

## SUMMARY OF FURTHER RESEARCH

### Objectives

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

1. Airborne fibre concentrations releases during the removal of textured decorative coatings (TDCs) from a wider range of surfaces to those reported in an earlier survey (see IF2005/03);
2. Change in the personal airborne asbestos fibre concentrations inside the enclosed area during the removal of TDCs, if no air extraction is used to keep a reduced pressure inside the enclosure; and
3. Effectiveness of the clearance, following removal of TDCs, based on a visual assessment alone.

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

4. What are the likely airborne releases from poorly controlled removal of TDCs?
5. What is the airborne concentration outside the enclosure during removal of TDCs, if no air extraction is used?
6. What are the airborne exposures that will be experienced by persons reoccupying a building, following the removal of TDCs?

### Method

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

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

- personal fibre concentrations of operatives during peak removal and cleaning activities;
- personal gravimetric dust exposure of operatives during peak removal and cleaning activities;
- static fibre concentration in the airlock during removal, and

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

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

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

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

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

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

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

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

## Results and Main Findings

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

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

- Hand scraping TDC from concrete (one site) and hard finishing plaster (two sites);
- Removing plaster and TDC from brickwork with a hammer and chisel (one site);
- Removing a chrysotile containing paint on pebbledash from brickwork with a Kango powered chisel;
- Demolition and removal of TDC and the under laying plasterboard using a hammer and crowbar.

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

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

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

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

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

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

**Table S2: Summary of the TEM analysis of personal samples**

Site	Sample Number	PCM fibre concentration (f/ml)	PCME chrysotile fibres	
			(f/ml)	(N°.)
Removal with controls				
B	00458/06	0.58	<0.07	(ND)
	00474/06	0.34	<0.08	(ND)
D	00156/06	0.41	<0.07	(ND)
	00164/06	0.46	<0.07	(ND)
R	11671/05*	0.06	<0.01	(ND)
	11675/05*	0.07	0.02	2
S	00326/06	0.05	0.06	3
Removal with no controls				
S	00321/06*	0.05	0.21	7
R	11641/05*	0.03	0.02	3
	11643/05*	0.04	<0.01	(ND)

	11656/05*	0.06	0.01	11
	11661/05*	0.05	0.02	2
	11667/05**	0.11	0.18	8
	11668/05**	0.09	0.12	5
Y	00360/06	0.34	<0.05	(ND)
	00368/06	0.54	<0.08	(ND)
ND = non detected *NPU off, **dry				

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

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

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

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

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

***The likely airborne releases from poorly controlled removal***

The PCM results showed no clear pattern of reduction between dry and wet removal of TDCs at the two sites sampled. This is because it is difficult to 'wet' the TDC matrix (being composed of a type plastic material. The 'wetting' does however suppress the generation of dust from the the plaster, cement or other underlying material. This is in complete contrast to effective wet removal of other licensed ACMs, where uncontrolled dry removal produces a two to three order of magnitude increase in airborne fibre exposures. (The comparison between the gravimetric and PCM results show that if the total and inhalable airborne dust concentrations are controlled, then the airborne asbestos ones are also.)

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

As most of the sites had one or more rooms as the enclosure, it was not possible to sample outside the enclosure in a meaningful way. The only place where escape of airborne dust was likely was at the "airlock" exit from the enclosure but as these were generally situated outside the building it was again thought to be of little use to sample around the exit in ambient air. It is a current requirement that licensed removal sites use at least a three stage entry and exit "airlock" for person entering and exiting the enclosure with an

inward flow of air. In the draft guidance a two stage “airlock” without any inward airflow has been suggested as sufficient. To test the effectiveness of the two arrangements air monitoring was carried out inside the airlock two flaps away from the source in the enclosure, which is equivalent to the second airlock chamber.

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

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

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

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

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

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

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

In order to investigate with greater precision, the potential airborne release from the disturbance of debris remaining following removal of TDC, a simulation was carried out in the HSL 9 m<sup>3</sup> dust chamber (see IF/2006/01). This used about 100g of dry, friable dust and debris recovered from the dry removal of the TDC at site R. With an air exchange rate of 2.4 room volumes per hour, 30 minutes walking over the debris produced personal PCM

airborne fibre concentrations of ~0.014 f/ml (for all fibres, no wet-wicking was used). Given that the amount of debris was more than two orders of magnitude higher than what would be easily seen in a visually clean area and the likelihood of disturbance of such a small amount of remaining debris is much lower: it is unlikely that any remaining dust and debris following removal of TDCs would contribute significantly measurable airborne fibre concentrations to the indoor environment.

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

### ***Implications for the risk assessment***

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

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

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

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

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

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

### **Conclusions**

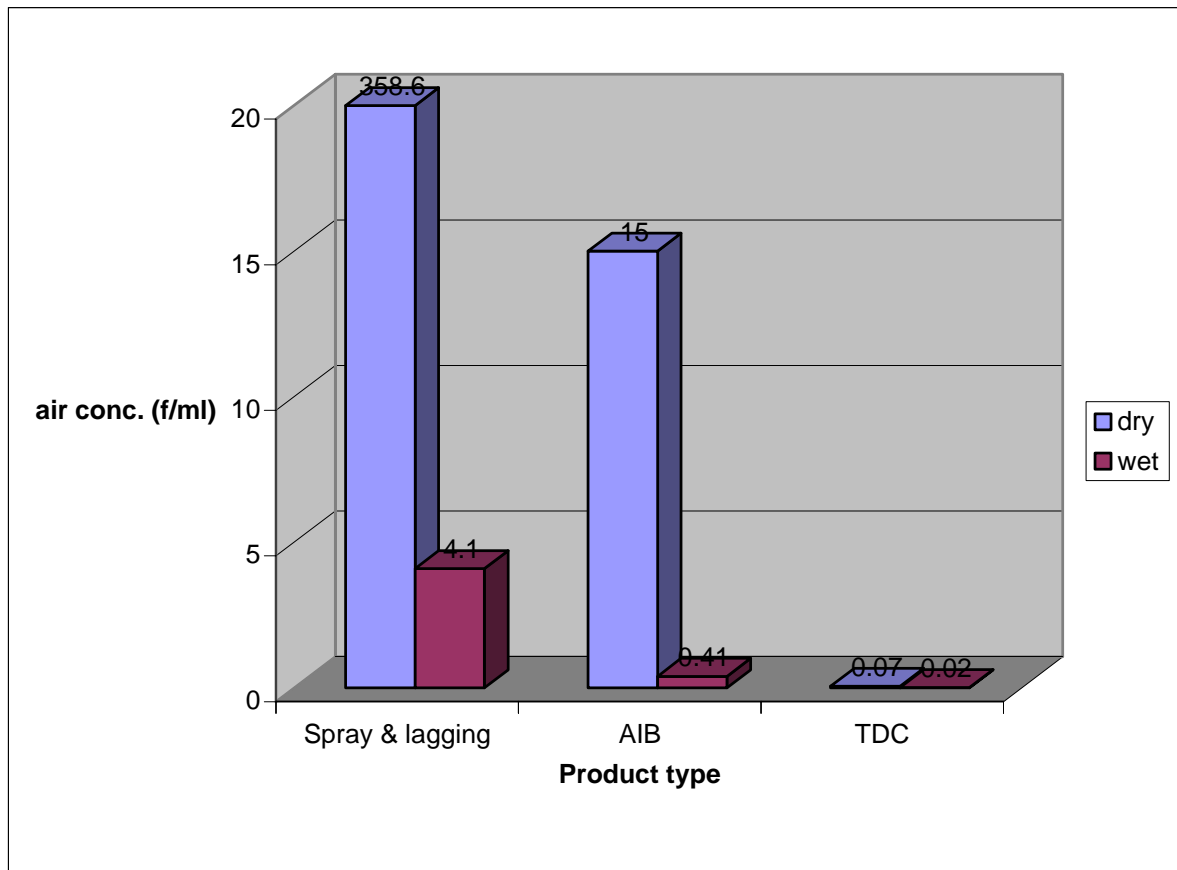
For risk assessment purposes, 0.08 f/ml provides a high upper estimate for the average annual PCM airborne asbestos fibre exposure of asbestos workers removing TDCs. It is important to note that a very conservative risk estimate would be obtained based on this figure, particularly as it does not

take account of any respiratory protective equipment worn by those undertaking TDC removal work.

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

Figures 1 and 2 below show the PCM asbestos fibre emissions from the three main categories of licensed asbestos products.

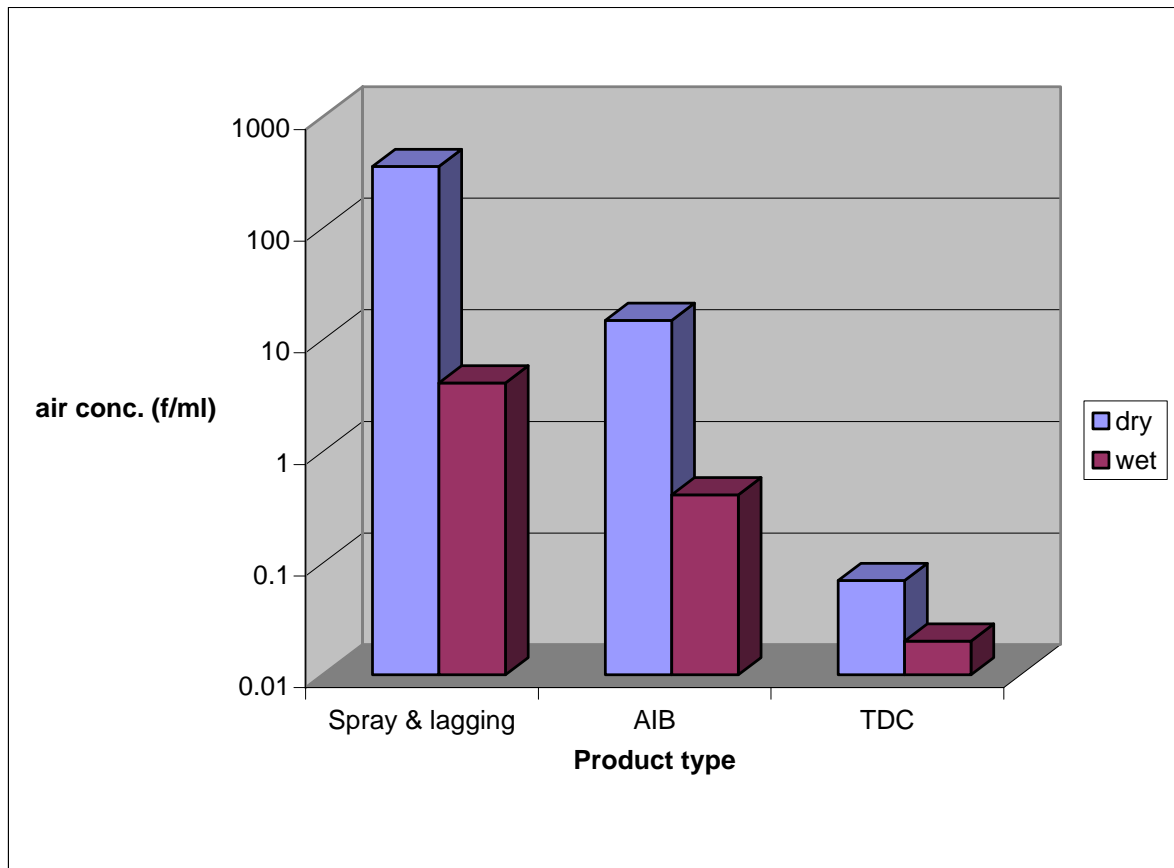
**Figure 1**



The bar graph (Figure 1) shows the relative PCM asbestos fibre emissions from the main categories of licensed asbestos products. The data represents the arithmetic average personal concentrations from HSE's database of asbestos removal concentrations and includes updated values for TDC removal from latest research. The mean values for each category are shown but Y axis ceases at 20 some 18 times lower than the average values for dry removal of sprays and laggings.

(The value for the wet removal of TDC's is an estimated value for controlled wet removal as several samples were below the analytical sensitivity.)

Figure 2



The bar graph (Figure 2) shows the relative order of magnitude (logarithmic scale) of PCM asbestos fibre emissions from the main categories of licensed asbestos products. The data represents the arithmetic average personal concentrations from HSE's data base of asbestos removal concentrations and includes updated values for TDC removal from latest research. The value for the wet removal of TDC's is an estimated value for controlled wet removal as several samples were below the analytical sensitivity.

**Abbreviations and units**

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