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AIR QUALITY MONITORING FOR RESPIRABLE DUST: LUL TRAIN OPERATORS AND PLATFORM STAFF

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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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1. Introduction

1.1 LUL Procedure No. 3-05106-601 (Issue 1 Cat 5) contains requirements for dust monitoring on the Underground.

1.2 At the request of Chris Beach, LU Occupational Hygiene Specialist, personal monitoring for respirable dust exposure was to be undertaken on Station Staff conducting platform duties and Train Operators whilst driving. 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	District Line
Baker Street	Jubilee Line
Elephant and Castle	Bakerloo Line
Euston Square	Circle and Hammersmith Line
Hampstead	Northern Line
Oxford Circus	Bakerloo Line
Piccadilly Circus	Piccadilly Line
Tottenham Court road	Central Line
Vauxhall	Victoria Line

1.4 Train operator monitoring was to be carried out on the Central, Bakerloo, Piccadilly, Jubilee, Northern, Circle and Hammersmith and Victoria Lines. 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 or the open sections of the Circle and Hammersmith Line. Train operators driving trains on the Circle section of the Circle and Hammersmith Line were to be monitored.

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 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*).

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 0.3mg/m^3 averaged over an 8-hour reference period (*HSE Document EH40/05*).

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 4.

3.2 Sampling pumps equipped with respirable dust cyclone dust heads were worn by the Train Operators and Station Staff. An example of a cyclone dust head is shown in Figure 1. Monitoring was carried out at each of the stations for one shift timed to include the morning peak. Monitoring of the Train Operators was carried out over three shifts on each Line again timed to include the morning peak.

3.3 One of the primary aims was to obtain close to 8 hours of monitoring data 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 are used each must be run for sufficient time for the filter to make a measurable weight gain.

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. It should however be noted that static results are not the same as personal sampling results although can be indicative in some circumstances.

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 the personal respirable dust samples and selected static respirable dust samples together with blanks were submitted to the Institute of Occupational Medicine (IOM) for quartz analysis.

5. Results

5.1 Train Operators

5.1.1 Central Line

The respirable dust exposure levels measured are given in Table 1. The levels measured on the 21st, 22nd and 24th March 2005 were from 0.21 to 0.36mg/m^3.

5.1.2 Jubilee Line

The respirable dust exposure levels measured are given in Table 2. The levels measured on the 23rd, 25th and 26th April 2005 were from 0.07 to 0.22mg/m^3.

5.1.3 Circle Line

The respirable dust exposure levels measured are given in Table 3. The levels measured on the 9th, 31st March and 1st April 2005 were from 0.25 to 0.34mg/m^3.

5.1.4 Northern Line

The respirable dust exposure levels measured are given in Table 4. The levels measured on the 16th, 19th and 20th April 2005 were from 0.24 to 0.91mg/m^3.

5.1.5 Piccadilly Line

The respirable dust exposure levels measured are given in Table 5. The levels measured on the 14th, 15th March and 28th April 2005 were from 0.23 to 0.36mg/m^3.

5.1.6 Victoria Line

The respirable dust exposure levels measured are given in Table 6. The levels measured on the 9th, 11th and 15th April 2005 were from 0.50 to 0.57mg/m^3. It was noted that the rail grinding train had been in operation on the Victoria Line during the period of monitoring which may have elevated the dust levels.

5.1.7 Bakerloo Line

The respirable dust exposure levels measured are given in Table 7. The levels measured on the 6th, 7th and 8th April 2005 were from 0.35 to 0.46mg/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 8. The monitoring was carried out on the 13th April 2005. In normal circumstances there are no planned SAT's (Station Assistant Trains) duties at this station hence static sampling was set up on one of the platforms and by the lifts on level 3. Static sampling results can be used for guidance but do not replace personal sampling. On the day of the monitoring visit a failure of the train radio system necessitated that the platforms were staffed hence results for personal monitoring were obtained.

The results of the personal samples of staff with platform duties were 0.42 and 0.71mg/m^3. That for the Station Supervisor was 0.26 mg/m^3, this lower level is likely a consequence that a significant part of the Supervisor's Duty is in the upper parts of the station.

5.2.2 Baker Street Station

The results for the monitoring at Baker Street Station are given in Table 9. The monitoring was carried out on the 18th April 2005. The range of the main body of results was 0.05 – 0.43mg/m^3.

A single result of 4.78mg/m^3 numerically exceeded the Workplace Exposure Limit of 4mg/m^3 (8hr Time Weighted Average) for respirable dust. The monitoring period for this sample was 06.25 to 13.00hrs i.e. a total of 6hrs and 35minutes monitoring. Therefore, assuming no further exposure before the shift and after, the exposure as an 8hr TWA would be 3.93mg/m^3. It was also noted that the rubber boot (Figure 1) on the particular cyclone head was almost completely full of dust. This is a very unusual sampling situation which is not indicative of airborne dust exposure but more representative of dust being directly sucked into the sampling head by accidental contact with a dusty shelf or ledge.

5.2.3 Euston Square Station

The results for the monitoring at Euston Square Station are given in Table 10. The monitoring was carried out on the 19th April 2005. The results for the personal samples on the gate line were 0.53 and 0.69mg/m^3. On the day of the visit SAT's duties were not scheduled, therefore in order to gain some guidance static samples were taken on the platforms. The results of the static samples were 0.82 and 0.87mg/m^3.

5.2.4 Aldgate East

The results for the monitoring at Aldgate East Station are given in Table 11. The monitoring was carried out on the 21st April 2005. The results for the personal samples on the gate line were 0.42 and 0.33mg/m^3. That in the Ticket Office was 0.22 mg/m^3. On the day of the visit SAT's duties were not scheduled, therefore in order to gain some guidance static samples were taken on the platforms. The results of the static samples were 0.52 and 0.49mg/m^3.

5.2.5 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 22nd April 2005. The results for the staff who had undertaken platform duties were 0.21 and 0.33mg/m^3. The personal sample taken solely on the gate line was 0.06mg/m^3 which likely represents air coming from the street into the station.

The results of the static samples, which were on the platforms for 8 hours continuously, were 0.32 mg/m^3 for the Bakerloo Line platforms and 0.62 and 0.77mg/m^3 for the Northern Line platform No's 1 and 2 respectively. Hence, for a shift involving 4 hours on the gate line and 4hrs on platform No 2 the 8 hour time weighted average exposure would be 0.42mg/m^3.

5.2.6 Oxford Circus Station

The results for the monitoring at Oxford Circus Station are given in Table 13. The monitoring was carried out on the 26th April 2005. Personal samples were taken staff with duties on the Bakerloo, Victoria and Central Line platforms, the results covered the range 0.54 to 0.97mg/m^3.

5.2.7 Piccadilly Circus Station

The results for the monitoring at Piccadilly Circus Station are given in Table 14. The monitoring was carried out on the 25th April 2005. Personal samples were taken for staff working for part of their duties on the northbound Bakerloo Line and both Piccadilly Line platforms, the results were from 0.27 to 0.60mg/m^3.

5.2.8 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 27th April 2005. Personal samples were taken for staff working for part of their duties on the Northern and Central Line platforms, the results were from 0.18 to 0.36mg/m^3.

5.2.9 Vauxhall Station

The results for the monitoring at Vauxhall Station are given in Table 16. The monitoring was carried out on the 28th April 2005. Platform duties took place for 1 hour 30 minutes on the northbound platform, the result for the personal sample collected was 0.24mg/m^3.

5.3 The IOM certificates for the analysis of quartz on the samples No's 041223/24, 26, 29, 32, 36, 38, 75 and B3 (blank) are included in Appendix 1. The results for each of the Lines are given in Table 17. Small differences in the detection limit reflect the sample volumes which were tailored to the duties and respirable dust monitoring.

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, Northern, Piccadilly, Victoria and Bakerloo were all below 4mg/m^3.

6.2 The levels of respirable quartz (crystalline silica) were all significantly below the Workplace exposure limit of 0.3mg/m^3 (long term 8hour time weighted average). In most cases crystalline silica was not detected.

6.3 The levels of airborne respirable dust measured for personal samples taken on staff carrying out platform duties as part of their shifts at the following stations: Hampstead, Elephant and Castle, Oxford Circus, Piccadilly Circus, Tottenham Court Road and Vauxhall were all below 4mg/m^3.

6.4 At Baker Street the levels of airborne respirable dust measured for personal samples taken on staff carrying out platform duties as part of their shifts were all except one below 4mg/m^3.

6.5 Platform duties were not scheduled on the day of the monitoring visit to Aldgate East. 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 dust on the platforms would be below 4mg/m^3.

6.6 Similarly platform duties were not scheduled on the day of the monitoring visit to Euston Square. 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 dust on the platforms would also be below 4mg/m^3.

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
041223/9	RD	[redacted] TO/Driving Train	21/03/05	06.04	09.16	2.2	422.4	0.26	Ruislip Depot → North Acton → Ealing Broadway → Epping → Ealing Broadway → Hainault → Ealing Broadway → Hainault → Ealing Broadway
	RD	[redacted] TO/Driving Train	21/03/05	09.16	10.38	2.2	180.4		
	RD	[redacted] TO/Driving Train	21/03/05	10.46	12.06	2.2	176		
	RD	[redacted] TO/Driving Train	21/03/05	12.12	13.20	2.2	140.6		
	RD	[redacted] TO/Driving Train	21/03/05	13.31	14.43	2.2	158.4		

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
041223/10	RD	[redacted] TO/Driving Train	22/03/05	06.10	09.15	2.2	407	0.33	Ruislip Depot → West Acton → North Acton → West Ruislip → Epping → North Acton → Hainault → Ealing Broadway → Hainault → Ealing Broadway
	RD	[redacted] TO/Driving Train	22/03/05	10.37	13.10	2.2	336.6		
041223/12	RD	[redacted] TO/Driving Train	22/03/05	13.14	14.39	2.2	187	0.36	
	RD	[redacted] TO/Driving Train	22/03/05	14.52	16.00	2.2	149.6		

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
041223/29	RD	[redacted] TO/Driving Train	24/03/05	06.10	08.38	2.2	325.6	0.23	West Ruislip → Epping → West Ruislip → Epping → West Ruislip → Loughton → West Ruislip
	RD	[redacted] TO/Driving Train	24/03/05	09.41	12.41	2.2	396		
041271/31	RD	[redacted], TO/Driving Train	24/03/05	12.48	14.35	2.2	235.4	0.21	
	RD	[redacted], TO/Driving Train	24/03/05	14.41	15.52	2.2	156.2		

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
041223/38	RD	[redacted] IO/Driving Train	23/04/05	08.41	11.22	2.2	354.2	0.19	Neasden Depot → Stratford → Neasden → Stratford → Willesden Green → Stratford → Neasden → Stratford → Willesden Green → North Greenwich
	RD	[redacted] IO/Driving Train	23/04/05	12.10	15.12	2.2	400.4		
041223/39	RD	[redacted] TO/Driving Train	23/04/05	15.20	17.42	2.2	312.4	0.22	

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
041223/82	RD	[redacted], TO/Driving Train	25/04/05	06.15	10.15	2.2	528	0.14	Wembley Park → Stratford → Stanmore →Stratford → North Greenwich → Stratford →Wembley Park → Stratford → Stanmore →Wembley Park
041223/85	RD	[redacted] TO/Driving Train	25/04/05	10.15	14.15	2.2	528	0.07	

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
041223/119	RD	[redacted], TO/Driving Train	26/04/05	06.10	10.10	2.2	528	0.17	Wembley Park → Stratford → Stanmore →Stratford → North Greenwich → Stratford →Wembley Park → Stratford → Stanmore →Wembley Park
041223/86	RD	[redacted], TO/ Driving Train	26/04/05	10.15	11.15	2.2	528	0.10	
	RD	[redacted] TO/ Driving Train	26/04/05	11.15	14.15	2.2			

Table 3: Circle 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
041223/24	RD	[redacted] TO/Driving Train	09/03/05	08.23	11.19	2.2	387.2	0.25	Edgware Road, three circle complete then signal failure at Victoria divert to Hammersmith return to Edgware Road then 4 complete circles
	RD	[redacted] TO/Driving Train	09/03/05	12.04	12.28	2.2	52.8		
	RD	[redacted] TO/Driving Train	09/03/05	12.50	14.08	2.2	171.6		
	RD	[redacted], TO/Driving Train	09/03/05	14.15	16.13	2.2	259.6		
	RD	[redacted] TO/Driving Train	09/03/05	16.14	18.20	2.2	277.2		

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
041223/14	RD	[redacted] TO/Driving Train	31/03/05	08.00	11.00	2.2	396	0.34	8 Complete circles to and from Edgware Road
	RD	[redacted] TO/Driving Train	31/03/05	11.00	12.00	2.2	132		
	RD	[redacted] TO/Driving Train	31/03/05	12.00	13.00	2.2	132		
	RD	[redacted] TO/Driving Train	31/03/05	13.05	14.05	2.2	132		
	RD	[redacted] TO/Driving Train	31/03/05	14.20	16.20	2.2	264		

Table 3 (Continued): Circle 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
041223/18	RD	[redacted] TO/Driving Train	01/04/05	07.35	09.45	2.2	280	0.28	7 Complete circles to and from Edgware Road. Delay on eighth round as person reported to be on the track at Paddington
	RD	[redacted] TO/Driving Train	01/04/05	09.45	10.50	2.2	143		
	RD	[redacted] TO/Driving Train	01/04/05	10.50	11.50	2.2	132		
	RD	[redacted] TO/Driving Train	01/04/05	11.50	13.50	2.2	264		
	RD	[redacted] TO/Driving Train	01/04/05	13.50	15.35	2.2	231		

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
041223/52	RD	[redacted] TO/Driving Train	16/04/05	06.51	10.18	2.2	455.4	0.36	Golders Green → Morden via Bank → Edgware via Bank → Morden via Bank → Mill Hill East via CX → Kennington via CX → Edgware via CX → Kennington via CX
	RD	[redacted] TO/Driving Train	16/04/05	12.43	15.06	2.2	314.6		
041223/53	RD	[redacted] TO/Driving Train	16/04/05	15.08	17.22	2.2	294.8	0.91	

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
041223/63	RD	[redacted] TO/Driving Train	19/04/05	06.20	11.10	2.2	638	0.24	Golders Green Depot → Edgware → Morden → Edgware → Morden → Mill Hill East → Kennington → Edgware → Golders Green
041223/61	RD	[redacted] TO/Driving Train	19/04/05	11.50	15.00	2.2	418	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
041223/73	RD	[redacted], TO/Driving Train	20/04/05	06.00	10.30	2.2	594	0.31	Golders Green Depot → Edgware → Morden → Edgware → Morden → High Barnet → Morden → Golders Green
041223/75	RD	[redacted] TO/Driving Train	20/04/05	10.45	13.45	2.2	396	0.55	
	RD	[redacted], TO/Driving Train	20/04/05	13.55	14.25	2.2	66		

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
041223/26	RD	[redacted] TO/Driving Train	14/03/05	05.46	08.42	2.2	387.2	0.33	Northfields → Heathrow 123 → Arnos Grove → Northfields Depot (Points failure hence diversion) → Acton → Cockfosters → Acton → Heathrow 123 → Cockfosters → Acton
	RD	[redacted] TO/Driving Train	14/03/05	09.29	09.42	2.2	28.6		
	RD	[redacted] TO/Driving Train	14/03/05	10.38	12.45	2.2	279.4		
	RD	[redacted] TO/Driving Train	14/03/05	12.48	15.52	2.2	404.8		

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
041223/6	RD	[redacted], TO/Driving Train	15/03/05	05.45	09.43	2.2	523.6	0.26	Northfields → Heathrow 123 → Arnos Grove → Ruislip → Acton → Cockfosters → Acton → Heathrow 123 → Cockfosters → Acton
	RD	[redacted], TO/Driving Train	15/03/05	10.38	12.47	2.2	283.8		
	RD	[redacted], TO/Driving Train	15/03/05	12.51	14.45	2.2	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
041223/116	RD	[redacted] TO/Driving Train	28/04/05	05.30	10.30	2.2	660	0.36	Acton → Arnos Grove → Cockfosters → Heathrow 123 → Arnos Grove → Cockfosters → Uxbridge → Arnos Grove
041223/110	RD	[redacted] TO/Driving Train	28/04/05	10.30	13.30	2.2	396	0.23	

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
041223/36	RD	[redacted] TO/Driving Train	09/04/05	08.17	12.16	2.2	525.8	0.50	Seven Sisters → Brixton → Walthamstow → Brixton → Walthamstow → Brixton → Seven Sisters → Brixton → Walthamstow → Brixton → Walthamstow → Seven Sisters
	RD	[redacted] TO/Driving Train	09/04/05	13.14	16.07	2.2	380.6		

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
041223/42	RD	[redacted] TO/Driving Train	11/04/05	07.57	10.26	2.2	327.8	0.57	Seven Sisters → Brixton → Seven Sisters Sidings → Brixton → Seven Sisters → Walthamstow → Brixton → Walthamstow → Brixton → Walthamstow→ Brixton → Walthamstow→ Brixton → Seven Sisters
	RD	[redacted] TO/Driving Train	11/04/05	11.38	14.23	2.2	363		
041223/37	RD	[redacted] TO/Driving Train	11/04/05	14.28	15.57	2.2	195.8	0.50	
	RD	[redacted] TO/Driving Train	11/04/05	15.57	17.22	2.2	187		

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
041223/51	RD	[redacted] TO/Driving Train	15/04/05	08.07	10.58	2.2	376.2	0.55	Seven Sisters → Walthamstow → Brixton → Walthamstow → Brixton → Seven Sisters → Walthamstow → Brixton → Walthamstow→ Brixton → Walthamstow → Brixton → Walthamstow → Brixton
	RD	[redacted] TO/Driving Train	15/04/05	12.00	15.04	2.2	404.8		
041223/50	RD	[redacted] TO/Driving Train	15/04/05	15.05	17.08	2.2	270.6	0.56	

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
041223/21	RD	[redacted] TO/Driving train	06/04/05	07.30	09.53	2.2	314.6	0.44	Queens Park → Harrow & Wealdstone → Elephant & Castle → Stonebridge Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Willesden Jct → Queens Park → Harrow & Wealdstone
	RD	[redacted], TO/Driving train	06/04/05	09.53	11.07	2.2	162.8		
	RD	[redacted] TO/Driving train	06/04/05	11.07	11.55	2.2	105.6		
	RD	[redacted] TO/Driving train	06/04/05	11.55	13.50	2.2	253		
	RD	[redacted] TO/Driving train	06/04/05	13.50	14.50	2.2	132		
	RD	[redacted] TO/Driving train	06/04/05	14.50	15.30	2.2	88		

Table 7: (Continued): 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
041223/23	RD	[redacted] TO/Driving train	07/04/05	07.10	08.40	2.2	198	0.46	Harrow & Wealdstone → Elephant & Castle → Harrow & Wealdstone → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Willesden Jct
	RD	[redacted] TO/Driving train	07/04/05	08.40	10.15	2.2	209		
	RD	[redacted] TO/Driving train	07/04/05	10.15	11.20	2.2	143		
	RD	[redacted] TO/Driving train	07/04/05	11.20	11.55	2.2	77		
	RD	[redacted] TO/Driving train	07/04/05	11.55	12.25	2.2	66		
	RD	[redacted] TO/Driving train	07/04/05	12.25	13.25	2.2	132		
	RD	[redacted] TO/Driving train	07/04/05	13.25	15.10	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
041223/32	RD	[redacted] TO/Driving train	08/04/05	08.00	09.30	2.2	198	0.35	Harrow & Wealdstone → Willesden Jct → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Willesden Jct → Elephant & Castle → Harrow & Wealdstone
	RD	[redacted] TO/Driving train	08/04/05	10.00	10.30	2.2	66		
	RD	[redacted], TO/Driving train	08/04/05	10.30	13.30	2.2	396		
	RD	[redacted] TO/Driving train	08/04/05	13.30	14.30	2.2	132		
	RD	[redacted] TO/Driving train	08/04/05	14.30	16.30	2.2	264		

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
041223/43	RD	Static P1 - by Lift Level 3	13/04/05	05.59	14.04	2.2	1067	0.87	Static sample 8hours
041223/45	RD	Static P2 - NB Platform Tail Wall	13/04/05	06.02	14.02	2.2	1056	1.09	Static sample 8hours
041223/46	RD	[redacted]	13/04/05	06.08	12.30	2.2	840.4	0.42	1hr 20mins on platform remainder some station checks, gate line and upper levels
041223/47	RD	[redacted] Station Supervisor	13/04/05	08.04	12.18	2.2	558.8	0.26	Approx 30mins on lower station levels remainder gate line, upper levels and station checks
041223/48	RD	[redacted]	13/04/05	08.51	14.09	2.2	699.6	0.71	2hr 40mins on platform remainder gate line and upper levels

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
041223/55	RD	[redacted]	18/04/05	06.13	12.25	2.2	818.4	0.16	Platform 6, H & C Line 2hrs 30mins, remainder gate line and break
041223/56	RD	[redacted]	18/04/05	06.25	13.00	2.2	869	4.78	Platform 5, H & C Line 1hr 30mins, Platforms 7 – 10, Jubilee and Bakerloo Lines 1hr 30mins, checking Section 12 rooms e.g. 5/376 on behalf of the Station Supervisor and checking headwall telephones on the Bakerloo and Jubilee Line platforms Remainder; gate line, showing visitors around and break
041223/58	RD	[redacted]	18/04/05	06.40	12.40	2.2	792	0.05	Station Control Room
041223/59	RD	[redacted]	18/04/05	07.20	12.40	2.2	704	0.43	Platform 7, Jubilee Line 2hrs 15mins, gate line 1hr 30mins, Platforms 5 & 6 H & C Line 1hr, remainder on upper levels
041223/60	RD	[redacted]	18/04/05	07.20	13.20	2.2	792	0.25	Platform 8, Bakerloo Line 1hr 30mins, Platforms 5 & 6 1hr 30mins, Jubilee and Bakerloo Line platforms 1hr 30mins, remainder break

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
041223/64	RD	[redacted]	19/04/05	06.22	12.44	2.2	840.4	0.53	Gate line duty with approx 30mins break
041223/66	RD	Platform 1, Eastbound Departure End	19/04/05	06.39	14.41	2.2	1060.4	0.82	Static as no platform duties
041223/67	RD	Platform 2, Westbound Departure End	19/04/05	06.41	14.45	2.2	1064.8	0.87	Static as no platform duties
041223/68	RD	[redacted]	19/04/05	07.46	10.46	2.2	396	0.69	Gate line duty

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
041223/72	RD	[redacted]	21/04/05	06.20	12.00	2.2	748	0.42	Gate line duty at north end of station
041223/69	RD	[redacted]	21/04/05	06.30	14.00	2.2	990	0.33	Gate line duty at south end of station
041223/71	RD	Platform Eastbound	21/04/05	06.25	14.25	2.2	1056	0.52	Static as no platform duties
041223/77	RD	Platform Westbound	21/04/05	06.27	14.27	2.2	1056	0.49	Static as no platform duties
041223/70	RD	[redacted]	21/04/05	08.00	12.00	2.2	528	0.22	In Ticket Office

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
041223/76	RD	[redacted]	22/04/05	07.00	15.00	2.2	1056	0.21	Northern Line platforms and gate line
041223/79	RD	[redacted]	22/04/05	06.40	13.30	2.2	902	0.06	Gate line duty
041223/81	RD	[redacted]	22/04/05	06.45	11.45	2.2	660	0.33	Bakerloo Line platforms and gate line
041223/78	RD	Bakerloo Line Platforms	22/04/05	06.30	14.30	2.2	1056	0.32	Static as limited time spent on platforms
041223/80	RD	Northern Line Platform 2	22/04/05	06.20	14.20	2.2	1056	0.77	Static as limited time spent on platforms
041223/83	RD	Northern Line Platform 1	22/04/05	06.25	14.25	2.2	1056	0.62	Static as limited time spent on platforms

Table 13: Oxford 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
041223/92	RD	[redacted]	26/04/05	06.24/ 11.03	10.32/ 13.22	2.2	864.6	0.55	Platform 2, Central Line 2hrs 10mins, remainder on gate line and upper levels
041223/97	RD	[redacted]	26/04/05	07.02	13.18	2.2	827.2	0.60	Platform 4, Bakerloo Line 2hrs 10mins, remainder on gate line and upper levels
041223/94	RD	[redacted]	26/04/05	07.36	10.25	2.2	371.8	0.89	Platform 5, Victoria Line 2hrs 20mins, and station checks
041223/96	RD	[redacted]	26/04/05	07.38	13.16	2.2	743.6	0.54	Platform 1, Central Line 2hrs 10mins, remainder on gate line and upper levels
041223/89	RD	[redacted]	26/04/05	07.48	11.25	2.2	477.4	0.58	Platform 6, Victoria Line 2hrs 10mins, remainder on gate line and upper levels
041223/98	RD	[redacted]	26/04/05	07.49	10.10	2.2	310.2	0.97	Platform 3, Bakerloo Line 2hrs 10mins

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
041223/88	RD	[redacted]	25/04/05	07.04	11.53	2.2	1034	0.27	AG Piccadilly Line platforms 2hrs, remainder of sample on gate line and upper levels
	RD	[redacted]	25/04/05	11.53	15.04				
041223/91	RD	[redacted]	25/04/05	07.14	15.01	2.2	1027.4	0.26	Piccadilly Line platforms 2hrs, remainder on gate line and upper levels
041223/87	RD	Static on Bakerloo, Southbound	25/04/05	08.04	15.13	2.2	943.8	1.23	Static sample as platform not attended
041223/93	RD	[redacted]	25/04/05	08.20	11.52	2.2	466.4	0.60	NB Bakerloo Line platform 1hr 20mins remainder on gate line and upper levels

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
041223/107	RD	Station Supervisor's Office	27/04/05	06.30	14.30	2.2	1056	0.06	Static sample
041223/109	RD	[redacted]	27/04/05	07.20	12.00	2.2	616	0.36	Platform 2, Central Line, 2hrs, gate line 1hr, lower circulating area 1hr remainder upper levels and break
041223/112	RD	[redacted]	27/04/05	06.45	14.00	2.2	957	0.22	Platform 3, Northern Line, 2hrs, Platforms 1 & 2, 1hr, gate line 3hr remainder upper levels and break
041223/114	RD	[redacted]	27/04/05	07.05	14.05	2.2	924	0.24	Platform 4, Northern Line, 1hr, gate line 1hr, lower circulating area 2hrs, remainder mobile and break
041223/115	RD	[redacted]	27/04/05	06.20	12.00	2.2	748	0.05	Gate line, upper levels and break
041223/117	RD	[redacted]	27/04/05	06.50	14.50	2.2	1056	0.18	Platform 4, Northern Line, 2hrs, gate line 3hrs, lower circulating area 1hr remainder mobile and break
041223/120	RD	[redacted]	27/04/05	07.10	14.10	2.2	924	0.34	Platform 2, Central Line, 2hrs, gate line 2hrs, lower circulating area 2hr remainder mobile & upper levels

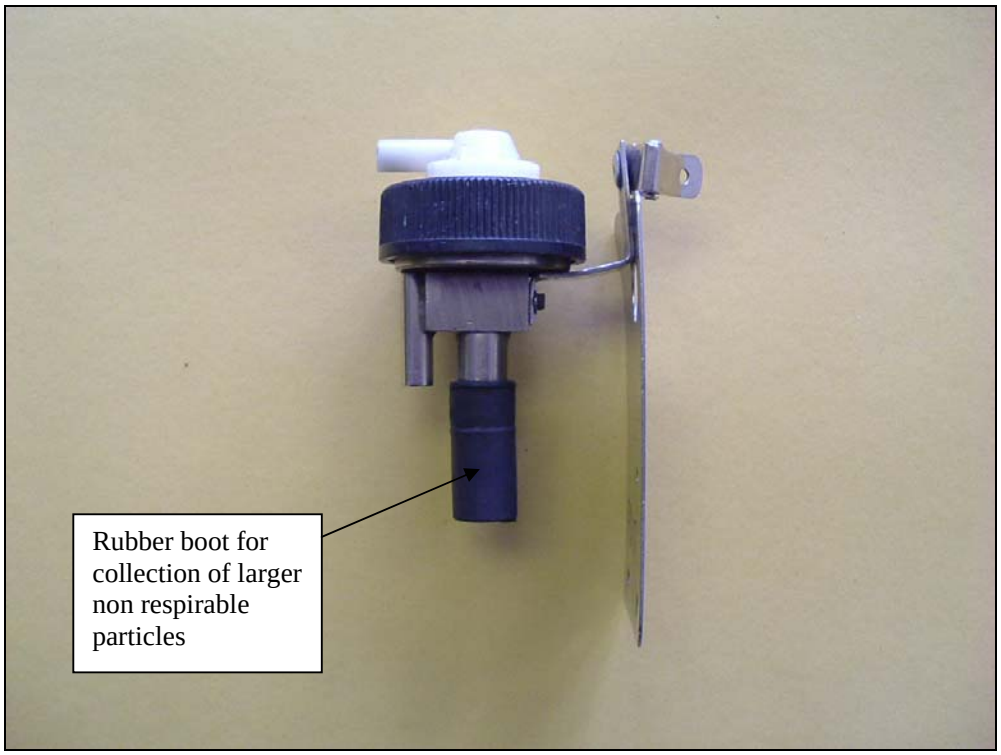
Table 16: Vauxhall Station

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
041223/101	RD	Platform 2, Southbound	28/04/05	07.01	15.03	2.2	1060.4	0.66	Static sample
041223/102	RD	Platform 1, Northbound	28/04/05	07.02	15.06	2.2	1064.8	0.62	Static sample
041223/104	RD	Alice O'Connor	28/04/05	07.29	11.45	202	810.6	0.24	NB Platform 1hr 30mins, station checks 30mins, remainder on gate line and upper levels
			28/04/05	13.00	14.57				

Table 17: 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
041223/29	RD	Central Line Train Operators Driving Trains	24/03//05	721.6	<0.01	<0.014	West Ruislip → Epping → West Ruislip → Epping → White City
041223/38	RD	Jubilee Line Train Operators Driving Trains	23/04/05	754.6	<0.01	<0.013	Neasden Depot → Stratford → Neasden → Stratford → Willesden Green → Stratford → Neasden
041223/24	RD	Circle Line Train Operators Driving Trains	09/03/05	1148.4	<0.01	<0.01	Edgware Road, three circle complete then signal failure at Victoria divert to Hammersmith return to Edgware Road then 4 complete circles
041223/75	RD	Northern Line Train Operators Driving Trains	20/04/05	462.0	0.01	0.02	Morden → High Barnet → Morden → Golders Green
041223/26	RD	Piccadilly Line Train Operators Driving Trains	14/03/05	1100.0	<0.01	<0.01	Northfields → Heathrow 123 → Arnos Grove → Northfields Depot (Points failure hence diversion) → Acton → Cockfosters → Acton → Heathrow 123 → Cockfosters → Acton
041223/36	RD	Victoria Line Train Operators Driving Trains	09/04/05	906.4	0.01	0.01	Seven Sisters → Brixton → Walthamstow → Brixton → Walthamstow → Brixton → Seven Sisters → Brixton → Walthamstow → Brixton → Walthamstow → Seven Sisters
041223/32	RD	Bakerloo Line Train Operators Driving Trains	08/04/05	1056	<0.01	<0.01	Harrow & Wealdstone → Willesden Jct → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park → Willesden Jct → Elephant & Castle → Harrow & Wealdstone

Figure 1 : Cyclone Dust Head



Appendix 1 : Crystalline Respirable Silica Results

Institute of Occupational Medicine
consulting

UKAS TESTING
0374

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 04956

PROJECT NO: 610

DATE OF ISSUE: 16.05.05

DATE SAMPLES RECEIVED: 05.05.05

DATE SAMPLES ANALYSED: 16.05.05

SAMPLES: Eight x 25mm PVC filters

ANALYSIS REQUESTED: Respirable Crystalline Silica (Quartz).

METHOD: The samples were analysed using a method based on;

MDHS 37: Health and Safety Executive (1987). "Quartz in respirable airborne dust". Laboratory method using infra-red spectroscopy (direct method). Methods for the Determination of Hazardous Substances No. 37. HMSO, London.

•Research Park North, Riccarton, Edinburgh, EH14 4AP, Scotland, UK (Registered Office)
Tel (44) 0870 850 5131 Fax (44) 0870 850 5132 E-mail iom@iomhq.org.uk

CONTRACT NO: 04956

PROJECT NO: 610

DATE OF ISSUE: 16.05.05

RESULTS:

Sample number	Quartz Weight (mg)
041223/24	<0.01
041223/26	<0.01
041223/29	<0.01
041223/32	<0.01
041223/36	0.01
041223/38	<0.01
041223/75	0.01
041223/B3	<0.01

Our 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 that have been incorrectly collected or despatched by external clients.

ANALYSED BY: [redacted]
S Clark
Mineralogy Section Manager

AUTHORISED BY [redacted]
C McGonagle
Chemistry Section Manager