

Technical Report**NOISE AT WORK ASSESSMENT FOR HAMMERSITH & CITY LINE TRAIN OPERATORS**

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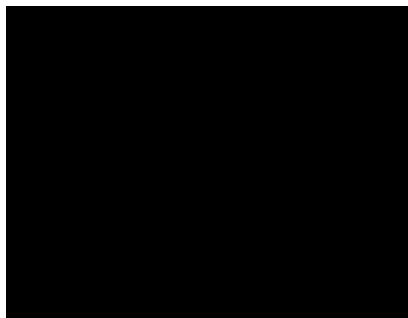
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1. Introduction

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 Hammersmith & City 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.

Table 1 – Noise exposure limit values and action values

	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)

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 Hammersmith & City 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 log 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 29th and 30th July 2020 using one 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.

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, i.e. noise exposure is likely to be lower if rest periods and dwell times are included.

It should be noted that at the time of the measurements, Stepney Green station was closed and as such, trains did not stop at that station.

Table 2 – Interstation noise levels for the eastbound road between Hammersmith and Barking sidings

Interstation Section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1000	2000	4000	8000
Hammersmith to Goldhawk Road	63	101	53	55	57	58	57	52	45	35
Goldhawk Road to Shepherd's Bush Market	62	95	53	55	56	56	56	50	42	33
Shepherd's Bush Market to Wood Lane	65	113	47	55	57	60	59	57	52	43
Wood Lane to Latimer Road	62	100	46	54	56	56	57	51	43	33
Latimer Road to Ladbrooke Grove	62	99	46	54	56	57	58	52	44	34
Ladbrooke Grove to Westbourne Park	65	98	47	57	60	59	58	53	46	34
Westbourne Park to Royal Oak	64	99	52	56	59	59	58	52	45	34
Royal Oak to Paddington	68	103	49	57	58	57	64	62	48	35
Paddington to Edgware Road	66	102	51	58	61	62	59	54	47	36
Edgware Road to Baker Street	62	99	49	55	56	56	54	50	44	33
Baker Street to Great Portland Street	65	106	49	56	58	59	60	57	53	43
Great Portland Street to Euston Square	66	102	53	57	59	60	61	56	51	40
Euston Square to King's Cross St Pancras	64	101	48	57	58	59	59	53	47	38
King's Cross St Pancras to Farringdon	68	101	52	59	62	64	62	56	50	39
Farringdon to Barbican	66	101	52	60	60	60	59	53	47	40
Barbican to Moorgate	67	103	52	58	60	62	61	57	50	39
Moorgate to Liverpool Street	68	102	49	56	57	66	61	54	47	36
Liverpool Street to Aldgate East	65	103	51	56	58	60	59	53	47	37
Aldgate East to Whitechapel	64	100	51	56	58	59	58	53	48	38
Whitechapel to Mile End	65	100	51	57	58	60	59	55	49	39
Mile End to Bow Road	63	98	51	56	57	57	57	52	46	35
Bow Road to Bromley-by-Bow	68	105	49	56	58	59	63	64	49	38
Bromley-by-Bow to West Ham	62	100	47	52	55	56	57	52	46	35
West Ham to Plaistow	65	101	49	56	57	60	59	56	52	40
Plaistow to Upton Park	61	99	47	52	54	56	56	51	45	34
Upton Park to East Ham	62	103	50	53	55	55	57	51	46	35
East Ham to Barking	66	105	52	57	60	61	60	55	50	39
Barking to Barking sidings	63	116	49	54	55	57	56	54	50	42



Table 3 – Interstation noise levels for the westbound road between Barking sidings and Hammersmith

Interstation Section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	A-Weighted Noise Spectral Analysis in Octave Bands (Hz)							
			63	125	250	500	1000	2000	4000	8000
Barking sidings to Barking	65	99	49	57	59	58	58	56	46	36
Barking to East Ham	69	103	51	60	64	63	61	57	52	37
East Ham to Upton Park	65	98	46	56	58	58	59	57	54	36
Upton Park to Plaistow	64	97	48	57	58	57	59	53	46	35
Plaistow to West Ham	63	100	48	56	58	58	58	51	44	34
West Ham to Bromley-by-Bow	63	98	46	53	56	57	58	52	45	34
Bromley-by-Bow to Bow Road	67	102	49	58	60	59	61	63	49	36
Bow Road to Mile End	62	97	45	52	55	56	58	52	45	34
Mile End to Whitechapel	63	102	47	55	57	57	58	52	46	34
Whitechapel to Aldgate East	67	108	53	59	61	62	60	54	48	37
Aldgate East to Liverpool Street	65	105	49	56	58	60	58	54	48	38
Liverpool Street to Moorgate	63	97	47	55	56	58	57	52	46	35
Moorgate to Barbican	65	103	50	56	59	59	59	54	48	36
Barbican to Farringdon	68	105	52	61	62	62	60	55	49	39
Farringdon to King's Cross St Pancras	69	103	50	61	63	64	62	55	49	38
King's Cross St Pancras to Euston Square	64	102	47	57	57	57	59	54	48	42
Euston Square to Great Portland Street	68	109	56	59	61	62	62	56	50	38
Great Portland Street to Baker Street	65	102	49	57	59	59	58	52	46	35
Baker Street to Edgware Road	67	113	47	54	56	57	58	62	60	56
Edgware Road to Paddington	68	108	51	59	61	63	61	56	50	41
Paddington to Royal Oak	65	98	48	56	58	61	59	58	51	36
Royal Oak to Westbourne Park	68	102	49	57	60	61	62	64	49	38
Westbourne Park to Ladbroke Grove	66	98	49	59	61	62	60	54	47	39
Ladbroke Grove to Latimer Road	62	96	46	56	56	55	57	52	45	35
Latimer Road to Wood Lane	62	99	44	55	56	55	58	50	44	34
Wood Lane to Shepherd's Bush Market	62	97	44	54	55	55	57	51	46	35
Shepherd's Bush Market to Goldhawk Road	62	96	44	54	56	55	56	51	44	34
Goldhawk Road to Hammersmith	65	104	50	57	58	60	60	55	49	40

Charts 1 and 2 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 and 3. Levels at stations are not shown since these were more a result of other sources rather than operating the train.



Chart 1 - Average weighted noise levels on the Hammersmith & City eastbound road, between Hammersmith and Barking sidings

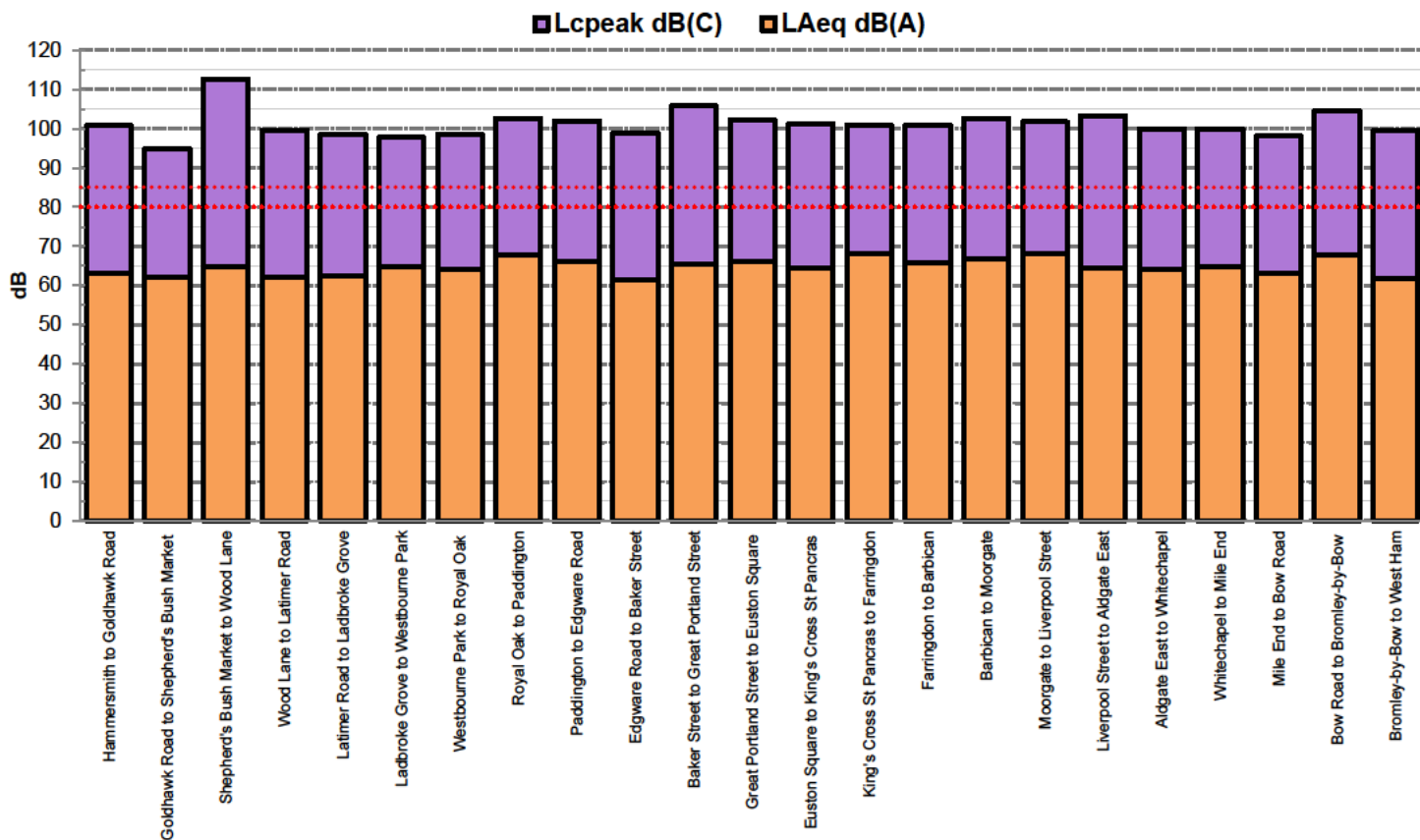
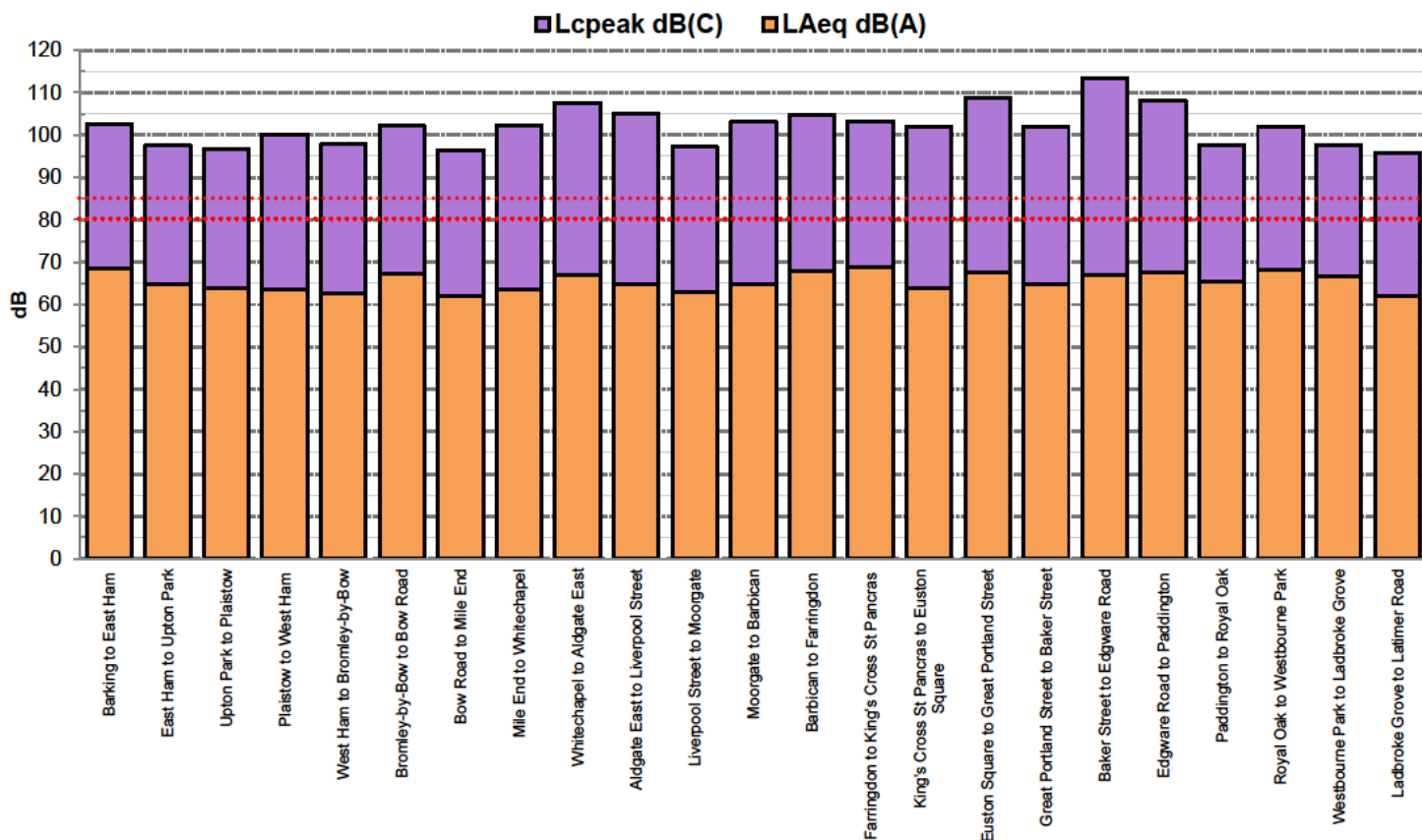


Chart 2 - Average weighted noise levels, on the Hammersmith & City westbound road, between Barking sidings and Hammersmith





The main differences between measurements on the same day are differences in the measured cabs. 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 log 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 ignored in this report, as these levels are considerably lower when compared to the cab noise levels when the train is moving.

Tables 2 and 3, show that **no** inter-station sections **reached or exceeded 80dB LAeq**.

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

- **Eastbound** – Moorgate to Liverpool Street and King's Cross St Pancras to Farringdon
- **Westbound** – Barking to East Ham and Farringdon to King's Cross St Pancras

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

The daily exposure $L_{EP,d}$ levels for train operators of the Hammersmith & City line, found in table 4, were based on the train operator duties. The duty books, Hammersmith, Edgware Road and Barking all apply from 30th December 2018 (working Timetable 35).

The calculations were based on a sample of 29 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.

Table 4– Duration of the duties chosen for the daily exposure calculations

Duty	Duty duration (hours:minutes)	Driving time (hours:minutes)	$L_{EP,d}$ dB(A)	Duty	Duty duration (hours:minutes)	Driving time (hours:minutes)	$L_{EP,d}$ dB(A)
101	6:25	3:03	61	607	6:24	4:22	62
102	6:09	3:21	62	608	6:39	2:59	61
103	5:12	3:17	62	609	6:31	2:58	61
104	7:05	3:57	63	610	7:22	4:22	63
105	5:55	3:17	62	001	5:00	3:13	61
107	7:17	4:28	63	002	6:11	3:57	63
108	7:44	5:19	64	003	5:00	3:29	62
109	6:09	3:36	62	004	6:44	4:16	63
110	7:15	4:35	63	005	4:04	3:03	62
111	6:59	4:14	63	006	6:07	3:15	62
601	4:58	2:13	60	007	7:08	5:14	64
602	4:53	2:34	61	008	7:18	4:01	63
603	7:29	2:38	61	009	7:18	4:10	63
605	7:13	3:27	62	010	7:13	5:14	64
606	7:26	4:35	63	607	6:24	4:22	62



5. Conclusions

- The daily exposure levels presented in Table 4 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 reduce, albeit negligibly. As such, the presented exposure levels are **only representative of train operation**.
- The S7 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 Hammersmith & City track that have corrugation (high rail roughness). Corrugation increases rolling noise and thus cab noise levels.
- No inter-station sections reached or exceeded 80dB LAeq.
- **All duties presented a daily exposure level below the Lower Exposure Action Value (LEAV)** for continuous noise at an L_{EP,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 L_{EP,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.
- Despite no requirement to provide train operators with ear defenders, if that is done, then 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 the measured inter-station sections measured below the LEAV for impulsive noise**, namely an instantaneous C-weighted peak level (L_{Cpk}) of 135 dB(C). The highest peak level, 116dB(C), was recorded on run 3 between Barking and Barking sidings, and was caused by a non-recurrent event, namely the cab door being slam shut.

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	11489



APPENDIX B – Full Line Testing Results

Table B.1 – Inter-station noise levels for the Eastbound road between Hammersmith and Barking sidings

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Hammersmith to Goldhawk Road	64.2	97.3	49.1	56.3	58.5	59.1	58.3	53.1	45.2	35.8
	61.7	100.8	54.5	53.5	54.8	55.8	56.0	50.5	45.2	34.4
Goldhawk Road to Shepherd's Bush Market	63.3	94.9	48.5	55.7	57.9	57.4	58.0	51.9	43.1	33.4
	60.1	93.8	54.9	53.8	53.4	53.5	53.9	47.5	41.0	31.7
Shepherd's Bush Market to Wood Lane	65.7	95.3	48.5	56.2	58.2	61.1	59.2	58.4	49.0	34.7
	63.5	112.7	43.0	53.9	54.0	57.2	57.9	56.3	53.3	45.9
Wood Lane to Latimer Road	63.5	99.7	48.3	56.0	57.9	57.3	58.1	52.2	43.6	33.1
	60.0	97.6	39.8	50.4	51.5	53.8	56.2	49.0	43.2	33.6
Latimer Road to Ladbroke Grove	63.9	98.6	48.6	56.2	58.2	58.0	58.5	52.8	44.6	34.8
	60.4	96.3	41.2	50.6	52.4	54.7	56.2	49.9	44.1	32.9
Ladbroke Grove to Westbourne Park	63.9	97.8	47.0	55.5	59.3	57.9	57.8	50.0	42.7	30.1
	65.5	96.9	49.4	58.2	60.7	59.9	58.9	53.3	45.7	36.3
	64.8	97.5	43.2	57.1	58.6	59.8	57.9	53.5	47.5	33.6
Westbourne Park to Royal Oak	63.9	97.7	47.9	53.6	59.0	58.8	58.4	51.4	43.7	30.6
	65.2	98.6	50.0	57.2	60.5	59.8	59.0	53.5	45.9	35.7
	63.6	97.7	54.8	55.0	58.4	58.3	57.2	51.3	44.5	32.7
Royal Oak to Paddington	62.4	97.5	47.4	54.5	56.8	56.0	56.8	50.8	45.4	33.6
	71.5	102.7	49.8	57.8	59.7	58.8	68.5	66.9	51.6	37.7
	63.0	97.5	50.5	57.2	57.6	57.0	56.6	50.6	45.0	33.7
Paddington to Edgware Road	65.9	101.8	50.4	56.0	60.1	61.7	59.5	52.8	46.7	35.9
	67.0	101.9	52.7	59.4	61.9	62.4	60.0	54.6	47.3	36.8
	65.8	101.2	50.0	57.2	59.6	61.9	58.9	53.1	47.4	35.6
Edgware Road to Baker Street	60.2	96.5	46.0	52.1	55.3	54.3	53.4	48.7	44.4	33.8
	63.6	98.9	51.8	58.2	58.7	57.7	56.1	51.4	44.1	34.1
	59.8	95.2	44.6	51.5	53.9	55.0	52.8	49.1	44.6	32.3
Baker Street to Great Portland Street	66.1	105.0	49.0	55.9	58.8	59.7	60.7	58.0	54.6	44.8
	64.7	105.8	48.9	55.4	57.8	58.0	59.4	56.8	52.8	44.2
	65.4	105.8	48.1	56.8	58.8	60.4	59.0	55.6	50.7	39.5
Great Portland Street to Euston Square	65.3	98.0	48.7	54.4	57.0	58.4	61.4	56.8	52.2	41.9
	66.4	102.3	54.7	59.0	59.4	59.5	61.0	56.9	50.3	39.3
	66.6	102.3	52.2	57.0	59.4	61.6	61.9	55.1	48.2	36.6
Euston Square to King's Cross St Pancras	63.2	99.0	46.4	55.3	57.2	57.6	57.8	51.9	45.1	34.2
	65.0	101.2	50.3	58.0	58.8	58.7	59.5	54.2	49.4	41.7
	64.8	98.7	45.5	56.1	57.8	59.2	60.0	53.3	46.5	34.3
King's Cross St Pancras to Farringdon	66.6	99.4	48.2	56.8	60.3	62.7	60.3	53.8	47.8	37.1
	68.4	100.9	53.5	61.0	62.6	63.8	61.7	56.5	49.9	41.1
	68.8	100.8	51.6	58.7	61.7	65.0	62.4	57.4	51.2	38.2
Farringdon to Barbican	62.7	97.7	47.9	56.1	57.9	56.4	55.2	49.9	44.3	35.8
	66.8	101.0	52.7	60.9	61.4	61.4	59.4	55.1	48.6	42.6
	66.9	100.7	53.8	60.2	60.5	61.3	60.8	53.6	47.9	38.4
Barbican to Moorgate	66.3	101.4	51.2	57.4	60.1	60.6	60.9	55.5	48.4	36.4
	65.5	101.1	53.3	59.3	59.9	59.7	58.8	54.5	47.6	37.7
	68.3	102.7	50.9	58.0	59.9	63.9	62.6	59.3	53.0	40.6
Moorgate to Liverpool Street	64.2	98.6	44.4	51.6	55.4	61.0	58.1	51.1	44.0	32.3
	67.1	100.5	52.1	59.0	59.6	63.2	60.5	55.1	48.0	37.1
	71.0	101.8	45.0	53.5	56.3	69.3	62.8	54.4	47.7	38.1
Liverpool Street to Aldgate East	63.3	101.2	47.7	53.7	57.4	58.6	57.3	51.6	44.8	34.1
	65.4	103.3	53.4	58.2	59.3	60.3	59.0	53.7	48.3	39.3
	64.9	100.4	48.4	55.6	58.3	60.2	59.5	53.2	47.0	35.4



Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Aldgate East to Whitechapel	63.0	98.5	49.3	54.4	57.2	58.1	56.7	50.8	45.3	36.2
	63.4	98.9	53.2	56.8	57.4	58.0	56.7	51.8	46.3	37.6
	65.6	100.0	50.1	57.4	59.5	60.6	59.8	54.6	50.1	39.3
Whitechapel to Mile End	64.2	98.9	48.6	55.9	58.0	58.9	58.1	52.6	47.4	41.7
	64.9	99.0	52.5	57.5	57.7	60.0	57.6	56.1	51.7	36.1
	65.1	100.0	49.9	57.1	58.3	59.7	59.9	54.1	48.0	38.0
Mile End to Bow Road	62.6	98.1	45.9	54.3	56.9	56.8	57.2	51.4	45.2	34.1
	62.6	97.5	52.1	56.4	57.4	56.6	55.9	50.8	45.1	34.7
	63.8	96.6	53.1	55.7	57.2	57.8	58.6	52.5	46.4	35.4
Bow Road to Bromley-by-Bow	64.5	102.5	46.7	55.4	57.8	59.4	58.8	54.6	48.9	37.6
	70.9	104.7	51.9	57.6	58.0	58.7	65.6	68.4	50.5	38.4
	65.1	99.6	44.9	56.0	57.2	58.3	60.6	57.2	48.2	37.5
Bromley-by-Bow to West Ham	62.8	97.5	42.9	51.4	55.2	57.6	57.9	54.3	48.3	36.3
	61.5	99.5	50.7	53.6	55.1	56.1	55.8	51.4	45.3	36.0
	61.0	97.0	40.4	50.6	53.2	53.9	57.7	50.2	43.4	31.5
West Ham to Plaistow	66.2	99.4	46.3	53.6	56.7	61.2	60.8	59.0	54.9	38.3
	64.7	100.9	52.0	56.5	57.8	59.2	58.4	55.5	51.5	43.5
	63.7	99.1	45.7	55.9	57.1	57.9	58.9	52.3	46.2	34.5
Plaistow to Upton Park	60.8	96.7	43.2	50.9	54.2	55.2	55.9	50.2	45.9	34.8
	61.2	99.3	50.3	54.5	54.6	55.5	55.6	50.7	44.6	34.7
	61.8	95.2	42.9	50.8	53.6	56.4	57.4	51.9	45.3	32.5
Upton Park to East Ham	60.8	103.1	41.3	49.8	54.0	55.7	55.6	50.2	44.7	34.6
	62.5	98.8	48.7	54.6	55.2	56.4	57.8	52.9	47.1	37.3
	61.5	94.9	52.6	54.1	54.9	53.8	57.4	50.1	44.4	32.4
East Ham to Barking	67.7	103.7	52.6	58.3	61.8	62.5	61.5	56.6	50.9	40.0
	65.2	104.6	52.5	57.4	58.8	59.8	58.8	54.6	48.5	38.7
	64.9	102.8	51.2	56.2	57.6	59.9	59.3	54.7	49.5	38.3
Barking to Barking sidings	60.3	97.1	44.6	53.4	55.3	55.1	51.3	46.9	42.7	35.4
	61.1	97.8	46.5	55.2	55.8	54.1	53.9	51.6	41.6	33.5
	64.9	115.8	52.1	54.0	54.4	59.2	59.5	57.6	53.8	46.2

Table B.2 – Inter-station noise levels for the Eastbound road between Barking sidings and Hammersmith

Interstation section	L _{Aeq} dB(A)	L _{Cpeak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Barking sidings to Barking	63.6	99.3	46.3	53.5	55.8	56.2	57.7	58.5	44.4	34.3
	65.5	98.4	49.7	58.7	60.3	59.1	58.4	55.5	45.9	36.2
	64.5	96.8	50.3	56.8	59.2	58.8	58.4	52.7	46.3	36.9
Barking to East Ham	66.0	102.0	49.2	58.3	62.6	59.9	58.4	52.6	45.8	33.7
	69.4	102.7	52.1	61.7	66.2	63.6	61.3	55.5	48.8	38.2
	69.6	99.3	51.3	58.6	63.7	64.6	63.0	60.5	56.2	38.0
East Ham to Upton Park	65.7	96.9	43.3	54.4	54.3	59.2	59.8	59.9	58.0	36.0
	64.9	97.5	47.0	57.8	59.3	58.6	59.0	54.0	48.2	37.2
	63.5	97.0	47.8	55.3	57.6	57.3	58.2	52.2	44.6	33.0
Upton Park to Plaistow	62.3	96.5	44.3	56.2	54.8	55.1	58.1	52.1	44.9	32.4
	64.9	96.8	47.0	57.8	59.2	58.5	59.3	53.4	47.0	36.2
	63.7	95.7	50.3	56.3	57.7	57.4	58.2	52.9	45.4	35.0
Plaistow to West Ham	61.1	98.9	45.0	52.5	54.6	55.4	56.3	49.4	43.8	33.5
	64.3	100.2	48.4	57.9	59.2	58.3	57.4	51.5	44.1	34.0
	64.3	99.6	49.9	56.5	58.5	58.4	58.8	52.2	45.4	35.4
West Ham to Bromley-by-Bow	60.4	95.5	42.6	50.5	53.5	55.2	55.8	49.7	43.9	31.5
	62.3	97.8	44.6	52.5	55.8	57.3	56.9	50.7	44.6	32.4
	64.5	94.7	48.5	55.3	58.0	59.0	59.4	53.9	46.4	36.3
Bromley-by-Bow to Bow Road	63.6	99.4	46.6	56.0	57.7	58.0	57.7	52.2	45.7	34.5
	70.1	102.1	48.3	59.7	60.2	59.6	63.5	67.1	50.9	37.9
	65.7	99.4	51.7	58.3	60.4	59.9	59.5	53.7	47.2	36.0
Bow Road to Mile End	61.9	95.1	44.5	50.7	54.1	55.0	59.0	51.0	44.6	33.2
	62.0	96.5	45.8	52.9	55.6	55.3	57.9	50.9	45.0	33.2
	62.5	95.5	44.3	51.3	56.1	56.6	58.0	52.7	46.6	35.4



Interstation section	L _{Aeq} dB(A)	L _{peak} dB(C)	Noise Spectral Analysis in Octave (Hz)							
			63	125	250	500	1000	2000	4000	8000
Mile End to Whitechapel	61.7	98.0	45.9	53.7	55.5	55.7	56.6	50.5	44.4	33.0
	64.1	102.1	49.2	56.8	58.0	57.8	58.6	52.3	46.1	34.7
	64.0	102.2	46.6	54.7	58.4	58.3	58.3	53.0	46.9	34.9
Whitechapel to Aldgate East	65.3	104.9	51.0	56.9	59.1	60.9	58.6	53.3	46.5	35.4
	68.4	107.6	54.5	61.5	63.1	63.5	60.7	54.7	47.8	36.8
	66.2	101.4	52.1	57.1	60.5	61.3	59.7	54.5	49.2	38.1
Aldgate East to Liverpool Street	63.6	102.4	48.5	56.6	56.5	59.5	56.4	52.3	46.9	36.8
	65.7	103.2	50.7	57.4	59.2	61.1	59.0	54.0	47.7	38.3
	64.6	105.2	48.1	54.8	58.2	59.4	58.5	54.8	48.8	39.2
Liverpool Street to Moorgate	61.7	95.6	45.2	54.3	55.0	56.1	56.2	51.8	46.6	35.3
	63.5	97.2	46.2	54.6	56.7	59.2	57.0	51.2	45.6	34.0
	63.2	96.5	48.0	56.9	56.8	57.5	57.5	52.3	46.5	35.3
Moorgate to Barbican	62.7	99.0	49.2	54.2	56.2	56.5	57.7	52.1	46.5	34.6
	65.7	102.9	52.5	58.0	59.8	59.6	59.8	53.6	48.9	35.4
	65.6	103.1	48.6	56.3	60.0	59.8	59.6	55.2	49.0	37.8
Barbican to Farringdon	67.1	104.5	51.6	60.6	61.3	61.9	59.6	54.6	48.5	37.7
	68.7	104.9	54.0	62.4	63.6	63.1	61.0	55.5	49.0	37.0
	67.5	103.8	51.0	59.6	62.2	62.4	60.0	56.1	50.5	41.5
Farringdon to King's Cross St Pancras	68.2	99.6	49.6	60.2	62.4	63.1	61.9	54.9	49.5	38.1
	70.2	103.3	51.5	63.1	64.3	64.9	63.8	55.5	47.8	35.9
	67.9	101.0	49.7	59.2	63.4	62.3	61.1	55.3	49.4	38.9
King's Cross St Pancras to Euston Square	63.0	99.9	45.4	54.1	55.5	56.2	57.6	54.5	51.0	46.1
	64.5	101.9	47.8	58.5	57.7	57.8	59.1	53.1	46.0	33.3
	64.1	101.1	47.2	56.4	57.5	58.2	58.9	52.9	46.3	34.5
Euston Square to Great Portland Street	66.2	105.6	55.4	57.5	60.0	60.4	60.6	54.2	49.4	37.0
	68.4	108.9	57.7	61.0	61.9	62.2	62.9	56.1	49.6	37.5
	67.8	104.3	52.9	58.7	61.4	62.5	62.5	56.8	50.4	39.5
Great Portland Street to Baker Street	63.5	97.6	47.4	55.4	57.9	58.4	57.4	51.2	46.0	34.5
	65.8	102.0	49.8	59.4	60.0	60.7	59.0	53.0	46.2	34.0
	64.5	100.3	48.7	56.4	59.9	58.8	57.6	52.4	46.9	37.2
Baker Street to Edgware Road	69.8	113.4	46.2	52.8	54.9	57.5	59.9	66.0	64.5	60.8
	65.0	107.9	48.1	55.7	57.3	57.7	58.6	58.2	54.3	49.1
	62.3	96.5	45.6	52.5	56.8	57.0	56.2	50.7	45.2	35.0
Edgware Road to Paddington	67.8	106.2	51.5	59.9	61.3	63.1	60.8	58.1	49.8	37.8
	68.0	108.2	52.3	60.0	61.5	63.3	61.3	55.6	49.9	42.3
	66.8	104.8	49.4	58.1	61.2	61.9	59.8	55.2	50.1	40.5
Paddington to Royal Oak	64.0	97.3	49.2	58.2	58.9	57.6	57.1	51.9	44.3	34.9
	68.2	97.6	48.5	55.7	58.2	64.1	61.6	61.5	55.5	36.3
	61.7	94.2	44.4	53.5	56.3	55.8	55.5	50.8	45.3	35.4
Royal Oak to Westbourne Park	68.1	98.9	48.7	58.5	60.2	60.7	60.7	64.2	49.3	37.5
	70.1	102.0	48.4	56.3	60.4	61.1	63.4	67.3	50.7	38.6
	65.4	99.8	49.3	54.5	60.3	60.4	59.7	54.8	47.1	37.3
Westbourne Park to Ladbroke Grove	66.8	97.0	49.3	60.2	61.9	61.8	59.6	53.8	45.8	34.3
	66.7	97.7	49.8	60.0	61.2	61.6	59.9	54.1	47.5	38.6
	65.9	95.8	45.5	56.4	60.9	61.2	59.2	53.3	48.7	41.4
Ladbroke Grove to Latimer Road	63.1	92.9	47.1	57.5	57.4	56.6	57.0	52.5	44.4	34.8
	62.3	95.9	47.6	56.2	55.1	54.8	57.5	53.5	46.2	35.7
	59.5	92.4	41.0	49.7	53.2	53.5	54.5	49.7	43.3	32.8
Latimer Road to Wood Lane	63.0	97.1	45.5	56.8	57.5	56.2	56.9	51.5	42.8	33.6
	61.5	99.3	44.7	54.8	55.0	53.9	56.2	50.4	44.9	34.9
	61.2	93.1	41.1	50.7	52.9	53.2	59.1	48.8	43.0	31.9
Wood Lane to Shepherd's Bush Market	62.8	96.4	45.1	56.0	57.4	56.3	56.9	51.6	43.8	34.9
	62.2	97.0	45.2	53.4	54.7	54.4	58.2	52.5	48.4	37.0
	59.1	93.1	41.8	50.7	52.9	53.1	53.7	47.8	41.8	31.4
Shepherd's Bush Market to Goldhawk Road	63.2	95.4	45.5	56.1	57.8	57.0	57.2	52.0	43.6	34.7
	61.1	96.0	44.9	53.0	55.0	54.9	55.8	50.1	44.0	35.3
	59.8	93.5	41.6	51.4	53.1	53.9	54.6	49.1	43.3	32.6
Goldhawk Road to Hammersmith	65.9	104.1	50.9	58.1	59.6	60.4	60.3	55.1	47.9	37.6
	64.9	103.2	50.8	55.9	58.2	59.4	59.2	55.2	49.6	41.0
	64.2	100.2	47.3	55.5	56.8	58.6	59.2	54.5	49.3	39.9

APPENDIX C – PHOTOGRAPHS

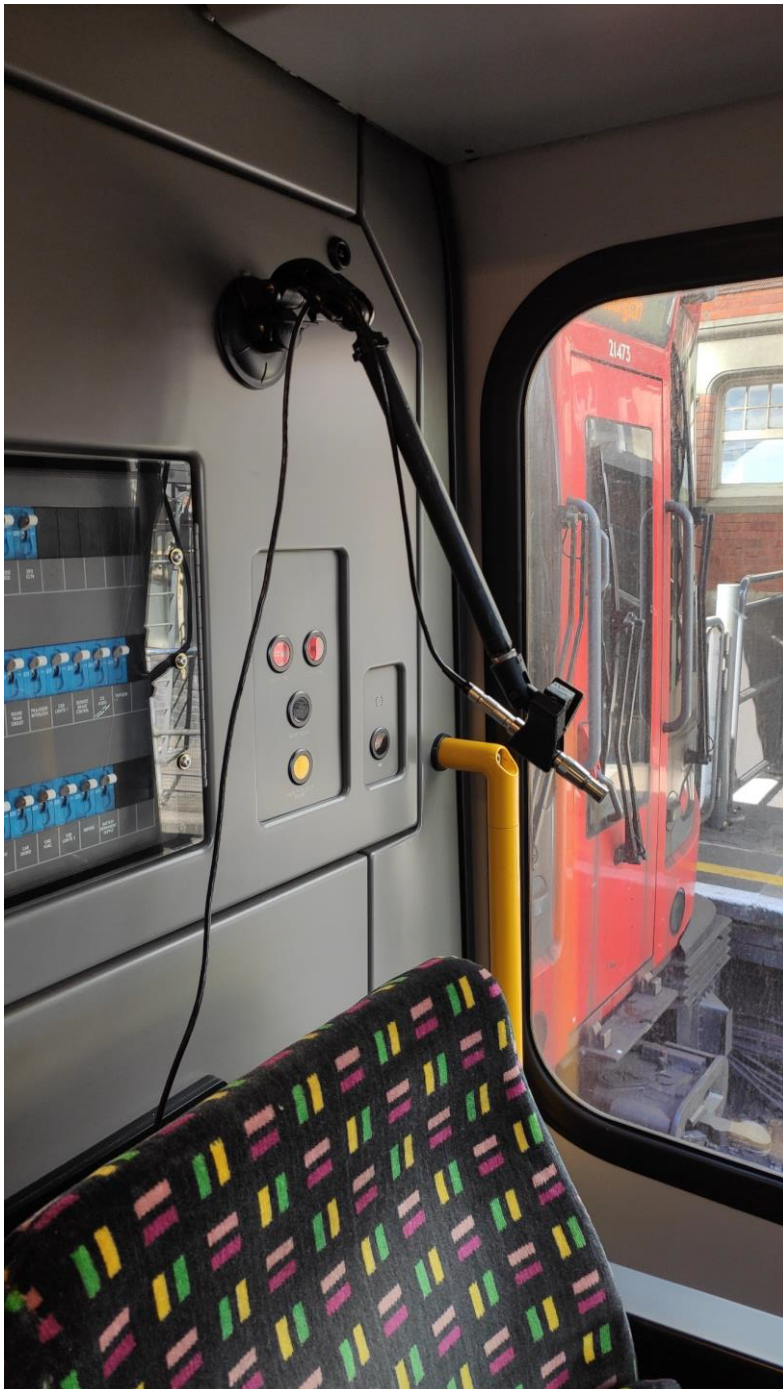


Figure C1 – Microphone arrangement during the measurements