of asbestos fibres in air is based on analytical transmission electron microscopy (TEM) as defined in ISO 10312:95. This method can be carried out on same types of filter that are used to sample air for the PCM analysis, provided

part of the filter is retained and not mounted between the glass microscope slide and cover slip for PCM analysis. As all of the filters collected by Santia had been mounted in this way it was not therefore possible to carry out TEM analysis on their original samples and resampling was the only way to identify whether the fibre concentration reported were due to asbestos fibres.

This report gives the full results of the air monitoring carried out by HSL to measure the airborne asbestos concentrations from some of the release and exposure scenarios identified in the Santia report. These were:

a) Free flowing air from the ceiling void to the occupied areas;

b) Ceiling tiles being disturbed through gusts of wind and doors being opened and closed.

c) Maintenance type disturbances by changing lights or working in the ceiling void,

d) The fans in the heater cupboards blowing fibres from the AIB debris in the ceiling void into the occupied areas; and

e) Impacts or damage to the AIB panels in the classroom releasing fibres directly to the occupied area.

HSL measurements found that airborne asbestos fibre concentrations in the areas suspected to be most at risk from the AIB debris in the ceiling voids were very low and many times lower than the concentrations assumed from the previous Santia PCM measurements made.

This confirmed what is already recognised by Analysts that counting “fibres” by light microscopy is unlikely to give accurate or reliable results for assessing the environmental asbestos exposure and risk in buildings. This is even more likely to apply (as in this case) when all the quoted results were below the limit of quantification (LOQ).

TEM results showed that the airborne concentrations of asbestos for sources: a) and d) above were at or below the target analytical sensitivity of 0.0001 f/ml and individual samples were unlikely to exceed the limit of quantification ~0.0002 – 0.0005 f/ml. Only one asbestos fibre, countable by light microscopy, was found during the TEM analysis of samples from these sources and gave a pooled average exposure of less than the LOQ (0.00003 f/ml). Provided the asbestos debris is not disturbed, its presence alone in the ceiling void is unlikely to result in classroom exposures above the LOQ.

Releases from wind disturbances (source b) were also monitored. Discussions while on site suggested that only one room (the library) reportedly experienced wind related movements of the ceiling tiles. Only MMMF ceiling tiles could move, as all the AIB ceiling tiles were screwed down to the ceiling with 4 screws in each. This room was sampled with the windows opened in windy conditions. The results showed that asbestos fibre concentrations were below the analytical sensitivity and the LOQ of 0.0005 f/ml. No asbestos fibres of any dimension were found during the analysis. It was felt that the conditions achieved would have created disturbances of the MMMF tiles if they were likely to occur. It was noted that one strip of smaller MMMF tiles had been taped, so the HSL sampling could not replicate the previous conditions. However it was possible to confirm that the normal sized MMMF tiles did not move at all despite external gusts of wind of ~20 mph with all windows open, that it was possible to open safely.

For the final period of sampling five classrooms were sampled, with windows and doors closed and heater fans running, as each AIB wall panel and heater cabinet panel was hit with reasonably strong force four times over a period of ~1 hour. The concentrations of PCME asbestos fibres measured over a ~2 hour sampling period were around the LOQ, with the range of individual values of between <0.0012 – 0.0043 f/ml. Clearly repeated striking of every AIB wall and heater panels with an open hand at least 4 times over ~1 hour was able to release some fibres to air. With doors and window closed but with heater fans running this represented a peak release episode. Although it is not possible to say with any certainty, there was much more flexibility on the heater cupboards panels when hit hard, than the under window panels and it is probable that the heater cupboards were the source of the fibres. As all the heater cupboards had been unscrewed and the front panels removed and inspected in the last month or so, this inspection may have damaged or released fine fibres on the surface of the AIB and added to the numbers of fibres readily available to be made airborne.

Excluding the IT room (where it was not possible to hit the panels so hard) the four classrooms where the disturbance tests were carried out on the AIB panels, gave a pooled average PCME asbestos fibre concentration of 0.0019 f/ml (0.0015 f/ml, including the IT room). For asbestos fibres of all sizes >0.5µm long the pooled concentration was 0.0064 s/ml (0.0052 s/ml including the IT room). All the asbestos fibres found in these samples were amosite asbestos and all but one of the non-PCME countable amosite fibres were short < 5µm long fibres.

Overall, the sampling and analytical TEM analysis carried out by HSL showed that there is no evidence for a quantifiable transfer of asbestos fibres from the ceiling void into the classrooms. The results demonstrated that the average concentrations of asbestos fibres in the occupied areas at Cwmcarn school including from the presence of the AIB debris in the ceiling void, were very low and below the LOQ. The study also showed that, in the wind conditions encountered, there was also no evidence of ceiling tile movement or fibre disturbance. The study did however show that sustained multiple direct impacts on heater cupboard panels could cause some short term fibre release but this may have been linked to particular conditions (i.e. loose surface material caused by the recent removal and inspection of front heater cupboard panels).

CONTENTS PAGE

1. INTRODUCTION

1.1 AIM

In recent years HSE has requested that HSL carry out a number of local research projects to add to HSE's existing data on the levels of airborne asbestos fibres in buildings. The closure of Cwmcarn High School (Chapel Farm, Cwmcarn, Gwent. NP11 7NG), and the issues raised in the now public Santia Asbestos Management report (1) identified the school as suitable premises for this approach. This was discussed when HSE met with the Caerphilly County Borough Council (CCBC) on the 6th November to review the situation.

The main aim of the sampling and analysis in this HSL study was to measure the release and transfer of airborne asbestos fibres into the classrooms. Of particular interest were the first floor classrooms in Block A, which contain fan-assisted warm air heaters in cupboards lined with asbestos insulating board (AIB) containing around 20-25% amosite asbestos. In addition, in some rooms where the AIB ceiling tiles had been replaced several years earlier, the ceiling inside the cupboards had been left open. Consequently the heater cupboards are connected directly to the ceiling void where AIB ceiling tile debris remains. In the Santia report, it was suggested that the presence of this AIB debris in the ceiling void was giving rise to above average exposures to asbestos fibres in the classrooms.

1.2 SOURCES OF ASBESTOS IN CWMCARN BLOCK A CLASSROOMS

According to the information currently available Block A of Cwmcarn High School was constructed in the 1950's, and as was common at the time, significant quantities of ACMs were used in the construction. The majority of the ACMs installed comprised of:

- AIB used in the panels below the windows, and around the heater cabinets on the first floor and AIB ceiling tiles for the suspended ceilings,
- Vinyl floor tiles covering many floors,
- Thermal insulation in the boiler house and related areas.

An updated full management survey of the block was carried out in 2009 by Enquin Environmental (2), which was attached as an appendix to the Santia report and lists other minor types of ACMs present in the building.

Over time, due to refurbishment, changes of use, additions and joining new areas to the block, a number of changes to the original ACMs have taken place. In several areas the AIB ceiling tiles have been removed and replaced with MMMF tiles. There seems to be two main phases of removal and replacement, one about 20 years ago and one more recently (approximately 4 – 8 years ago). The replacement of the AIB was not always complete. For example, the classrooms often have a small adjoining stock room, where the AIB ceiling tiles remained; also on the first floor, built-in ceiling to floor heater cupboards; the AIB was often left in place, or in the case of some of the heater cupboards, removed and not replaced. During the 2009 survey, it was noted that the ceiling areas that had been replaced with ceiling tiles had significant amounts of AIB debris resting on the steel joists a few centimetres above the new MMMF ceiling. This was confirmed by subsequent "mini-management" surveys conducted by Santia (3-7).

Although the ceiling void has not been inspected by HSL, the consensus opinion of the CCBC asbestos team and Santia personnel who have inspected the void space was that the AIB debris is the result of previous removal work, when the original AIB ceiling tiles were replaced with non-asbestos MMMF tiles. The most likely cause of these fragments is the use of improper dry removal, where the tile has been impacted upwards, spreading fragments and particles of AIB over a distance of potentially 1-2 metres. This resulted in visible AIB fragments collecting onto the horizontal bottom part of the “I“ beams and other horizontal surfaces (presumably both above and below the ceiling void). The failure to control the dust and spread of AIB during the removal was compounded by the lack of any attempt to clean the roof void of AIB debris and dust before installing the new suspended ceiling with asbestos free MMMF tiles. It appears that it is this presence of AIB debris in the ceiling void that has given rise to the concern that asbestos fibres had been released into the air of the classrooms below. This concern contributed to a decision to close the school and for the pupils and teachers being given health counselling.

1.3 EXPOSURE SCENARIOS

The presence of ACMs in a building does not give rise to a risk unless the asbestos fibres become airborne and are inhaled. Even then the probability or chance that any ill-health effects will occur is very small but will generally increase with increasing airborne concentration and duration of the exposure, this is termed the cumulative exposure. The concentration is measured in terms of asbestos fibres per millilitre of air and the duration in terms of years, to give units of f/ml.years. Most of what we know about the risk from asbestos exposures is based on workers who have been exposed to cumulative exposures above 1 f/ml.years and often to tens and hundreds of f/ml.years.

The site has a number of potential airborne exposure scenarios but it is only possible to measure the current airborne concentrations where the original AIB ceiling tiles remain intact and the areas where they have been removed and replaced by MMMF tiles.

The Santia report considered that there were five possible exposure scenarios that were likely to result in an increased risk to occupants, these were:

a) Free flowing air from the ceiling void to the occupied areas;
b) Ceiling tiles being disturbed through gusts of wind and doors being opened and closed.
c) Maintenance type disturbances by changing lights or working in the ceiling void,
d) The fans in the heater cupboards blowing fibres from the AIB debris in the ceiling void into the occupied areas; and
e) Impacts or damage to the AIB panels in the classroom releasing fibres directly to the occupied area.

The HSL monitoring has attempted to address some of the five exposure scenarios identified in the report. As Caerphilly County Borough Council had already advised us that they had monitoring data from maintenance access to the ceiling void and that a fully intrusive and destructive sampling survey was about to commence in block A, it was requested that they supply data and filters to HSL, so there was no need to address item c in this report or the level of release when the AIB is damaged (part of item e). However, impact release could be monitored if time allowed.

1.4 PREVIOUS AIR SAMPLING

The Santia report gives results of several air sampling exercises in appendices E and G of their report. The air samples were all analysed by PCM which counts all visible objects (fibres) >5 µm long, < 3 µm wide and with an aspect ratio >3:1. It does not discriminate whether they are asbestos or non-asbestos just that they meet the size criteria.

The first Santia air sampling was carried out on the 22/09/12. The report does not describe what the prevailing conditions were during the test other than the area was unoccupied. It was not recorded whether the heaters were turned on or not during this sampling.

As recorded in the PCM results in appendix E (6) of the Santia report, sixteen samples were collected and gave an average of 0.002 f/ml (range 0.001 – 0.007 f/ml). Ten samples were taken on the first floor where the heater fans were present and these samples (B-K), gave a combined fibre count of 42.5 fibres, an average of 4.25 fibres per filter counted. On the ground floor six samples were taken (A, L – P) where no fan cupboards are present, gave a total count of 23.5 PCM fibres, an average of 3.9 fibres per filter.

It should be noted that counts on unused blank filters of up to 5 fibres are expected and the precision of such low counts of fibres are poor with a Poisson 95% confidence interval of between 1 –11 fibres for a count of 4 fibres. This is best explained by considering if the same filter was counted again it would be expected to get a value of between 1 and 11 fibres, for 19 out of 20 recounts. All the results were below the limit of quantification (LOQ) for the method as set out in HSG 248 (8).

A second period of air sampling by Santia took place on the 3 & 4/10/12, once it had been decided that certain areas were contaminated with asbestos and the classrooms and stairwells were undergoing cleaning by the CCBC asbestos team. The result in appendix G (7) gave an average concentration for static samples in the centre of the classrooms and the stairwell of 0.005 f/ml (range 0.003 – 0.008 f/ml). These results have been quoted in the media and other reports (11-15) but were still below the LOQ. The results however are higher than the samples taken on 22/9/12, when no activity was taking place. However, if people were engaged in cleaning the area and shifting furniture etc., some increase in the PCM fibre concentration would be expected. The average was about twice that calculated previously for no activity.

On the 5/10/12 Santia collected three short-term (20 minutes) personal samples on the operatives carrying out the cleaning. These were low volume samples, which meant the LOQ was 0.12 f/ml and all results were again below the LOQ, with an average of 0.05 f/ml (range 0.03 – 0.07 f/ml). Personal samples are normally substantially higher than static samples, as the greatest particulate concentration is present in the direct vicinity of the person doing the dust raising activity. Also the distance from the dust source and hence dilution to the sampler is minimised.

1.5 HSE GUIDANCE ON PCM MONITORING AND THE LIMIT OF QUANTIFICATION

The method used by Santia followed HSE guidance in HSG 248 (8) which is designed for worker protection and for clearing an area for re-occupation after an asbestos removal. The method for assessing the 4-hour regulatory control limit for worker protection is laid down in some detail but considerable flexibility is allowed for other sampling as set out in paragraph 5.9 of HSG 248: "*When airborne sampling results are needed very quickly (e.g. in enclosure checking and clearance certification), the method can be adapted to allow wider variations in flow rate, increased numbers of graticule areas to be counted and to allow discrimination between fibre types using other microscopy techniques*".

The analytical sensitivity and the limit of quantification is set based on the background count as described in paragraph 5.11 "*The analytical sensitivity based on one half fibre counted in 200 graticules for a sample volume of air equivalent to at least 480 litres passed through a filter with an effective diameter greater than 20 mm is between 0.0002-0.0003 f/ml. However,* *due to background count levels on filters the limit of detection is about 0.003 f/ml and the limit of quantification of the method is set at 0.010 f/ml equivalent to a count of 40 fibre ends (20 fibres) in 200 graticules (see A1.7-A1.8). If fewer than 20 fibres are counted, the calculated result will have an increased imprecision and it is normal to calculate and report the results as less than the limit of quantification (i.e. 20 fibres). In some circumstances it may be useful to calculate the actual result even if <20 fibres (40 fibre ends) are counted but any interpretation will have to take into account the level of precision of the counts on the actual filters and the associated blanks. The accuracy and precision of fibre counting are discussed further in paragraphs A1.42–A1.45 in Appendix 1.*"

Also, the PCM method does not identify whether asbestos fibres are present, it merely counts all particles, which meet the international definition of a fibre as set out by EU regulations (9) and the World Health Organisation (WHO) method for fibres in air (10). It is well known that there are many other sources of "fibres" in the school environment including paper fibres, machine made mineral fibres (MMMF), clothing fibres, skin cells, calcium sulphate fibres from plasterboard and school chalk and other varieties of mineral fibres (e.g. talc, rutile, calcium silicate etc.).

Santia did not carry out any counting of the site blanks and did not allow for the limitations of the PCM method. This led to the following assumptions and conclusions:

- That the fibre concentrations are above the limit of quantification (LOQ);
- That the results are precise;
- The results show that the fibre concentrations in air were significantly raised above both blank filters and static background counts obtained for PCM fibres in other buildings;
- All the PCM fibres counted, are asbestos fibres;
- The results show that the asbestos fibre concentrations in air were significantly raised above the average background.

However, unless the fibres counted by the PCM are identified as asbestos by analytical electron microscopy it is not possible to confirm that the fibres measured were asbestos fibres.

1.6 POSSIBLE OVER-INTERPRETATION OF THE PCM RESULTS

Based solely on the PCM measurements, public statements have been made on the quantitative risk to the pupils and teachers at the school (11, 12) and health guidance and counselling has been given (13-15). Estimates of the risk from asbestos exposure are usually calculated for several years of cumulative exposure to airborne asbestos fibres. Also, only limited extrapolations from the occupational epidemiology for asbestos workers are considered to be reliable (16). This means that any risk estimates based on short term environmental PCM fibre counts are likely to overestimate the exposure and risk, as there is no reliable information on whether the fibres were, or were not, asbestos.

2. SAMPLING AND ANALYSIS

2.1 INITIAL HSL SAMPLING STRATEGY

When possible, sampling should be carried out during normal occupation as this encompasses the range of activities and disturbances taking place. For example, the samples collected to determine the quoted (17) background concentration of asbestos in buildings containing ACMs were, as far as possible, collected during normal occupation. This included sampling of maintenance activities, if they happened to have been taking place on the day the site was visited. Also the sampling was biased (as in this case) in that the sites chosen for sampling were often considered to be examples of buildings that were of concern or in poor condition and the samplers were positioned in areas of the site where the AIB was considered to be in poor condition and/or movement or disturbance may occur.

As the whole school site had been closed and vacated on the 12/10/12, it was not possible to sample under conditions of normal occupation. Also as some areas had been "environmentally cleaned" it was not possible to reliably simulate what the actual airborne asbestos exposures in the building were to occupants in early September 2012. However, we could to some extent replicate the Santia sampling of the 22/10/12, which was also carried out in an empty building and where the roof void and heating cupboards had not been disturbed since.

Shortly after the meeting between HSE and CCBC and Santia on the 6/11/12, HSL forwarded a draft sampling strategy to CCBC, to measure the asbestos concentration in air from the:

- Free flowing air from the ceiling void to the occupied areas;
- Ceiling tiles being disturbed through gusts of wind and doors being opened and closed.
- The fans of the heater cupboards blowing fibres from the AIB debris in the ceiling void into the occupied areas.

The presence or absence of occupants, removal of desks and chairs and some surface cleaning would make little or no difference to the results from these three exposure scenarios. Indeed there was the possibility that if the heater fans had not been run for some months and some cabinets had been unscrewed and disturbed for inspection and bulk sampling, that a release and accumulation of dust will have built up, which could give rise to a peak emission on starting the fans.

It was also proposed that samplers would be run at two flow rates and for longer than the previous PCM monitoring carried out by Santia. The higher flow rate sampler would aim to sample around 3000 litres of air instead of 500 to improve the analytical sensitivity. The lower flow rate samples would be available for use if the higher flow rate samples were found to be too dense with particles for analysis.

Due to the time constraints for sampling the draft strategy was adapted to fit into the window of time available from Monday evening 26/11/12 – Wednesday 28/11/12 when access was provided.

2.2 ANALYTICAL STRATEGY

The analytical strategy was that HSL would analyse half or quarter filters by analytical transmission electron microscopy (TEM), with Santia mounting the other half of the filter and analysing it by PCM, as previously. Analytical TEM is the "gold standard" method for the identification of asbestos fibres in air and the method is set out in ISO 10312:95 (18). This method can be carried out on same types of filter that are used to sample air for the PCM analysis, provided part of the filter is retained and not mounted between the glass microscope slide and cover slip for PCM analysis. Unfortunately, all the filters collected previously by Santia had been mounted in this way and therefore the only option was to resample.

The target was that sufficient area of the filter would be analysed to achieve an analytical sensitivity of $\leq$0.0001 f/ml for asbestos fibres, if reasonably practicable. ISO 10312:95 allows several sizes of fibres to be evaluated and in this case the primary aim was to count and identify any asbestos fibres that would be countable by PCM. These are known as PCM equivalent fibres (PCME). Thinner and shorter asbestos fibres would also be noted and recorded as seen but the focus of the analysis was to gather data on the exposure to regulatory defined asbestos fibres that are used for the estimation of occupational exposure and risk.

2.3 SAMPLING STRATEGY CARRIED OUT

Sampling took place on the 26 – 28th November 2012. HSL commenced sampling shortly before 4 pm that afternoon and overnight to midday of the 28/11/12. This amounted to over 230 hours of air sampling in the areas that were previously identified as the most polluted in the Santia report. A member of the CCBC asbestos team was at the site, as well as sampling personnel from Santia, during this period.

The original 3 day sampling strategy was adapted and it was decided to sample the first floor rooms where the AIB ceiling tiles had been replaced, and had been reported to have heater cupboards without ceiling tiles connecting directly to the ceiling void (rooms 179, 201, 203 and 175). As a control one classroom (IT room 184) with heater cupboards and AIB ceiling tiles still in place over the whole room was also sampled, as follows, in periods A –E below. The previous Enquin survey had identified some of these rooms as high risk due the presence of asbestos debris in the ceiling voids and or the heater cupboards (rooms 175, 179, 185 201).

A. 26/11/12 Overnight sampling to assess the movement of asbestos fibres from the ceiling void to the classroom with no fan heater units running.

B. 27/11/12 AM Four hour sampling with no fans running during the morning with some movement of people in the areas and opening and shutting doors

C. 27/11/12 PM Four hour sampling with the fans started a few minutes into the sampling period with the doors (and windows) closed but repeated entries to rooms were made about every hour to check flow rates.

D. 27-28/11/12 Overnight sampling with fans running and doors closed and no movement.

E. 28/11/12 AM Two-hour disturbance sampling with the fans running and doors closed.

Additional samples were taken for other reasons in specific areas as detailed in F - H:

F. 27/11/12 all day: Outside ambient sampling.

G. 27/11/12 pm: Wind disturbance of MMMF ceiling tiles.

H. 27-28/11/12: Classroom 047 on ground floor with AIB tiles and no heater cupboards (conventional hot-water radiators are used downstairs).

Due to the limited time available on the 26/11/12 – the site personnel had to secure and leave the site shortly after 4 pm it was not possible to set up and start all the pumps. However, sufficient samples were started to allow larger volumes of air to be sampled and for a progression from periods A – E to be followed over three rooms. Site security issues meant that all windows had to be closed at night, so it was only possible to take a sample of outside air during the day on the 27/11/12.

From further discussion while at the site, it appears that it was only in the library, that it had been reported, that the ceiling tiles moved on windy days. This made some sense, as every AIB ceiling tile was held in place by 4 screws and did not have the slightest possibility of moving. Also many of the MMMF ceiling tiles were of considerable size (and presumably weight) and did not look as if they could move due to wind pressure. The library was formed from two rooms that had been knocked into one and the ceiling was some two thirds AIB tiles and one-third MMMF. Where the ceilings joined it there was a thin strip of cut MMMF tiles about 15 cm in width, and apparently it was this small joining strip of tiles that had been reported to move. However, these tiles had been heavily taped (in the last few weeks) and conditions must have changed.

As there were Northerly winds gusting up to around 20 mph during the afternoon of the 27/11/12, eleven windows were opened (all that were able to do so safely) to attempt to induce the tiles to move. Even though the window blinds were made to billow and flap, and hanging notices to flatten themselves occasionally against the ceiling, it was not observed that any ceiling tiles moved. Given the library was on the first floor of the exposed NW corner of the building windows on two walls, it is unlikely any other room could match the air disturbance created. The other corner room at the exposed end of the building was the IT room, which had the original AIB ceiling tiles firmly screwed in place.

3. METHODOLOGY

3.1 SAMPLING

HSL sampling was carried out in accordance with HSG 248. Air was sampled through Millipore 0.8 µm pore size membrane filters pre-loaded in conductive plastic asbestos cowls. These are a trusted source of filter with no history of cross-contamination from previous batches. The main issue was pulling sufficient air through the filters and several types of pumps were employed to do this. As batteries have limited power output the pumps were checked regularly although most of the pumps used also had the option to run directly from mains power and as this was available it allowed longer sampling periods to be used. Flow rates of between 2 and 12 l/ minute were set and checked with a TSI flow calibrator, which has a precision down to 1 ml/minute. Sampling times were recorded to the nearest minute.

The filter cassettes were re-capped in the approved way after sampling and stored for transport back to HSL with the sampling information recorded on the cassette labels and in the sampling log.

3.2 ANALYSIS

The cassette top and stand were removed and the cowl unscrewed to allow the filter to be taken out for preparation. A quarter of each filter was then cut and mounted on a glass microscope slide using the in-house method and in accordance with ISO 10312:95. The filter is essentially collapsed, etched and carbon coated before cutting out 3 x 3 mm square for mounting onto a 200-mesh Copper electron microscopy (EM) finder grid. The remaining filter material was then dissolved in Dimethylformamide washer for several hours to leave the particles held in a thin carbon film supported on the EM grid mesh (with 95 x 95 µm grid openings) for analysis in the TEM.

The EM Grids were scanned at ~x5000 magnification using the image from a 16 mb CMOS Deben camera system fitted to an FEI Tecnai Spirit analytical transmission electron microscope. Any fibres seen, as defined in ISO 10312 (with largely parallel or stepped sides) were counted, sized and identified using electron diffraction and energy dispersive X-ray analysis using ISO 10312 and the relevant HSL's in-house methods. The primary purpose of the analysis was to measure asbestos fibres of the same size that would be counted in the light microscopy PCM analysis. These "PCM equivalent" (PCME) fibres were defined as: fibres >5 µm long and between 0.2 -3 µm width with an aspect ratio >3:1 and reported in terms of f/ml, the same as the PCM fibre counts. This analysis was done under HSL's UKAS accreditation.

Shorter (<5 µm long) or thinner (<0.2 µm width) asbestos fibres were also counted, if identified as asbestos. A minimum fibre length of 0.5 µm is counted by ISO 10312. These fibres were reported in terms of structures /millilitre (s/ml) of >0.5 µm length to separate them from PCM and PCME fibre concentrations, which were reported in terms of f/ml.

The analytical sensitivity is defined as a count of 1 identified asbestos fibre. The number of grid openings counted for each sample was adjusted, when practicable, so that a target analytical sensitivity of 0.0001 f/ml was achieved, based on a count of 1 fibre in 10,000 ml of air analysed. The amount of air analysed was calculated based on the fraction of the exposed filter area analysed x total volume of air sampled. The limit of quantification (LOQ) for the TEM analysis, is defined in ISO 10312:95 and as x2.99 the analytical sensitivity for 0 counts, and for 1 and 2 counts, x4.74 and x6.3 the analytical sensitivity, respectively.

4. RESULTS

4.1 SAMPLING

A summary of the sampling carried out by HSL is given in table 1. Some 248 hours of filter sampling took place, to sample over 72 cubic metres of air onto 28 samples at rates of between 2 – 12 l/minute for periods of up to 20.5 hours.

Table 1: Summary of the sampling carried out at Cwmcarn High School by HSL.

Sample Number	HSE Number	Sample Period	Room Number	Date Started	Start Pump	Flow (l/min.)	Stop Pump	Flow (l/min.)	Time (Hours)	Time (Min)
1	1208158	A	179	26-Nov	15:52	6.54	08:52	6.58	17	1020
2*	1208159	A	184	26-Nov	15:58	7.99	12:30	7.67	8	480
3	1208160	A	184	26-Nov	16:06	1.99	12:36	1.92	20.5	1230
4	1208161	A	203	26-Nov	16:09	2.09	13:12	2.31	21.05	1263
5	1208162	B	179	27-Nov	08:56	11.97	12:56	11.89	4	240
6	1208163	B	201	27-Nov	09:07	7.21	12:18	6.71	4.18	251
7	1208164	B	203	27-Nov	09:23	8.34	13:10	7.8	3.78	227
8	1208165	F	0utside	27-Nov	10:19	2.53	17:38	2.48	7.32	439
9	1208166		Blank	27-Nov	-	-	-	0	0	0
10	1208167	C	184	27-Nov	13:22	9.8	17:24	9.75	4.03	242
11	1208168	C/D	184	27-Nov	13:22	1.995	08:03	1.928	18.32	1099
12	1208169	C	179	27-Nov	13:23	13:12	17:33	11.68	4.17	250
13	1208170	C	201	27-Nov	13:24	7.4	17:04	6.95	3.67	220
14	1208171	C/D	203	27-Nov	13:29	2.1	08:53	2.1	17.4	1044
15A	1208172	C	203	27-Nov	13:29	8.01	17:47	7.9	4.3	258
15B	1208173	C	175	27-Nov	13:34	5.01	17:55	4.89	4.35	261
16	1208174	H	47	27-Nov	13:44	2.01	09:22	2.04	19.63	1178
17	1208175	G	Library	27-Nov	13:49	7.71	17:31	7.38	3.7	222
18	1208176	D	179	27-Nov	18:12	11.83	08:01	11.66	13.82	829
19	1208177	D	201	27-Nov	18:02	4.26	08:44	3.2	14.7	882
20	1208178	D	175	27-Nov	18:06	2.52	08:11	2.41	14.08	845
21	1208179	D	184	27-Nov	17:43	7	08:21	6.95	14.63	878
22	1208180	D	203	27-Nov	17:50	4.8	08:50	4.29	15	900
23	1208181	E	175	28-Nov	08:13	7.9	10:23	7.36	2.17	130
24	1208182	E	184	28-Nov	08:34	10.03	10:34	10.13	2.00	120
25	1208183	E	179	28-Nov	08:40	11.61	10:40	11.5	2.00	120
26	1208184	E	201	28-Nov	09:04	6	11:20	5.7	2.27	136
27	1208185	E	203	28-Nov	09:13	7.6	11:21	7.3	2.13	128
*Note: Sample 2 was mistakenly set to a 4 hour timed period and restarted at 08:30 to sample 8 hours										

The samplers were usually placed within 1-2 m of the heater cupboard bottom grill and 1-2 m above the floor. A plan of the sampling positions is given in Annex 1. A few samples were collected in the centre of the room. The library, IT room and room 047 on the ground floor, still had AIB ceiling tiles present. All the other rooms sampled had non-asbestos MMMF ceiling tiles but some rooms still had adjoining stock rooms in which AIB tiles remained (e.g. room 179).

4.2 TEM CONCENTRATIONS OF AIRBORNE ASBESTOS FIBRES

The target was to achieve an analytical sensitivity of 0.0001 f/ml, which would give an LOQ for individual samples of <0.0003 f/ml. However, it would not be possible to do this on the lower flow rate samplers without substantial counting times on the TEM. The results of the analysis are given in table 2. All the asbestos fibres identified were amosite fibres. As several classrooms with similar releases mechanisms were sampled the results from the individual samples have been pooled by combining samples from the same sampling period/scenario to give a better estimate of the fibre exposures to occupants. The pooled average for the sampling period was calculated from the sum of the fibre counts on each sample / sum of the equivalent volumes of air analysed for each sample. The results for PCME asbestos fibres and all asbestos fibres are given in tables 3 & 4.

4.2.1 Periods C & D: heater fans running

Due to the low concentration of asbestos fibres found in the first two samples analysed, the sample analysis was prioritised to look at the samples taken during the start-up (Period C) and steady state running (Period D) of the heater fans. The first four-hour period (C) of sampling with the heaters started and running at the beginning the period, were expected to give the highest concentrations. This was because fine dust may have been deposited inside the heater cupboards from the ceiling voids, since the last time they were run, either on the 22/10/12, or possibly in early spring, and this deposited dust would be potentially disturbed when the fans were switched on. Period (D) was likely to be representative of the airborne concentrations in the normal running of the heating in the building during the winter, when the heater cupboards were switched on daily without weeks of accumulated dust deposits.

One PCME asbestos fibre was found in the analysis of samples taken in these two periods (C & D), showing that all individual samples were below LOQ and all but one was below the analytical sensitivity. When no asbestos was found in the analysis this meant that there was 95% confidence that the airborne concentrations were <0.0003 f/ml, if the target analytical sensitivity of 0.0001 f/ml was achieved. If we look at the classrooms with fan heaters in block A as a whole, and pool the total volume of air examined during the TEM analysis, it can be calculated that asbestos concentrations during the 4 hour period with the fan start-up, were less than the calculated pooled LOQs of 0.00006 f/ml and during normal running overnight were less than 0.00004 f/ml. One PCME asbestos fibre was found in sample 14, which ran continuously over both periods. This gave a calculated pooled LOQ for all samples during the running of the fan heaters (periods C & D) was 0.00003 f/ml. It is unlikely that the asbestos debris in the ceiling voids will result in average classroom exposures to asbestos fibres above the LOQ, from normal running of the heaters.

One short (<5 µm long) amosite fibre (termed as a structure) was also found in sample 12, which would not have been countable by PCM. This gave an analytical sensitivity of 0.00008 s/ml with an LOQ for all asbestos structures below 0.0004 s/ml. The pooled result for period C and periods C & D combined were below the LOQs of, 0.00009 and 0.00005 s/ml, respectively.

Clearly, the transfer of airborne asbestos fibres from the ceiling voids during the periods of sampling, were very low. In terms of PCME asbestos fibres, which are used for the assessment of risk, concentrations were below the pooled LOQ (0.00003 f/ml) and also well below the average fibre levels quoted in the Santia report. It is therefore unlikely that the asbestos debris in the ceiling void will be a significant source for asbestos exposure of staff and pupils at Cwmcarn High School, provided that the requirements in the duty to manage are followed.

Table 2: Summary of the TEM results for asbestos fibres in air at Cwmcarn High School.

Sample Number	HSE Number	Room Number	Sample Period	Sample Length (min.)	Sampled Volume (l)	Number of TEM grid openings analysed	Analytical Sensitivity. (f/ml)	Number of >5µm long fibres	Number of PCME fibres	Number of >0.5µm long structures	Conc. of >5µm long fibres (f/ml)	Conc. of PCME fibres (f/ml)	Conc. of >0.5µm long structures. (s/ml)
1	1208158	179	A	1020	6691.2	98	0.000065	0	0	0	<0.00019	<0.00019	<0.00019
2	1208159	184	A	480	3758.4	Sample not analysed as periods C & D were below the LOQ and at or below the analytical sensitivity							
3	1208160	184	A	1230	2404.7	“ “							
4	1208161	203	A	1263	2778.6	“ “							
5	1208162	179	B	240	2863.2	“ “							
6	1208163	201	B	251	1746.8	“ “							
7	1208164	203	B	227	1831.7	“ “							
8	1208165	0utside	F	439	1099.7	“ “							
9	1208166	Blank		0	0.0	“ “							
10	1208167	184	C	242	2365.5	187	0.000096	0	0	0	<0.00029	<0.00029	<0.00029
11	1208168	184	C/D	1099	2155.7	Sample not analysed as other samples from the same room have been analysed which were <LOQ.							
12	1208169	179	C	250	2903.8	192	0.000076	0	0	1	<0.00023	<0.00023	<0.00040
13	1208170	201	C	220	1578.2	281	0.000096	0	0	0	<0.00029	<0.00029	<0.00029
14	1208171	203	C/D	1044	2192.4	208	0.000093	1	1	1	<0.00045	<0.00045	<0.00045
15A	1208172	203	C	258	2052.4	135	0.000154	0	0	0	<0.00030	<0.00030	<0.00030
15B	1208173	175	C	261	1292.0	340	0.000097	0	0	0	<0.00029	<0.00029	<0.00029
16	1208174	47	H	1178	2385.4	190	0.000094	0	0	0	<0.00028	<0.00028	<0.00028
17	1208175	Library	G	222	1675.0	166	0.000153	0	0	0	<0.00046	<0.00046	<0.00046
18	1208176	179	D	829	9736.6	179	0.000024	0	0	0	<0.00007	<0.00007	<0.00007
19	1208177	201	D	882	3289.9	150	0.000086	0	0	0	<0.00026	<0.00026	<0.00026
20	1208178	175	D	845	2082.9	205	0.000100	0	0	0	<0.00030	<0.00030	<0.00030
21	1208179	184	D	878	6124.0	80	0.000087	0	0	0	<0.00026	<0.00026	<0.00026
22	1208180	203	D	900	4090.5	115	0.000090	0	0	0	<0.00027	<0.00027	<0.00027
23	1208181	175	E	130	991.9	105	0.000408	3	3	13	<0.0032	<0.0032	0.0053
24	1208182	184	E	120	1209.6	90	0.000391	0	0	0	<0.0012	<0.0012	<0.0012
25	1208183	179	E	120	1386.6	85	0.00036	3	3	14	<0.0028	<0.0028	0.0051
26	1208184	201	E	136	795.6	125	0.000428	11	10	27	0.0047	0.0043	0.0120
27	1208185	203	E	128	953.6	106	0.000421	4	4	12	0.0017	0.0017	0.0051

Table 3: Calculated pooled average fibre concentrations for PCME asbestos fibres.

Exposure Scenario	HSL Sampling period	HSL Samples pooled	Pooled volume analysed (ml)	Number of asbestos fibres	Analytical Sensitivity (f/ml)	PCM asbestos Conc. (f/ml)
a	A	1	224601.4	0	0.000065	<0.000194
a	B	Samples not analysed as periods C & D were below the LOQ				
d	C	5	54240.3	0	0.000018	<0.000055
d	D	5	85179.57	0	0.000012	<0.000035
d	C+D	11	150139.3	1	0.000007	<0.000032
a+d	C+D+A	12	165553.4	1	0.00006	<0.000029
e	E	4	10258.34	20	0.00010	0.001950
e	E + IT room	5	12817.56	20	0.00008	0.00156
outside	F	Sample not analysed as periods C & D were below the LOQ				
b	G	1	1675	0	0.000153	<0.00046

Table 4:Calculated pooled average fibre concentrations for all >0.5μm long asbestos fibres

Exposure Scenario	HSL Sampling period	HSL Samples pooled	Pooled volume analysed (ml)	Number of asbestos fibres	Analytical Sensitivity (s/ml)	All >0.5μm asbestos Conc. (s/ml)
a	A	1	224601.4	0	0.000065	0.000194
a	B	Samples not analysed as periods C & D were below the LOQ				
d	C	5	54240.3	1	0.000018	<0.000089
d	D	5	85179.57	0	0.000012	<0.000035
d	C+D	11	150139.3	2	0.000007	<0.000046
a+d	C+D+A	12	165553.4	2	0.000006	<0.000040
e	E	4	10258.34	66	0.0001	0.0064
e	E + IT room	5	12817.56	66	0.00008	0.0052
outside	F	Sample not analysed as periods C & D were below the LOQ				
b	G	1	1675	0	0.000153	<0.00046

4.2.2 Periods A & B: no heater fans running

The potential transfer of asbestos from the ceiling voids to the first floor classroom when the heaters were not in use was measured by the sampling in periods A and B. Period B had more in-room movement and doors were opened and shut several times during the 4 hour sampling period. No windows were open during any of this sampling. Due to the very low concentrations found with the fans running, it was decided not to carry out analysis of further samples in periods A & B.

The reason for this was that the mechanisms for the transfer of fibres without the fans running would still be present with the heater fans running so we had effectively covered both the ambient situation already in periods C and D. Also there was no possibility of finding any statistical difference between the two scenarios with counts at or below the analytical sensitivity for asbestos PCME fibres for periods C & D.

The one sample counted early on in the analysis had no asbestos fibres detected and concentrations were below the analytical sensitivity of 0.000065 f/ml and the LOQ of 0.0002 f/ml, showing that asbestos fibre concentrations were very low.

4.2.3 Period F: Outside air and field blank

Given the results for periods C & D it was decided that there would be no additional benefit from analysing the blank sample or the outside air sample, that was collected for the same reasons as for periods A & B.

4.2.4 Period G: Wind disturbance of MMMF ceiling tiles.

As described earlier, the AIB tiles were all screwed firmly to the ceiling and could not move and most of the MMMF tiles were too large and probably too heavy to move from wind pressure and draughts. It was only in one room, the library, where there was a narrow strip MMMF tiles that the reports of ceiling tile movement appeared to have originated.

This room was sampled with the windows opened in windy conditions and the results showed that asbestos fibre concentrations were below the analytical sensitivity achieved (0.00015 f/ml) and below a LOQ of 0.0005 f/ml. No asbestos fibres of any dimension were found during the analysis. It was felt that the conditions achieved would have created disturbances of the MMMF tiles if they were likely to occur. However, it was recognised that the CCBC asbestos team had taped up the thin strip of tiles in recent weeks, so HSL could not replicate the previous conditions. However it was possible to confirm that the normal MMMF tiles did not move at all despite the gust of ~20 mph Northerly winds, with all windows that it was possible to open, opened. Therefore, it is likely that in terms of inducing movement of the ceiling tiles, this was a worst-case situation, which was in far in excess of what would be acceptable in a library.

Even, if the small cut MMMF tiles had moved previously, it is likely there was a good deal of dilution taking place, so any fibres coming from the ceiling void would have been carried out of the windows in a relatively short time. The dilution level in the room would have been substantial and it is hard to see how any dust or debris left in the ceiling void could give a measurable concentration at the present time.

Without further inspection it is not possible to say whether the MMMF tiles are butting directly against the AIB tiles or the suspended ceiling hanger frame is in-between. It is possible, if the MMMF tiles had simply been wedged directly against the edge of the AIB tile that some abrasion between the two tiles may occur, if the small MMMF cut tiles are moving. This may have a potential to give a fibre release but it is more likely the MMMF tile after moving once would have sat on top of the AIB tile rather than dropping back down, if there was a close fit. Again this must be stressed this is a possible source of asbestos fibre from the ceiling void, which may or may not be present, and fibre release would only have taken place when high dilutions of air inside the room were present. The monitoring of the current situation did not show that any measurable exposure was occurring.

4.2.5 Period H: Classroom 047 on ground floor with AIB tiles and no heater cupboards

Some downstairs classrooms had been sampled in the Santia report and as limited pumps were available it was only possible to re-sample one of the four classrooms sampled previously. These still had carpets intact and had smaller MMMF ceiling tiles with the lights recessed and hence flush with the ceiling tiles. Conventional hot water radiators around the walls heated the rooms. No asbestos fibres of any dimensions were found in the analysis and the result showed that the concentration of asbestos fibres in air were below the analytical sensitivity 0.0001f/ml and the LOQ0.0003f/ml.

4.2.6 Period E: Peak disturbance testing of classrooms with the fans running

Period E was carried out to represent a peak disturbance activity where the AIB material present around the heater cupboards and on the walls were repeatedly impacted but without penetrating or breaking through the encapsulated coating. A 2-hour sampling period was used with repeated major disturbance taking place at the start and after about one hour. The high flow rate pumps were used to sample over a shorter 2-hour period to avoid the batteries running out.

Amosite fibres were detected in 4 of the 5 rooms tested. The IT room was the non-detected room. This was the room where it was difficult to reach the under-window AIB panels and where the heater cupboard that could be turned on had a different construction.

The concentrations were around the LOQ with a range of individual values of between <0.0012 – 0.0043 f/ml. Clearly repeated striking of every AIB wall and heater panels with an open hand at least 4 times over ~1 hour was able to release some fibres to air. With doors and window closed but with heater fans running, this represented a peak release episode.

When striking the heater cupboard panels, there was much more flexing and movement of the front panels, compared to the under window panels. Although it is not possible to say with certainty, it is probable that the heater cupboards were the main source of the airborne fibres from the repeated impacts. Also, as all the cupboards had been unscrewed and the front panels removed and inspected in the last month or so, this inspection may have damaged or released fine fibres on the surface of the AIB and this may have added to the numbers of fibres made airborne.

The number and intensity of the impacts applied to the AIB panels was representative of a maintenance type activity (e.g. where the heaters were being serviced and the cupboard panels were being pushed back into place etc). However, each heater cabinet was hit some 24 times in ~1 hour with the fans running, this simulation must be viewed as representing a high level of disturbance.

All the asbestos fibres found in these samples were amosite asbestos. Excluding the IT room the four classrooms where the disturbance tests were carried out on the AIB panels, gave an average PCME asbestos fibre concentration of 0.0019 f/ml (0.0015 f/ml including the IT room) with a range for individual samples from <0.0012 – 0.0043 f/ml.

For asbestos fibres of all sizes >0.5 µm long the pooled concentration was 0.0064 s/ml (0.0052 s/ml including the IT room) with a range of individual samples from <0.0012 – 0.012 s/ml.

Although these short asbestos fibres indicate that a peak release took place, they are not used for estimating risk.

Is it important to note that the intensity of the disturbance activities simulated are unlikely to occur during normal occupation. They represented a short-term exaggerated/aggravated peak disturbance release that would start to be dispersed once the activity ceased. The results accord with the general observation, that for most ACMs that the greater the energy or disruption imparted - the greater the number of fibres that are likely to be displaced and released to air.

4.3 OTHER INFORMATION AND SITE FACTORS

4.3.1 Measurements adjacent to a fallen MMMF ceiling tile and open ceiling void

On the previous day before HSL sampled, an MMMF tile had fallen from the ceiling in the corridor outside room 203, leaving a gap in the ceiling. The tile had fallen due to a roof leak and was left in place and the area unsealed throughout the sampling as it represented the building as found. Room 203 door was left open during periods C& D and the only PCME asbestos fibre found in a sample was from the pump placed close to the open doorway with the fallen tile about 1.5 m away. There was a ceiling tile missing in the corridor immediately outside the entrance to room 203. This meant there was more opportunity for fibres to move from the ceiling void to the corridor and to room 203. As the double swing doors were kept closed most of the time (except to gain entry to other rooms) the pump was well-placed to sample any air filtering down from the ceiling void. However, as the door was used the ceiling tile debris was also disturbed on some occasions. It is not possible to say whether this single fibre was of any significance, but as this pump was placed more or less adjacent to an opening to the ceiling void and by double swing doors which would disturb the debris from the fallen MMMF ceiling tile, this gives further evidence that air movement from the ceiling void to the occupied areas gave very low airborne concentrations.

4.3.2 Side-by-side sampling by Santia Environmental Ltd.

Santia sampling personnel were on-site and carried out side–by-side sampling during the 26–27th November 2012, but their pumps had some difficulty running more than 4 hours at high flow rates. They analysed the samples by PCM on site but cut filters in half first and stored one half should further analysis be necessary. The fibre counts obtained were again low (a few fibres per analysis) and below the LOQ. Due to the higher volumes of air sampled, these counts indicated that the numerical PCM fibre concentrations for all types of fibres were around 0.001 f/ml.

4.3.3 Spread of debris from the previous removal

Although not the subject of this report, if due to the removal of the AIB ceiling tiles, easily visible debris was left on the “I” beams in the ceiling void, it is possible/probable that dust also spread onto some of the hard to reach out of the way horizontal surfaces within the classroom. There is no reason to expect that these surfaces were cleaned and decontaminated any more thoroughly than the “I” beams.

Therefore the wipe samples taken on rarely cleaned or accessed horizontal surfaces, may be recording the absence of, or the limited cleaning carried out, since the removal work. Similarly the presence of asbestos debris on the under stairs support structures, may have come from the transfer of the removed asbestos from the classrooms to outside. The stairs found to have debris were the obvious transit route for the removed AIB ceiling tile debris. If the contractor had used dry removal, it is possible that they weren't too careful about putting the waste AIB debris in double-sealed polythene sacks or wiping them down before taking them from the removal areas to outside via the corridors and staircase.

Therefore the surface dust samples taken by Santia to some extent supports the concerns raised in their report that the removal had not been carried out by a contractor in a way that had complied with the asbestos regulations.

4.4 COMPARISONS WITH PREVIOUS MEASUREMENTS

The flow of air alone in ceiling voids has not been found to give high levels of airborne asbestos fibres. A number of buildings were reported in the HEI report (19). One office building in particular was studied for several years which had sprayed chrysotile asbestos in a return air plenum and amosite thermal pipe insulation. Some 328 TEM samples over a 3 year period were analysed and for asbestos fibres >5 µm long, the mean concentration for the data set was 0.00004 f/ml and for all asbestos fibres (>0.5 µm long) the mean concentration for the data set was 0.00189 s/ml. These measured concentrations are higher than the overall pooled mean values for Cwmcarn High School but involved a much greater interface, with the circulating of air from the ceiling void passing over the sprayed asbestos. The US building operated an operations and management programme (i.e. similar to the requirements under the HSE's duty to manage) to limit maintenance type peak release episodes. A UK building with sprayed crocidolite insulation in the return air plenum (ceiling void) sampled in the UK (17) also gave low airborne levels in the return air plenum where detached sprayed asbestos could be seen. These sites show that settled dust is not readily entrained by air movement from heating systems and that the situation at Cwmcarn school is unlikely to have been a significant source of airborne asbestos fibres in the classroom.

4.5 SUMMARY AND FURTHER WORK

Overall, the sampling and analytical TEM analysis carried out by HSL showed that there is no evidence for a quantifiable transfer of asbestos fibres from the ceiling void into the classrooms. The results demonstrated that the average concentrations of PCME asbestos fibres in the occupied areas at Cwmcarn school including from the presence of the AIB debris in the ceiling void, were very low and below the LOQ. Provided maintenance activities are carried out with the appropriate precautions, the debris in the ceiling void is unlikely to result in quantifiable airborne asbestos exposures to occupants.

The results for the PCME asbestos fibre concentrations in this report are significantly lower than the fibre concentrations previously reported by Santia. This difference is due mainly to the limit of quantification achieved in the previous sampling being only down to 0.010 f/ml and the assumption that all PCM fibres counted were asbestos fibres.

In reference to the five possible exposure scenarios in the Santia report that were likely to result in an increased risk to occupants:

a) Free flowing air from the ceiling void to the occupied areas;
b) Ceiling tiles being disturbed through gusts of wind and doors being opened and closed.
c) Maintenance type disturbances by changing lights or working in the ceiling void,
d) The fans in the heater cupboards blowing fibres from the AIB debris in the ceiling void into the occupied areas; and
e) Impacts or damage to the AIB panels in the classroom releasing fibres directly to the occupied area.

The HSL results showed that occupant exposures from scenarios a) and d) above are very low and below the LOQ ~0.0003 f/ml. Given the current information and site changes the contribution from wind disturbance b) is also likely to be very low and below the LOQ. Overall the samples from these periods when pooled showed that average exposures from these sources are below 0.00003 f/ml.

Airborne asbestos PCME fibre concentrations released from impacts e) were simulated on the readily accessible AIB materials on the walls of the classroom and the heater cupboards. Each AIB panel was struck four 4 times over about 1 hour. This was seen as an extreme impact scenario and included each heater cupboard being hit at least 24 times with reasonably strong force with an open hand. Airborne asbestos concentrations of PCME asbestos fibres of 0.0019 f/ml (0.0015 f/ml including the IT room) with a range for individual samples from <0.0012 – 0.0043 f/ml were measured over an approximately 2 hour period. It is unlikely that the number of blows and intensity of the force applied would occur under normal occupation and should be seen as the upper peak impact release from the readily accessible AIB in the classrooms. In addition, the extent of fibre release may be linked to particular conditions which occurred at this time (i.e. presence of loose surface material caused by the recent removal and inspection of front heater cupboard panels).

Measurements of activity c) and e), when the AIB is being worked on, broken or damaged, may be carried out in future, when the destructive inspection survey takes place. HSL has requested that half filter be kept back so that any airborne asbestos concentrations can be confirmed, if required.

5. REFERENCES

.

1. Asbestos Investigation Report for Cwmcarn High School. Santia Asbestos Management Ltd report. 30th October 2012. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Asbestos_Investigation_Final_Report_30.11.12.pdf

2. Enquin Environmental Ltd., Asbestos Survey Report for Caerphilly County Borough Council at Cwmcarn High School. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Appendix_B.pdf

3. Asbestos Refurbishment Survey Reports for Cwmcarn High School. See Santia Asbestos Management Ltd report Appendix C1. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Appendix_C(1).pdf

4. Asbestos Refurbishment Survey Reports for Cwmcarn High School. See Santia Asbestos Management Ltd report Appendix C2. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Appendix_C(2).pdf

5. Asbestos Refurbishment Survey Reports for Cwmcarn High School. See Santia Asbestos Management Ltd report Appendix C3. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Appendix_C(3).pdf.

6. Air monitoring results 22/09/12. Santia Asbestos Management Ltd report Appendix E. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Appendix_E.pdf

7. Air monitoring results October 3 – 6th, 2012. . See Santia Asbestos Management Ltd report Appendix G. http://www.caerphilly.gov.uk/pdf/Education_learning/cwmcarn_high_school/Appendix G.pdf.

8. HSG248, Asbestos: The analyst's guide for sampling, analysis and clearance procedure, HSE 01/05; ISBN 0-7176-2875-2, 2005. Available from HSE Books.

9. EU Asbestos worker protection directive Directive 2009/148/EC of the European Parliament and of the Council of 30 November 2009 on the protection of workers from the risks related to exposure to asbestos at work (Text with EEA relevance). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0148:EN:NOT

10. WHO, Determination of airborne fibre number concentration. A recommended method by phase-contrast optical microscopy (membrane filter method). World Health Organisation, Geneva. 1997

11. Public Health Wales: www.nhsdirect.**wales**.nhs.uk/news/?gcid=209

12. Article on Cwmcarn High School, http://www.bbc.co.uk/news/uk-wales-20131119

13. News article on health clinics run for staff and pupils http://www.caerphilly.gov.uk/application.aspx?s=Be1HHt9Zwb/L58FinyN+oGyEaHAqs dlu603zSzHp+0tTx9KhJAXqUqs3g1lZom+SoG+66xc+wDM=

14. Report of high asbestos levels http://www.bbc.co.uk/news/uk-wales-south-east-wales-19955816

15. Report of high asbestos levels http://www.bbc.co.uk/news/uk-wales-south-east-wales-2040040b.

16. WATCH, 2011, final WATCH position on asbestos risk assessment http://www.hse.gov.uk/aboutus/meetings/iacs/acts/watch/agendas.htm

17. Burdett, G.J.; Jaffrey, S.A.M.T. (1986) Airborne asbestos concentrations in buildings, Annals of Occupational Hygiene, 30, 2, 185-199.

18. ISO 10312:1995. Ambient Air - Determination of asbestos fibres - direct transfer transmission electron microscopy procedure. International Standards Organisation. Geneva. 1995. Available from British Standards Institute, 389 Chiswick High Road, London W4 4AL

19. HEI-AR, Asbestos in Public and Commercial Buildings A Literature Review and Synthesis of Current Knowledge, Health Effects Institute - Asbestos Research 1991-01-01.

6. GLOSSARY OF TERMS AND ABBREVIATIONS

ACM — Asbestos containing material.

AIB — Asbestos insulating board

Analytical Sensitivity: The detection of 1 fibre (or 1 structure) in the area of the filter examined or the equivalent volume of air this represents.

Analytical TEM: The use of transmission electron microscopy with additional methods such as electron diffraction and energy dispersive X-ray analysis to identify fibres.

Asbestos — A term applied to a group of silicate minerals belonging to the serpentine and amphibole groups which have crystallized in the asbestiform habit, causing them to be easily separated into long, thin, strong fibres when crushed or processed. The Chemical Abstracts Service Registry Numbers of the most common asbestos varieties are: chrysotile (12001-29-5), crocidolite (12001-28-4), grünerite asbestos (amosite) (12172-73-5), anthophyllite asbestos (77536-67-5), tremolite asbestos (77536-68-6) and actinolite asbestos (77536-66-4).

Aspect ratio — The particles longest dimension (length) / the particle width.

CCBC — Caerphilly County Borough Council.

f/ml — Units of fibre concentration for PCM and PCME fibres per millilitre of air.

HSE — Health and Safety Executive.

HSL — Health and Safety Laboratory.

LOQ — Limit of quantification. Defined as a count of 20 fibres for PCM counts in HSG 248 or as 2.99 fibres for 0 counts, 4.74 for 1 count, 6.63 for 2 counts in ISO 10312:95 for TEM counts of PCME fibres.

MMMF — Machine made mineral fibres.

PCM — Phase contrast microscope.

PCM fibres — Fibres >5 um long, <3 um width and > 3:1 aspect ratio and visible in the PCM microscope following HSG 248 Annex 1. Note: does not discriminate type.

PCME fibre — PCM equivalent fibre (the same size of fibre that would be seen by PCM – with a width of between 0.2 –3 µm, length > 5 µm and an aspect ratio >3:1) with parallel or stepped sides.

Pooled average — The calculated average from combining several samples from the same sampling period/scenario to give a better estimate of the fibre exposures to occupants. It is calculated from the sum of the fibre counts on each sample / Sum of the equivalent volumes of air analysed for each sample.

s/ml — Units of fibre concentration for all fibres > 0.5 µm long.

TEM — Transmission electron microscope.

7. APPENDIX 1: SAMPLING PLAN OF FIRST FLOOR OF BLOCK A, CWMCARN HIGH SCHOOL 26 – 28/11/12