Scientific Services
for Transport & Industry
4-RAIL Services Ltd

Unit 11, Ironbridge Close, Great Central Way
London NW10 0UF

Telephone: 020 8955 1700
Facsimile: 020 8830 1003
Email: enquiries@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: *M Seller*
Technologist

Signature: .....

Certified by: *Dr I R Girling*
Senior Consultant

Signature: .....

CONDITIONS OF ISSUE OF REPORTS.

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 and inhalable dust exposure was to be 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 inhalable dust heads and 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, Euston Square, Baker Street, Piccadilly Circus, Tottenham Court Road, Elephant & Castle, Vauxhall and Kings Cross. Additional monitoring for respirable and inhalable dust was carried out at Morden and Colliers Wood. This additional monitoring was carried out at the request of the Group Station Manager to provide reassurance on the dust levels at these two stations outside of the Central London area. Train Operator dust exposure monitoring was carried out on the Central, Jubilee, Bakerloo, Circle and Hammersmith & City, Northern, Piccadilly and Victoria ('67 and '09 stock) Lines.

For Train Operators the results showed that respirable dust concentration levels were all below 1 mg/m^3. These results are not directly comparable to the similar dust monitoring carried out previously as the Train Operator Duties were unavoidably different. However, as a 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 Jubilee Line and also for two of the shifts on the Victoria Line '09 stock. The levels recorded for all the lines were well below 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 1.5 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 similar to those measured previously, with static samples situated on platforms giving the highest readings. The additional monitoring at Morden and Colliers wood for respirable and inhalable dust also showed levels well below the Workplace Exposure Limits of 4 mg/m^3 and 10 mg/m^3 respectively.

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.

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) 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	Platform Locations
Aldgate East	Staff on gate line duties. Static on District line platforms.
Baker Street	Staff on gate line duties and combined platform/gate line duties. Static on Jubilee, Bakerloo and Circle & Hammersmith line platforms.
Elephant and Castle	Static in ticket office. Staff on gate line duties. Static on Bakerloo and Northern line platforms.
Euston Square	Staff on gate line duties. Static on Circle & Hammersmith line platforms.
Hampstead	Staff on gate line duties. Static on Northern line platforms.
King's Cross	Staff on gate line duties and combined platform/gate line duties. Static on Piccadilly and Victoria line platforms.
Piccadilly Circus	Static in ticket hall. Staff on gate line duties and combined platform/gate line duties. Static on Bakerloo line platforms.
Tottenham Court Road	Staff on gate line duties and combined platform/gate line duties. Static on Central and Northern line platforms.
Vauxhall	Staff on gate line duties and combined platform/gate line duties. Static on Victoria line platforms.
Colliers Wood	Staff on gate line duties.
Morden	Static on Northern line platforms.

1.4 Train operator monitoring was to be carried out on the Central, Bakerloo, Piccadilly, Jubilee, Northern, Circle and Hammersmith & City and Victoria ('67 and '09 stock) Lines. A day was spent on the Victoria Line monitoring on a '67 stock train following an '09 stock train to investigate if the new '09 stock changed the dust levels.

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 Metropolitan or District Lines 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 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/m^3 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. Seven days were spent monitoring on the Victoria line in order to cover both the '67 and '09 stock, including a period monitoring in a '67 stock train following an '09 stock train.

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 infra red 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 For the additional monitoring requested at Colliers Wood and Morden, monitoring for both respirable and inhalable dust was carried out.

3.7 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 3rd, 4th and 5th November 2009 were from 0.21 to 0.34 mg/m^3.

5.1.2 Jubilee Line

The respirable dust exposure levels measured are given in Table 2. The levels measured on the 20th, 23rd and 24th November 2009 were from 0.12 to 0.19 mg/m^3.

5.1.3 Circle and Hammersmith Lines

The respirable dust exposure levels measured are given in Table 3. The levels measured on the 6th, 9th and 10th November 2009 were from 0.22 to 0.35 mg/m^3.

5.1.4 Northern Line

The respirable dust exposure levels measured are given in Table 4. The levels measured on the 25th, 26th and 27th November 2009 were from 0.35 to 0.46 mg/m^3.

5.1.5 Piccadilly Line

The respirable dust exposure levels measured are given in Table 5. The levels measured on the 17th, 18th and 19th November 2009 were from 0.22 to 0.31 mg/m^3.

5.1.6 Victoria Line - '67 Stock

The respirable dust exposure levels measured are given in Table 6. The levels measured on the 14th, 15th and 17th December 2009 were from 0.46 to 0.56 mg/m^3.

The level measured for the '67 stock following an '09 stock train was 0.44 mg/m^3. The monitoring period for this sample was 97minutes. Therefore, the maximum short term exposure averaged over a single 15 minute period would be 2.85mg/m^3 (this is assuming that a member of staff was exposed to all of the dust collected over the 97 minute period, during a 15 minute period).

5.1.7 Victoria Line - '09 Stock

The respirable dust exposure levels measured are given in Table 7. The levels measured on the 28th January 2010, 1st and 2nd of February 2010 were from 0.13 to 0.44 mg/m^3.

5.1.8 Bakerloo Line

The respirable dust exposure levels measured are given in Table 8. The levels measured on the 11th, 12th and 13th November 2009 were from 0.19 to 0.28 mg/m^3.

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 4th December 2009. The results of the personal samples for the staff on gate line duties were between 0.23 and 0.41 mg/m^3. The results of the static sample on the platform was 1.27 mg/m^3.

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 1st December 2009. The results for the personal samples for staff on platform/gate line duties were between 0.25-0.30 and 0.40 mg/m^3. The results of the static samples on the platforms were between 0.32 and 0.93 mg/m^3.

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 3rd December 2009. The results of the personal samples for the staff on gate line duties were between 0.46 and 0.87 mg/m^3. The results of the static samples taken on the platforms were between 0.94 and 1.14 mg/m^3.

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 11th December 2009. The results of the personal samples for the staff on gate line duties were between 0.27 and 0.28 mg/m^3. The results of the static samples from the platforms were between 0.50 and 0.70 mg/m^3.

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 2nd December 2009. The results for the personal samples for staff on platform/gate line duty were between 0.13 and 0.21 mg/m^3. The results of the static samples on the platforms were between 0.25 and 0.64 mg/m^3. The result of the static sample in the ticket office was 0.21 mg/m^3.

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 8th December 2009. The results for the personal samples for staff on platform/gate line duties were between 0.21 and 0.24 mg/m^3. The results of the static samples on the platforms were between 0.76 and 0.83 mg/m^3. The result of the static sample in the ticket hall was 0.04-0.05 mg/m^3.

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 9th December 2009. The result for the personal sample for the member of staff on gate line duties was 0.16 mg/m^3. The results for the personal samples for members of staff on platform/gate line duties were between 0.40 and 0.44 mg/m^3. The results of the static samples on the platforms were between 0.78 and 1.05 mg/m^3.

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 10th December 2009. The results for the personal samples for staff on gate line duties were between 0.08 and 0.09 mg/m^3. Another member of staff was on both gate line and platform duties and that personal sample had a slightly higher result of 0.16 mg/m^3. The results of the static samples on the platforms were between 0.58 and 0.60 mg/m^3.

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 7th December 2009. The results for the personal samples for members of staff on both platform and gate line duties were between 0.31 and 0.48 mg/m^3. The results of the static samples on the platforms were between 0.51 and 1.38 mg/m^3.

5.2.10 Colliers Wood Station

The result for the monitoring at Colliers Wood Station is given in Table 18. The monitoring was carried out on the 26th November 2009. The result for the personal sample for a member of staff on gate line duties was 0.28 mg/m^3. This was for inhalable dust.

5.2.10 Morden Station

The results for the monitoring at Morden Station are given in Table 19. The monitoring was carried out on the 27th November 2009. The results for the static samples on platforms were 0.03 mg/m^3 for inhalable dust and 0.04 mg/m^3 for respirable dust.

5.3 The IOM certificates for the analysis of quartz on the seven samples taken during the train operator monitoring across all of the different Lines, plus the blank (control) sample 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/m^3 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/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 3 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.

The results from the Victoria Line from a '67 stock train following an '09 stock train showed that dust levels were around the same as the three days spent on the '67 stock train on a normal shift. The level measured on the '67 stock following an '09 stock train was 0.44 mg/m^3. The monitoring period for this sample was 97minutes in total. Therefore, the maximum short term exposure, averaged over a single 15 minute period, would be 2.85mg/m^3 (this worst case assumes all the dust sampled was only present over a 15 minute period within the 97 minutes total).

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

6.3 The levels of airborne respirable and inhalable dust measured for personal samples taken on staff carrying out platform/gate line duties as part of their shifts at the following stations: Hampstead, Baker Street, Kings Cross, Piccadilly Circus, Tottenham Court Road, Vauxhall, Colliers Wood and Morden 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).

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 and inhalable dust of 4 mg/m^3 and 10 mg/m^3 respectively (long term 8 hour time weighted average).

6.5 Compared to the previous monitoring exercises (4RS-RH-060755-R148027, issued March 2007 and 4RS-CSI-080096-R188127, issued 13th October 2008) the majority of the results for the Train Operators are very similar.

6.6 Although not all of the duties and locations were monitored exactly the same as that performed in 2007 and 2008, those that were repeated, or performed in similar locations, generally gave similar results with no really 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
090457/ 031109/1	RD	1202962, TO, Driver	03/11/09	09:00	11:15	2.1-2.4	295.5	0.34	White City → Ealing Broadway → Newbury Park → White City → Hainault → White City
		1202962, TO, Driver	03/11/09	12:18	14:16	2.2	259.6		

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
090457/ 041109/1	RD	1937903, TO, Driver	04/11/09	10:17	13:40	2.1-2.2	443.6	0.21	White City → Northolt → Loughton → Northolt → White City → Northolt → Bond Street
		8656866, TO, Driver		15:17	16:18	2.15-2.2	132.675		

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
090457/ 051109/1	RD	6899765, TO, Driver	05/11/09	09:58	12:39	2.15-2.2	353.65	0.29	White City → Debden → Northolt → White City → Ealing Broadway → Hainault → White City
		9451869, TO, Driver		13:42	16:05	2.2-2.3	317.6		

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
090457/ 201109/1	RD	5032089, TO, Driver	20/11/09	09:15	13:25	2.2	550	0.12	Wembley Park → Stratford → Willesden Green → Stratford → Wembley Park → Stratford → Wembley Park
		1937089, TO, Driver		14:20	16:00	2.2	220		

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
090457/ 231109/1	RD	1859865, TO, Driver	23/11/09	10:05	10:55	2.2-2.4	113.5	0.19	Wembley Park → West Ham → Stratford → Willesden Green → Stratford → Wembley Park → Stratford → Wembley Park
		4801963, TO, Driver		12:05	14:48	2.1-2.2	357.85		
		4761189, TO, Driver		15:15	17:00	2.2	231		

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
090457/ 241109/1	RD	5116964, TO, Driver	24/11/09	09:40	15:40	2.2	792	0.17	Wembley Park → North Greenwich → Wembley Park → Stratford → Stanmore → Stratford → Wembley Park
		4736861, TO, Driver							
		6908968, TO, Driver							

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
090457/ 061109/2	RD	M Seller 4RS with 8590961, TO, Driver	06/11/09	08:48	10:52	2.2	266.2	0.26	Edgware Road → Edgware Road → Edgware Road → Edgware Road → Hammersmith → Barking → Baker Street
				12:39	15:47	2.1-2.2	428.2		

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
090457/ 091109/1	RD	8249862, TO, Driver	09/11/09	08:28	11:26	2.1-2.2	391.6	0.35	Edgware Road → Edgware Road → Edgware Road → Edgware Road → Moorgate → Edgware Road → Edgware Road
				11:50	14:45	2.1-2.2	203.95		

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
090457/ 101109/1	RD	8249862, TO, Driver	10/11/09	09:30	10:53	2.2	182.6	0.22	Edgware Road → Plaistow → Edgware Road → Barking → Edgware Road → Hammersmith → Whitechapel → Edgware Road
				11:45	14:55	2.2	418		

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
090457/ 251109/1	RD	0594089, TO, Driver	25/11/09	09:40	11:23	2.2	226.6	0.35	Golders Green → Edgware Golders → Golders Green → Edgware →Kennington → Edgware → Kennington →Golders Green
				12:15	15:54	2.1-2.2	478.8		

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
090457/ 261109/1	RD	3281904, TO, Driver	26/11/09	09:40	10:35	2.2	121	0.46	Golders Green → Bank → Colliers Wood → Bank → Edgware → Bank → Colliers Wood → Bank → Edgware → Golders Green
		0270865, TO, Driver		11:15	13:40	2.1-2.2	316		
				14:10	15:45	2.2	209		

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
090457/ 271109/1	RD	1170968, TO, Driver	27/11/09	09:15	10:15	2.2	33-132*	0.35-0.41*	Golders Green → Morden → High Barnet → Morden → Edgware → Golders Green
		2656965, TO, Driver		11:05	13:45	2.2	352		
		4558089, TO, Driver		14:25	16:00	2.2	209		
		0034964, TO, Driver							

*Pump found to have been accidentally turned off between 09:30 and 10:15 hence range of values

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
090457/ 171109/1	RD	4674968, TO, Driver	17/11/09	08:12	11:15	2.0 - 2.4	400.6	0.31	Acton Town → Rayners Lane → Cockfosters → Acton Town → Rayners Lane → Cockfosters → Acton Town
				12:15	15:26	2.2	420.2		

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
090457/ 181109/1	RD	7813969, TO, Driver	18/11/09	09:10	12:45	2.2 - 2.3	476.75	0.24	Acton Town → Heathrow Airport 4 → Cockfosters → Acton Town → Heathrow 123 & 4 → Acton Town
				13:30	15:30	2.1 - 2.2	260.5		

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
090457/ 191109/1	RD	7199769, TO, Driver	19/11/09	08:48	12:50	2.2 - 2.3	535.4	0.22	Arnos Grove → Cockfosters → Uxbridge → Arnos Grove → Heathrow Terminal 5 → Arnos Grove
				13:50	16:50	2.1 - 2.2	393		

Table 6: Victoria Line (67 Stock) 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
090457/ 141209/1	RD	5270964, TO, Driver	14/12/09	09:50	11:58	2.2	281.6	0.56	Brixton → Walthamstow Central → Brixton → Seven Sisters → Walthamstow Central → Brixton → Walthamstow Central → Brixton
		0491966, TO, Driver		13:15	15:26	2.2	288.2		

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
090457/ 151209/1	RD	2913189, TO, Driver	15/12/09	10:08	12:45	2.2	345.4	0.46	Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow Central → Brixton
		5004869, TO, Driver		13:37	16:53	2.1-2.4	435.05		
		7964964, TO, Driver							

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
090457/ 171209/3	RD	6689035, TO, Driver	17/12/09	09:45	11:40	2.1-2.2	251.75	0.55	Brixton → Walthamstow Central → Brixton → Seven Sisters → Walthamstow Central → Brixton → Walthamstow Central → Brixton
				12:37	15:01	2.2	316.8		

'67 stock train following an '09 stock train:

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
090457/ 230310/1	RD	5154307, TO, Driver	23/03/10	11:03	12:10	2.1-2.2	145.4	0.44	Seven Sisters → Brixton → Seven Sisters → Brixton
		7858865, TO, Driver		14:05	14:35	2.1-2.2	64.5		

Table 7: Victoria Line (09 Stock) 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
090457/ 280110/1	RD	1240961, TO, Driver 5355706, TO, Driver 9686964, TO, Driver	28/01/10	10:25	12:02	2.0-2.2	206.7	0.44	Northumberland Park Depot → Seven Sisters → Brixton → Seven Sisters → Northumberland Park Depot

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
090757/92	RD	9698963, TO, Driver 5776963, TO, Driver	01/02/10	13:25	16:25	2.2	396	0.14	Northumberland Park Depot → Seven Sisters → Brixton → Seven Sisters → Walthamstow Central →Brixton → Seven Sisters → Northumberland Park Depot

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
090457/ 020210/1	RD	9698963, TO, Driver 5776963, TO, Driver	02/02/10	13:04	15:58	2.2	174	0.13	Northumberland Park Depot → Seven Sisters → Brixton → Walthamstow Central →Brixton → Seven Sisters → Northumberland Park Depot

Table 8: 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
090457/ 111109/1	RD	0321966, TO, Driver	11/11/09	09:20	12:03	2.2	358.6	0.19 - 0.22	Queens Park → Harrow and Wealdstone → Elephant and Castle → Harrow and Wealdstone → Queens Park → Harrow and Wealdstone → Elephant and Castle → Queens Park
				14:23	15:40	2.2	169.4 - 250.8		

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
090457/ 121109/1	RD	0321966, TO, Driver	12/11/09	09:25	14:15	2.2	638	0.24	Queens Park → Elephant and Castle → Queens Park → Elephant and Castle → Stonebridge Park → Kilburn High Road → Harrow and Wealdstone → Kilburn High Road → Queens Park → Elephant and Castle → Queens Park
				14:55	16:34	2.2	217.8		

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
090457/ 131109/1	RD	0321966, TO, Driver	13/11/09	09:20	12:33	2.2	424.6	0.28	Queens Park → Harrow and Wealdstone → Elephant and Castle → Harrow and Wealdstone → Elephant and Castle → Harrow and Wealdstone →Elephant and Castle → Queens Park
		5056089, TO, Driver		13:54	16:20	2.2	321.2		
		0483866, TO, Driver							

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
090457/ 041209/1	RD	Static on Platform 1, northbound	04/12/09	08:50	15:00	2.2	814	1.27	Behind gate by tunnel entrance.
090457/ 041209/3	RD	3869089	04/12/09	08:37	10:52	2.1-2.2	293.8	0.41	Gate line duties
090457/ 041209/4	RD	0850967	04/12/09	08:30	14:48	2.2	831.6	0.29	Gate line duties
090457/ 041209/5	RD	0084769	04/12/09	08:35	14:50	2.1-2.2	818.5	0.23	Gate line duties

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
090457/ 011209/1	RD	Static on Platform 6, WB, H&C line	01/12/09	08:11	12:07	2.0-2.2	509	0.32	Behind gate, by tunnel entrance.
090457/ 011209/2	RD	Static on Platform 8, SB, Bakerloo	01/12/09	08:48	13:30	2.1-2.2	613.55	0.93	Behind gate, by tunnel entrance.
090457/ 011209/4	RD	7588189	01/12/09	09:00	13:40	2.0-2.2	630.5	0.30	Platform duties then gate line duties
090457/ 011209/5	RD	3629189	01/12/09	08:01	12:15	2.2	462.8-561.8	0.25-0.30	Gate line duties
090457/ 011209/6	RD	3485189	01/12/09	08:22	13:35	2.2	688.6	0.40	Platform duties then gate line duties

*Pump found to have been accidentally turned off between 11:30 and 12:15 hence range of values

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
090457/ 031209/1	RD	Static on Platform 1, Westbound	03/12/09	07:57	15:05	2.2	941.6	0.94	Behind gate by tunnel entrance.
090457/ 031209/2	RD	Static on Platform 2, Eastbound	03/12/09	07:50	15:18	2.2	985.6	1.14	Behind gate by tunnel entrance.
090457/ 031209/3	RD	9439189	03/12/09	08:10	10:30	2.0-2.2	302	0.87	Gate line duties
090457/ 031209/4	RD	9986089	03/12/09	08:10	15:10	2.2	924	0.46	Gate line duties

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
090457/ 111209/1	RD	Static on Platform 2, Eastbound	11/12/09	09:20	15:18	2.2	787.6	0.50	Behind gate by tunnel entrance.
090457/ 111209/2	RD	Static on Platform 1, Westbound	11/12/09	09:25	15:11	2.2	761.2	0.70	Behind gate by tunnel entrance.
090457/ 111209/3	RD	4281965/3562969	11/12/09	09:30	15:13	2.2	754.6	0.28	Gate line duties
090457/ 111209/4	RD	6676089/static in ticket hall	11/12/09	09:45	15:09	2.2	712.8	0.27	Gate line duties/static next to gates in ticket office where duty had been undertaken

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
090457/ 021209/1	RD	Static Platform 1, NB, Northern line	02/12/09	08:40	14:00	2.2	704	0.64	Behind gate by tunnel entrance.
090457/ 021209/2	RD	Static Platform 4, NB, Bakerloo line	02/12/09	08:55	13:54	2.1-2.2	652.6	0.25	Behind gate by tunnel entrance.
090457 021209/4	RD	0330865	02/12/09	11:55	14:05	2.2	286	0.13	General station duties
090457/ 021209/5	RD	4961766/9643189	02/12/09	08:35	13:45	2.2	682	0.21	Platform duties then gate line duties
090457/ 021209/6	RD	Bakerloo line ticket hall	02/12/09	10:35	13:45	2.2	418	0.21	On top of information booth

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
090457/ 081209/1	RD	Static on Platform 4, Piccadilly WB	08/12/09	09:00	14:55	2.2	781	0.76	Behind gate by tunnel entrance.
090457/ 081209/2	RD	Static on Platform 1, Bakerloo NB	08/12/09	08:55	15:00	2.2	803	0.83	Behind gate by tunnel entrance.
090457/ 081209/3	RD	2363189/6571189	08/12/09	08:50	14:40	2.2	770	0.24	Platform duties, then gate line duties
090457/ 081209/5	RD	3752189/5997189	08/12/09	08:50	14:50	2.2	792	0.21	Platform duties, then gate line duties

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
090457/ 091209/1	RD	Static, Platform 3, Northern line NB	09/12/09	08:45	13:50	2.2	671	0.78	Behind gate by tunnel entrance.
090457/ 091209/2	RD	Static, Platform 1, Central line WB	09/12/09	08:30	13:55	2.2	715	1.05	Behind gate by tunnel entrance.
090457/ 091209/3	RD	2565961	09/12/09	08:10	13:32	2.2	708.4	0.44	Platform duties, then gate line duties
090457/ 091209/4	RD	0078189	09/12/09	08:14	12:07	2.2	512.6	0.16	Gate line duties
090457/ 091209/5	RD	1224189	09/12/09	08:05	13:32	2.2	719.4	0.40	Platform duties, then gate line duties

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
090457/ 101209/1	RD	Static on Platform 2, Victoria, SB	10/12/09	08:55	14:28	2.2	732.6	0.58	Behind gate by tunnel entrance.
090457/ 101209/2	RD	Static on Platform 1, Victoria, NB	10/12/09	08:50	14:30	2.2	748	0.60	Behind gate by tunnel entrance.
090457/ 101209/3	RD	2471074	10/12/09	08:37	12:15	2.2	479.6	0.08	Gate line duties.
090457/ 101209/4	RD	7078189	10/12/09	08:39	14:24	2.2	759	0.09	Gate line duties.
090457/ 101209/5	RD	4626089	10/12/09	08:48	14:20	2.2	730.4	0.16	Platform and gate line duties.

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
090457/ 071209/1	RD	Static on Platform 3, Victoria NB	07/12/09	08:20	14:31	2.0-2.2	807.1	1.38	Behind gate by tunnel entrance.
090457/ 071209/2	RD	Static on Platform 5, Piccadilly WB	07/12/09	08:35	14:27	2.2	774.4	0.51	Behind gate by tunnel entrance.
090457/ 071209/4	RD	1947089	07/12/09	08:40	14:40	2.2	792	0.47	Platform and gate line duties
090457/ 071209/5	RD	7215189/8442807	07/12/09	08:14	14:47	2.2	864.6	0.48	Platform and gate line duties
090457/ 071209/6	RD	1814189/0162862	07/12/09	08:30	14:20	2.2	770	0.31	Platform and gate line duties

Table 18: Colliers Wood 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
090457/ 261109/4	ID	Staff on gate line duty	26/11/09	10:50	13:46	2.1	369.6	0.28	Gate line duty

Table 19: Morden 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
090457/ 271109/3	ID	Static on platform 2, Northern, SB end	27/11/09	10:50	14:05	2.025	394.875	0.03	By tunnel entrance
090457/ 271109/4	RD	Static on platform 2, Northern, SB end	27/11/09	10:50	14:05	2.2	429	0.04	By tunnel entrance

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
090457/ 051109/1	RD	Central Line Train Operators Driving Trains	05/11/09	671.25	< 0.01	< 0.01	White City → Debden → Northolt → White City → Ealing Broadway → Hainault → White City
090457/ 241109/1	RD	Jubilee Line Train Operator Driving Trains	24/11/09	792	< 0.01	< 0.01	Wembley Park → North Greenwich → Wembley Park → Stratford → Stanmore → Stratford → Wembley Park
090457/ 101109/1	RD	Circle Line Train Operator Driving Trains	10/11/09	600.6	< 0.01	< 0.01	Edgware Road → Plaistow → Edgware Road → Barking → Edgware Road → Hammersmith → Whitechapel → Edgware Road
090457/ 271109/1	RD	Northern Line Train Operator Driving Trains	27/11/09	594-693	< 0.01	< 0.01	Golders Green → Morden → High Barnet → Morden → Edgware → Golders Green
090457/ 191109/1	RD	Piccadilly Line Train Operator Driving Trains	19/11/09	928.4	< 0.01	<0.01	Arnos Grove → Cockfosters → Uxbridge → Arnos Grove → Heathrow Terminal 5 → Arnos Grove
090457/ 171209/1	RD	Victoria Line Train Operator Driving Trains - '67 Stock	17/12/09	568.55	< 0.01	< 0.01	Brixton → Walthamstow Central → Brixton → Seven Sisters → Walthamstow Central → Brixton → Walthamstow Central → Brixton
090457/ 020210/1	RD	Victoria Line Train Operator Driving Trains - '09 Stock	02/02/10	174	<0.01	<0.01	Northumberland Park Depot → Seven Sisters → Brixton → Walthamstow Central →Brixton → Seven Sisters → Northumberland Park Depot
090457/ 131109/1	RD	Bakerloo Line Train Operator Driving Trains	13/11/09	745.8	< 0.01	< 0.01	Queens Park → Harrow and Wealdstone → Elephant and Castle → Harrow and Wealdstone → Elephant and Castle → Harrow and Wealdstone →Elephant and 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
Unit 11 Ironbridge Close
Great Central Way
London
NW10 0UF

CONTRACT NO: 20162

PROJECT NO: 610

DATE OF ISSUE: 23.02.2010

DATE SAMPLES RECEIVED: 19.02.2010

DATE SAMPLES ANALYSED: 23.02.2010

SAMPLES: 9 X 25mm GLA-5000 PVC filters

ANALYSIS REQUESTED: Quartz

METHOD: The samples were analysed using methods based on;

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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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 0374

CONTRACT NO: 20162
PROJECT NO: 610
DATE OF ISSUE: 23.02.10

RESULTS:

Sample Number	Quartz Weight (mg)
090457/131109/1	<0.01
090457/171209/1	<0.01
090457/241109/1	<0.01
090457/051109/1	<0.01
090457/020210/1	<0.01
090457/271109/1	<0.01
090457/191109/1	<0.01
090457/101109/1	<0.01
090457/silica blank	<0.01

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

COMMENTS:

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

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

ANALYSED BY: .....
J Forbes
Chemist

AUTHORISED BY: .....
S Clark
Mineralogy Section Manager

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