Scientific Services
for Transport & Industry

4-RAIL Services Ltd

Head Office: Unit 3, Metro Centre,
Britannia Way, London, NW10 7PA
Phone: 020 8955 9680 Fax: 020 8955 9689

Laboratory: Unit 11, Ironbridge Close,
Great Central Way, London, NW10 0UF
Phone: 020 8955 1700 Fax: 020 8830 1003
Email: enquiries@4-rail.com
Web: www.4-rail.com

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

Prepared for: *Louise Stokes*
London Underground Limited
5th Floor Albany House
Petty France
London
SW1H 9EA

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Prepared by: *R Lopez*

Signature: ..... [redacted] *.....*

Certified by: *Dr I R Girling*
Senior Consultant

Signature: ..... [redacted] *...*

VAT Registration No: 691 5975 82
Registered Office: Unit 3, Metro Centre,
Britannia Way, London, NW10 7PA
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FURTHER INFORMATION.

REQUESTS FOR ADDITIONAL INFORMATION ON THE SUBJECT OF THIS REPORT OR OTHER QUERIES SHOULD BE ADDRESSED TO THE AUTHOR.

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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, Kings Cross and Paddington. Train Operator dust exposure monitoring was carried out on the Central, Jubilee, Bakerloo, Circle and Hammersmith, Northern, Piccadilly and Victoria Lines.

For Train Operators the results showed that respirable dust concentration levels were all below 0.56 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 Central Line. The levels recorded for all lines were significantly less than 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 all below 0.68 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 mg/filter, and were therefore well below the Workplace Exposure Limit of 0.1 mg/m^3 (long term 8 hour time weighted average).

1. Introduction

1.1 At the request of Louise Stokes, London Underground Limited, personal monitoring for respirable dust exposure was to be undertaken on Train Operators whilst driving and Station Staff conducting gate line duties, platform duties (Station Assistant Trains, SAT) and other station duties.

1.2 Static monitoring was also carried out on various platforms. 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	Sample Type
Aldgate East	Platform and gate line duties	Personal
	District line platforms	Static
Baker Street	Gate line, platform & station checks duties	Personal
	Hammersmith and Circle line platforms	Static
Elephant and Castle	Gate line and platform duties.	Personal
	Bakerloo and Northern line platforms.	Static
Euston Square	Platform, gate line duties & Station Supervisor	Personal
	Circle & Hammersmith line platforms	Static
Hampstead	Gate line, station checks duties & Station Supervisor	Personal
	Northern line platforms	Static
King's Cross	Gate line, platform & station checks duties	Personal
	Victoria line platforms	Static
Piccadilly Circus	Gate line, platform & station checks duties	Personal
	Piccadilly line platforms	Static
Tottenham Court Rd	Staff on gate line and platform duties	Personal
Vauxhall	Gate line duties and platforms	Personal
	Northern line platforms	Static
Paddington	Gate line duties and Station supervisor	Personal
	Bakerloo line platforms	Static

1.4 Train operator monitoring was to be carried out on the Central, Bakerloo, Piccadilly, Jubilee, Northern, Circle and Hammersmith & City and Victoria 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 or Metropolitan Line as the Circle and Hammersmith Lines covered the relevant cut and cover sections.

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/m^3 and 10 mg/m^3 averaged over an 8-hour reference period (Health and Safety Executive Document EH40/05, 2nd Edition 2011). Short-term exposure limits do not currently exist for airborne dust, but usually the short-term exposure limits are taken to be 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/m^3 averaged over an 8-hour reference period (HSE Document EH40/05, 2nd Edition 2011).

3. Method

3.1 Respirable 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 respirable dust cyclone dust heads as appropriate 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.

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.

- Central Line
  The respirable dust exposure levels measured are given in Table 1. The levels measured on the 17th and 18th of December 2012 and on the 16th April 2013 for the Train Operators were from 0.08 – 0.54 mg/m^3.

- Jubilee Line
  The respirable dust exposure levels measured are given in Table 2. The levels measured on the 7th, 8th and 9th of January and the 15th April 2013 for the Train Operators were from 0.15 to 0.34 mg/m^3.

- Circle and Hammersmith Lines
  The respirable dust exposure levels measured are given in Table 3. The levels measured on the 18th and 22nd of January and 17th April 2013 for the Train Operators were from 0.19 to 0.47 mg/m^3.

- Northern Line
  The respirable dust exposure levels measured are given in Table 4. The levels measured on the 10th, 11th and 14th of January 2013 for the Train Operators were from 0.16 to 0.26 mg/m^3.

- Piccadilly Line
  The respirable dust exposure levels measured are given in Table 5. The levels measured on the 2nd, 3rd and 4th of January 2013 for the Train Operators were from 0.11 to 0.29 mg/m^3.

- Victoria Line
  The respirable dust exposure levels measured are given in Table 6. The levels measured on the 15th, 16th and 17th of January 2013 for the Train Operators were from 0.27 to 0.29 mg/m^3.

- Bakerloo Line
  The respirable dust exposure levels measured are given in Table 7. The levels measured on the 20th, 21st and 27th of December 2012 for the Train Operators were from 0.26 to 0.56 mg/m^3.

5.2 Station Staff

The dust levels in stations are known to be highest on the station platforms and on some gate line areas where the air currents carry dust from the platforms and tunnels past the gate line. The aim of the monitoring is to ensure that exposure is ALARP (as low as reasonably practicable) hence the monitoring was conducted in primarily in gate line and platform areas.

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.

- Hampstead Station
  The results for the monitoring at Hampstead Station are given in Table 8. The monitoring was carried out on the 29th of January 2013. The results of the personal samples for the staff on platform lift /station supervisor duties were between 0.04 and 0.64 mg/m^3. The results of the static samples on the platforms/ gate line were between 0.52 and 0.74 mg/m^3.

- Baker Street Station
  The results for the monitoring at Baker Street Station are given in Table 9. The monitoring was carried out on 24th of January 2013. The results for the personal samples for staff on platform/gate line duties were between 0.07 and 0.39 mg/m^3. The result of the static sample on the platform was 0.25 mg/m^3.

- Euston Square Station
  The results for the monitoring at Euston Square Station are given in Table 10. The monitoring was carried out on the 28th of January 2013. The results of the personal samples for the staff on platform/gate line duties and Station Supervisor were 0.18 and 0.47 mg/m^3. The results of the static samples taken on the platforms were 0.62 and 0.73 mg/m^3.

- Aldgate East
  The results for the monitoring at Aldgate East Station are given in Table 11. The monitoring was carried out on the 23th of January 2013. The results of the personal samples for the staff on platform/station checks/gate line duties were 0.05 and 0.58 mg/m^3. The results of the static samples from the platforms were between 0.58 and 0.70 mg/m^3.

- Elephant and Castle
  The results for the monitoring at Elephant and Castle Station are given in Table 12. The monitoring was carried out on the 25th of January 2013. The results for the personal samples for staff on platform/gate line duties were between 0.01 and 0.50 mg/m^3. The results of the static samples on the platforms were between 0.16 and 0.73 mg/m^3.

- Piccadilly Circus Station
  The results for the monitoring at Piccadilly Circus Station are given in Table 13. The monitoring was carried out on the 31st of January 2013. The results for the personal samples for staff on platform/station checks/gate line duties were between 0.23 and 0.36 mg/m^3. The results of the static samples on the platforms were 0.59 and 0.68 mg/m^3.

- Tottenham Court Road Station
  The results for the monitoring at Tottenham Court Road Station are given in Table 14. The monitoring was carried out on the 1st of February 2013. The results for the personal samples for members of staff on platform/station checks/station supervisor office/gate line duties were between 0.02 and 0.68 mg/m^3.

- Vauxhall Station
  The results for the monitoring at Vauxhall Station are given in Table 15. The monitoring was carried out on the 4th of February 2013. The results for the personal samples for staff on platform/gate line duties were between 0.14 and 0.52 mg/m^3. The results of the static samples on the platforms were 0.36 and 0.54 mg/m^3.

- Kings Cross Station
  The results for the monitoring at Kings Cross Station are given in Table 16. The monitoring was carried out on the 30th of January 2013. The results for the personal samples for members of staff on platform/gate line/station supervisor office/station checks duties were between 0.1 and 0.24 mg/m^3. The results of the static samples on the platforms were 0.26 and 0.44 mg/m^3.

- Paddington Station
  The results for the monitoring at Paddington Station are given in Table 17. The monitoring was carried out on the 5th of February 2013. The results for the personal samples for members of staff on gate line/station supervisor duties were between 0.18 and 0.49 mg/m^3. The results of the static samples on the platforms were 0.78 and 0.96 mg/m^3.

5.3 The IOM certificate for the analysis of quartz on the samples taken during the train operator monitoring across all of the different Lines is 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 found was below the detection limit of the analytical method i.e. <0.01mg/filter. The calculated levels of airborne respirable crystalline silica where therefore all <0.016 mg/m^3 when the volume of air sampled was accounted for.

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/m^3 (long-term 8 hour time weighted average). No limit exists for short-term exposure, but typically, short-term exposure limits are taken as three times the limit for long-term exposure i.e. 12 mg/m^3 over a 15 minute period. Therefore, the levels recorded for the train operators and station personnel were significantly below the short-term exposure limit.

6.2 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, Vauxhall and Paddington were all below the Workplace exposure limits for respirable and inhalable dust of 4 mg/m^3 and 10 mg/m^3 respectively (long-term 8 hour time weighted average). In any case, shifts are equal to or less than 8 hours when trains are running so they should all be below the 4 mg/m^3 limit.

6.3 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/m^3 (long term 8 hour time weighted average).

6.4 Compared to the previous monitoring exercises (4RS-RH-060755-R148027, issued March 2007, 4RS-CSI-080096-R188127, issued 13th October 2008, 4RS-MS-090457-R219301R3, issued 26th May 2010 and 4RS-MS-110247-R317726, issued 6th October 2011) the majority of the results for the Train Operators are similar and consistently lower than the Workplace exposure limits for respirable dust of 4mg/m^3 (long-term 8 hours time weighted average).

6.5 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 hours 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, 2009 and 2011 those that were repeated, or performed in similar locations, generally gave similar results with no significant variations.

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
120749/09	RD	[redacted] Rail Analyst	17/12/12	08:35 12:20	11:40 16:20	2.2	935	0.08	Hainault → White City→ Loughton→ White City→ Ealing Broadway→ Hainault→Ealing Broadway→ Hainault
120749/10	RD	[redacted] TO - Driver	17/12/12	08:36 12:21	11:41 16:21	2.2	935	0.08	

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
120749/11	RD	[redacted] - 4-Rail Analyst	18/12/12	09:00 12:45	12:00 16:35	2.2	902	0.14	Leytonstone→ Epping → West Ruislip → Leytonstone → Epping → West Ruislip → Epping → Loughton
120749/12	RD	[redacted] TO - Driver	18/12/12	09:01 12:46	12:01 16:36	2.2	902	0.03	

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
120749/115	RD	[redacted] - 4-Rail Analyst	16/04/13	08:40 10:36	09:36 13:43	2.21	537.4	0.51	Hainault → White City → Hainault → Ealing Broadway → Woodford →Leytonstone
120749/116	RD	[redacted] TO - Driver	16/04/13	08:39 10:36	09:35 13:45	2.1	501.2	0.54	

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
120749/39	RD	[redacted] TO - Driver	07/01/13	07:35	11:15	2.05	810.8	0.23	Stratford → Stanmore → Stratford → Stanmore → Wembley Park → Stanmore → Stratford → Stanmore → Stratford
				12:30	15:51	2.1			
120749/38	RD	[redacted] - 4-Rail Analyst	07/01/13	07:38	11:13	2.15	898.15	NA*	
				12:30	15:46	2.15			

*Filter Damage.

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
120749/43	RD	[redacted] TO - Driver	08/01/13	07:14	08:01	2.2	462.5	0.15	Stratford →Wembley Park → Stratford → Wembley Park → Stratford
				09:07	11:55	2.1			
120749/44	RD	[redacted] - 4-Rail Analyst	08/01/13	07:15	08:00	2.2	462	0.17	
				09:07	11:52	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
120749/285	RD	[redacted] TO - Driver	15/04/13	08:45	10:09	2.1	608.5	0.34	Stratford → Stanmore → Wembley Park → Stanmore → Stratford → Stanmore → Stratford
				11:22	14:42	2.15			
120749/286	RD	[redacted] - 4-Rail Analyst	15/04/13	08:45	10:10	2.15	612.25	0.86	
				11:22	14:39	2.16			

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
120749/48	RD	[redacted] 4-Rail Analyst	09/01/13*	08:30	12:15	2.15	921.75	0.12	Wembley Park → Stratford → Willesden Green → Stratford → Wembley Park → Stratford → Willesden Green → Stratford → Wembley Park
				13:30	16:45				

*Run where the filter used for the Train Operator was found to be damaged and the shift repeated. This filter was submitted for analysis of respirable silica as close to 8hr monitoring achieved.

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
120749/82	RD	[redacted] TO - Driver	18/01/13	08:54	12:05	2.2	633.6	0.38	Edgware Road → Hammersmith → Barking → Hammersmith → Edgware Road → Moorgate → Hammersmith → Edgware Road
				13:01	14:38				
120749/83	RD	[redacted] - 4-Rail Analyst	18/01/13	08:55	12:06	2.1	627.6	0.44	
				13:01	14:38	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
120749/104	RD	[redacted] - 4-Rail Analyst	22/01/13	08:50	11:04	2.2	793.45	0.27	Edgware Road → Hammersmith → Plaistow → Edgware Road → Barking → Hammersmith → Barking → Edgware Road
				11:57	15:44	2.2			
120749/103	RD	[redacted] TO - Driver	22/01/13	08:50	11:03	2.2	769	0.19	
				11:56	15:47	2.15			

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
120749/279	RD	[redacted] - 4-Rail Analyst	17/04/13	08:04	10:53	2.15	691	1.11	Edgware Road → Edgware Road Edgware Road → Hammersmith → Edgware Road Edgware Road → Edgware Road → Hammersmith → Edgware Road
				11:50	14:22	2.19			
120749/280	RD	[redacted] TO - Driver	17/04/13	08:04	10:52	2.2	705	0.47	
				11:49	14:27	2.1			

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
120749/53	RD	[redacted]- 4-Rail Analyst	11/01/13	08:47	11:47	2.15	786.4	0.13	Morden → High Barnet → Kennington Charing Cross → East Finchley → Morden → High Barnet → Morden
				12:15	13:15	2.15			
				14:20	16:20	2.2			
120749/54	RD	[redacted] TO - Driver	11/01/13	08:46	11:46	2.15	787.7	0.16	
				12:16	13:16	2.2			
				14:21	16:21	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
120749/63	RD	[redacted] TO - Driver	14/01/13	08:51	12:05	2.2	855.8	0.19	High Barnet → Kennington Edgware→ Morden → High Barnet → Kennington→ High Barnet
				12:47	16:00	2.2			
120749/64	RD	[redacted]- 4-Rail Analyst	14/01/13	08:52	12:03	2.15	819.8	0.22	
				12:50	15:53	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
120749/58	RD	[redacted] TO - Driver	10/01/13	08:40	10:59	2.15	582.05	0.26	Golders Green → Edgware → Kennington → Edgware → Golders Green → Edgware → Golders Green → Colindale → Kennington → Golders Green
				11:21	12:03	2.2			
				15:03	16:30	2.15			
120749/59	RD	[redacted]- 4-Rail Analyst	10/01/13	08:45	10:59	2.2	580.8	0.31	
				11:23	12:02				
				15:00	16:31				

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
120749/05	RD	[redacted]- 4-Rail Analyst	02/01/13	09:11 12:58	12:11 16:40	2.2	884.4	0.19	Arnos Grove → Heathrow T4 → Arnos Grove → Cockfosters → Heathrow T4 → Cockfosters → Arnos Grove
120749/06	RD	[redacted]TO - Driver	02/01/13	09:10 12:57	12:10 16:41	2.2	888.8	0.28	

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
120749/32	RD	[redacted]- 4-Rail Analyst	03/01/13	10:08 12:55	11:10 14:55	2.2	400.4	0.27	Acton Town → Rayners Lane → Acton Town → Cockfosters → Arnos Grove → Acton Town
120749/33	RD	[redacted]TO - Driver	03/01/13	10:07 12:56	11:10 14:56	2.2	402.6	0.11	

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
120749/26	RD	[redacted] TO – Driver	04/01/13	09:06	12:26	2.15	882.1	0.29	Acton Town → Heathrow T 1,2,3 & 5 → Cockfosters → Acton Town* Acton Town → Heathrow T 1,2,3 & 5 → Cockfosters → Acton Town
		[redacted] TO - Driver		12:46	16:10	2.15			
120749/27	RD	[redacted]- 4-Rail Analyst	04/01/13	09:08 12:47	12:22 16:00	2.2	851.4	0.31	

*Change of Train Operator

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
120749/68	RD	[redacted] TO - Driver	15/01/13	08:43	11:24	2.2	690.8	0.29	Brixton → Seven Sisters → Brixton → Seven Sisters → Northumberland Park Depot → Brixton → Walthamstow Central → Brixton → King's Cross → Brixton
				13:58	16:31				
120749/69	RD	[redacted] - 4-Rail Analyst	15/01/13	08:45	11:25	2.2	679	0.29	
				14:00	16:30	2.15			

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
120749/78	RD	[redacted] TO - Driver	16/01/13	08:35	11:59	2.2	795.3	0.27	Seven Sisters → Brixton → Seven Sisters → Northumberland Park Depot → Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Seven Sisters
				13:16	16:16	1.1 *			
120749/79	RD	[redacted] 4-Rail Analyst	16/01/13	08:36	11:58	2.2	831.6	0.28	
				13:19	16:15				

*Pump found to have been accidentally turned off between 15:31 and 16:16 hence range of values.

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
120749/73	RD	[redacted] 4-Rail Analyst	17/01/13	08:46	12:12	2.25	842.5	0.38	Seven Sisters → Sidings → Seven Sisters → Brixton → Seven Sisters → Northumberland Park Depot → Brixton → Walthamstow Central→ Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Seven Sisters
				13:20	16:17	2.15			
120749/74	RD	[redacted] TO - Driver	17/01/13	08:45	12:13	2.25	853.4	0.27	
				13:19	16:19	2.15			

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
120749/03	RD	[redacted] TO - Driver	20/12/12	08:44	12:28	2.2	492.8	0.26	Elephant & Castle → Harrow& Wealdstone → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park
				13:48	16:20	2.15	331.4		
120749/04	RD	[redacted] - 4-Rail Analyst	20/12/12	08:47	12:29	2.2	488.4	0.29	
				13:54	16:15	2.15	302.8		

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
120749/13	RD	[redacted] TO - Driver	21/12/12	09:38	11:53	2.2	645	0.56	Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Stonebridge Park → Elephant & Castle
				14:08	16:59				
120749/15	RD	[redacted] 4-Rail Analyst	21/12/12	09:39	11:54	2.2	641.85	0.17	
				14:09	17:00				

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
120749/20	RD	[redacted] TO - Driver	27/12/12	10:19	12:43	2.2	758.05	0.36	Elephant & Castle → Harrow & Wealdstone → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Stonebridge Park → Elephant & Castle
				13:35	16:57	2.15			
120749/21	RD	[redacted] - 4-Rail Analyst	27/12/12	10:21	12:44	2.2	744	0.30	
				13:36	16:58	2.05			

Table 8: 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
120749/182	RD	Static on Platform 2 head wall, NB	29/01/13	07:15	11:15	2.25	534	0.53	Behind gate, by tunnel entrance.
120749/183	RD	[redacted] 4-Rail Analyst	29/01/13	08:00	09:30	2.2	198	0.64	Platforms and Lifts
120749/184	RD	Static on Platform 1 head wall, SB	29/01/13	07:20	11:20	2.15	522	0.74	Behind gate, by tunnel entrance.
120749/185	RD	Static on Heath Street Gate Line	29/01/13	07:35	10:35	2.2	396	0.52	Gate line duty position
120749/186	RD	[redacted] Station Personnel	29/01/13	07:40	11:40	2.2	528	0.04	Station Supervisor

Table 9: 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
120749/137	RD	[redacted] Station Personnel	24/01/13	07:45	10:30	2.15	360	0.39	S.A.T., Platform 7
120749/139	RD	[redacted] Station Personnel	24/01/13	07:42	12:12	2.2	594	0.07	Madame Tussauds/Marylebone Gate line duty
120749/140	RD	[redacted] Station Personnel	24/01/13	07:50	11:00	2.15	412	0.19	Gate line duty
120749/141	RD	Static on Platform 5 head wall, EB	24/01/13	08:00	12:15	2.2	561	0.25	Behind gate, by tunnel entrance.

Table 10: 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
120749/146	RD	[redacted] Station Personnel	28/01/13	07:56	09:27	2.2	200.2	0.18	Station Supervisor
120749/147	RD	[redacted] Station Personnel	28/01/13	08:00	12:44	2.15	622.1	0.47	Platform / Gate line duties
120749/148	RD	Static on Platform 2 head wall, Eastbound	28/01/13	08:11	12:52	2.1	613.3	0.73	Behind gate by tunnel entrance.
120749/150	RD	Static on Platform 1 head wall, Westbound	28/01/13	08:05	13:01	2.2	652.95	0.62	Behind gate by tunnel entrance.

Table 11: 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
120749/130	RD	[redacted] - 4-Rail Analyst	23/01/13	08:16	09:20	2.2	140.8	0.58	Shadowing S.A.T. on Platform 1
120749/131	RD	[redacted] Station Personnel	23/01/13	07:45	12:20	2.2	605	0.05	Station checks / Gate line duties, exits 1& 2 and 3&4
120749/132	RD	Static on Platform 1 head wall, Westbound	23/01/13	07:50	12:21	2.15	593.2	0.58	Behind gate by tunnel entrance.
120749/133	RD	Static on Platform 2 head wall, Eastbound	23/01/13	08:15	12:22	2.15	540.4	0.70	Behind gate by tunnel entrance.

Table 12: 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
120749/173	RD	[redacted] Station Personnel	25/01/13	08:00	09:20	2.2	176	0.50	Platform 1 Duties
120749/174	RD	[redacted] – 4-Rail Analyst	25/01/13	08:07	09:12	2.25	138	0.41	Platform 2
120749/176	RD	Static on Platform 1 head wall, NB	25/01/13	08:05	12:41	2.0	552	0.66	Behind gate by tunnel entrance.
120749/177	RD	Static on Platform 2 head wall, SB	25/01/13	08:16	12:35	2.0	518.9	0.73	Behind gate by tunnel entrance.
120749/170	RD	Static on Platform 3 head wall, NB	25/01/13	10:10	12:45	2.1	335	0.16	Behind gate by tunnel entrance.
120749/178	RD	[redacted]	25/01/13	09:44	11:20	2.2	211.2	0.01	Gate line duties, Bakerloo line exit

Table 13: 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
120749/162	RD	[redacted] Station Personnel	31/01/13	07:43	12:39	2.15	648.2	0.25	Platform 3 / station checks/ Gate line duties
120749/163	RD	[redacted] Station Personnel	31/01/13	08:04	11:34	2.10	456	0.36	Gate line duties/ Platform 3 / station checks
120749/164	RD	[redacted] Station Personnel	31/01/13	08:15	11:43	2.15	454.6	0.23	Gate line duties/ Platform 4 / station checks
120749/167	RD	Static on Platform 3 head wall, EB	31/01/13	08:23	12:14	2.2	530.2	0.68	Behind gate by tunnel entrance.
120749/168	RD	Static on Platform 4 head wall, WB	31/01/13	08:27	12:17	2.1	501.2	0.59	Behind gate by tunnel entrance.

Table 14: 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
120749/190	RD	[redacted]0 Station Personnel	01/02/13	07:25	10:55	2.15	458.75	0.20	S.A.T on Platform 2
120749/191	RD	[redacted] Station Personnel	01/02/13	07:40	11:20	2.15	478	0.12	Gate line duties
120749/192	RD	[redacted]Station Personnel	01/02/13	07:30	11:30	2.15	516	0.02	Gate line duties
120749/193	RD	[redacted] Station Personnel	01/02/13	07:20	11:20	2.2	528	0.68	SS Office
120749/194	RD	[redacted]Station Personnel	01/02/13	07:17	11:17	2.2	528	0.03	SS Office & Station Checks

Table 15: 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
120749/198	RD	Static on Platform 2, head wall SB	04/02/13	07:50	10:00	2.15	283	0.54	Behind gate by tunnel entrance.
120749/199	RD	[redacted]Station Personnel	04/02/13	07:42	09:42	2.2	264	0.14	S.A.T. Platform 1
120749/200	RD	[redacted] Station Personnel	04/02/13	07:40	09:50	2.2	286	0.15	Gate line duties
120749/201	RD	Static on Platform 1, head wall NB	04/02/13	07:48	09:58	2.25	289	0.36	Behind gate by tunnel entrance.
120749/202	RD	[redacted] Station Personnel	04/02/13	07:45	09:45	2.2	264	0.52	S.A.T. Platform 1

Table 16: 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
120749/156	RD	[redacted] Station Personnel	30/01/13	07:57	12:52	2.2	649	0.24	Platform 8 / Gate line duties
120749/154	RD	[redacted] Station Personnel	30/01/13	08:01	12:32	2.1	584	0.1	Platform 5 / Gate line duties/ station checks
120749/155	RD	[redacted] Station Personnel	30/01/13	08:09	10:28	2.0	285.9	0.14	Gate line duties / Office
120749/157	RD	Static on Platform 3 head wall, NB	30/01/13	08:23	12:38	2.2	561	0.44	Behind gate by tunnel entrance.
120749/158	RD	Static on Platform 4 head wall, SB	30/01/13	08:17	12:43	2.2	582.95	0.26	Behind gate by tunnel entrance.

Table 17: Paddington 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
120749/222	RD	[redacted] Station Personnel	05/02/13	09:07	11:11	2.1	260.8	0.18	Station Supervisor
120749/223	RD	[redacted] Station Personnel	05/02/13	09:27	13:04	1.91	408.2	0.49	Gate line duty, exit C
120749/224	RD	[redacted] Station Personnel	05/02/13	09:52	13:38	2.2	497.2	0.40	Gate line duty, exits C & B
120749/225	RD	Static on Platform 3 head wall, NB	05/02/13	09:12	13:12	2.18	522	0.78	Behind gate by tunnel entrance.
120749/226	RD	Static on Platform 4 head wall, SB	05/02/13	09:22	13:17	2.19	514	0.96	Behind gate by tunnel entrance.

Table 18: Train Operator Respirable Crystalline Silica Monitoring

Filter Number	Sample Type (Respirable Dust, RD, Inhalable Dust, ID)	Sample Location – Process Monitored	Date	Volume of air (litres)	Crystalline silica (mg/filter)	Crystalline silica (mg/m^3)	Locations & Comments
120749/02	RD	Central Line Train Operators Driving Trains	19/12/12	873.4	<0.01	<0.012	White City→ West Ruislip→ Loughton→Northolt → White City → Northolt → Loughton → Ealing Broadway → White City
120749/48	RD	Jubilee Line Train Operator Driving Trains	09/01/13	921.75	<0.01	<0.011	Wembley Park → Stratford → Willesden Green → Stratford → Wembley Park → Stratford → Willesden Green → Stratford → Wembley Park
120749/82	RD	Circle Line Train Operator Driving Trains	18/01/13	633.6	<0.01	<0.016	Edgware Road → Hammersmith → Barking → Hammersmith → Edgware Road → Moorgate → Hammersmith → Edgware Road
120749/54	RD	Northern Line Train Operator Driving Trains	11/01/13	787.7	<0.01	<0.013	Morden → High Barnet → Kennington Charing Cross → East Finchley → Morden → High Barnet → Morden
120749/6	RD	Piccadilly Line Train Operator Driving Trains	02/01/13	888.8	<0.01	<0.011	Arnos Grove → Heathrow T4 → Arnos Grove → Cockfosters → Heathrow T4 → Cockfosters → Arnos Grove
120749/78	RD	Victoria Line Train Operator Driving Trains	16/01/13	795.3	<0.01	<0.013	Seven Sisters → Brixton → Seven Sisters → Northumberland Park Depot → Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Seven Sisters
120749/3	RD	Bakerloo Line Train Operator Driving Trains	20/12/12	824.2	<0.01	<0.012	Elephant & Castle → Harrow& Wealdstone → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park

Figure 1: Cyclone Dust Head

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: 33284
PROJECT NO: 610
DATE OF ISSUE: 10.04.13

DATE SAMPLES RECEIVED: 27.03.13

DATE SAMPLES ANALYSED: 08.04.13

SAMPLES: 25mm "GLA-5000" PVC filters

NO. OF SAMPLES: Eight

ANALYSIS REQUESTED: Respirable Crystalline Silica (as Quartz)

METHOD: The samples were analysed using an in-house method described in IOM instruction manual number 2 (IM2) using a modification of the following method;

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.

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Multi-disciplinary specialists in Occupational and Environmental Health and Hygiene
IOM CONSULTING LIMITED, Research Avenue North, Riccarton, Edinburgh, EH14 4AP, United Kingdom
Telephone: +44 (0)131 449 8000. Facsimile: +44 (0)131 449 8084. Email: iom@iom-world.org
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UKAS TESTING 0174

CONTRACT NO: 33284

PROJECT NO: 610

DATE OF ISSUE: 10.04.13

RESULTS:

Sample Reference	Quartz Weight (mg)
120749/2	<0.01
120749/3	<0.01
120749/6	<0.01
120749/48	<0.01
120749/54	<0.01
120749/56	<0.01
120749/78	<0.01
120749/82	<0.01

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

COMMENTS:

IOM Consulting cannot accept responsibility for samples that have been incorrectly collected or despatched by external clients.

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

AUTHORISED BY: [redacted]

C McGonagle
Senior Chemist

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