

Technical Report**NOISE AT WORK ASSESSMENT FOR PICCADILLY LINE TRAIN OPERATORS**

Prepared for:

Louise Dearman - Human Factors & Occupational Hygiene Advisor

Nick Wilson - Occupational Hygienist

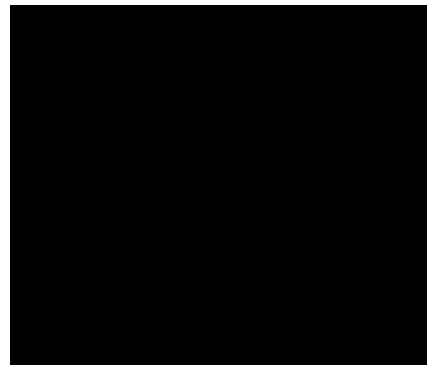
Nicki Selling - HSE Manager LU Operations

Issue Date: 2nd February 2021

Reference: RP-R2899

Prepared by: Chris McCollin MIOA

Reviewed by: José Barros

**CONDITIONS OF ISSUE OF REPORT**

THIS REPORT IS ISSUED TO THE CLIENT IN CONFIDENCE AND SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF LONDON UNDERGROUND LIMITED.

QUERIES OR FURTHER INFORMATION

ANY QUERIES OR REQUESTS FOR ADDITIONAL INFORMATION ON THE SUBJECT OF THIS REPORT SHOULD BE ADDRESSED TO THE AUTHOR WHO MAY BE CONTACTED AT THE ADDRESS GIVEN ON THE TITLE PAGE.

© LONDON UNDERGROUND LIMITED



1. Introduction

The noise and vibration team in Technical Services was asked to measure noise levels in accordance with The Control of Noise at Work Regulations 2005 for train operators on the Piccadilly line and to identify track sections where the noise levels were high.

2. Summary of the Control of Noise at Work Regulations 2005

The aim of the regulations is to protect persons against risk to their health and safety arising from exposure to noise at work. The general aspiration of the regulations is to reduce noise levels for all employees to as low a level as reasonably practicable. The following duties are placed on an employer:

- assessment of employees' risk and periodic review of the risks (this can include noise measurements);
- implementation of controls to eliminate the risk or reduce it to as low as possible (by either reducing the noise levels or exposure time);
- provision of personal hearing protectors as appropriate to the exposure level determined;
- health surveillance as appropriate; and
- provision of information, instruction and training to employees at risk.

The regulations define noise exposure limit values and action values. These are provided in **Table 1**.

	Daily Personal Noise Exposure $L_{EP,d}$	Peak Sound Pressure L_{Cpeak}
Lower Exposure Action Values	80 dB(A)	135 dB(C)
Upper Exposure Action Values	85 dB(A)	137 dB(C)
Exposure Limit Values	87 dB(A)	140 dB(C)

Table 1 – Noise exposure limit values and action values

The equation used to calculate a daily personal noise exposure, $L_{EP,d}$ is defined as

$$L_{EP,d} = L_{Aeq,Te} + 10 \log \left(\frac{T_e}{T_0} \right)$$

where,

$L_{Aeq,Te}$ is the equivalent continuous A-weighted sound pressure level,

T_e is the duration of exposure to the noise, in seconds, and

T_0 is the reference duration of 8 hours (28,800 seconds).

Hearing protection should only be considered when organisational and technical methods to reduce noise levels to as low as possible have been found not to be reasonably practical. In such circumstances employees exposed to levels at or above the lower action values shall be advised of the risks and personal hearing protectors shall be made available to them.

Employees who are exposed to levels at or above the upper action values must be provided with personal hearing protectors by their employer and the employer is required to enforce their mandatory use.

The employer must ensure that employees are not exposed to noise above the exposure limit values, which includes allowing the employer to take into account the noise reduction provided by hearing protection.



3. Measurements and Results

The LU HSE team asked Technical Services to carry out the monitoring of train operator's noise levels for the Piccadilly line. This was to ensure that train operator noise exposure is minimised and controlled in line with the Control of Noise at Work Regulations 2005.

A train operator's daily noise exposure level is a logarithmic average of all the noise levels he/she is exposed to throughout an 8 hour shift. If the amount of time spent at high noise levels can be reduced either by reducing the noise levels or exposure time this will reduce the daily noise exposure level. The highest noise levels a train operator is exposed to are when he/she is in the cab and the train is moving. These cab noise levels can be broken down into inter-station noise levels.

The measurements were carried out on the 24/11/20, 27/11/20, 03/12/20 and 04/12/20 using a handheld sound level meter (SLM), with the microphone located next to the driver's most exposed ear. The details regarding the meter can be found in Appendix A. Each direction was measured multiple times in randomly selected cabs. Due to the Coronavirus pandemic and the working restrictions imposed at the time, it was not possible to complete a full sample set of measurements. However, the tunnel sections of the Piccadilly Line which are likely to give the highest recorded levels had a full set of measurements. As such the following samples were captured:

- Run #1 – 24/11/2020:
 - Cockfosters to Heathrow Terminal 5 and Terminals 1, 2 and 3;
 - Heathrow Terminal 5 and Terminals 1, 2 and 3 to Cockfosters.
- Run #2 – 27/11/2020:
 - Cockfosters to Uxbridge; and
 - Uxbridge to Cockfosters.
- Run #3 – 27/11/2020:
 - Cockfosters to Heathrow Terminals 4; and
 - Heathrow Terminal 4 to Cockfosters.
- Run #4 - 04/12/2020:
 - Cockfosters to Uxbridge; and
 - Uxbridge to Cockfosters.

The average levels for all cab runs are presented in the tables below. These measurements start when the train starts moving at the start station and finish when the train comes to rest at the end station. These overall levels do not include the dwell time spent at stations.



Interstation section	L _{eq} dB(A)	L _{peak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Uxbridge to Hillingdon	71	111	52	59	61	63	68	61	59	48
Hillingdon to Ickenham	70	112	51	62	62	62	66	61	55	49
Ickenham to Ruislip	70	112	52	60	61	63	66	62	56	49
Ruislip to Ruislip Manor	70	112	48	57	59	62	67	62	56	48
Ruislip Manorto Eastcote	70	112	50	57	60	62	67	61	57	50
Eastcote to Rayners Lane	71	112	53	59	62	63	67	62	57	50
Rayners Laneto South Harrow	72	112	53	61	63	65	67	63	59	51
South Harrowto Sudbury Hill	72	113	51	59	61	62	69	61	60	50
Sudbury Hill to Sudbury Town	70	112	49	56	61	62	66	62	56	50
Sudbury Town to Alperton	72	112	51	56	61	63	69	62	60	51
Alperton to Park Royal	70	114	51	57	61	63	66	61	57	49
Park Royal to North Ealing	70	112	49	57	60	63	66	62	57	50
North Ealing to Ealing Common	74	112	51	60	64	65	70	65	62	51
Ealing Common to Acton Town	70	109	52	59	62	63	65	62	57	49
Acton Town to Hammersmith	77	119	57	62	70	70	71	66	63	50
Hammersmith to Barons Court	75	117	53	63	67	67	70	65	61	56
Barons Court to Earl's Court	75	115	54	62	67	70	69	65	59	53
Earl's Court to Gloucester Road	77	118	51	60	64	72	74	67	61	53
Gloucester Road to South Kensington	75	117	52	58	62	69	72	66	60	52
South Kensington to Knightsbridge	76	117	52	61	66	74	69	65	59	51
Knightsbridge to Hyde Park Comer	76	115	51	59	67	71	71	66	61	54
Hyde Park Corner to Green Park	76	119	55	65	67	71	71	67	60	52
Green Park to Piccadilly Circus	74	115	52	59	63	69	70	66	60	52
Piccadilly Circus to Leicester Square	75	118	56	66	66	69	71	66	61	53
Leicester Square to Covent Garden	74	117	51	59	62	67	71	66	62	54
Covent Garden to Holborn	78	118	55	63	66	75	71	67	66	51
Holbom to Russell Square	78	116	58	64	66	75	72	67	60	52
Russell Square to King's Cross St. Pancras	76	116	58	65	66	72	71	66	60	51
King's Cross St. Pancras to Caledonian Road	76	115	56	64	67	71	71	66	59	49
Caledonian Road to Holloway Road	76	116	56	65	67	70	72	66	60	51
Holloway Road to Arsenal	76	115	53	68	67	70	72	66	59	52
Arsenal to Finsbury Park	77	116	54	66	68	71	72	68	62	54
Finsbury Park to Manor House	79	116	57	65	68	73	76	68	61	52
Manor House to Turnp ke Lane	77	113	56	61	65	72	75	67	60	48
Turnp ke Lane to Wood Green	77	116	55	65	69	73	73	67	60	51
Wood Green to Bounds Green	78	117	57	65	69	74	74	68	61	51
Bounds Green to Arnos Grove	76	115	52	59	63	70	71	67	62	50
Arnos Grove to Southgate	74	115	53	60	65	69	70	64	59	51
Southgate to Oakwood	76	117	53	64	68	68	73	65	60	51
Oakwood to Cockfosters	71	113	52	60	61	65	66	64	62	53

Table 2 – Interstation noise levels for the eastbound road between Uxbridge and Cockfosters



Interstation section	L _{eq} dB(A)	L _{peak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Cockfosters to Oakwood	69	113	50	58	61	62	64	61	59	56
Oakwood to Southgate	73	115	52	60	64	65	68	65	59	56
Southgate to Arnos Grove	75	113	51	59	63	67	67	70	60	58
Arnos Grove to Bounds Green	76	113	55	63	67	71	71	68	62	57
Bounds Green to Wood Green	77	113	55	63	67	72	72	67	60	51
Wood Green to Turnpike Lane	77	117	54	60	66	73	74	67	61	52
Turnpike Lane to Manor House	79	116	57	65	69	73	74	70	62	52
Manor House to Finsbury Park	78	113	53	61	65	75	72	68	61	53
Finsbury Park to Arsenal	79	116	59	70	72	74	74	70	63	54
Arsenal to Holloway Road	75	119	55	66	66	68	71	66	60	52
Holloway Road to Caledonian Road	73	113	52	59	63	68	68	63	58	49
Caledonian Road to King's Cross St. Pancras	75	113	55	64	68	70	70	66	59	49
King's Cross St. Pancras to Russell Square	77	119	56	65	68	72	72	67	61	52
Russell Square to Holborn	75	118	54	61	64	70	70	65	60	52
Holborn to Covent Garden	76	117	55	64	68	72	71	66	59	50
Covent Garden to Leicester Square	75	119	52	60	64	67	71	67	62	54
Leicester Square to Piccadilly Circus	75	112	54	61	65	70	70	67	61	52
Piccadilly Circus to Green Park	73	115	50	57	64	68	69	65	60	51
Green Park to Hyde Park Corner	77	118	56	64	68	71	72	68	62	52
Hyde Park Corner to Knightsbridge	76	118	54	61	65	71	71	66	60	53
Knightsbridge to South Kensington	77	113	51	59	65	74	70	65	59	50
South Kensington to Gloucester Road	75	116	56	62	64	71	70	66	60	51
Gloucester Road to Earl's Court	77	115	52	58	63	72	75	67	60	52
Earl's Court to Barons Court	77	115	55	61	65	74	71	65	59	53
Barons Court to Hammersmith	73	115	51	60	66	66	68	65	61	54
Hammersmith to Acton Town	75	115	56	65	70	69	68	64	59	52
Acton Town to Ealing Common	71	111	52	62	65	65	66	62	57	50
Ealing Common to North Ealing	72	112	50	60	62	64	67	66	59	51
North Ealing to Park Royal	72	110	49	56	60	63	66	68	58	50
Park Royal to Alperton	73	112	51	56	61	63	67	70	59	50
Alperton to Sudbury Town	74	110	51	56	62	65	69	68	61	51
Sudbury Town to Sudbury Hill	71	113	50	55	60	63	65	66	58	50
Sudbury Hill to South Harrow	70	110	50	58	62	64	65	62	56	49
South Harrow to Rayners Lane	73	113	54	60	63	64	68	66	58	49
Rayners Lane to Eastcote	72	111	54	60	62	64	66	66	58	50
Eastcote to Ruislip Manor	70	114	50	57	60	63	66	62	56	48
Ruislip Manor to Ruislip	70	111	50	57	61	63	66	62	56	48
Ruislip to Ickenham	71	111	53	60	62	63	66	66	59	49
Ickenham to Hillingdon	73	112	53	65	67	65	66	62	56	49
Hillingdon to Uxbridge	69	112	51	58	61	62	64	62	58	51

Table 3 – Interstation noise levels for the westbound road between Cockfosters and Uxbridge



Interstation section	L _{eq} dB(A)	L _{peak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Sidings to Heathrow Terminal 5	60	103	35	50	48	51	52	55	52	49
Heathrow Terminal 5 to Heathrow Terminals 1, 2, 3	81	109	58	64	70	77	76	68	62	49
Heathrow Terminals 1, 2, 3 to Hatton Cross	81	115	57	64	70	77	76	67	59	52
Hatton Cross to Hounslow West	75	117	60	65	69	69	69	66	60	59
Hounslow West to Hounslow Central	71	114	51	58	61	63	66	62	60	58
Hounslow Central to Hounslow East	72	116	50	57	60	63	67	63	60	60
Hounslow East to Osterley	73	116	51	60	64	64	67	63	60	59
Osterley to Boston Manor	72	116	52	60	64	65	67	63	61	57
Boston Manor to Northfields	70	114	49	58	62	63	65	62	60	57
Northfields to South Ealing	72	117	48	56	61	63	68	64	59	53
South Ealing to Acton Town	73	117	53	61	65	67	67	64	60	58

Table 4 – Interstation noise levels for the eastbound road between Heathrow Terminal 5 / Sidings and Acton Town

Interstation section	L _{eq} dB(A)	L _{peak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Acton Town to South Ealing	72	114	55	61	65	66	66	65	59	54
South Ealing to Northfields	73	117	50	59	63	65	69	65	60	55
Northfields to Boston Manor	72	117	52	61	64	65	67	63	59	55
Boston Manor to Osterley	72	114	52	59	62	64	65	64	60	58
Osterley to Hounslow East	72	118	53	58	62	65	68	64	60	58
Hounslow East to Hounslow Central	72	118	51	58	61	65	68	64	61	58
Hounslow Central to Hounslow West	72	114	51	58	61	64	65	66	61	57
Hounslow West to Hatton Cross	73	114	57	62	66	67	67	64	59	56
Hatton Cross to Heathrow Terminals 1, 2, 3	77	111	56	63	69	73	70	65	58	48
Heathrow Terminals 1, 2, 3 to Heathrow Terminal 5	78	109	57	66	70	74	72	66	59	47
Heathrow Terminal 5 to Sidings	72	113	57	62	65	67	66	64	61	53

Table 5 – Interstation noise levels for the westbound road between Acton Town and Heathrow Terminal 5 / Sidings

Interstation section	L _{eq} dB(A)	L _{peak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Hatton Cross to Heathrow Terminal 4	74	114	53	59	64	68	69	66	65	54
Heathrow Terminal 4 to Heathrow Terminals 1, 2, 3	79	117	59	65	70	73	75	70	62	52

Table 6 – Interstation noise levels for the westbound road between Hatton Cross and Heathrow Terminals 1, 2 & 3 via Terminal 4

Charts 1 to 4 show the average weighted noise levels of all runs on each inter-station section in a graphical representation. These values are taken from Tables 2 to 6. Levels at stations are not shown since the main noise exposure arises from the rolling stock in operation..

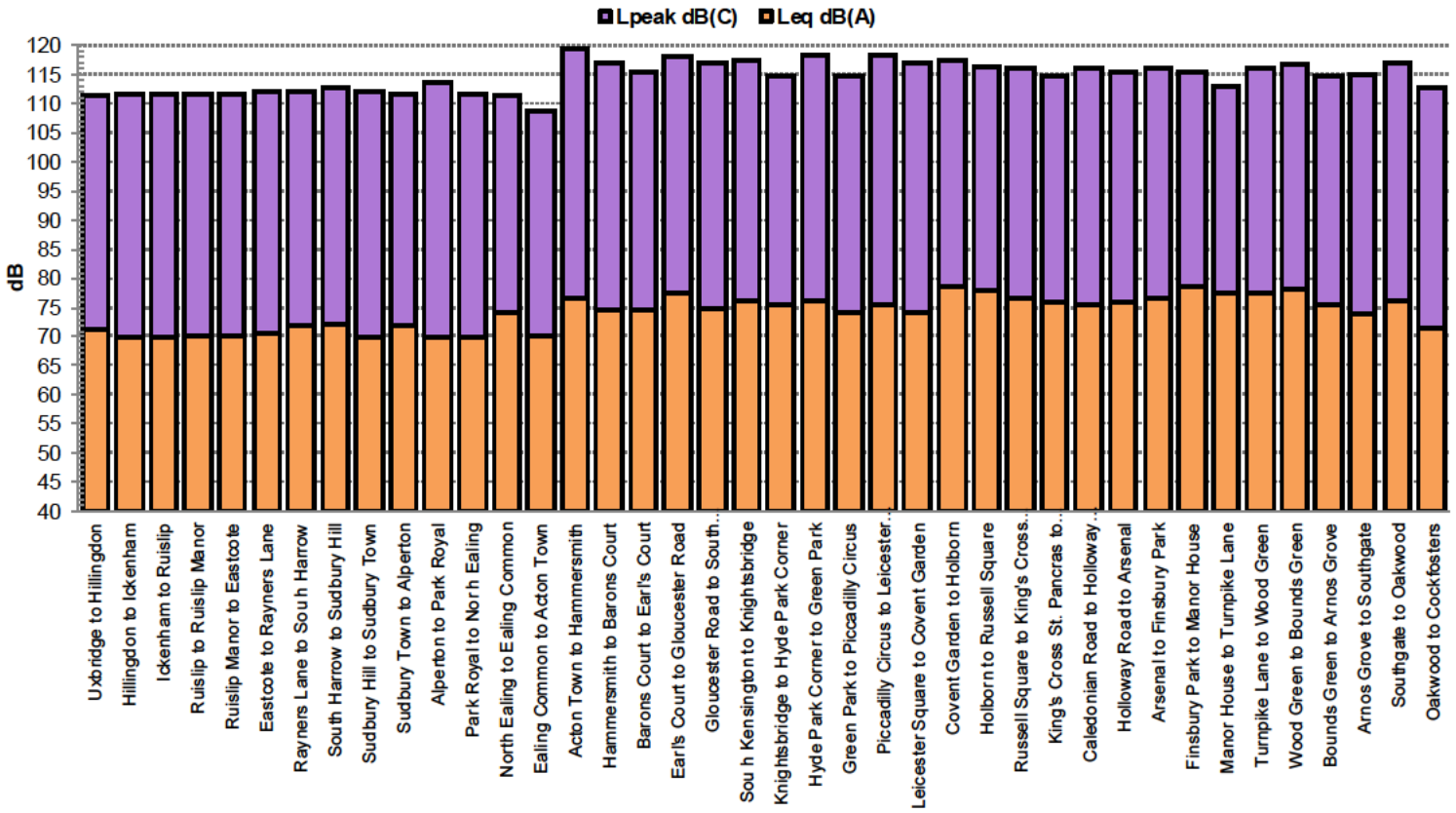


Chart 1 - Average weighted noise levels on the Piccadilly eastbound road, between Uxbridge and Cockfosters

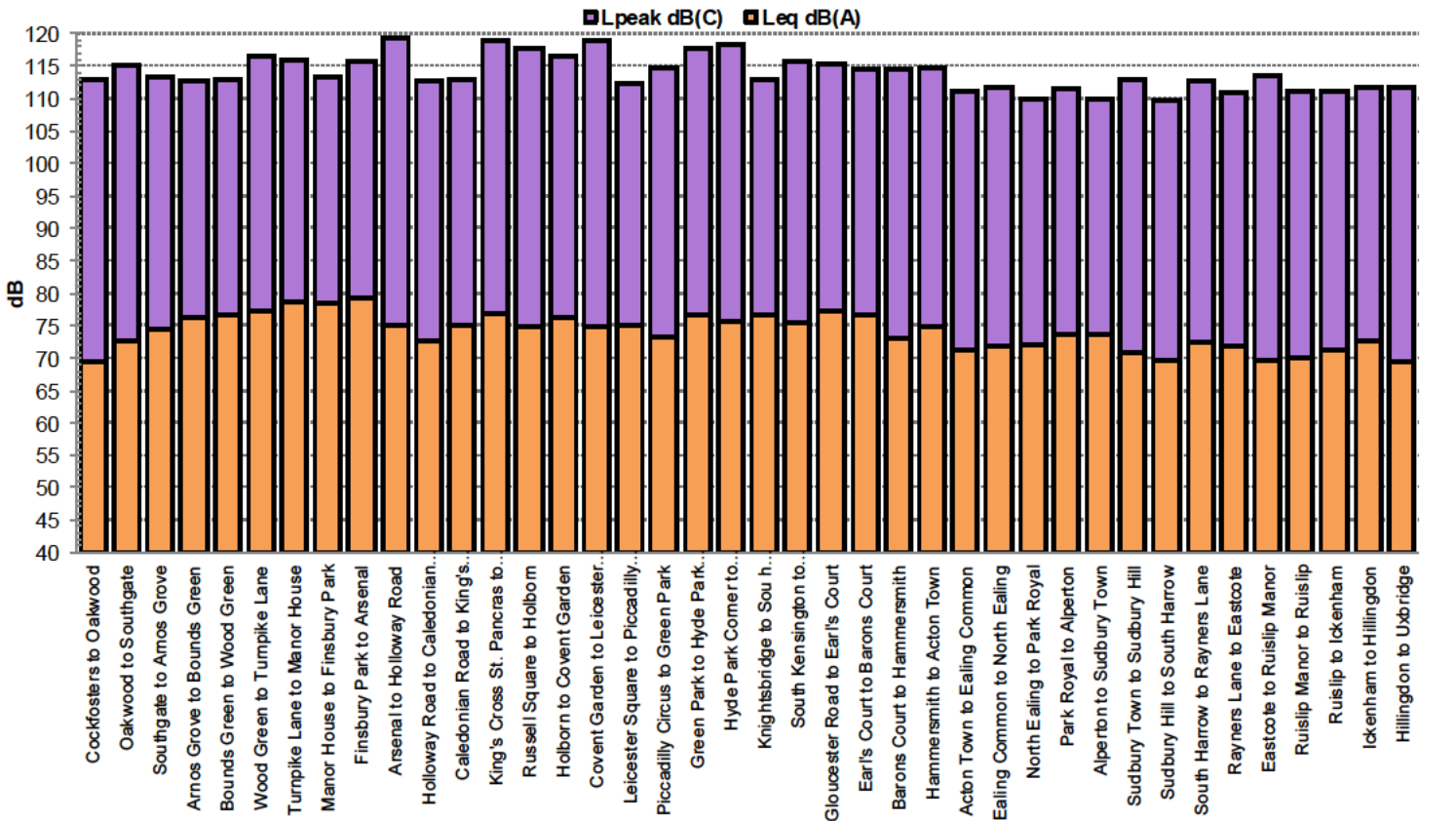


Chart 2 - Average weighted noise levels, on the Piccadilly westbound road, between Cockfosters and Uxbridge

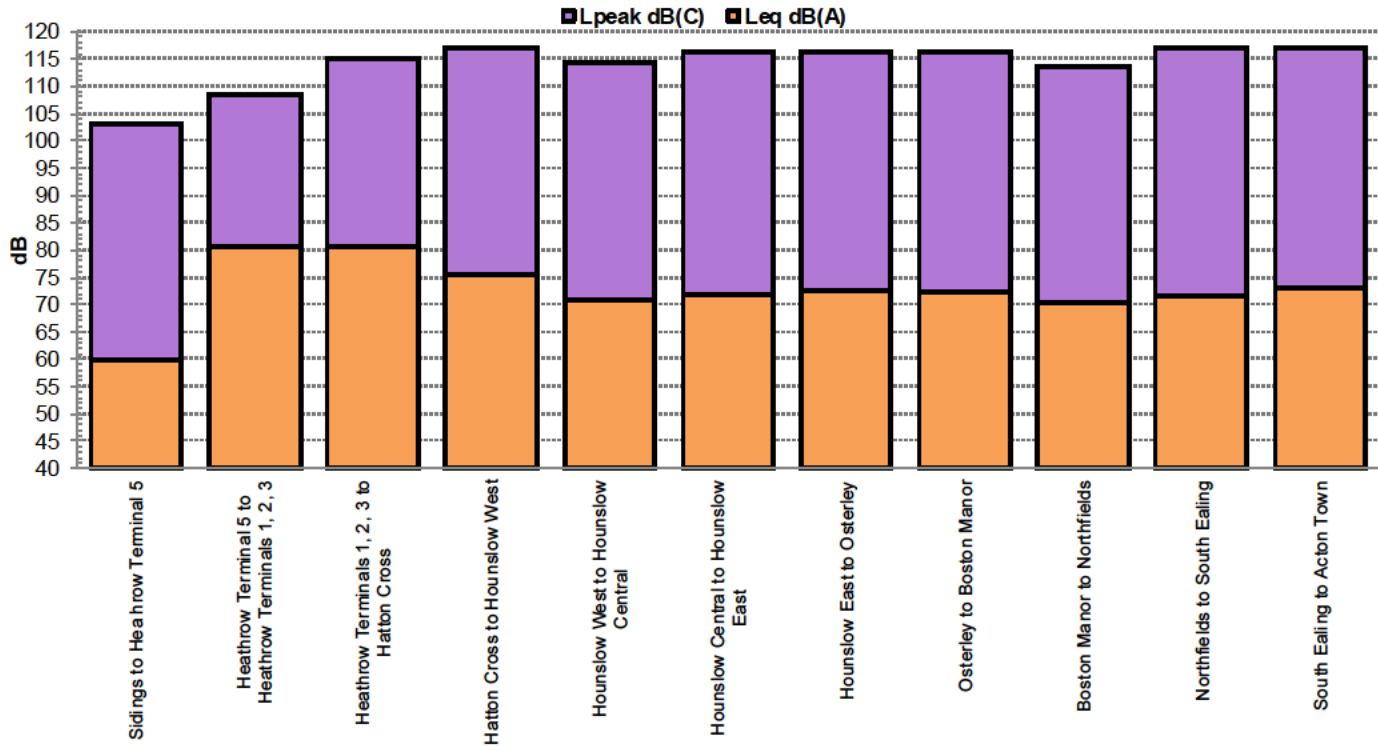


Chart 3 - Average weighted noise levels on the Piccadilly eastbound road, between Sidings / Heathrow Terminal 5 and Acton Town

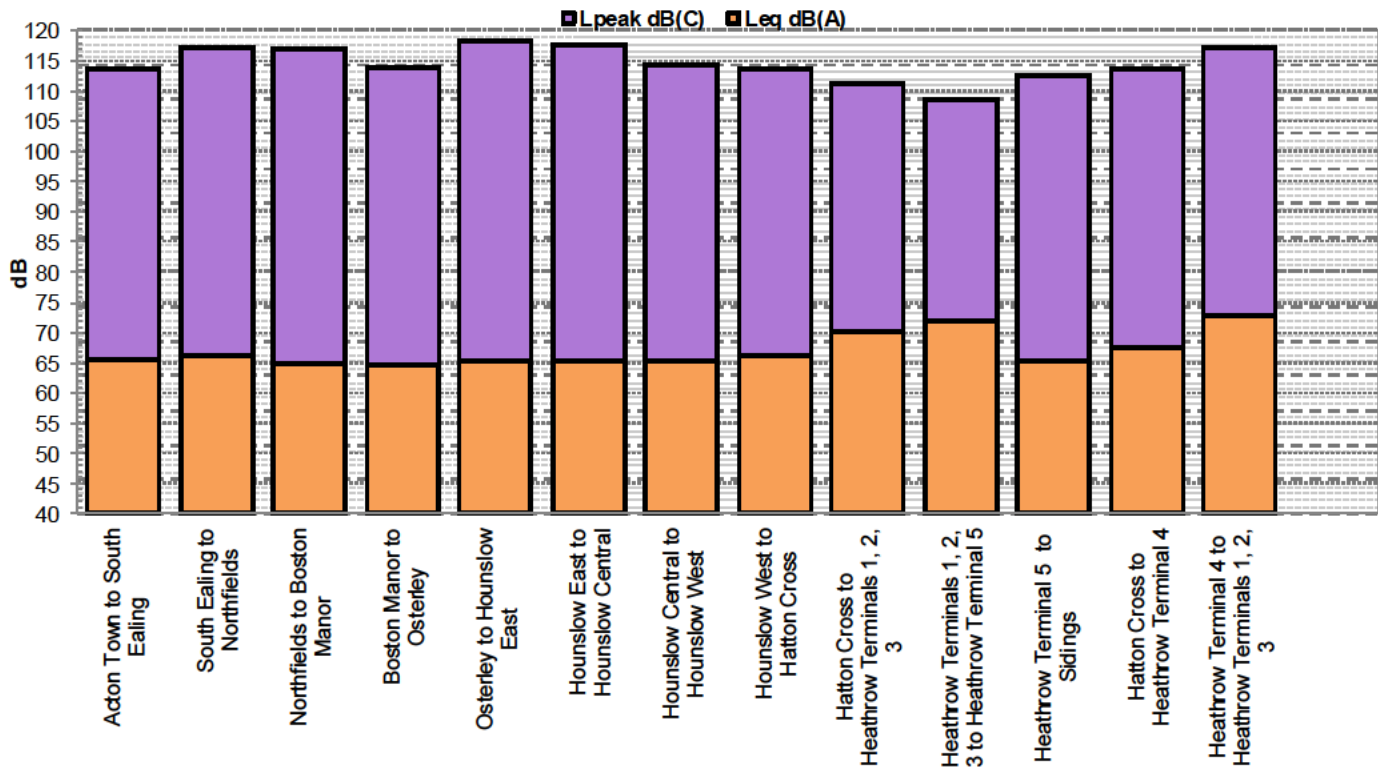


Chart 4 - Average weighted noise levels, on the Piccadilly westbound road, between Acton Town and Heathrow stations (includes Terminals 1, 2 & 3 via Terminal 4 and Terminal 5)



The main differences between measurements on the same day are differences in the measured cabs, as each run is on a different train. The track condition on the same day is very unlikely to change. Other things that could affect the results are train speed, radio announcements and driver's talking on the radio and stops at signals.

The calculated daily noise exposure level for train operators is based on the noise level at ear level and is a logarithmic average of all the inter-station sections travelled as well as the noise when stopped at signals. The noise level during breaks and stops as well as the noise level at stations are not included in this report, as these levels are considerably lower when compared to the cab noise levels when the train is moving.

Tables 2 to 6 show that the only two inter-station sections were above 80dB $L_{Aeq,T}$, both of which on the eastbound road. In addition, none of the inter-station sections were above 85dB $L_{Aeq,T}$.

The two inter-station sections with the highest noise levels for each of the measured directions are shown below.

- **Eastbound:**
 - Heathrow Terminal 5 to Heathrow Terminals 1, 2 and 3; and
 - Heathrow Terminals 1, 2 and 3 to Hatton Cross.
- **Westbound:**
 - Turnpike Lane to Manor House; and
 - Finsbury Park to Arsenal.

4. Daily Exposure $L_{EP,d}$ Levels

The daily exposure $L_{EP,d}$ levels for train operators of the Piccadilly line, found in Table 7, were based on the train operator duties. The duty books, Acton Town, Arnos Grove, Cockfosters and Northfields all apply from 5th October 2020 until 23rd December 2020.

The calculations were based on a sample of 42 duties. These were representative of the spread of duration of the different duties and the different start and end points of the runs. The duties selected ranged between 4 to 8h in duration.

In order to calculate the $L_{EP,d}$ of each trip, they were partitioned into inter-station sections. Each inter-station exposure level was calculated based on the average value of all runs and the average time between stations taken from all runs.

To obtain the total exposure level, all the partial exposures comprised in a specific duty were added, and a $L_{EP,d}$ exposure level was achieved. The table below shows the total duration of the duties chosen for the analysis.

Duty	Duty duration (hh:mm)	Operating time (hh:mm)	$L_{EP,d}$ dB(A)
601	7:24	4:06	73
602	7:39	3:52	73
603	6:02	3:32	72
604	8:00	3:40	72
605	5:09	1:58	69
606	7:53	4:04	73
607	5:27	2:41	70



Duty	Duty duration (hh:mm)	Operating time (hh:mm)	L _{EP,d} dB(A)
608	8:00	4:59	73
609	6:11	2:52	70
610	5:15	2:58	71
611	6:41	3:57	72
612	7:59	4:43	73
401	7:08	3:49	73
402	6:47	3:01	72
403	7:19	4:13	73
404	7:51	4:27	73
405	7:11	4:27	73
406	7:28	4:11	73
407	7:41	4:27	73
408	4:02	2:05	70
409	4:12	2:29	70
410	8:00	4:59	73
411	7:35	4:28	73
412	7:34	4:18	73
001	4:09	2:21	70
002	7:51	4:36	73
003	7:15	3:58	73
004	7:50	4:26	73
005	7:54	4:26	73
006	7:17	3:10	72
007	5:38	3:07	71
008	7:52	4:36	73
009	4:21	2:37	70
010	4:56	2:37	70
801	5:47	3:24	72
802	5:31	2:45	70
803	7:11	3:56	73
804	7:27	4:23	73
805	4:51	2:31	70
806	4:51	2:17	70
807	7:58	4:13	73
808	6:26	3:14	71

Table 7– Duration of the duties chosen for the daily exposure calculations



5. Conclusions

- The daily exposure levels presented in Table 7 are a worst-case scenario. If dwell times at stations, meal breaks and time waiting to pick up trains were to be included in the measurements, the overall noise level would not have any impact. As such, the presented exposure levels are **only representative of train operation**.
- The 1973 Tube Stock cab noise is dominated by rolling contact noise. This airborne noise outside the train influences the noise levels inside the cab. There are two methods to reduce the rolling noise in the cab: the noise can be reduced at source and/or the transmission path can be inhibited.
- The transmission path of the airborne rolling noise includes paths through the cab side doors. Reduced cab sealing will increase noise levels. It should be noted that the microphone position during the measurements, was located next to the left-hand side ear of the train operator, i.e. the ear most affected by noise, which was closer to the cab door.
- There are sections of the Piccadilly track that have corrugation (high rail roughness). Corrugation increases rolling noise and thus cab noise levels. In addition, resilient track has been installed in certain sections to cope with groundborne noise, which may lead to an increase of in-tunnel noise. However, during all runs, that outcome did not occur.
- Only two inter-station sections reached, or exceeded 80dB LAeq, both on the eastbound road.
- Daily exposure levels are dominated by interstation sections with noise levels below 80dB(A), and no inter-station sections reached or exceeded 85dB LAeq,T.
- **All duties presented a daily exposure level below the Lower Exposure Action Value (LEAV)** for continuous noise at an LEP,d of 80dB(A) and as such train operators are not at risk of reaching or exceeding the daily LEAV within an 8-hour working day.
- **All duties presented a daily exposure level below the Upper Exposure Action (UEAV)** for continuous noise at an LEP,d of 85dB(A) and as such train operators are not at risk of reaching or exceeding the daily UEAV within an 8-hour working day.
- If train operators are provided with ear defenders, these should have low attenuation (5-10 dBA) to avoid over-protection, which could lead to train operators having difficulties with communication and hearing warning signals. They may also become isolated from their environment, leading to safety risks.
- **All of the measured inter-station sections measured below the LEAV for impulsive noise**, namely an instantaneous C-weighted peak level (LCpk) of 135 dB(C). The highest peak level, 119 dB(C), was recorded on run 1 between Covent Garden to Leicester Square. Note that through this section, the second and third run showed lower peak levels.

6. References

1. Statutory Instrument 2005 No. 1643. The Control of Noise at Work Regulations 2005.
2. Controlling Noise at Work, Guidance Document L108, Health and Safety Executive 2005.
3. Health and Safety Executive Daily Noise Exposure Calculator
www.hse.gov.uk/noise/dailycalc.xls



APPENDIX A – Equipment Details

Table A.1 – Equipment used for the train operator noise exposure measurements

Item	Make	Model	Serial No.
Sound Level Meter	01dB	Fusion	12501
Calibrator	Rion	NC-74	34851903



APPENDIX B – Full Line Testing Results

Table B.1 – Inter-station noise levels for the eastbound road between Uxbridge and Cockfosters

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Uxbridge to Hillingdon	69	110	52	57	60	62	65	61	60	48
	73	111	53	61	63	64	71	62	57	48
Hillingdon to Ickenham	69	109	51	60	61	61	64	61	55	49
	71	112	51	63	62	63	68	60	55	49
Ickenham to Ruislip	69	108	51	57	60	62	64	61	56	48
	71	112	52	62	63	64	67	62	57	50
Ruislip to Ruislip Manor	70	112	48	55	59	61	66	62	56	48
	71	111	48	58	60	63	68	61	56	48
Ruislip Manor to Eastcote	69	110	50	55	59	61	66	62	57	50
	71	112	50	58	61	63	68	61	57	51
Eastcote to Rayners Lane	69	108	53	58	62	62	65	61	55	49
	72	112	53	60	63	64	68	62	58	51
Rayners Lane to South Harrow	70	109	53	59	63	64	65	62	56	47
	73	112	53	62	64	66	69	65	61	54
South Harrow to Sudbury Hill	69	109	51	58	61	62	64	61	61	48
	75	113	51	60	62	62	74	61	58	51
Sudbury Hill to Sudbury Town	69	111	49	55	61	62	65	62	58	50
	70	112	50	58	61	63	67	61	55	50
Sudbury Town to Alpertons	70	109	51	55	60	63	65	61	62	48
	74	112	51	57	61	64	72	62	58	53
Alpertons to Park Royal	69	112	51	56	60	62	65	61	56	47
	71	114	51	59	62	64	67	61	58	50
Park Royal to North Ealing	68	107	49	55	60	62	63	62	56	49
	71	112	49	58	61	63	68	62	57	51
North Ealing to Ealing Common	70	106	51	58	64	64	63	61	63	50
	78	112	51	61	63	66	76	69	61	52
Ealing Common to Acton Town	70	109	52	59	62	63	65	62	57	49
	70	109	52	59	62	63	65	62	57	49
Acton Town to Hammersmith	73	109	56	61	68	65	65	63	65	51
	80	119	59	63	72	74	77	69	61	49
Hammersmith to Barons Court	75	117	52	63	66	66	71	65	64	65
	73	111	55	62	67	67	67	65	59	51
	75	117	53	63	66	69	72	66	60	51
Barons Court to Earl's Court	75	113	54	62	67	71	69	66	62	61
	74	106	55	62	68	70	68	64	56	46
	74	115	53	63	66	70	70	64	58	51
Earl's Court to Gloucester Road	79	118	52	61	65	73	77	69	62	54
	76	109	51	59	64	72	72	67	61	50
	77	116	51	60	62	72	73	66	61	54
Gloucester Road to South Kensington	76	117	52	59	63	70	73	67	62	54
	73	111	52	58	62	68	70	65	59	49
	75	116	51	59	61	70	72	65	60	52



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
South Kensington to Knightsbridge	76	117	51	60	66	73	70	65	60	52
	74	109	53	61	66	70	68	64	59	49
	79	116	52	61	65	78	70	65	59	53
Knightsbridge to Hyde Park Corner	75	115	50	59	66	70	71	67	61	55
	75	109	52	59	68	71	71	66	60	52
	76	114	50	59	66	72	71	66	61	54
Hyde Park Corner to Green Park	76	119	54	64	67	71	72	68	62	55
	75	112	56	65	68	71	70	66	59	47
	77	115	56	65	68	73	73	67	61	54
Green Park to Piccadilly Circus	75	113	51	59	63	69	71	67	61	54
	74	110	53	59	64	69	69	65	59	50
	75	115	52	59	62	69	71	65	60	53
Piccadilly Circus to Leicester Square	76	118	54	66	65	68	72	67	62	55
	74	110	56	66	66	68	69	66	61	52
	76	116	57	67	66	70	72	65	59	52
Leicester Square to Covent Garden	76	117	50	59	62	67	73	68	64	57
	73	110	52	59	62	66	68	66	59	51
	74	115	51	59	62	67	71	65	62	54
Covent Garden to Holborn	78	118	54	63	65	75	72	66	59	54
	79	109	57	62	66	75	70	68	73	49
Holborn to Russell Square	79	116	58	65	66	77	73	67	60	53
	75	109	57	64	67	70	70	65	59	50
	79	116	58	65	66	77	73	67	60	53
Russell Square to King's Cross St. Pancras	77	116	57	65	66	73	72	66	60	51
	75	111	59	64	67	70	70	66	60	51
	77	116	57	65	66	73	72	66	60	51
King's Cross St. Pancras to Caledonian Road	76	115	56	64	67	72	72	66	60	50
	75	110	56	63	68	70	70	66	59	48
	76	115	56	64	67	72	72	66	60	50
Caledonian Road to Holloway Road	76	116	56	65	67	70	72	66	60	52
	75	108	56	65	67	69	70	65	59	49
	76	116	56	65	67	70	72	66	60	52
Holloway Road to Arsenal	76	115	53	69	67	70	73	66	60	52
	75	110	54	67	67	69	70	65	58	51
	76	115	53	69	67	70	73	66	60	52
Arsenal to Finsbury Park	77	116	54	66	68	71	73	68	63	56
	75	109	55	65	68	70	69	67	60	51
	77	116	54	66	68	71	73	68	63	56
Finsbury Park to Manor House	79	116	57	65	68	73	77	68	61	52
	77	112	57	64	67	71	74	67	61	51
	79	116	57	65	68	73	77	68	61	52
Manor House to Turnpike Lane	78	113	57	62	65	73	75	66	60	47
	77	112	55	61	65	71	75	67	61	51
	78	113	57	62	65	73	75	66	60	47
Turnpike Lane to Wood Green	78	116	55	65	69	73	74	67	60	53
	77	108	55	65	70	72	72	67	60	49
	78	116	55	65	69	73	74	67	60	53



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Wood Green to Bounds Green	78	117	57	65	69	74	75	68	61	52
	78	111	57	65	70	73	73	68	60	49
	78	117	57	65	69	74	75	68	61	52
Bounds Green to Arnos Grove	77	115	52	60	63	71	73	68	62	50
	73	109	53	58	63	69	68	64	62	51
	77	115	52	60	63	71	73	68	62	50
Arnos Grove to Southgate	74	115	53	61	64	69	71	64	59	52
	73	111	53	59	65	68	68	64	59	51
	74	115	53	61	64	69	71	64	59	52
Southgate to Oakwood	78	117	53	65	67	68	76	67	61	51
	73	110	53	62	68	68	67	63	60	51
	78	117	53	65	67	68	76	67	61	51
Oakwood to Cockfosters	72	113	51	60	61	66	67	64	63	54
	71	110	52	59	62	63	65	64	59	53
	72	113	51	60	61	66	67	64	63	54

Table B.2 – Inter-station noise levels for the eastbound road between Cockfosters and Uxbridge

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Cockfosters to Oakwood	72	113	51	60	62	64	67	64	63	63
	68	108	47	56	60	61	62	59	57	58
	68	112	51	58	61	61	64	59	56	48
Oakwood to Southgate	72	112	53	60	64	66	67	64	61	58
	70	109	50	59	63	65	64	61	58	58
	75	115	54	60	65	64	72	69	59	50
Southgate to Arnos Grove	74	113	52	60	64	68	69	67	63	62
	76	109	49	58	62	66	65	74	60	62
	73	113	52	59	63	67	68	67	58	50
Arnos Grove to Bounds Green	78	113	56	64	68	73	73	71	64	59
	75	109	53	62	66	71	69	65	61	61
	75	113	56	63	66	70	71	66	61	52
Bounds Green to Wood Green	74	113	52	59	64	70	69	66	59	51
	77	110	54	63	68	73	72	68	60	48
	78	113	58	65	69	73	74	68	62	54
Wood Green to Turpike Lane	79	117	54	60	66	73	75	69	61	55
	75	110	51	58	64	71	71	65	59	49
	78	113	57	61	67	73	75	67	63	53
Turpike Lane to Manor House	79	116	57	65	69	74	74	71	63	53
	78	113	55	65	69	72	74	69	61	51
	79	116	59	66	70	74	75	69	63	53
Manor House to Finsbury Park	78	113	52	61	64	75	73	69	62	54
	78	108	51	59	64	75	71	67	61	52
	79	112	57	63	67	76	74	67	61	53
Finsbury Park to Arsenal	80	116	58	69	71	76	75	71	63	55
	79	111	58	70	72	73	73	68	62	52
	79	111	61	71	73	73	74	70	63	54



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Arsenal to Holloway Road	76	119	54	66	65	69	73	68	60	55
	74	106	55	65	66	68	68	64	58	48
	75	112	56	67	67	68	71	66	61	53
Holloway Road to Caledonian Road	72	103	53	59	63	69	67	62	56	47
	72	109	50	58	63	67	67	64	59	49
	74	113	54	59	64	68	70	65	60	53
Caledonian Road to King's Cross St. Pancras	75	107	56	64	67	70	69	65	58	48
	75	108	53	63	67	70	69	67	60	49
	76	113	57	65	68	70	71	66	60	49
King's Cross St. Pancras to Russell Square	77	119	55	65	67	72	73	68	61	54
	76	109	55	65	67	72	70	67	61	50
	77	113	57	66	68	71	72	67	61	53
Russell Square to Holborn	76	118	53	59	65	71	72	67	60	53
	73	109	54	61	64	67	68	64	58	50
	75	112	54	62	65	70	71	66	60	53
Holborn to Covent Garden	78	117	55	64	69	74	73	68	62	55
	75	107	54	63	67	71	68	64	58	46
	76	110	56	66	69	72	71	65	58	48
Covent Garden to Leicester Square	77	119	53	61	64	69	75	69	62	57
	72	110	52	59	63	66	68	65	60	50
	75	114	53	60	65	67	71	67	63	55
Leicester Square to Piccadilly Circus	76	112	54	62	65	71	71	68	63	56
	74	104	52	60	64	70	67	65	58	47
	76	111	55	62	66	70	71	67	61	53
Piccadilly Circus to Green Park	74	115	50	57	63	68	70	66	61	57
	72	103	48	57	64	68	66	63	60	46
	74	113	52	59	65	68	70	64	60	51
Green Park to Hyde Park Corner	76	118	56	63	66	71	72	68	62	53
	76	114	56	64	68	71	71	69	62	50
	77	115	58	65	69	72	72	68	62	53
Hyde Park Corner to Knightsbridge	77	118	55	61	65	72	73	68	62	56
	74	108	52	59	64	70	68	65	58	49
	76	113	56	61	66	72	72	66	60	53
Knightsbridge to South Kensington	77	113	51	58	64	75	69	66	59	52
	76	102	50	58	65	74	68	63	56	45
	78	111	52	59	66	74	73	68	62	54
South Kensington to Gloucester Road	76	116	56	62	64	71	72	67	60	53
	74	107	56	61	64	71	68	64	60	47
	76	112	57	62	66	72	71	67	62	52
Gloucester Road to Earl's Court	78	115	52	59	63	73	76	68	61	54
	76	108	51	58	63	71	73	67	60	51
	77	112	52	59	63	72	74	67	61	52
Earl's Court to Barons Court	76	115	55	61	65	72	70	65	62	63
	78	109	54	60	65	76	71	66	57	47
	76	112	56	62	66	73	71	65	58	49



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Barons Court to Hammersmith	73	115	51	60	64	66	68	66	63	58
	73	109	50	60	66	67	66	66	60	51
	73	112	53	61	67	65	68	64	60	52
Hammersmith to Acton Town	75	115	56	65	70	69	68	64	61	58
	75	107	54	65	70	69	67	66	57	46
	75	111	57	66	71	68	68	63	58	51
Acton Town to Ealing Common	71	111	53	62	65	65	66	62	57	50
	71	107	50	60	64	65	65	63	57	50
	71	111	53	62	65	65	66	62	57	50
Ealing Common to North Ealing	73	112	51	60	63	64	68	69	59	52
	70	107	47	59	61	63	65	62	57	49
	73	112	51	60	63	64	68	69	59	52
North Ealing to Park Royal	71	110	50	56	61	63	67	65	58	49
	74	107	46	55	60	64	65	73	59	50
Park Royal to Alperton	72	112	52	56	60	62	68	67	58	51
	76	110	49	56	62	64	65	75	60	50
	72	112	52	56	60	62	68	67	58	51
Alperton to Sudbury Town	74	110	52	56	62	65	71	67	60	51
	73	107	48	55	62	66	66	70	62	52
	74	110	52	56	62	65	71	67	60	51
Sudbury Town to Sudbury Hill	70	113	50	55	60	63	66	64	58	50
	72	108	48	55	60	63	64	70	58	49
	70	113	50	55	60	63	66	64	58	50
Sudbury Hill to South Harrow	70	110	51	58	62	64	65	62	57	50
	70	105	49	58	62	64	64	62	55	47
	70	110	51	58	62	64	65	62	57	50
South Harrow to Rayners Lane	73	113	55	60	63	64	69	66	59	50
	72	108	52	59	62	65	66	67	57	48
	73	113	55	60	63	64	69	66	59	50
Rayners Lane to Eastcote	72	111	55	60	62	63	67	66	58	50
	72	108	52	59	62	64	65	67	59	49
	72	111	55	60	62	63	67	66	58	50
Eastcote to Ruislip Manor	70	114	51	58	61	63	67	62	56	48
	69	107	50	57	60	62	64	61	56	49
	70	114	51	58	61	63	67	62	56	48
Ruislip Manor to Ruislip	70	111	50	57	61	63	66	62	56	48
	70	107	48	56	61	64	65	63	57	48
	70	111	50	57	61	63	66	62	56	48
Ruislip to Ickenham	71	111	54	60	61	63	67	65	58	49
	72	108	52	59	62	64	65	67	60	48
	71	111	54	60	61	63	67	65	58	49
Ickenham to Hillingdon	73	112	54	66	67	65	67	62	57	50
	72	105	52	64	68	65	64	62	55	47
	73	112	54	66	67	65	67	62	57	50
Hillingdon to Uxbridge	70	112	52	58	61	62	65	62	59	52
	69	109	50	57	61	63	63	62	57	49
	70	112	52	58	61	62	65	62	59	52



Table B.3 – Inter-station noise levels for the eastbound road between Heathrow Terminal 5 and Acton Town

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Sidings to Heathrow Terminal 5	60	103	35	50	48	51	52	55	52	49
Heathrow Terminal 5 to Heathrow Terminals 1, 2, 3	81	109	58	64	70	77	76	68	62	49
Heathrow Terminals 1, 2, 3 to Hatton Cross	81	112	57	64	71	77	76	66	60	50
	80	115	57	64	70	77	76	67	59	54
Hatton Cross to Hounslow West	76	111	61	65	69	71	69	68	59	50
	75	117	60	65	68	69	69	65	61	63
Hounslow West to Hounslow Central	68	103	50	57	60	63	61	60	53	45
	72	114	52	58	62	64	68	63	63	64
Hounslow Central to Hounslow East	68	104	51	57	60	63	62	59	52	45
	74	116	49	57	60	64	70	65	64	67
Hounslow East to Osterley	70	107	53	61	65	65	61	60	52	46
	74	116	51	60	64	64	69	64	64	66
Osterley to Boston Manor	71	105	52	59	63	64	67	61	54	45
	73	116	52	61	64	66	68	64	64	63
Boston Manor to Northfields	66	109	47	55	60	60	61	58	53	47
	72	114	50	60	64	64	67	64	64	62
Northfields to South Ealing	69	103	51	57	62	64	61	60	56	47
	73	117	47	55	61	63	71	66	60	57
South Ealing to Acton Town	72	108	54	62	66	67	65	62	56	47
	74	117	53	61	64	66	69	64	62	63

Table B.4 – Inter-station noise levels for the westbound road between Acton Town and Heathrow Terminal 5

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Acton Town to South Ealing	72	107	57	62	65	66	65	66	55	46
	72	114	54	61	65	66	67	64	61	58
South Ealing to Northfields	69	106	50	58	63	65	63	61	54	47
	75	117	50	59	63	65	72	67	62	59
Northfields to Boston Manor	70	104	54	61	65	65	64	60	54	46
	73	117	51	61	63	64	69	65	61	59
Boston Manor to Osterley	70	108	52	58	61	63	64	67	53	45
	72	114	52	60	63	64	66	63	64	64
Osterley to Hounslow East	69	102	55	57	61	64	63	60	54	48
	74	118	52	58	62	65	70	66	63	63
Hounslow East to Hounslow Central	67	104	51	56	59	63	62	59	53	47
	75	118	51	60	62	66	71	66	65	64
Hounslow Central to Hounslow West	71	102	51	56	58	62	62	69	55	45
	72	114	51	59	62	65	67	65	64	62
Hounslow West to Hatton Cross	71	108	56	61	64	65	65	59	53	43
	74	114	57	63	66	68	68	66	62	62
Hatton Cross to Heathrow Terminals 1, 2, 3	77	111	56	63	69	73	70	65	58	48



Interstation section	L _{Aeq} dB(A)	L _{cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Heathrow Terminals 1, 2, 3 to Heathrow Terminal 5	78	109	57	66	70	74	72	66	59	47
Heathrow Terminal 5 to Sidings	72	113	57	62	65	67	66	64	61	53

Table B.5 – Inter-station noise levels for the westbound road between Hatton Cross and Heathrow Terminal 1, 2 &3 via Terminal 4

Interstation section	L _{Aeq} dB(A)	L _{cpeak} dB(C)	Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1k	2k	4k	8k
Hatton Cross to Heathrow Terminal 4	74	114	53	59	64	68	69	66	65	54
Heathrow Terminal 4 to Heathrow Terminals 1, 2, 3	79	117	59	65	70	73	75	70	62	52