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**AIR QUALITY MONITORING FOR AIRBORNE DUST :
LUL TRAIN OPERATORS AND STATION STAFF**

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Executive Summary

At the request of Louise Stokes, London Underground Limited, personal dust monitoring for respirable dust exposure was undertaken on Station Staff and Train Operators at various stations and train lines. Selected samples from Train Operators were also analysed for crystalline silica. The samples were collected by respirable dust cyclone heads worn by the Station Staff and Train Operators during their shifts. In addition, static air sampling was undertaken to assist in the assessment of airborne dust levels in cases where little or no platform duties were carried out by Station Staff.

The Stations where monitoring was carried out were Hampstead, Aldgate East, Euston Square, Baker Street, Piccadilly Circus, Tottenham Court Road, Elephant & Castle, Vauxhall and Kings Cross. Train Operator dust exposure monitoring was carried out on the Central, Jubilee, Bakerloo, Circle and Hammersmith, Northern, Piccadilly, Victoria and Metropolitan (S Stock only) Lines.

For Train Operators the results showed that respirable dust concentration levels were all below 0.4 mg/m^3 . Whilst these results are not directly comparable to previous dust monitoring because Train Operator duties vary, as a good general indication, the respirable dust concentration exposure levels for Train Operators were similar to those measured previously. The lowest levels were recorded for Train Operators working on the Metropolitan Line, with the Jubilee Line also having low readings. The levels recorded for all lines were equal to or less than a tenth of the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour weighted average). No defined short term exposure limits exist for airborne dust but typically the short-term exposure limits are estimated to be 3 times the long term exposure limit i.e. 12 mg/m^3 over a 15 minute period. Therefore, the levels measured for the Train Operators were significantly below the short-term workplace exposure limit.

For Station Staff on duty the dust levels measured were also all below 0.7 mg/m^3 , and therefore well below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour weighted average). Results for the static samples were also below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour weighted average). Static samples were similar to those measured previously, with static samples situated on platforms giving the highest readings.

Lower dust concentrations were recorded from personal samples taken from staff on gate line duties than from those on platform duties. At some stations, platform duties had not been scheduled, however the combined results of personal samples from Station Staff and the static monitoring samples indicate that the respirable dust concentrations at the stations assessed were below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour time weighted average).

Selected samples taken from collectors worn by Train Operators were analysed for crystalline silica content by the Institute of Occupational Medicine. In all cases, the levels found were below the detection limit of $<0.01 \text{ mg/filter}$, and were therefore well below the Workplace Exposure Limit of 0.1 mg/m^3 .

1. Introduction

- 1.1 At the request of Louise Stokes, London Underground Limited, personal monitoring for respirable and inhalable dust exposure was to be undertaken on Station Staff conducting gate line duties, platform duties (Station Assistant Trains, SATS), other station duties and Train Operators whilst driving. Static monitoring was also carried out on platforms.
- 1.2 In addition, one sample from each Line, collected whilst monitoring Train Operator exposure, was to be analysed for crystalline silica.
- 1.3 The specific stations and locations where monitoring was requested were:

Stations	Sampling Locations
Aldgate East	Staff on platform and gate line duties. Static on District line platforms.
Baker Street	Staff on gate line and platform duties. Static on Jubilee, Bakerloo and Circle & Hammersmith line platforms.
Elephant and Castle	Static in ticket hall. Staff on gate line duties. Static on Bakerloo and Northern line platforms.
Euston Square	Staff on platform and gate line duties. Static on Circle & Hammersmith line platforms.
Hampstead	Staff on gate line and station check duties. Station supervisor. Static on Northern line platform.
King's Cross	Staff on gate line and platform duties. Static on Piccadilly and Victoria line platforms.
Piccadilly Circus	Static in ticket hall. Staff on gate line and station check duties. Static on Bakerloo line platforms.
Tottenham Court Road	Staff on gate line and platform duties and on duty at base of escalator Static on Central line platforms. Static in ticket office.
Vauxhall	Staff on gate line duties Static on Victoria line platforms.

- 1.4 Train operator monitoring was to be carried out on the Central, Bakerloo, Piccadilly, Jubilee, Northern, Circle and Hammersmith, Victoria and Metropolitan (S stock) Lines.
- 1.5 It is known that the highest levels of airborne dust are found in tunnel and cut and cover sections of the track. Therefore monitoring was not scheduled for the District Line as the Circle and Hammersmith Lines covered the relevant cut and cover sections. In addition to regular lines, monitoring was carried out on the new Metropolitan line trains (S stock) to elucidate if dust levels are affected by the use of the new trains.

2. Technical Background

- 2.1 The health effects concerning inhalation exposure to dust are dependent upon the size, shape and composition of the particles. In occupational health, general dust is classified in terms of particle size, termed either as inhalable, or respirable. The inhalable fraction of dust is defined as particles that can be inhaled and deposited throughout the respiratory tract, i.e. from the nasal to the alveolar region in the lungs. Respirable dust is the term given to dust particles that are small enough to penetrate and therefore largely deposit in the alveolar region.
- 2.2 Respirable and inhalable dusts are currently assessed against the respective Workplace Exposure Limits (WEL's) of 4 mg/m³ and 10 mg/m³ averaged over an 8-hour reference period (Health and Safety Executive Document EH40/05 and amendments October 2007). Short-term exposure limits do not currently exist for airborne dust, but usually the short-term exposure limits are taken to 3 times the long-term exposure limits.

The long term 8 hour exposure limits are averages for an 8 hour shift. Consequently, if a during a shift the operator is only exposed to a level of dust for 6 hours, to allow comparison with the HSE limits the 8 hour time weighted average exposure needs to be calculated. For the example of 6 hours exposure in an 8 hour period the time weighted average is 3/4 of the level measured for the six hour period. The values quoted in the results tables are dust concentrations, therefore they are equivalent to 8 hours exposure in an 8 hour period. Actual exposure will be less than this.

- 2.3 Prolonged exposure to respirable quartz may result in silicosis, a progressive and irreversible condition in which healthy lung tissue becomes replaced with areas of fibrosis. The HSE Workplace Exposure Limit (WEL) for respirable crystalline silica has been set at a level of 0.1 mg/m³ averaged over an 8-hour reference period (HSE Document EH40/05 and amendments October 2007).

3. Method

- 3.1 Respirable and inhalable dust levels were measured following the guidance set out in the Health & Safety Executive Document MDHS 14/3: General methods for sampling and gravimetric analysis of respirable and inhalable dust, and in house test procedure 4R-E206 Issue 5.
- 3.2 Sampling pumps equipped with inhalable dust heads and respirable dust cyclone dust heads were worn by the Train Operators and Station Staff. The locations and location codes are given in the results tables. An example of a cyclone (respirable) dust head is shown in Figure 1. Monitoring was carried out at each of the stations for one shift; timed to include the peak hours. Monitoring of the Train Operators was carried out over three shifts on each Line, again timed to include peak hours.
- 3.3 One of the primary aims was to obtain monitoring data for a shift on each occasion. This was either achieved by a sequence of individuals wearing the same sampling head, or each wearing a separate sampling head. Where separate sampling heads were used, each was run for sufficient time to allow the filter to make a measurable weight gain in order to ensure accurate results. Where the duty had to break (e.g. staff reallocated to another station) and the time achieved during personal monitoring was too short for a meaningful result the monitoring was continued as a static sample in the same location.

- 3.4 The samples were collected on glass fibre type A/E filters for gravimetric analysis, or GLA 5000 PVC filters to allow both gravimetric analysis and then subsequent analysis for respirable quartz by infrared spectroscopy.
- 3.5 In locations where there would be little or no duties on the platforms, static sampling pumps were set up in strategic locations where possible. It should however be noted that static results are not the same as personal sampling results, although they can be indicative in some circumstances.
- 3.6 Sampling periods are chosen to obtain sufficient dust on the filters for reliable gravimetric analysis.

4. Analysis

- 4.1 The samples taken on site were returned to the laboratory and gravimetric analysis undertaken in accordance with MDHS 14/3.
- 4.2 Following gravimetric analysis of the personal respirable dust samples, selected personal respirable dust samples, together with blanks were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis.

5. Results

- 5.1 Train Operators
The monitoring was aimed at assessing the level of respirable dust that Train Operators are exposed to during travel, by means of personal sampling. Selected respirable dust samples, together with blanks, were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis. In the following results summary, the focus is on the personal samples where possible.
 - 5.1.1 Central Line
The respirable dust exposure levels measured are given in Table 1. The levels measured on the 19th, 20th and 21st July 2011 were from 0.11 to 0.23 mg/m³.
 - 5.1.2 Jubilee Line
The respirable dust exposure levels measured are given in Table 2. The levels measured on the 1st, 2nd and 3rd August 2011 were from 0.09 to 0.16 mg/m³.
 - 5.1.3 Circle and Hammersmith Line
The respirable dust exposure levels measured are given in Table 3. The levels measured on the 30th, 31st August and 1st September 2011 were from 0.16 to 0.21 mg/m³.
 - 5.1.4 Northern Line
The respirable dust exposure levels measured are given in Table 4. The levels measured on the 4th, 5th and 8th August 2011 were from 0.16 to 0.21 mg/m³.
 - 5.1.5 Piccadilly Line
The respirable dust exposure levels measured are given in Table 5. The levels measured on the 27th, 28th and 29th July 2011 were from 0.16 to 0.18 mg/m³.

5.1.6 Victoria Line

The respirable dust exposure levels measured are given in Table 6. The levels measured on the 9th, 10th and 11th of August 2011 were from 0.15 to 0.20 mg/m³.

5.1.7 Bakerloo Line

The respirable dust exposure levels measured are given in Table 7. The levels measured on the 22nd, 25th and 26th July 2011 were from 0.20 to 0.30 mg/m³.

5.1.8 Metropolitan Line

The respirable dust exposure levels measured are given in Table 8. The levels measured on the 23rd, 24th and 25th August 2011 were from 0.03 to 0.07 mg/m³.

5.2 Station Staff

The monitoring was primarily aimed at assessing the exposure of staff carrying out platform duties to respirable dust by means of personal sampling. Where no platform duties were carried out static samples were taken, these however cannot directly replace personal samples. In the following results summary, the focus is on the personal samples where possible.

5.2.1 Hampstead Station

The results for the monitoring at Hampstead Station are given in Table 9. The monitoring was carried out on the 8th July 2011. The results of the personal samples for the staff on gate line/station check duties were between 0.10 and 0.50 mg/m³. The result of the static sample on the platform was 1.01 mg/m³. The station supervisor sample became slightly damaged filter and was therefore unable to be analysed. The amount of dust present on the filter was comparable to the other personal samples, as can be seen in Figure 2.

5.2.2 Baker Street Station

The results for the monitoring at Baker Street Station are given in Table 10. The monitoring was carried out on the 5th July 2011. The results for the personal samples for staff on platform/gate line duties were between 0.12 and 0.21 mg/m³. The results of the static samples on the platforms were between 0.68 and 1.23 mg/m³.

5.2.3 Euston Square Station

The results for the monitoring at Euston Square Station are given in Table 11. The monitoring was carried out on the 7th July 2011. The results of the personal samples for the staff on platform/gate line duties were between 0.58 and 0.63 mg/m³. The result of the static sample taken on the platform was 0.56 mg/m³.

5.2.4 Aldgate East

The results for the monitoring at Aldgate East Station are given in Table 12. The monitoring was carried out on the 15th July 2011. The results of the personal samples for the staff on platform/gate line duties were between 0.31-0.33 and 0.41 mg/m³. The results of the static samples from the platforms were between 0.55 and 0.66 mg/m³.

5.2.5 Elephant and Castle

The results for the monitoring at Elephant and Castle Station are given in Table 13. The monitoring was carried out on the 18th July 2011. The results for the personal/static samples for staff on gate line duty/static in ticket hall were between <0.02 and 0.08 mg/m³. The results of the static samples on the platforms were between 0.20 and 0.57 mg/m³. The result of the static sample in the ticket office was <0.02 mg/m³.

5.2.6 Piccadilly Circus Station

The results for the monitoring at Piccadilly Circus Station are given in Table 14. The monitoring was carried out on the 12th July 2011. The results for the personal samples for staff on station check/gate line duties were between 0.08 and 0.16 mg/m³. The results of the static samples on the platforms were between 0.58 and 1.00 mg/m³. The result of the static sample in the ticket hall by the barrier was 0.03 mg/m³.

5.2.7 Tottenham Court Road Station

The results for the monitoring at Tottenham Court Road Station are given in Table 15. The monitoring was carried out on the 13th July 2011. The results for the personal/static samples for members of staff on platform/gate line/bottom of escalator duties were between 0.15 and 0.40 mg/m³. The results of the static samples on the platforms were between 0.86 and 0.95 mg/m³.

5.2.8 Vauxhall Station

The results for the monitoring at Vauxhall Station are given in Table 16. The monitoring was carried out on the 14th July 2011. The results for the personal samples for staff on gate line duties were between 0.16 and 0.20 mg/m³. The results of the static samples on the platforms were between 0.63 and 0.77 mg/m³.

5.2.9 Kings Cross Station

The results for the monitoring at Kings Cross Station are given in Table 17. The monitoring was carried out on the 11th July 2011. The results for the personal samples for members of staff on platform/gate line duties were between 0.16 and 0.66 mg/m³. The results of the static samples on the platforms were between 0.48 and 0.61 mg/m³.

5.3 The IOM certificates for the analysis of quartz on the eight samples taken during the train operator monitoring across all of the different Lines, plus several blanks are included in Appendix 1. The results for each of the Lines are given in Table 20. For each filter, the level of crystalline silica present was below the detection limit (i.e. <0.01 mg/filter) which in turn gave a silica concentration of <0.01 mg/m³ for each sample taken.

6. Discussions and Conclusions

6.1 The levels of airborne respirable dust measured for personal samples on Train Operators on the following lines: Central, Jubilee, Circle and Hammersmith & City, Northern, Piccadilly, Victoria and Bakerloo were all below the Workplace exposure limit for respirable dust of 4 mg/m³ (long term 8 hour time weighted average). No limit exists for short-term exposure, but typically, short-term exposure limits are taken as 3 times the limit for long term exposure i.e. 12 mg/m³ over a 15 minute period. Therefore, the levels recorded for the train operators and station personnel were significantly below the short-term exposure limit.

The results from the new Metropolitan Line S stock trains showed dust levels to be the lowest out of all the lines monitored, as is to be expected from new trains with a high build quality.

- 6.2 The levels of respirable quartz (crystalline silica) were all less than the detection limit (i.e. <0.01 mg/filter) and thus significantly below the Workplace exposure limit of 0.1 mg/m³ (long term 8 hour time weighted average).
- 6.3 The levels of airborne respirable dust measured for personal samples taken on staff carrying out platform/gate line/station check duties as part of their shifts at the following stations: Hampstead, Baker Street, Euston Square, Aldgate East, Elephant and Castle, Kings Cross, Piccadilly Circus, Tottenham Court Road and Vauxhall were all below the Workplace exposure limit for respirable dust of 4 mg/m³ (long term 8 hour time weighted average). In any case, shifts are equal to or less than 8 hours and therefore should all be below this level.
- 6.4 Platform duties were not scheduled at all of the stations. However, the results of the static samples on the platforms and personal samples worn by personnel on the gate lines suggest that personal exposure to respirable and inhalable dust on the platforms would be below the Workplace exposure limits for respirable dust of 4 mg/m³ (long term 8 hour time weighted average).
- 6.5 Compared to the previous monitoring exercises (4RS-RH-060755-R148027, issued March 2007, 4RS-CSI-080096-R188127, issued 13th October 2008 and 4RS-MS-090457-R219301R3, issued 26th May 2010) the majority of the results for the Train Operators are very similar and consistently lower than the Workplace exposure limits for respirable dust of 4 mg/m³ (long term 8 hour time weighted average).

It should also be noted that the respirable dust levels reported for the station personnel and train operators are for the monitoring period in each case. Where a shift lasts for less than 8 hours, the 8 hour time weighted average exposure will be lower than the measured level.

- 6.6 Although not all of the duties and locations were monitored exactly the same as that performed in 2007, 2008 and 2009 those that were repeated, or performed in similar locations, generally gave similar results with no significant variations.

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 1: Central Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/86	RD	0651905, TO	19/07/11	09:41	13:12	2.1 - 2.2	460.15	0.11	Leytonstone → Epping → West Ruislip → Leytonstone → Hainault

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/91	RD	0651905 / 7164866, TO	20/07/11	09:47	10:45	2.1 - 2.2	716.45	0.15	Hainault → White City → Ealing Broadway → Hainault → Ealing Broadway → Stratford
				11:31	13:01	2.2			
				13:40	15:36	2.2			

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/41	RD	2254961 / 3989103, TO	21/07/11	07:35	11:44	2.0 - 2.2	543.8	0.23	Hainault → North Acton → Loughton → Northolt → Loughton

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 2: Jubilee Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/115	RD	3966968, TO	01/08/11	06:45	13:40	2.2	913	0.14	Wembley Park → Stratford → Stanmore → Stratford → Stanmore → Stratford

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/121	RD	3966968, TO	02/08/11	08:09	11:33	2.2	488.8	0.16	Stratford → Willesden Green → Stratford → Stanmore → Wembley Park

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/56	RD	3966968, TO	03/08/11	07:37	13:08	2.2 - 2.3	729.4	0.09	Neasden → Stanmore → Wembley Park → Stratford → Stanmore → Stratford → Neasden

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 3: Circle and Hammersmith Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/176	RD	6140669, TO	30/08/11	08:31	12:57	2.2	585.2	0.16	Hammersmith depot → Hammersmith → Moorgate → Hammersmith → Plaistow → Hammersmith → Plaistow → Hammersmith → Edgware Road

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/201	RD	6005969, TO	31/08/11	11:07	16:08	2.2	662.2	0.21	Hammersmith → Edgware Road → Edgware Road → Hammersmith → Edgware Road

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/182	RD	5244964, TO	01/09/11	09:46	14:56	2.2	682	0.18	Hammersmith → Edgware Road → Hammersmith → Edgware Road → Edgware Road
		4527806, TO							
		3888966, TO							

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 4: Northern Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/125	RD	6559767, TO	04/08/11	12:35	18:06	2.2	728.2	0.21	Morden → Bank → High Barnet → Charing Cross → Kennington → Charing Cross → High Barnet → Bank → Morden

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/130	RD	1691202, TO	05/08/11	08:11	15:13	2.2	928.4	0.19	Golders Green → Charing Cross → Kennington → Charing Cross → Edgware → Bank → Morden → Bank → Edgware → Bank → Morden → Bank

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/141	RD	2068967, TO	08/08/11	09:13	15:03	2.2	770	0.16	East Finchley → High Barnet → Charing Cross → Kennington → Charing Cross → High Barnet → Bank → Morden → Bank → High Barnet

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 5: Piccadilly Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/52	RD	5353868, TO	27/07/11	13:27	18:47	2.2 - 2.4	711.3	0.18	Arnos Grove → Cockfosters → Rayners Lane → Acton Town → Arnos Grove → Holborn

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/110	RD	8073868, TO	28/07/11	13:32	20:31	2.1-2.3	859.9	0.17	Arnos Grove → Cockfosters → Rayners Lane → Cockfosters → Arnos Grove → Uxbridge → Holborn

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/52	RD	7199769, TO	29/07/11	07:29	13:23	2.1 - 2.2	773.3	0.16	Oakwood → Heathrow T5 → Acton Town → Heathrow T5 → Cockfosters → Arnos Grove

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 6: Victoria Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/135	RD	0868962, TO	09/08/11	09:18	14:28	2.1 - 2.2	679.2	0.16	Seven Sisters → Walthamstow Central → Brixton → Seven Sisters → Walthamstow Central → Brixton → Seven Sisters

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/140	RD	4315863, TO	10/08/11	09:12	16:07	2.2	913	0.15	Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow central → Brixton → Seven Sisters → Northumberland Park Depot → Brixton
		5562868, TO							

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/146	RD	TO	11/08/11	07:52	15:31	2.2	972.4	0.20	Seven Sisters → Brixton → Seven Sisters → Brixton → Walthamstow Central → Seven Sisters → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow Central

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 7: Bakerloo Line Train Operators

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/95	RD	0432865, TO	22/07/11	09:34	10:04	2.2	409.2	0.22	Elephant and Castle → Queens Park → Elephant and Castle → Queens Park
				10:58	11:34	2.2			
				12:46	14:46	2.2			

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/46	RD	6796864, TO	26/07/11	06:35	11:51	2.2	699.6	0.20	London Road → Harrow and Wealdstone → Elephant and Castle → Stonebridge Park → Queens Park → Harrow and Wealdstone → Baker Street

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/101	RD	2530865, TO	25/07/11	09:25	12:42	2.2	433.4	0.30	Elephant and Castle → Stonebridge Park → Elephant and Castle → Stonebridge Park → Elephant and Castle

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 8: Metropolitan Line Train Operators (S Stock)

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/166	RD	6764868, TO	23/08/11	09:50	14:47	2.2	653.4	0.06	Euston Square → Uxbridge → Baker Street → Watford → Baker Street → Watford → Wembley Park
		3224707, TO							
		6784016, TO							
		1994962, TO							

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/171	RD	7361609, TO	24/08/11	10:32	14:52	2.2	572	0.03	Rickmansworth → Baker Street → Amersham → Baker Street → Amersham → Wembley Park
		0292868, TO							

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	ROUTE COVERED
110247/151	RD	0852703, TO	25/08/11	10:16	14:41	2.2	583	0.07	Harrow on the Hill → Uxbridge → Aldgate → Uxbridge → Aldgate → Wembley Park
		7019867, TO							
		7805307, TO							

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 9: Hampstead Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/12	RD	7093189	08/07/11	08:07	12:54	2.2	631.4	0.10	Gate line duty / station checks
110247/13	RD	0192189	08/07/11	08:13	10:05	2.2	246.4	0.50	Gate line duty
110247/14	RD	9594866	08/07/11	08:22	13:16	2.2	646.8	-*	Station supervisor
110247/15	RD	Static on Platform 1, northbound	08/07/11	08:35	13:35	2.2	660.0	1.01	Behind gate, by tunnel entrance.

*filter damaged, filter fibres became detached at edge during weighing

Table 10: Baker Street Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/1	RD	6107189	05/07/11	08:17	12:32	2.2	561.0	0.12	Platform / gate line duties
110247/2	RD	Static on Platform 8 tail wall, SB, Bakerloo	05/07/11	08:36	14:20	2.2	756.8	1.23	Behind gate, by tunnel entrance.
110247/3	RD	3835189	05/07/11	08:56	13:50	2.2	646.8	0.21	Platform / gate line duties
110247/4	RD	Platform 10, tail wall	05/07/11	09:36	14:27	2.2	640.2	0.68	Behind gate, by tunnel entrance.
110247/5	RD	Platform 9, head wall	05/07/11	09:40	14:24	2.2	624.8	1.00	Behind gate, by tunnel entrance.

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 11: Euston Square Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/7	RD	4054189	07/07/11	08:12	13:30	2.2	699.6	0.58	Gate line duties
110247/8	RD	9986089	07/07/11	08:16	13:30	2.2	690.8	0.63	Platform then gate line duties
110247/10	RD	Static on Platform 1, Westbound	07/07/11	08:10	13:30	2.2	704	0.56	Behind gate by tunnel entrance.

Table 12: Aldgate East Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)*	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/70	RD	0115862	15/07/11	08:36	13:02	2.2	502.8 - 585.2*	0.31 - 0.33*	Gate line duties
110247/71	RD	5256189	15/07/11	08:40	13:02	2.2	576.4	0.41	Platform then gate line duties
110247/72	RD	Static on Platform 1, Westbound	15/07/11	08:53	13:04	2.2	552.2	0.55	Behind gate by tunnel entrance.
110247/73	RD	Static on Platform 2, Eastbound	15/07/11	08:57	13:06	2.2	547.8	0.66	Behind gate by tunnel entrance.

*Pump found to have been accidentally turned off between 10:55 and 11:32 hence range of values

Air Quality Monitoring for Airborne Dust: Train Operators and Platform Staff

Table 13: Elephant and Castle Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/77	RD	Top of assistance booth	18/07/11	09:01	13:03	2.2	532.4	<0.02	Bakerloo line ticket hall
110247/78	RD	Static Platform 1, NB, Northern line	18/07/11	08:39	12:57	2.2 - 2.3	571.2	0.57	Behind gate by tunnel entrance.
110247/79	RD	Static Platform 3, NB, Bakerloo line	18/07/11	08:31	12:54	2.2 - 2.1	573.5	0.20	Behind gate by tunnel entrance.
110247/80	RD	7711073 / static in ticket hall	18/07/11	08:46	12:52	2.2 - 2.4	472.2	<0.02	Gate line duties / static in ticket hall
110247/81	RD	0330865 / static in ticket hall	18/07/11	08:35	13:07	2.0 - 2.4	475.2	0.08	Gate line duties / static in ticket hall

Table 14: Piccadilly Circus Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/26	RD	1412189 / 6571186 / 7975186	12/07/11	08:03	12:26	2.2	578.6	0.16	Gate line duties / station checks
110247/27	RD	7245189	12/07/11	08:19	11:16	2.2	389.4	0.08	Gate line duties / station checks
110247/28	RD	Static, Bakerloo SB	12/07/11	08:25	12:46	2.2	574.2	1.00	Behind gate by tunnel entrance.
110247/29	RD	Static, Piccadilly WB	12/07/11	08:32	12:50	2.2 - 2.3	579.4	0.58	Behind gate by tunnel entrance.
110247/30	RD	Ticket hall	12/07/11	08:48	12:53	2.2	539.0	0.03	By barrier

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Table 15: Tottenham Court Road Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/35	RD	9843189 / static in ticket hall	13/07/11	08:30	13:09	2.1 - 2.2	610.8	0.40	Platform duties, then static in ticket hall
110247/36	RD	7549962 / 2202189	13/07/11	08:43	12:07	2.2	448.8	0.32	Duty at bottom of escalator, then gate line
110247/37	RD	8341967	13/07/11	08:52	12:07	2.2	429.0	0.15	Gate line duties
110247/38	RD	Static, Central line EB	13/07/11	08:34	13:09	2.2 - 2.3	608.0	0.95	Behind gate by tunnel entrance.
110247/39	RD	Static, Central line WB	13/07/11	08:38	13:09	2.2	596.2	0.86	Behind gate by tunnel entrance.

Table 16: Vauxhall Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/63	RD	1311072 / 5342189	14/07/11	08:32	12:01	2.2	454.7	0.20	Gate line duties
110247/64	RD	1024189	14/07/11	08:29	12:00	2.2	464.2	0.16	Gate line duties
110247/65	RD	Static on Platform 1, Victoria, NB	14/07/11	08:36	12:06	2.2	465.6	0.63	Behind gate by tunnel entrance.
110247/66	RD	Static on Platform 2, Victoria, SB	14/07/11	08:38	12:03	2.2	451.0	0.77	Behind gate by tunnel entrance.

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Table 17: Kings Cross Station

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	START TIME	FINISH TIME	FLOW RATE (l/min)	VOLUME OF AIR (litres)	CALC. DUST CONC ^N (MG/M ³)	LOCATIONS & COMMENTS
110247/17	RD	Static, Piccadilly WB	11/07/11	08:43	13:00	2.2	565.4	0.61	Behind gate by tunnel entrance.
110247/19	RD	4455189 / 5067189	11/07/11	08:38	12:32	2.2	514.8	0.66	Mainly platform and then some gate line duties
110247/20	RD	Static, Victoria NB	11/07/11	08:29	13:03	2.2	602.8	0.48	Behind gate by tunnel entrance.
110247/21	RD	7215189	11/07/11	08:23	11:26	2.2	402.6	0.29	Platform and gate line duties
110247/22	RD	9782089	11/07/11	08:58	12:30	2.2	466.4	0.16	Gate line duties

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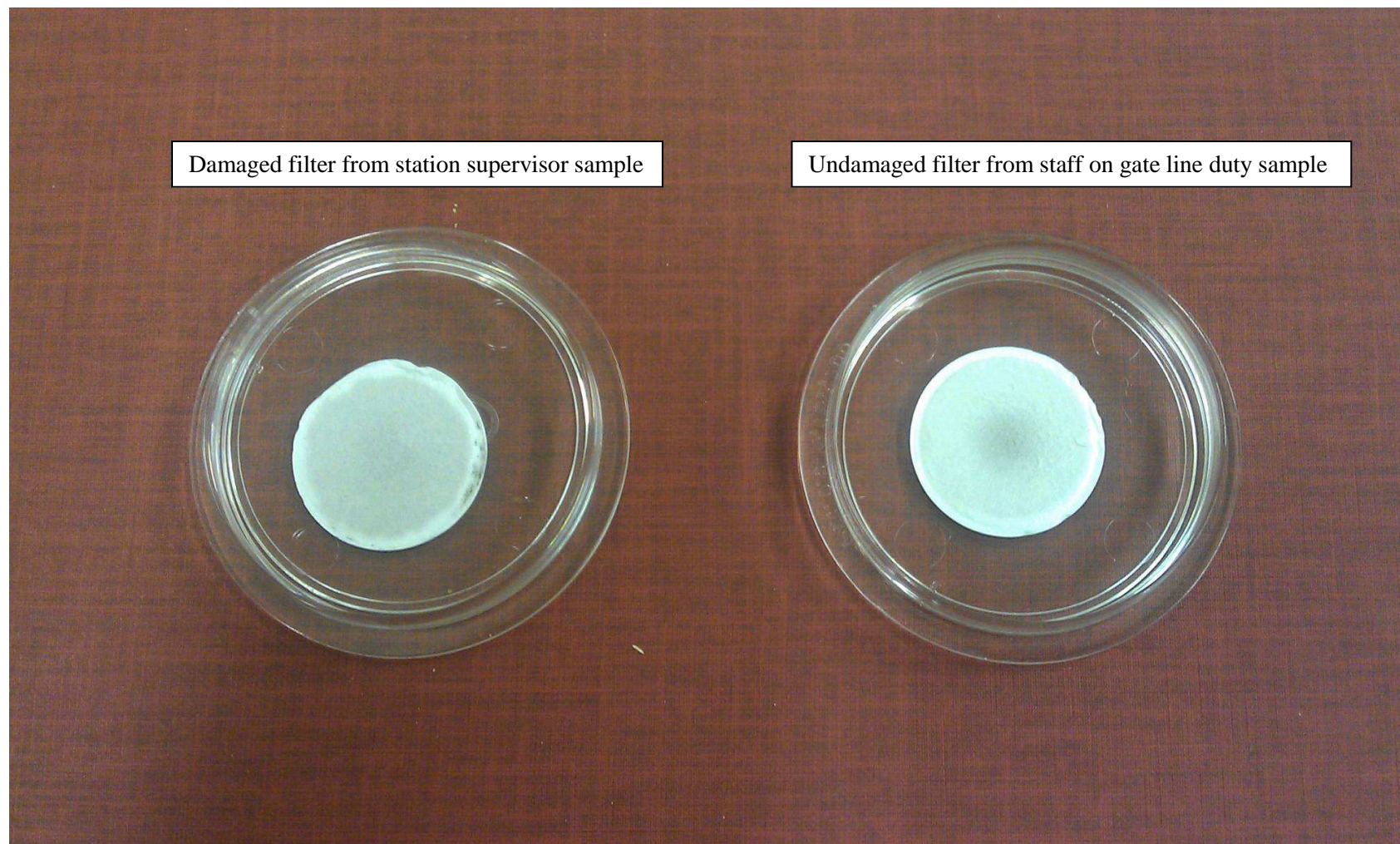
Table 20: Train Operator Respirable Crystalline Silica Monitoring

FILTER NUMBER	SAMPLE TYPE (RESPIRABLE DUST, RD, INHALABLE DUST, ID)	SAMPLE LOCATION	DATE	VOLUME OF AIR (litres)	CRYSTALLINE SILICA (mg/filter)	CRYSTALLINE SILICA (mg/m ³)	LOCATIONS & COMMENTS
110247/41	RD	Central Line Train Operators Driving Trains	19/07/11	460.15	< 0.01	< 0.01	Hainault → North Acton → Loughton → Northolt → Loughton
110247/56	RD	Jubilee Line Train Operator Driving Trains	03/08/11	729.4	< 0.01	< 0.01	Neasden → Stanmore → Wembley Park → Stratford → Stanmore → Stratford → Neasden
110247/182	RD	Circle Line Train Operator Driving Trains	01/09/11	682	< 0.01	< 0.01	Hammersmith → Edgware Road → Hammersmith → Edgware Road → Edgware Road
110247/141	RD	Northern Line Train Operator Driving Trains	08/08/11	770	< 0.01	< 0.01	East Finchley → High Barnet → Charing Cross → Kennington → Charing Cross → High Barnet → Bank → Morden → Bank → High Barnet
110247/52	RD	Piccadilly Line Train Operator Driving Trains	29/07/11	773.3	< 0.01	<0.01	Oakwood → Heathrow T5 → Acton Town → Heathrow T5 → Cockfosters → Arnos Grove
110247/146	RD	Victoria Line Train Operator Driving Trains	11/08/11	972.4	< 0.01	< 0.01	Seven Sisters → Brixton → Seven Sisters → Brixton → Walthamstow Central → Seven Sisters → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow Central
110247/101	RD	Bakerloo Line Train Operator Driving Trains	25/07/11	433.4	< 0.01	< 0.01	Elephant and Castle → Stonebridge Park → Elephant and Castle → Stonebridge Park → Elephant and Castle
110247/151	RD	Metropolitan Line Train Operator Driving Trains	25/08/11	583	<0.01	<0.01	Harrow on the Hill → Uxbridge → Aldgate → Uxbridge → Aldgate → Wembley Park

Figure 1 : Cyclone Dust Head



Figure 2 : Damaged and undamaged filters from Hampstead Station



Appendix 1 : Crystalline Respirable Silica Results



WORKING FOR A HEALTHY FUTURE

CERTIFICATE OF ANALYSIS

ANALYSIS REQUESTED BY: Chris Isgrove
4-Rail Services Ltd
Unit 11
Ironbridge Close
Great Central Way
London
NW10 0UF

CONTRACT NO: 26265
PROJECT NO: 610
DATE OF ISSUE: 08/09/2011

DATE SAMPLE RECEIVED: 06/09/2011

DATE SAMPLE ANALYSED: 07/09/2011

SAMPLES: 25mm "GLA-5000" PVC filters

NO. OF SAMPLES: Seventeen

ANALYSIS REQUESTED: Quartz

METHOD: The samples were prepared for analysis in accordance with in-house method IM 2 using a modification of MDHS 101

MDHS 101: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

RESEARCH CONSULTING SERVICES

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CONTRACT NO: 26265

PROJECT NO: 610

DATE OF ISSUE: 08/09/2011

RESULTS:

Sample reference	Quartz weight (mg)
100247/41	<0.01
100247/42	<0.01
100247/43	<0.01
100247/46	<0.01
100247/47	<0.01
100247/51	<0.01
100247/52	<0.01
100247/56	<0.01
100247/57	<0.01
100247/141	<0.01
100247/142	<0.01
100247/146	<0.01
100247/147	<0.01
100247/151	<0.01
100247/152	<0.01
100247/181	<0.01
100247/182	<0.01

Our detection limit for quartz by this method is 0.01mg.

COMMENTS:

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients, this includes calculated results based on the clients sampling information

Any opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

ANALYSED BY:



Jean Forbes
Chemist

AUTHORISED BY:



Carolyn McGonagle
Senior Chemist

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