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**Tests to determine release of respirable
asbestos fibres from asbestos insulating board
due to drawing-pin damage**

MF2004/02

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HSL report approval:	Dr. M. Piney (WMSWSGHEALTH)
Date of issue:	August 2004
Job number:	JS2003802
Registry file:	
Electronic filename:	H:\Projects\2004\Pins in AIB.Doc

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EXECUTIVE SUMMARY

This work was commissioned by Dr. M. Piney, WMSWSGHEALTH to determine the asbestos fibre releases when pins are stuck into asbestos insulation board (AIB). Tests using two sampling techniques were employed, vacuum sampling and airborne fibre sampling.

Two devices were employed to vacuum up fibres released when a pin was stuck into the test material (AIB density 0.8 g cm^{-3}), one collected debris directly onto a filter and used the MDHS 39/4 counting rules to discriminate countable fibres and the other device vacuumed debris into a glass bottle and size selected it using a cyclone elutriator. Fibre densities were determined using the MDHS 39/4 counting rules. The number of countable fibres generated ranged from 5 to 6000 fibres per hole and were affected by a range of factors, including dwell time, orientation of the board and spacing of the insertion points.

Airborne fibres were collected using airborne sampling techniques based on the method described in MDHS 39/4. Samples were collected at distances ranging from 12.5 millimetre to 75 millimetres from the point of insertion and airborne fibre concentrations determined by counting the fibres using the MDHS 39/4 counting rules. Airborne concentrations ranged from <0.01 to 0.09 f ml^{-1} with the release of up to 60 fibres per hole.

An additional set of tests using a powered hand drill to drill holes in the test material were also carried out. The sampling distance was 12 centimetres from the holes and results are not directly comparable with the pin tests. The results using a 2-millimetre drill gave airborne fibre levels of up to 0.17 f ml^{-1} [one result of 1.73 f ml^{-1} was recorded but was suspect because it was an order of magnitude greater than all the other values]. Drilling using a 7-millimetre [$\frac{1}{4}$ inch] drill produced airborne fibre levels ranging from 0.35 to 0.90 f ml^{-1} within the chamber. On average 1,800 airborne fibres were collected from each hole drilled. When the dust generated was confined within a plastic shroud the average number of fibres collected increased to 2,500 fibres per hole.

Many of the samples were collected over short time periods and only small volumes of air were sampled; consequently only small numbers of fibres were collected and individual values may not be statistically significant and must be treated with caution.

1 INTRODUCTION

This report gives the results of tests designed to establish the magnitude of airborne fibre releases that occur when pins (e.g. drawing pins) are pushed into and removed from asbestos insulation board (AIB).

The rationale behind the tests described developed over the period of this period.

The initial series of tests worked by vacuuming the holes created by the pins. The number of respirable fibres collected was then determined by applying the MDHS39/4 (Methods of Determination of Hazardous Substances) fibre counting rules¹. Two different sampling devices were employed to vacuum the holes.

One device vacuumed all the debris into a glass container inside of which was a cyclone elutriator. This cyclone separated the respirable material (collected on a filter) from the remaining non-respirable debris². See Figure 1.

The other device was a standard plastic cowl (as used for sampling airborne asbestos) with a nozzle extension (a 1 mm diameter plastic tube) attached to the entry of the cowl; see Figure 2. A pin was glued to the nozzle so that the point protruded about 4 mm in front of the nozzle, the intention being that any material disturbed by the pin would be vacuumed into the cowl and collected on the filter. This device did not attempt any size selection, relying solely on the MDHS 39/4 counting rules to determine the countable fibres.

After the first series of tests another series of measurements were carried out, sampling for airborne respirable asbestos fibres and a strategy, with a series of objectives, for the tests were identified. See Memo from Dr Piney at Appendix A. The second series of tests sampled the airborne fibres generated using conventional sampling techniques as described in MDHS 39/4. In these tests the sampling cowl was positioned at fixed distances from the AIB surface. To achieve this a brass sleeve was fitted over the cowl to position the pin a prescribed distance in front of the cowl. Obstruction to the entry of the cowl was minimised allowing, as far as possible, for it to operate as normal. The samples were then collected with the pin at the AIB surface ensuring that the cowl was this distance from the surface.

In addition to the tests using pins, similar tests in the same test chamber, using a powered drill, were carried out on the same material.

¹ A countable fibre is defined as 'any object longer than 5 µm, with a width less than 3 µm and having an aspect (length / width) ratio greater than 3:1, which does not touch (or appear to touch) a non-fibrous particle with a maximum dimension greater than 3 µm.

² This device was designed by Robin Howie Associates and loaned to HSL for these tests.



Figure 1: Photograph of the sampling device designed by Robin Howie Associates.



Figure 2: Photograph of device used to hold the point of the pin in front of the nozzle used to vacuum debris into a standard sampling cowl.

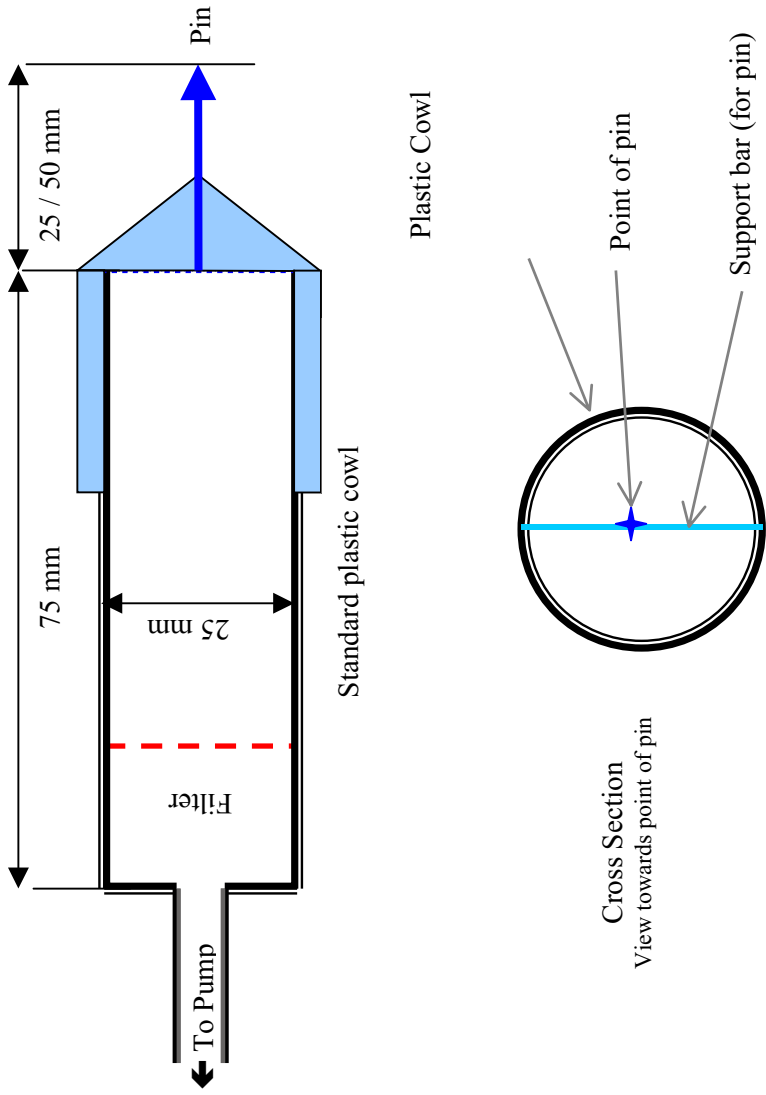


Figure 3 Schematic diagram of device used to hold the point of the pin a fixed difference from the sampling cowl.

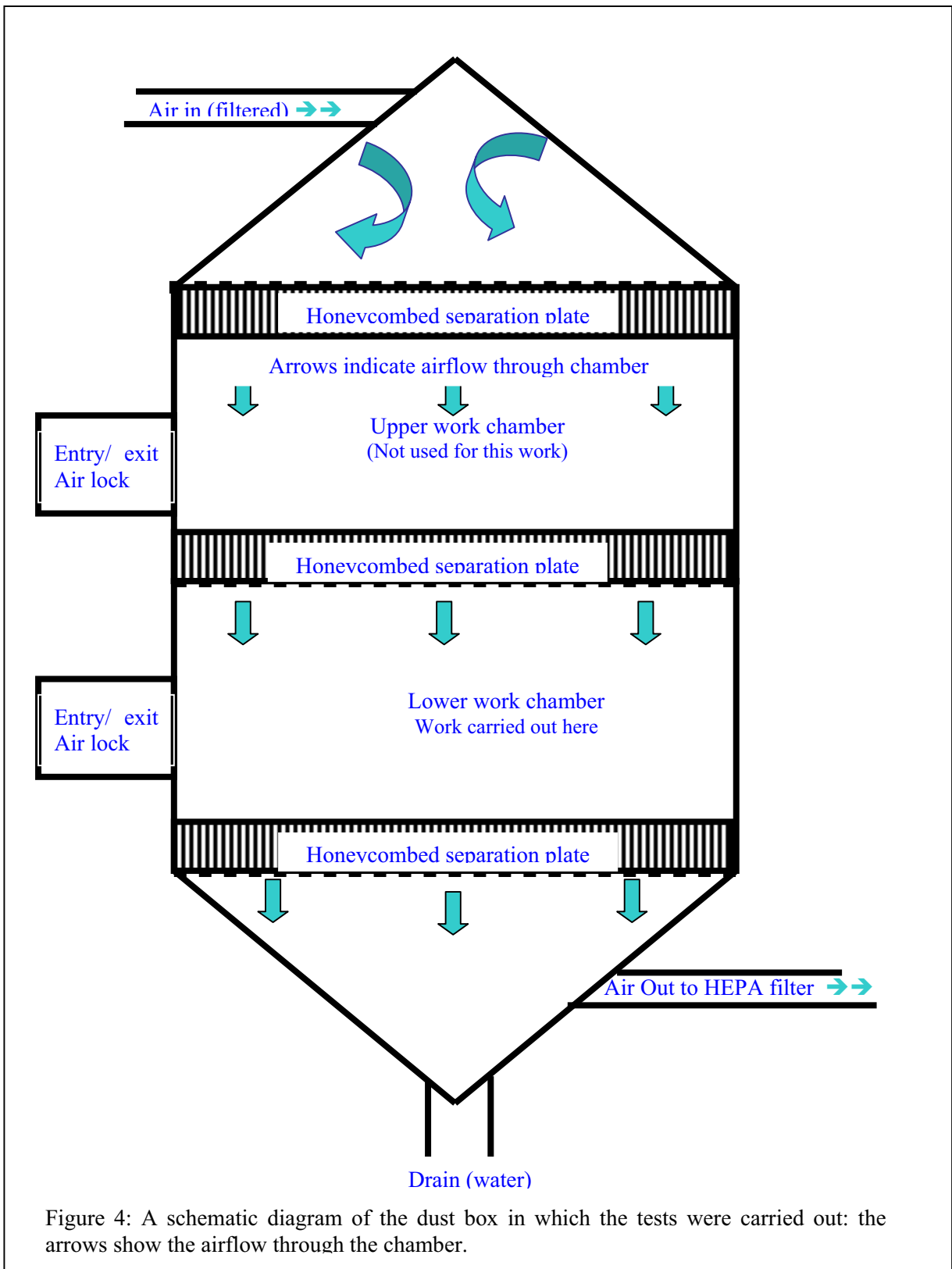


Figure 4: A schematic diagram of the dust box in which the tests were carried out: the arrows show the airflow through the chamber.

2 TESTS – DESCRIPTIONS AND RESULTS

2.1 METHOD AND MATERIALS

All the tests were carried out in a sealed chamber under negative pressure to ensure that fibres were not released into the environment (see figure 4). Although there was some air movement inside the chamber this was downward and would have had minimal³ affect on sampling using vacuum techniques. It may however, have had a small effect on airborne samples collected using cowls as these were positioned at different distances from the generation point. Although the intention was to simulate the effect of sticking pins into asbestos insulation board (AIB) a variety of pointed metal probes with similar cross-sections to a ~ 1 mm diameter standard pin were used. These were easier to manipulate through the gloves ports of the chamber and were an integral part of the customised tool used in some of the second series of airborne tests.

All the tests were carried out on a piece of AIB (density 0.8 g cm⁻³) at two orientations with respect to the floor of the chamber (board horizontal or vertical). One side of the board was coated in white paint. One test was carried out with the paint intact but the remainder were carried out either on areas from which the paint had been removed prior to the tests, or on the unpainted surface. [Although removing the paint could have damaged the AIB surface, possibly leading to greater fibre release, the paint was very easily removed in large (cm) flakes leaving what appeared to be an undamaged surface. It is also possible that where the surface was painted, 'solvent' from the paint dried during / after application, binding the underlying AIB and reducing fibre releases].

In each of the tests, unless specified, one hundred pin holes were made either well spaced so there was little chance of further damaging the AIB, or in a small area with a high probability of damage to existing holes. In some of the earlier tests, following the approach adopted by Robin Howie Associates, one included using both widely spaced and closely spaced overlapping pinholes. This made calculation of fibre numbers per hole impossible because one test measured fibre numbers from two different conditions. In later runs separate tests were carried out using widely spaced and potentially overlapping holes.

The numbers of fibres sampled (collected on filters) were determined using the fibre counting method and rules given in MDHS 39/4 irrespective of how the sample was collected (vacuuming or airborne sampling).

A series of scanning electron microscope images of typical pinholes and an energy dispersive x-ray (EDX) spectrum of one of the asbestos fibres found in the board are included in appendix B.

2.2 FIRST SERIES OF TESTS – VACUUM SAMPLING

2.2.1 Initial Tests – Robin Howie Associates Sampler

The first test (08381/03) was carried out on an area of the board from which the paint had been removed. Seventy-five well-spaced insertions followed by twenty-five closely grouped insertions were made. Some of these latter holes overlapped causing collateral damage to existing holes.

The test was repeated (08382/03) on an area where the paint was intact and again on board from which the paint had been stripped but with the board perpendicular to, rather than parallel to, the chamber floor (08383/03).

³ The work chamber has a variable control ranging from 0.05 m³ sec⁻¹ to 64 m³ sec⁻¹. The tests were carried out with the extraction rate close to its minimum setting; effectively this was less than 0.1 m³ sec⁻¹. An anemometer inside the chamber was unable to register any air movements above its lower limit of measurement (0.1 m sec⁻¹).

An additional airborne sample using the sampling techniques described in MDHS 39/4 was carried out using a high volume pump with the sampling cowl about 50 centimetres from the surface of the AIB (08384/03).

The results in terms of fibre densities and total number of fibres are shown in table 1. The values (fibre densities / fibre numbers) were probably a slight overestimation as the cyclone sampler was operated at 1.9 litres per minute (this was in error) rather than 2.2 litres per minute.

For comparison purposes, fibre numbers reported by Robin Howie Associates are shown. The fibre density ($f \text{ mm}^{-2}$) was calculated from the number of fibres reported and assuming a deposit area (22 mm diameter).

Table 1: Results of initial tests using Robin Howie Associates sampler

Sample N ^o	F mm^{-2}	f ml^{-1}	Total N ^o Fibres	Fibres per hole	Comment
08381/03	488	1.5	13,808	138	No paint (paint removed) – board flat
08382/03	341	1	9,654	96	Paint – board flat
08383/03	1,147	3	32,446	324	No paint (paint removed) – board perpendicular
08384/03		0.07	4,398	44	No paint (paint removed)– cowl sample at ~ 50 cm
Robin Howie Associates	1,710*	>20 [#]	650,000	6,500	*Calculated assuming fibres were in a 22 mm diameter deposit. # sample time assumed to be 15 minutes

2.2.2 Second Set of Vacuum Tests

From the experience gained from the initial set of tests a further series of tests were carried out. These proposed tests were:

- (a) 100 well spaced holes (no overlap) using the Robin Howie Associates sampler [08386/03].
- (b) As above but using a cowl fitted with a 1 mm nozzle (a tube attached as inlet to a standard cowl). This is a technique often employed for surface sampling. [08387/03].
- (c) Airborne sampling using a cowl sampler (high volume pump – 9.5 L min^{-1}), a cyclone sampler (2.2 L min^{-1}) and a cowl with a blanking plate concentrating the deposit onto a 6 mm diameter area of the filter (2.2 L min^{-1}). All three devices were positioned about 50 centimetres from the board.
- (d) Repeats of tests (a) [08389/03; 08415/03] and test (b) [08390/03; 08416/03] but with closely spaced holes allowing the probability of overlap.
- (e) Vacuum a 10 x 10 centimetre area of the board surface (unpainted side) using the same sampling device as in (b) [08388/03].
- (f) Repeat of test (b) but sampling from the underside (below) the horizontal board. To carry out this test one hand was required to hold the AIB⁴ and the other to insert the pin. Therefore a pin was glued to the plastic inlet tube of a cowl (used as a vacuum device)

⁴ Whilst it may have been possible to hold the board mechanically it was easier and more convenient to support it from underneath (on bricks) and hold it down (prevent movement) from above using one hand.

so that the point was in front of the 1 mm orifice. The pin could then be pushed into the board and the entry nozzle positioned using just one hand. (Figure 2)

- (g) A cowl angled at about 30° from horizontal, ~ 25 centimetre below board when carrying out test (f).

The results from this set of tests are shown in Table 2.

Problems were identified with two of the tests [08389/04 and 08390], which were repeated.

Table 2: Results from second set of vacuum sample tests

<u>Sample N^o</u>	<u>F mm⁻²</u>	<u>F ml⁻¹</u>	<u>Total N^o Fibres</u>	<u>Fibres per hole</u>	<u>Comment</u>
08386/03	1536.18	33.18	589,580	5,896	100 well spaced holes – Howie [#] sampler as 08381/03 (table 1)
08387/03	337.76	11.67	128395	1,284	100 well spaced holes – modified cowl with attached pin
08388/03	5.85	<0.44	2,222	22	Cowl used to vacuum a ~ 100 sq. cm area of board (paint removed).
08389/03*	2.27 ?	<0.56	864 ?	13	65 holes close / overlapping holes – cowl sample.
08415/03	40.60	1.40	15,432	154	Repeat of 08390/03 – 100 holes
08390/03*	-	-	-	-	As 08389/03 but with the Howie [#] sampler
08416/03	154.08	6.66	58,570	586	Repeat of 08390/03
08391/03	96.95	3.35	36,853	369	Cowl with attached pin from unpainted board – 100 well spaced holes
08412/03	2.27	<0.09	864	9	Howie [#] sampler ~ 50 cm from vertical unpainted board – 100 holes.
08413/03	1.3	<0.37	494	5	As 08412/03 – 6.5 mm diameter deposit – cowl sampling at 2.2 l/min
08414/03	2.6	<0.37	988	10	As 08412/03– cyclone sampling at 2.2 l/min
08417/03	1.95	<0.12	740	7	Cowl angled up at about 30° to horizontal 25 cm below horizontal board {simulating debris falling onto a face}.

* test was suspected of being faulty and was repeated. # Robin Howie Associates

2.2.3 Observations and comments – Vacuum sampling

From these tests, vacuuming debris into the sampling device, a number of observations were made:

- The fibre counting statistics [MDHS 39/4] show that the lower 95 % confidence limit is approximately 50 % of the reported value and the upper 95% confidence limit about double the reported value. (i.e. if 10 fibres are counted then the lower 95% confidence limit will be 5 fibres, ~ ½ the number counted, and the upper 95% confidence limit will be 20, ~ double the number counted, and that for nine out of ten counts (90%) on this sample the number of fibres counted will be between 5 and 20).
- Density of the board. These tests were carried out on a typical AIB, density 0.8 g cm⁻³, but there is a wide range of other AIBs varying in composition, density and friability.

- The devices used to produce the pinholes were about 1 mm in diameter with a sharply pointed end. Not only will there be a range of pin sizes but the technique for producing holes will vary. The pin could be pushed in at different angles, with varying degrees of force, to different depths and in these tests removed using a single pull or ‘waggled’ to loosen the pin before removal.
- Vacuuming will tend to collect loosely bound debris near to and from inside the holes created by the pin. Most of this debris would not normally become airborne.
- Orientation of board. When vacuum sampling from above horizontal boards, only debris that can be pulled from the disturbed surface / hole will enter the sampler. When sampling from a vertical (perpendicular to floor of chamber) or from below the board dust could fall from the hole into the sampling device. Once debris has fallen beyond the entry to the sampler it is lost, whereas debris on the upper surface of a horizontal board can be vacuumed into the device whenever suction is applied.
- Dwell time, the length of time the suction is applied, will affect the amount of material collected. Although these dwell times were not measured they were short, as the action of extracting the pin tended to take it away from the hole and the surface of the AIB. It was estimated that on average these dwell times would be less than one second.
- When a sample is collected using a cyclone the material collected is size selected using centrifugal forces. These forces could break up large non-respirable pieces of debris releasing further countable respirable fibres.

2.3 SERIES TWO – AIRBORNE SAMPLING

After discussion with Dr. Piney, regarding the results of vacuum sampling, it was agreed to carry out further tests to determine, in a direct way, airborne respirable fibre releases (see Appendix A –Memo from Dr. Piney dated 6th January 2004). A series of tests were carried out using the device shown in Figure 2. Tests were carried out with the cowl at about 12.5, 25, 50 and 75 centimetre above a horizontal board. Three tests at each distance were carried out with the holes (100) well spaced and then repeated with the holes close together in groups of four. The sampling flow rate for all the tests was 11 litres per minute with the time required to complete each test being about five minutes. Some of the tests were repeated using an extended dwell time (the cowl being kept at the prescribed distance above the hole for about two seconds).

The results of these tests are shown in Table 3.

2.3.1 Comments on Series two – Airborne Sampling Tests

The results are, in broad terms, consistent. The further the cowl was from the hole (AIB surface) the lower was the airborne fibre concentration. Also the airborne fibre concentrations from the tests using closely packed holes were higher than from well-spaced holes.

It was observed that when the pin is pulled out of the board surface it usually comes out with a jerk and the point moves away from the surface. In normal usage it would be taken completely away (from the hole) but here, each insertion (except the last) was followed by another, with the pin being moved back to the AIB surface at the next insertion point, usually a few millimetres away. This meant that although the pin initially moved away from the surface it was quickly brought back to approximately the displacement distance for the test being carried out.

Although some fibres may be released during the insertion of the pin many more will be released when the pin is pulled out. Not only does the pin block off the hole when it is pushed in, but when it is pulled out it probably creates a suction affect. This suction will pull loose

material out of the pinhole and generate a small cloud of airborne material immediately above it. In still air there will be an initial tendency for the cloud to expand and disperse. Larger particles will tend to fall out near the insertion point but respirable particles may remain airborne for minutes, if not longer. The suction, applied to the cowled sampling head, by the sampling pump, will draw in, a proportion of the dust-laden air. The stronger the suction (sampling rate), the closer the cowl is to the AIB surface and the longer the duration for which it acts, then the greater the probability that air containing airborne fibres will be pulled into the cowl and onto the sample filter. The sampling cowl in the test arrangement acts as a small local exhaust ventilation i.e. a “captor hood”.

If a pin is pushed into, an existing hole, or very close to one, then it may widen the hole or loosen further material increasing airborne fibre releases. In effect it does additional damage to the AIB matrix and causes more disturbance and fibre and debris release.

Table 3: Results from 3rd set of tests – Airborne Sampling.

<u>Sample N^o</u>	<u>Fibre density on filter (f mm⁻²)</u>	<u>Airborne fibre concentration (f ml⁻¹)</u>	<u>Total N^o Fibres on the filter</u>	<u>Fibres per hole</u>	<u>Comment</u>
08007/04	0.32	0.002*	123	1	100 well-spaced holes, cowl 25 mm from the point of the ‘pin’.
08023/04	2.92	0.02*	1,111	11	
08008/04	4.22	0.04* (0.003*)	1,605	16	
08009/04	7.79	0.04* (0.019*)	2,963	30	
Average	4.98	0.03^P	1,893	19	95 % range 2 – 12 f mm⁻².
08010/04	14.61	0.09 (0.07)	5,555	56	100 holes in tight groups of 4, cowl 25 mm from the point of the ‘pin’.
08011/04	15.76	0.08 ((0.06)	5,989	60	
08012/04*	0.97	0.00	368	4	
08024/04	13.64	0.09 (0.06)	5,185	52	
Average	14.67	0.09^P	5576	56	95 % range 8 – 28 f mm⁻².
08001/04	1.95	0.01*	740	7	100 well-spaced holes, cowl 50 mm from the point of the ‘pin’.
08002/04	2.27	0.01*	864	9	
08003/04	3.25	0.01*	1,234	12	
08025/04	1.30	0.01*	494	5	
Average	2.19	0.03*^P	833	8	95 % range 0.6 – 7 f mm⁻².
08004/04	2.20	0.02*	835	8	100 holes in tight groups of 4, cowl 50 mm from the point of the ‘pin’.
08005/04	3.11	0.02*	1,181	12	
08006/04	3.90	0.03* (0.001)	1,481	15	
08013/04	6.82	0.07 * (0.03)	2,593	26	
Average	4.01	0.04^P	1523	16	95 % range 1 – 10 f mm⁻².
08031/04	0.65	0.002*	247	2	100 well-spaced holes, cowl 25 mm from the point of the ‘pin’. Extended dwell time
08032/04	11.04	0.04* (0.025)	4,197	42	
08033/04	2.60	0.01*	988	10	
08045/04	4.87	0.02* (0.003)	1,852	19	
Average	6.17	0.02^P	2346	23	95 % range 2 – 14 f mm⁻².
08053/04	1.30	0.007 *	494	5	100 well-spaced holes, cowl 75 mm from the point of the ‘pin’. Normal dwell time.
08054/04	0.32	0.002*	123	1	
08055/04	0.97	0.006*	370	4	
Average	0.86	<0.02 *^P	329	3	

Table 3: Results from 3rd set of tests – Airborne Sampling.					
Sample N^o	Fibre density on filter (f mm⁻²)	Airborne fibre concentration (f ml⁻¹)	Total N^o Fibres on the filter	Fibres per hole	Comment
08056/04	0.97	0.005* (0.004)	370	4	100 well-spaced holes, cowl 12.5 mm from the point of the 'pin'. Normal dwell time.
08057/04	4.87	0.029* (0.006)	1,852	19	
08058/04	11.04	0.061* (0.04)	4,197	42	
Average	5.63	0.03^P	2140	21	95 % range 2 – 13 f/mm²
<p>The fibre densities and airborne concentrations have been calculated for all the counted samples but for many (marked with an asterisk: *) the number of fibres counted was less than 20⁵ and would, under MDHS 39/4 counting rules, be reported as <LOD [limit of detection].</p> <p>The values shown in brackets have been blank corrected using a value of 6 fibres per 200 fields of view: values that are <= 0 are not shown.</p> <p>P = result from pooling the sample set.</p> <p>♣ Filter found unseated in cowl.</p> <p>Some results were outside the 95% fibre counting confidence intervals for the group average (cells greyed) and were suspect. These tests were repeated and the suspect values excluded from the averages.</p>					<p>The 95 % ranges are the lower and upper 95% fibre counting confidence limits for the average fibre density value in f mm⁻².</p>

2.4 DRILLING TESTS

As an initial attempt at a comparison a set of drilling tests were carried out on the same material. A series of holes were drilled into the board using a powered hand drill.

2.4.1 Drill test 1.

An initial test with the board parallel to the floor (2 mm drill) was followed by tests using 2-millimetre and 7-millimetre [$\frac{1}{4}$ inch] drill sizes on a board held perpendicular to the floor of the chamber.

The results from these tests are shown in table 4. Each test was repeated three times using high volume (12.5 L min⁻¹) and low volume (2.2 L min⁻¹) samplers. A period of about twenty seconds was allowed between drilling successive holes. It took about three seconds to drill each hole with a total sampling time for each test of four to five minutes.

It was noted that when drilling holes with a 2-millimetre drill on a board parallel to the floor much of the debris was deposited in a neat annulus around the hole. When the board was perpendicular to the floor the debris fell to the floor, increasing the possibility of fibres becoming airborne.

The airborne fibres sampled will depend on the position of the sampling cowls in relation to the holes. Both cowls were sited about 12 centimetres above the drill position and about 15 centimetres apart. The holes were drilled in line so that for each test one or other of the sampling cowls would be closer to holes than the other.

⁵ The MDHS 39/4 LOD; 0.01 f/ml, is derived by counting 200 fields of view from a 480 litre air sample. Counting 20 fibres under these conditions gives an airborne fibre concentration of 0.01 f/ml. If (as in these tests) the volume of air sampled is less than 480 litres the LOD increases by the ratio 480 / volume sampled. Although blank correcting is not normally carried out, MDHS 39/4 states the count from a blank unused filter can be up to 6 fibres per 200 fields of view.

By pooling the results from a series of similar samples a statistically more significant result may be achieved.

It was noted that in both the 2-millimetre drill tests the average values were influenced by single values, which were much greater than the others for the comparable tests. Therefore averages excluding the highest and lowest (max, min) values have also been calculated.

It was reported in IR/L/MF/08/99 that similar drilling tests carried on an asbestos cement sheet (speakers slate), density 2.1 g cm⁻¹ containing about 13 % chrysotile asbestos produced average airborne fibre levels 0.44 f ml⁻¹ when drilling ten, five millimetre holes.

This initial set of drilling tests were not directly comparable with the pin tests as in the latter an attempt was made to collect all the respirable airborne fibres emitted from pin disturbance. These initial drilling tests did not collect all the respirable airborne fibres released by drilling and a second test was developed to make the pin and drilling tests more directly comparable.

Table 4: Airborne fibre levels twelve centimetres above holes drilled in AIB.

Test N ^o .	Sample N ^o .	F mm ⁻²	F ml ⁻¹	Total N ^o Fibres	Fibres per hole	Comment
1a	08080/04	3.90	0.17	1,481	148	Ten, 2 mm holes; board parallel to floor – dust forms piles around hole. Average 62 (49) fibres per hole.
1b	08081/04	0.65	0.01*	247	25	
2a	08082/04	1.62	0.07*	617	62	
2b	08083/04	1.95	0.02*	740	74	
3a	08084/04	0.65	0.03*	247	25	
3b	08085/04	0.97	0.01*	370	37	
Average (1 – 3)		1.62 (1.30)	0.05 (0.03) 0.025* ^P	617 (494)	Values in brackets exclude the highest and lowest value of the set. P = result from pooled data	
4a	08086/04	21.11	0.72	8,025	80	¼ inch (7 mm) drill, board vertical – dust falls to floor. Average 1,828 (1,690) fibres per hole.
4b	08087/04	65.61	0.40	24,941	249	
5a	08088/04	10.02	0.43	3,808	762	
5b	08089/04	45.47	0.35	17,284	3,456	
6a	08090/04	23.38	0.90	8,889	889	
6b	08091/04	74.92	0.51	28,479	2,848	
Average (4 – 6)		40.08 (38.89)	0.55 (0.51)	15,237 (14,784)	Values in brackets exclude the highest and lowest value of the set	
7a	08092/04	1.30	0.06*	494	49	2 mm drill, board vertical – dust falls to floor. Average 307 (117) fibres per hole.
7b	08093/04	2.60	0.02*	988	99	
8a	08094/04	55.21	1.73	20,988	1,399	
8b	08095/04	7.47	0.04*	2,839	189	
9a	08096/04	0.64	0.02*	244	12	
9b	08097/04	5.52	0.02*	2,099	105	
Average (7 – 9)		12.12 (4.22)	0.32 (0.04) 0.11 ^P	4,609 (1,605)	Values in brackets exclude the highest and lowest value of the set P = result from pooled data	
* these values would normally be reported as less than the theoretical LOD. Shading is used to indicate the pairs of samples from each test; the test number also identifies them with sample b being the high volume sample of each sample pair.						

2.4.2 Drill test 2:

A plastic shroud was placed around the drill, see figure 5, so that any airborne fibres released would be contained within the shroud and sampled by a standard cowl sampler within the

shroud. During sampling, care was taken to ensure that the cowl was always positioned above the drill hole so that non-respirable debris did not fall into it. The test was repeated three times, and on each occasion a single hole was drilled. For holes one and three (table 5) there was a delay between switching the sampling pump on and drilling the hole (~ ½ minute) but for hole two the delay was much shorter (~ 10 seconds). It took about ten seconds to drill the holes but the shroud was held in place for a further two minutes, sampling the airborne fibres released. During this period the drill was left in the hole preventing escape through it. The results of airborne sampling at 2 litres per minute are shown in table 5. On average the number of airborne fibres released per hole (2,546) was higher than from the previous unconfined tests (1,828 fibres per hole) using the same ¼ inch drill. [If only the two higher values (table 5) were considered, then the average of 3,326 fibres per hole, was nearly double the unconfined value].

Table 5: Airborne fibre levels inside a shroud around holes drilled in AIB.

Test N ^o .	Sample N ^o .	F mm ⁻²	F ml ⁻¹	Fibres per hole	Comments
1	08254/04	7.76	0.59*	2948	3 single, ¼” holes; each hole took ~ 10 secs. to drill but dust collected over 2 min. periods.
2	08255/04	2.60	0.25*	988	
3	08256/04	9.74	0.74*	3704	
	Average	6.70	0.55 ^P	2546	
<p>* these values would normally be reported as being less than the limits of detection (<0.98, <1.23 and <0.98 f/ml) for the volumes of air sampled. P = pooled data.</p>					

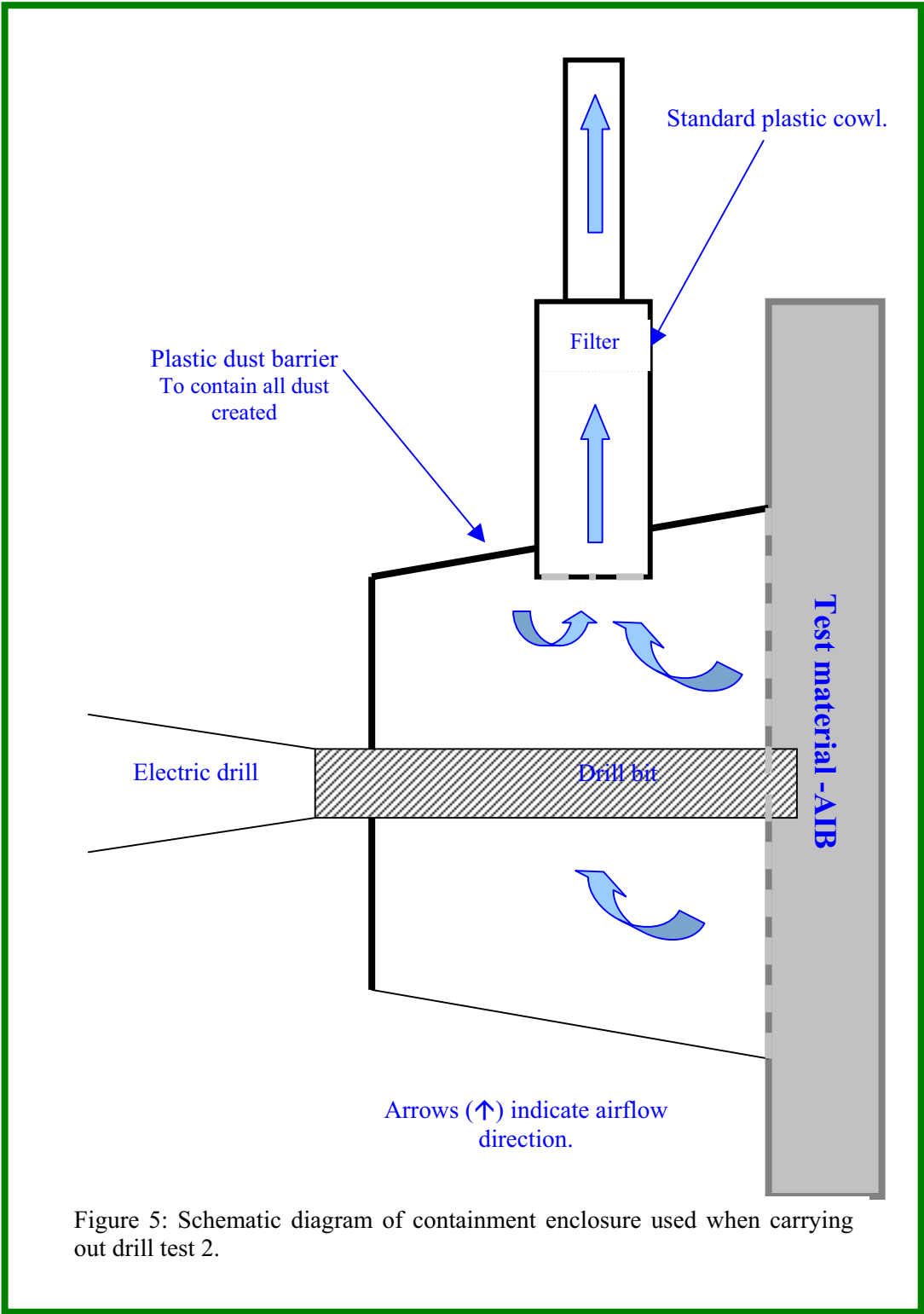


Figure 5: Schematic diagram of containment enclosure used when carrying out drill test 2.

3 COMMENTS

Disturbing any asbestos containing material is likely to release fibres, which then may become airborne. The number of respirable fibres made airborne will depend on a range of factors including the amount of damage done to the asbestos-containing material, the energy involved and the degree of disturbance and damage. Sticking pins into AIB will release fibres but far less so than drilling into AIB. [Inserting a pin into a 'soft' material pushes material aside to allow the pin into it. The pin then blocks the hole preventing material escaping. It is only when the pin is pulled out that loosened material can escape from the hole. This escape is assisted by a 'vacuum' created as the pin is withdrawn pulling loose material with it and releasing this material into the environment. Drills however, not only employ substantial energy but also are designed to remove debris from the hole they create, throwing it out into the environment with considerable force.]

Countable fibres [MDHS 39/4] were found using both vacuum and airborne sampling strategies. It is however, difficult to relate the results from these very different sampling techniques. Airborne fibre sampling, even under artificial conditions pertaining here, will give an indication of possible asbestos fibre exposures when carrying out this type of activity. The relationship between vacuum sampling, and airborne fibre levels is unclear and difficult to assess. The processes employed in vacuum sampling may well affect the material being sampled.

Many of the samples were collected over short time periods and only small volumes of air were sampled; consequently only small numbers of fibres were collected and counted. The fibre concentrations (and fibre numbers) from low volume, low fibre number samples must be treated with caution and not over interpreted. However, whilst these individual results, in themselves, may not be significant they may help to demonstrate trends or patterns.

4 APPENDIX A

Memo

6th January 2004

To Graham Revell, HSL Fibres Section

From Mark Piney, W&SW SG

Dear Graham

Respirable asbestos fibre release from AIB due to drawing pin damage

1 Thanks for the all the work you have done so far. As you have pointed out there are a lot of variables that can affect the results. As we discussed earlier today I think we have been a bit mesmerised by the technique developed by Robin Howie Associates and we need to stand back and re-assess what we are trying to find out.

2 What is of interest and importance is the number of respirable airborne asbestos fibres released when drawing pins are stuck into and pulled out of AIB. What is needed is a fair and more-or-less repeatable test to airborne respirable asbestos fibres.

3 Looking at the results of your earlier tests when you used the device devised by Robin Howie Associates and your adapted cowl as a vacuum cleaner I believe that both methods probably overestimate respirable airborne asbestos fibre release. As you point out this is partly because the test method hoovers fibres out of the pins holes but I believe there may be at least two other mechanisms, which increase the recorded fibre numbers on the sample filters. The hoovering will tend to suck up particles and bits of AIB which are not respirable. These bits will then tend to become broken up by the action of the hoovering process. I suppose what I am saying is that the hovering method, while at first sight a fair test method, is liable to produce inflated results i.e. higher results than more gentle method of sampling.

Standing back and considering what we want to discover by means of the tests I think the aim and the objectives of the investigation are:

Aim To assess, by quantitative and other means, the degree of respirable airborne asbestos fibre release and the damage caused when AIB is punctured by drawing pins (and drilled?)

Objectives

1 To develop a simple, reproducible test method for pin insertion and removal and a realistic method of measuring airborne respirable asbestos fibre release.

2 To develop simple qualitative ways of assessing damage to AIB and release of fine airborne dust

3 To apply the methods, in a repeatable way, to examine the release of airborne respirable asbestos fibres from AIB under different circumstances.

4 To draft a report with an agreed layout and content at the completion of the test series

Tests

Test 1 Horizontal AIB of known density and bulk composition held horizontal. An asbestos cowled sampler with pin attached (centrally is possible) used to make holes in AIB. Two test distances from AIB surface to mouth of cowl – 2.5 cm and 5.0 cm. Tests repeated three times for each distance to check on the repeatability of the test method. Holes well spaced and not overlapping. Number of holes per test? Not sure but will leave that up to you. Depends upon the number of airborne, respirable asbestos fibres released per hole and the sensitivity of the sampling and analytical method.

Test 2 Same as for 1 but with holes made in close-together groups, say, four per group.
Comment 1: I think this approach is preferable to simply stabbing the same area repeatedly in that the damage can be, to an extent, reproducible and the method can be described.
Comment 2: I would expect the results of these tests to be less reproducible than Test 1.

Final comments Once the results of Tests 1 and 2 are available it may be useful to consider further tests. These could include comparative tests with other forms of disturbance. I am particularly interested in how many more airborne, respirable fibres are released by drilling AIB with a small diameter drill. We could also consider reproducing Test 1 but use a cyclone sampler instead of a cowled sampler. And there may be other useful tests which come to mind. But before doing these further tests lets see and review what Tests 1 and 2 reveal.

Regards

Mark

5 APPENDIX B

SEM images of typical examples of the pinholes.

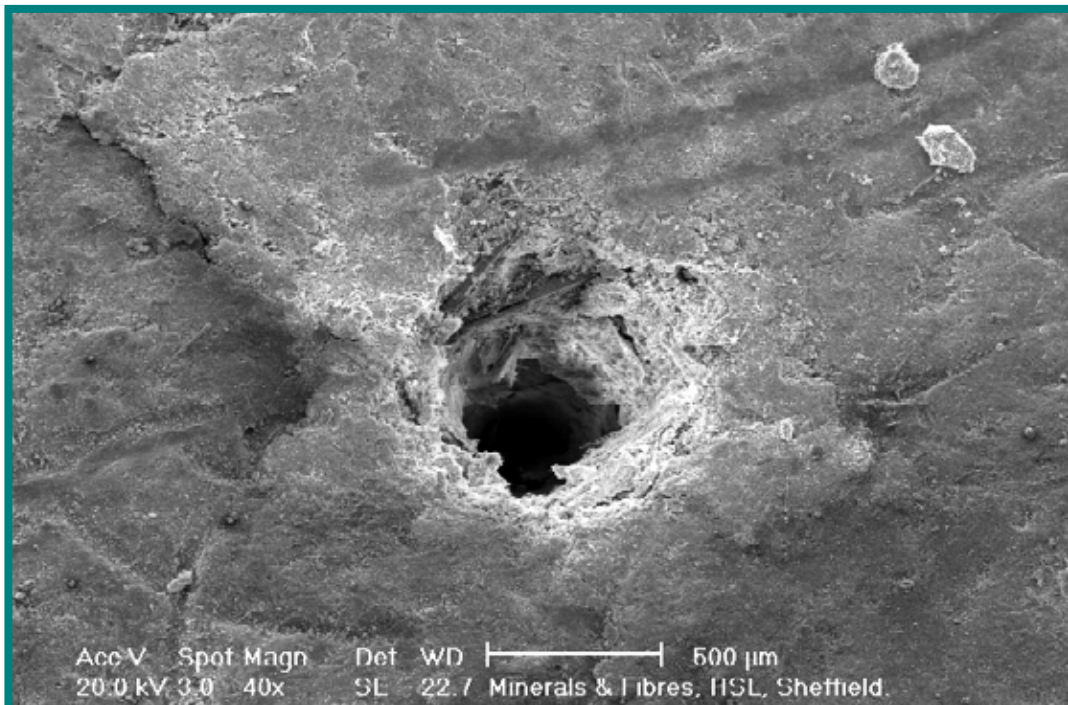


Figure 1: SEM image of a single pinhole.

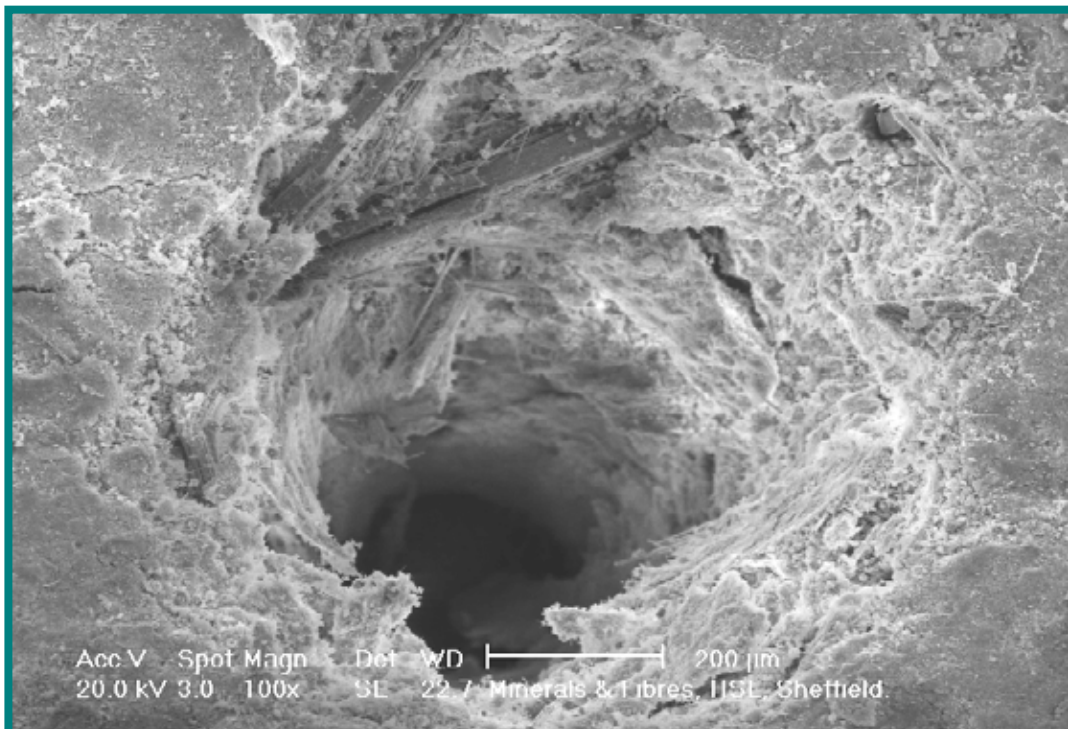


Figure 2: Higher magnification SEM image of hole shown in figure 1.

6 REFERENCES

MDHS 39/4: Methods for the Determination of Hazardous Substances; Asbestos fibres in air; HSE November 1995.

IR/L/MF/08/99: Speakers Slate: An Assessment of Fibre Release; Minerals and Fibres Section Report; G Revell; 1999.