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for Transport & Industry

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TRAFFIC EMISSIONS MONITORING ON STAFF MEMBERS AT LONDON UNDERGROUND STATIONS

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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.

REVISIONS		
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	Draft for comment	1st May 2018
01	General weather data included	9th May 2018
02	Re-issue following clients comments	15th May 2018

CONTENTS

1. INTRODUCTION

1.1 4-RAIL Services Ltd were requested by Mr Nick Wilson, Transport for London, to monitor potential London Underground Limited (LUL) station staff exposure to traffic fume. Concerns have been raised regarding staff that spend significant periods in areas where there is a possible risk of exposure to traffic emissions.

1.2 London Underground station staff carry out various duties throughout the station environment. One particular responsibility involves spending long periods of time within the station ticket hall assisting on the gate-line. At a number of stations the ticket hall is located in close proximity to busy main roads that regularly experience heavy traffic flow. This could potentially lead to the build-up of toxic fumes that may then penetrate into the ticket hall, resulting in possible exposure. This initial investigation aims to ascertain whether there may be cause for concern regarding the air quality within the ticket hall at the specified underground stations located within London.

2. BACKGROUND

2.1 Traffic fumes, mainly from both petrol and diesel, contain a complex mixture of gases, vapours, liquid aerosols and particulates. These products include the following:

- Carbon (soot)
- Nitrogen, N_2
- Water, H_2O
- Carbon monoxide, CO
- Oxides of nitrogen, NO_x (e.g. nitrogen monoxide, NO, and nitrogen dioxide, NO_2)
- Oxides of sulphur, SO_x (e.g. sulphur dioxide, SO_2)
- Aldehydes
- Polycylic aromatic hydrocarbons, PAH

2.2 Exhaust emissions from diesel engines are usually more visible than those emitted from petrol engines as they contain over ten times more soot particles. In general diesel engines produce less carbon monoxide than petrol engines but more oxides of nitrogen, oxides of sulphur (dependant on the sulphur content of the fuel), aldehydes and particulate matter.

2.3 These hazardous substances are the most practical to assess and will allow a good exposure assessment. Workplace Exposure Limits (WEL) in the UK are governed by Health & Safety Executive (HSE) document EH40/2005 Workplace Exposure Limits Second Edition. Where no WEL is given in EH40, other documentation is used to help assess the exposure.

2.4 WELs and other occupational exposure limits are values designed to help protect the health of workers for compliance to Control of Substances Hazardous to Heath (COSHH) regulations.

2.5 WELs are given as a concentration in air averaged over a specified period of time. These time periods are:

- 8 hours, a Time Weighted Average (TWA) also known as the Long-Term Exposure Limit (LTEL)

- 15 minutes, also known as the Short-Term Exposure Limit (STEL)

2.6 WELs are given in units of parts per million (ppm) and/or milligrams per meter cubed of air (mg/m^3).

2.7 From a practical perspective, and in agreement with the client, the following substances were assessed during the monitoring.

- Nitrogen Dioxide
- Formaldehyde

2.8 Nitrogen Dioxide

2.8.1 Nitrogen dioxide reacts slowly with water to form nitric acid and nitrous acid. This makes nitrogen dioxide an irritant to the eyes, respiratory tract and the deep compartment of the respiratory tract. Research into the health effects and Occupation Exposure Limits (OEL) is ongoing.

2.8.2 There is currently no WEL for nitrogen dioxide in HSE EH40/2005 Workplace Exposure Limits Second Edition. Exposure to nitrogen dioxide is currently governed by COSHH regulations. Therefore, exposure to nitrogen dioxide should be kept as low as reasonably practicable.

2.8.3 'CD283 HSE Consultation Document: Consultation on implementing new and revised Workplace Exposure Limits' proposes that a 1ppm STEL and 0.5ppm TWA are to be adopted on 21st August 2018. TFL Procedure PR703 A1 has already adopted these limits.

2.9 Formaldehyde

2.9.1 Aldehydes form part of exhaust fumes. Formaldehyde is known to be one of the more carcinogenic aldehydes.

2.9.2 Formaldehyde has a WEL in HSE EH40/2005 Workplace Exposure Limits Second Edition of 2.5 mg/m^3 for the 8-hour TWA LTEL and 2.5 mg/m^3 for the 15 minute STEL.

Table 1: Exposure Limits

Substance	Long - term exposure limit (8-hour time weighted average)	Short term exposure limit (STEL) – 15 minute average	Guidance Document
Nitrogen Dioxide	0.5 ppm	1.0 ppm	TFL - PR703 A1 HSE – CD283
Formaldehyde	2.5 mg/m^3	2.5 mg/m^3	EH40/2005

3. SAMPLING AND METHODOLOGY

3.1 10 shifts of monitoring were conducted between 12th and 23rd March 2018. Monitoring was undertaken by Mr C. Davies, Mr A. Urquhart and Mr C. Gravesen of 4-RAIL Services Ltd (4RS). Personal samples were collected on staff working in the station environment, as well as static samples positioned within the ticket hall. 10 different stations were visited over the two weeks, the list of stations was decided prior to the sampling by the client. All the stations were located next to roads with the ticket hall in close proximity to the curb. Appendix 3 contains general weather observations from each day of sampling.

Table 2: Sampling Schedule

Station	Date of Sampling	No. of Samples
Great Portland Street	12/03/2018	4
Warren Street	13/03/2018	5
Lancaster Gate	14/03/2018	4
Queensway	15/03/2018	5
Camden Town	16/03/2018	5
Bromley by Bow	19/03/2018	3
Hanger Lane	20/03/2018	3
Elephant & Castle	21/03/2018	5
Mornington Crescent	22/03/2018	4
East Ham	23/03/2018	4

3.2 The following substances were assessed during the monitoring. These substances are the most suitable to monitor, and allow a good assessment of exposure to be determined to the desired limit of detection. Exposure can then be compared to known and proposed Workplace Exposure Limits (WELs), based on an 8-Hour TWA. Refer to Table 1 for WELs used in this assessment.

In addition to this, regular spot measurements were taken throughout the station for the airborne total volatile organic compound (TVOC) concentration, taken with a Multirae Systems direct reading instrument. Traffic fume is a major source of TVOC, and therefore spot measurements taken throughout the station may highlight any potential hot spots of traffic fumes.

Substance	Sampling Media / Technique	Sampling Period
Nitrogen Dioxide	Gastec Passive Dosi Tubes	Full shift or minimum 4 hours
Formaldehyde	UME×100 Passive sampler	Full shift or minimum 4 hours

4. RESULTS & DISCUSSION

4.1 Results of the monitoring carried out can be seen within Appendix 1 and 2.

4.2 All nitrogen dioxide concentrations were below the limit of detection of the sampling media used in the study. The vast majority of concentrations were within the region of <0.04 - <0.06 ppm, around ten times lower than the WEL adopted for this study. The highest result seen was <0.09 ppm at Hanger Lane, however, this is likely due to the short sample length which in turn increases the limit of detection. A handful of results of <0.07 ppm were observed at East Ham and Elephant & Castle station, again likely due to the shorter sampling period. These low concentrations suggest that any potential traffic fume being produced at road level is being dispersed into the atmosphere rather than penetrating into the station.

4.3 Formaldehyde concentrations ranged from 0.007 mg/m^3 – 0.034 mg/m^3, with the bulk of the results lower than the limit of detection (LOD). There were 6 results above the LOD, found at 5 different stations following no particular pattern. The observed concentrations are all well below the WEL of 2.5 mg/m^3 detailed within EH40/2005 for formaldehyde. This indicates that the potential risk of exposure to components of traffic fume is minimal within the station ticket hall.

4.4 Spot measurements were taken throughout the station environment on a regular basis throughout the sampling. All spot measurements taken for total VOC concentration were less than 1 ppm. Following the manufacturer's correction factors a calculated concentration for benzene of <0.47 can be reported for all spot measurements taken. As these are only short static measurements they are only for information purposes, and not to be compared to WELs.

4.5 Samples were collected over the region of 4 – 8 hours. Consequently this means that all the observed concentrations are comfortably below the WEL's used for this investigation.

5. CONCLUSIONS & RECOMMENDATIONS

5.1 4-RAIL Services were requested by Mr Nick Wilson, Transport for London, to assess potential traffic fume exposure to London Underground station staff. A number of stations throughout London were visited and personal and static samples were collected for subsequent analysis for nitrogen dioxide and formaldehyde, in addition spot measurements for total VOC were taken.

5.2 All results indicate that any exposure to the hazards detailed is minimal and below the workplace exposure limits utilised in this study. The majority of concentrations were below the limit of detection of the sampling method being used.

5.3 As with all studies of this nature external factors will have an on influence on the outcome of the investigation. Weather will affect the results to a large degree. Any wind or rain outside of the station will act to dilute any potential pollution being created outside, consequently diluting any possible fumes that would have penetrated into the station. Further to this the amount of traffic outside the station cannot be influenced during the sampling period. This will ultimately determine whether high enough levels of pollution will be produced to possibly expose staff to elevated levels. A worst case scenario would be a still day with a large amount of non-moving traffic idling outside of the station entrance.

5.4 Whilst further monitoring of this kind is likely to yield similar results, consideration may be given to monitoring a worst case scenario, so that on days where pollution levels are expected to rise, a more accurate idea of likely exposure staff may receive will be recorded, however intermittent this may be.

6. REFERENCES

Control of Substances Hazardous to Health Regulations 2002 (As amended).

HSE Document, EH40/2005 Workplace Exposure Limits (Second edition).

European Commission Scientific Committee on Occupational Exposure Limits (SCOEL/SUM/53) – Recommendation from the Scientific Committee on Occupational Exposure Limits for Nitrogen Dioxide.

HSE Document HSG187, Control of Diesel Engine Exhaust Emissions in the Workplace.

TFL Management System Procedure, PR0703 A1 Control of Diesel Engine Exhaust Emissions.

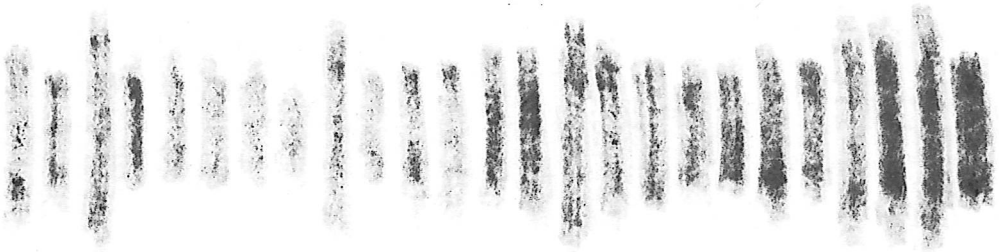
MDHS 14/4: General methods for sampling and gravimetric analysis of respirable, thoracic and inhalable aerosols

Occupational exposure limit from National Institute of Occupational Safety and Health (NIOSH)

HSG173: Monitoring strategies for toxic substances

Technical-Note-106: A-Guideline-for-Pid-Instrument-Response

Atmos. Chem. Phys., 9, 7491–7504, 2009: Vehicular emission of volatile organic compounds (VOCs) from a tunnel study in Hong Kong



Appendix 1: Results of NO_2 and CH_2O Monitoring

Station	Sample No.	Sample Location	Start	End	Analysis Concentration		TWA Concentration	
					NO_2 (ppm)	CH_2O (mg)	NO_2 (ppm)	CH_2O (mg/m^3)
GPS	170660/120318/01	[redacted]	07:52	14:24	<0.3	0.0001	<0.05	0.009
	170660/120318/02		07:54	15:54	<0.3	<0.0001	<0.04	<0.007
	170660/120318/03		07:57	12:46	<0.3	<0.0001	<0.06	<0.012
	170660/120318/04		08:07	15:54	<0.3	<0.0001	<0.04	<0.007
Warren Street	170660/130318/01		07:37	15:37	<0.3	<0.0001	<0.04	<0.007
	170660/130318/02		07:37	15:37	<0.3	<0.0001	<0.04	<0.007
	170660/130318/03		07:37	15:37	<0.3	0.0001	<0.04	0.007
	170660/130318/04		07:37	15:37	<0.3	0.0001	<0.04	0.007
	170660/130318/05		07:37	15:37	<0.3	<0.0001	<0.04	<0.007
Lancaster Gate	170660/140318/01		11:00	18:50	<0.3	<0.0001	<0.04	<0.007
	170660/140318/02		11:02	18:50	<0.3	<0.0001	<0.04	<0.007
	170660/140318/03		11:04	18:50	<0.3	<0.0001	<0.04	<0.008
	170660/140318/04		11:05	18:50	<0.3	<0.0001	<0.04	<0.008
Queensway	170660/150318/01		07:46	14:46	<0.3	<0.0001	<0.04	<0.008
	170660/150318/02		07:46	14:46	<0.3	<0.0001	<0.04	<0.008
	170660/150318/03		07:46	14:46	<0.3	<0.0001	<0.04	<0.008
	170660/150318/04		07:50	15:13	<0.3	<0.0001	<0.04	<0.008
	170660/150318/05		09:55	15:13	<0.3	0.0001	<0.06	0.011
Camden Town	170660/160318/01		07:56	14:05	<0.3	<0.0001	<0.05	<0.009
	170660/160318/02		07:56	15:04	<0.3	<0.0001	<0.04	<0.008
	170660/160318/03		07:56	15:04	<0.3	<0.0001	<0.04	<0.008
	170660/160318/04		07:58	14:08	<0.3	<0.0001	<0.05	<0.009
	170660/160318/05		07:58	15:14	<0.3	<0.0001	<0.04	<0.008
Bromley by Bow	170660/190318/01		07:48	12:50	<0.3	<0.0001	<0.06	<0.012
	170660/190318/02		07:48	12:50	<0.3	<0.0001	<0.06	<0.012

TRAFFIC EMISSIONS MONITORING ON STAFF MEMBERS AT LONDON UNDERGROUND STATIONS

Station	Sample No.	Sample Location	Start	End	Analysis Concentration		TWA Concentration	
					NO_2 (ppm)	CH_2O (mg)	NO_2 (ppm)	CH_2O (mg/m³)
Bromley by Bow	170660/190318/03	[redacted]	07:50	12:50	<0.3	<0.0001	<0.06	<0.012
Hanger Lane	170660/200318/01		08:14	14:33	<0.3	<0.0001	<0.05	<0.009
	170660/200318/02		08:19	14:38	<0.3	<0.0001	<0.05	<0.009
	170660/200318/03		11:14	14:37	<0.3	0.0002	<0.09	0.034
Elephant & Castle	170660/210318/01		07:35	12:25	<0.3	<0.0001	<0.06	<0.012
	170660/210318/02		07:40	12:30	<0.3	0.0001	<0.06	0.012
	170660/210318/03		07:50	12:56	<0.3	<0.0001	<0.06	<0.011
	170660/210318/04		08:00	12:35	<0.3	<0.0001	<0.07	<0.013
	170660/210318/05		08:05	12:45	<0.3	<0.0001	<0.06	<0.012
Mornington Crescent	170660/220318/01		12:10	16:50	<0.3	<0.0001	<0.06	<0.012
	170660/220318/02		12:10	19:10	<0.3	<0.0001	<0.04	<0.008
	170660/220318/03		12:10	19:10	<0.3	<0.0001	<0.04	<0.008
	170660/220318/04		12:10	19:10	<0.3	<0.0001	<0.04	<0.008
East Ham	170660/230318/01		07:40	11:50	<0.3	<0.0001	<0.07	<0.014
	170660/230318/02		07:40	11:50	<0.3	<0.0001	<0.07	<0.014
	170660/230318/03		07:40	11:50	<0.3	<0.0001	<0.07	<0.014
	170660/230318/04		07:40	11:50	<0.3	<0.0001	<0.07	<0.014

*

Key
Minimal Measurements

Appendix 2: VOC Spot Measurements

Station	Total VOC Concentration Spot Measurements (ppm)					
	1	2	3	4	5	6
Great Portland Street	<1	<1	<1	<1	<1	-
Warren Street	<1	<1	<1	<1	-	-
Lancaster Gate	<1	<1	<1	<1	<1	-
Queensway	<1	<1	<1	<1	<1	-
Camden Town	<1	<1	<1	<1	-	-
Bromley by Bow	<1	<1	<1	<1	-	-
Hanger Lane	<1	<1	<1	<1	<1	<1
Elephant & Castle	<1	<1	<1	<1	-	-
Mornington Crescent	<1	<1	<1	<1	-	-
East Ham	<1	<1	<1	-	-	-

Station	Calculated Benzene Concentration Spot Measurements (ppm)					
	1	2	3	4	5	6
Great Portland Street	<0.47	<0.47	<0.47	<0.47	<0.47	-
Warren Street	<0.47	<0.47	<0.47	<0.47	-	-
Lancaster Gate	<0.47	<0.47	<0.47	<0.47	<0.47	-
Queensway	<0.47	<0.47	<0.47	<0.47	<0.47	-
Camden Town	<0.47	<0.47	<0.47	<0.47	-	-
Bromley by Bow	<0.47	<0.47	<0.47	<0.47	-	-
Hanger Lane	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47
Elephant & Castle	<0.47	<0.47	<0.47	<0.47	-	-
Mornington Crescent	<0.47	<0.47	<0.47	<0.47	-	-
East Ham	<0.47	<0.47	<0.47	-	-	-

Appendix 3: Weather Observations

Date	Weather
12/03/2018	Overcast, cold, some rain and wind
13/03/2018	Overcast, some wind
14/03/2018	Overcast, little wind
15/03/2018	Overcast, some wind and rain
16/03/2018	Overcast, some wind and rain, warm
19/03/2018	Cold and windy
20/03/2018	Cold, windy, some rain
21/03/2018	Sunny with some clouds, cold, little wind
22/03/2018	Cloudy, windy, cold
23/03/2018	Cloudy, windy, cold