



TfL Technical Services Report

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ACOUSTIC SURVEY IN PASSENGER CAR OF 1972 TUBE STOCK

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INTRODUCTION

1. The 1972 Tube Stock (72TS) Fleet are to be fitted with a new Passenger Information System (PIS), supplied by EKE Electronics, as part of the Central Line Improvement Programme. The process for validating the acoustic performance of the system against TfL Requirements Documents are described elsewhere (LTG Document No 3044325). TfL Technical Services were tasked to acquire acoustic data in the passenger saloon of 72TS to support the acoustic testing of the new PIS. This report provides a summary of the acoustic data obtained during a 72TS test run between Stonebridge Park and Elephant and Castle stations on 16 July 2023.

EQUIPMENT AND PROCEDURE

The vehicle

2. The London Underground 1972 Stock is the type of rolling stock in service on the Bakerloo Line. The rail vehicles were manufactured by Metro-Cammell and entered service in June 1972. Normal formation for 1972 Tube Stock comprises seven cars with a maximum full load standing capacity of 700 people. This vehicle is equipped for conventional driving and manual operation is utilised across the Bakerloo Line network.

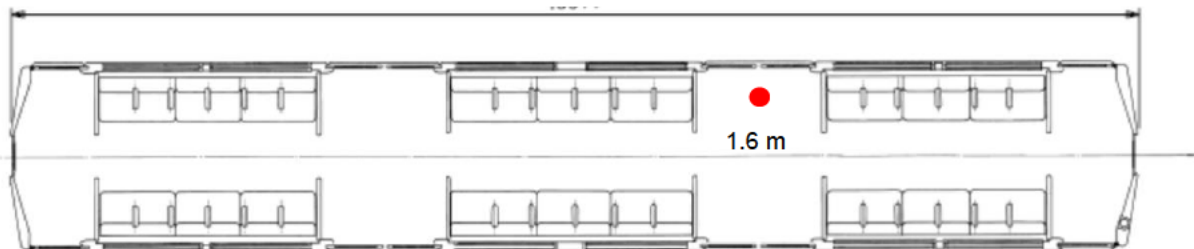


Figure 1. Approximate measurement locations in passenger car.

Acoustic measurements

3. Acoustic measurements were obtained in a 72TS on 16 July 2023 whilst the vehicle was operating at normal line speed between Stonebridge Park and Elephant and Castle stations. Measurement equipment was installed in a mid-train passenger saloon car (unit 3 off 7). Sound pressure data were acquired using an integrating sound level meters (SLM) with combined $\frac{1}{2}$ " microphone and preamplifier sets. The measurement system was configured for use with external microphone set-up. The microphone was positioned at 1.6 m (standing) height from the deck and more than 0.3 m distance from a reflecting surface; cabling was secured to handrail using cable ties, duct tape and 2.5 mm string. Figure 1 shows the approximate measurement location in the passenger car. Further details of the measurement equipment are shown in Table 1. Measurements were made by Technical Services Senior Engineer (James Carey).

4. Field calibration of the SLM were performed using an acoustic calibrator which gave a sinusoidal calibration tone of 94 dB at a frequency of 1000 Hz. The field calibration was carried out before and after the survey; the measurements remained stable throughout. The SLM and acoustic calibrator conform to 'class 1' specifications for corresponding equipment



defined in British Standards BS EN 61672-1:2013, BS EN 61260-3:2016 and BS EN 60942:2018. The SLM had been calibrated to traceable standards within the preceding two years, and the acoustic calibrators within the preceding 12 months.

Table 1 Details of Sound Level Meters and Field Calibrator.

Item (height)	Manufacturer	Type	Serial No	Certificate No	Date
SLM (1.6 m)	01dB	Fusion	12501	191694	05/05/2023
Calibrator	Svantek	SV36	79808	1503419-2	24/10/2022

5. The data were analysed using 01 dBTrait software (version 6.3.1 build 1) and the following parameters were determined for station-to-station transit: the frequency-weighted equivalent continuous sound pressure level ($L_{Aeq,T}$ and $L_{Ceq,T}$), the C-weighted peak sound pressure level (L_{Cpeak}); and one-third octave band unweighted equivalent continuous sound pressure level (L_{eqT}) for centre band frequencies 20 Hz to 20,000 Hz.

RESULTS

6. The A-weighted equivalent continuous sound pressure levels (L_{Aeq}) obtained for each station-to-station section are shown in Table 2 (southbound) and Table 3 (northbound). All acoustic data are presented in the Appendix, for completeness. The train number/reference was 745/1385711. The passenger car was unoccupied for the duration of the test run and all passenger announcements were disabled throughout.

7. Operating conditions for the vehicle are representative of normal service and there were no notable delays reported during the measurement run. Periods of slow travel (e.g. between Lambeth North and Elephant and Castle stations) or brief pauses in vehicle movement were included in the analysis.



Table 2 Southbound station-to-station LAeqT measured at standing position on 72TS during normal operations on the Bakerloo Line 16 July 2023

Station	Duration	LAeq dB(A)
	(mm:ss)	Standing (1.6 m)
Stonebridge Park to Harlesden		
Harlesden to Willesden Junction		
Willesden Junction to Kensal Green		
Kensal Green to Queens Park North Junction		
Queens Park North Junction to Queens Park		
Queens Park to Kilburn Park	01:39	81
Kilburn Park to Maida Vale	01:30	83
Maida Vale to Warwick Avenue	01:24	89
Warwick Avenue to Paddington	01:38	83
Paddington to Edgware Road	01:31	85
Edgware Road to Marylebone	01:03	82
Marylebone to Baker Street	01:13	74
Baker Street to Regent's Park	01:47	84
Regent's Park to Oxford Circus	01:52	80
Oxford Circus to Piccadilly Circus	01:50	82
Piccadilly Circus to Charing Cross	01:18	88
Charing Cross to Embankment	00:57	79
Embankment to Waterloo	01:58	79
Waterloo to Lambeth North	01:33	80
Lambeth North to Elephant and Castle	05:36	74



Table 3 Northbound station-to-station L_{AeqT} measured at standing position on 72TS during normal operations on the Bakerloo Line 16 July 2023.

Station	Duration (mm:ss)	L_{Aeq} dB(A) Standing (1.6 m)
Elephant and Castle to Lambeth North	02:21	82
Lambeth North to Waterloo	01:41	87
Waterloo to Embankment	01:16	84
Embankment to Charing Cross	00:58	76
Charing Cross to Piccadilly Circus	01:26	83
Piccadilly Circus to Oxford Circus	01:59	84
Oxford Circus to Regent's Park	01:46	84
Regent's Park to Baker Street	01:56	87
Baker Street to Marylebone	01:11	78
Marylebone to Edgware Road	01:04	79
Edgware Road to Paddington	01:33	87
Paddington to Warwick Avenue	01:46	86
Warwick Avenue to Maida Vale	01:39	84
Maida Vale to Kilburn Park	01:32	80
Kilburn Park to Queens Park	01:48	83
Queens Park to Queens Park North Junction	00:48	66
Queens Park North Junction to Kensal Green	01:46	73
Kensal Green to Willesden Junction	02:05	76
Willesden Junction to Harlesden	01:46	74
Harlesden to Stonebridge Park	05:38	66



REFERENCES

British Standards Institution (2018) Electroacoustics – Sound calibrators. BS EN 60942 (2018). BSI Publications 2018.

British Standards Institution (2016) Electroacoustics – Octave-band and fractional-octave-band filters Periodic tests. BS EN 61260-3 (2016). BSI Publications 2016.

British Standards Institution (2013) Electroacoustics – Sound level meters – Part 1: Specifications. BS EN 61672-1 (2013). BSI Publications 2013.

Luminator Technology Group (2023) 72TS/92TS PIS Passenger Information System, STIPA Measurement Description. Document No 3044325 Rev A. LTGRail, Canada 18 April 2023

DISTRIBUTION [By Email]

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APPENDIX

Tables A1 to A6 present acoustic data measured in the passenger saloon car (unit 3 off 7) of 72TS on 16 July 2023 between Stonebridge Park and Elephant and Castle stations

Table A1 Station-to-station frequency-weighted sound pressure levels from Queens Park to Elephant and Castle Station.

Section	Duration mm:ss	Standing (1.6 m)		
		L _{AeqT} dB(A)	L _{CeqT} dB(C)	L _{Cpeak} dB(C)
STP-HAR				
HAR-WIJ				
WIJ-KEG				
KEG-QPNJn				
QPNJn-QUP				
QUP-KIP	01:39	81.3	87.9	110.0
KIP-MAV	01:30	83.0	89.2	108.3
MAV-WAA	01:24	89.0	92.3	111.4
WAA-PAD	01:38	83.4	90.6	108.3
PAD-EDR	01:31	85.1	93.6	111.4
EDR-MAR	01:03	81.7	89.2	106.9
MAR-BAS	01:13	74.0	84.3	101.8
BAS-REP	01:47	83.5	90.1	109.7
REP-OXC	01:52	80.3	87.6	110.2
OXC-PIC	01:50	82.3	89.1	108.2
PIC-CHC	01:18	87.8	92.3	110.5
CHC-EMB	00:57	79.1	87.1	107.6
EMB-WAT	01:58	79.3	87.9	107.4
WAT-LAN	01:33	79.5	88.5	111.5
LAN-EAC	05:36	74.4	84.0	107.9



Table A2 Station-to-station frequency-weighted sound pressure levels from Elephant and Castle to Stonebridge Park stations.

Section	Duration	Standing (1.6 m)		
		L _{AeqT}	L _{CeqT}	L _{Cpeak}
	mm:ss	dB(A)	dB(C)	dB(C)
EAC-LAN	02:21	81.8	88.6	111.0
LAN-WAT	01:41	86.5	91.3	110.8
WAT-EMB	01:16	83.6	90.7	109.0
EMB-CHC	00:58	76.0	87.7	106.4
CHC-PIC	01:26	82.6	88.9	107.4
PIC-OXC	01:59	84.1	90.1	107.3
OXC-REP	01:46	83.6	88.4	111.5
REP-BAS	01:56	87.3	93.0	113.5
BAS-MAR	01:11	77.8	87.6	108.9
MAR-EDR	01:04	79.3	89.0	107.2
EDR-PAD	01:33	87.1	92.0	110.7
PAD-WAA	01:46	86.0	93.5	114.2
WAA-MAV	01:39	84.1	90.1	109.5
MAV-KIP	01:32	79.8	86.9	105.6
KIP-QUP	01:48	82.7	88.7	107.0
QUP-QPNJn	00:48	66.4	83.2	99.3
QPNJn-KEG	01:46	72.5	85.9	106.7
KEG-WIJ	02:05	76.2	89.3	108.9
WIJ-HAR	01:46	73.7	86.2	107.9
HAR-STP	05:38	66.1	81.0	100.9



Table A3 Station to station unweighted one-third octave band L_{eq} at 1.6 m standing position (Queens Park to Elephant and Castle)

	Centre Frequency (Hz)																															
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	
STP-HAR																																
HAR-WIJ																																
WIJ-KEG																																
KEG-QPNJn																																
QPNJn-QUP																																
QUP-KIP	79.2	83.3	78.9	77.4	75.8	72.0	74.8	74.7	76.1	72.0	74.7	73.4	75.0	73.7	75.3	76.3	76.4	72.1	68.7	64.4	62.0	61.3	58.4	55.0	52.4	47.1	42.7	40.0	39.7	36.7	30.2	
KIP-MAV	77.3	83.0	79.5	77.5	76.4	72.6	76.8	77.4	77.0	75.8	78.4	75.7	75.9	75.9	77.6	77.8	78.2	73.4	69.8	65.5	63.7	63.1	59.4	55.3	52.1	50.8	44.4	42.0	44.3	42.6	38.2	
MAV-WAA	76.5	82.9	78.7	79.7	78.1	75.0	75.7	75.8	74.1	75.3	78.7	73.9	75.6	77.6	87.3	83.9	81.3	78.0	72.1	66.1	69.1	80.0	60.0	54.9	56.2	48.2	43.3	41.2	43.6	42.3	35.8	
WAA-PAD	79.0	83.4	79.7	79.7	78.3	75.8	77.9	79.4	79.1	77.4	81.7	78.5	78.8	76.7	76.4	76.6	78.8	74.4	69.4	64.0	62.4	61.8	58.0	54.4	51.3	47.2	43.1	43.4	42.3	40.1	31.9	
PAD-EDR	80.7	85.5	84.8	83.3	81.0	80.1	82.4	84.2	83.5	81.3	83.7	81.2	80.4	77.4	82.0	78.5	78.0	74.2	69.5	65.5	65.8	64.6	61.3	58.4	56.8	52.3	46.1	42.8	42.3	37.9	30.7	
EDR-MAR	78.2	82.5	77.5	78.6	77.8	74.3	77.7	76.9	76.7	73.9	79.7	77.2	79.7	76.4	75.3	75.6	76.5	70.4	64.3	59.8	59.0	58.1	53.3	49.5	46.7	42.7	38.0	39.4	37.4	35.1	27.9	
MAR-BAS	76.5	83.3	76.2	72.4	73.1	71.4	71.7	72.1	70.9	67.9	71.9	69.0	68.4	66.9	69.7	68.2	68.2	64.1	59.1	55.5	54.0	53.9	51.1	47.5	44.6	41.1	35.9	34.5	35.2	34.9	29.0	
BAS-REP	79.7	83.5	79.6	78.1	77.5	76.7	78.6	79.0	78.6	75.4	78.5	75.2	76.3	76.7	81.9	79.0	76.2	71.5	66.8	62.8	61.4	63.3	56.3	52.8	50.2	45.6	41.1	38.3	37.9	34.3	27.2	
REP-OXC	77.1	83.2	76.7	74.5	74.1	72.6	74.1	75.1	74.6	76.3	78.3	73.3	76.2	74.2	77.8	74.0	73.1	67.8	68.6	60.6	56.4	56.9	53.1	49.4	47.0	42.7	38.8	36.4	36.6	33.5	26.4	
OXC-PIC	78.1	83.2	79.6	77.1	76.3	75.9	79.3	78.9	76.7	72.9	76.1	73.8	75.5	74.3	79.7	76.5	77.4	72.4	65.0	59.6	59.0	59.6	54.8	51.3	49.4	44.5	38.4	37.9	37.4	34.2	27.4	
PIC-CHC	81.4	84.3	79.1	78.1	77.0	73.3	76.2	77.4	77.4	76.7	79.3	75.6	77.1	76.0	89.3	78.3	74.7	73.2	76.1	66.8	61.8	61.3	55.3	52.2	60.6	54.4	40.2	39.9	38.7	36.3	29.7	
CHC-EMB	76.1	82.1	77.0	73.0	74.9	72.5	78.3	78.7	75.9	73.0	75.1	72.8	72.0	70.2	72.7	73.0	75.1	70.8	63.6	59.1	58.6	58.0	54.5	50.3	49.7	44.9	39.5	38.4	38.5	36.2	28.7	
EMB-WAT	77.1	82.6	76.9	76.9	77.4	75.7	78.9	78.2	77.4	72.9	75.0	72.3	73.6	71.5	77.3	72.9	73.0	67.6	63.1	59.7	58.4	56.9	52.9	50.8	55.1	46.7	40.9	40.1	38.6	35.0	28.2	
WAT-LAN	80.5	83.8	79.3	76.7	77.3	77.6	78.9	77.6	77.4	73.5	75.8	72.9	72.8	72.6	78.0	72.1	72.6	69.1	62.6	59.5	58.7	58.0	53.8	52.5	52.5	49.0	45.9	44.2	43.1	39.7	31.1	
LAN-EAC	73.6	83.1	73.6	71.9	72.0	70.2	74.5	71.3	71.6	68.7	71.4	69.0	68.3	66.7	72.3	66.9	66.7	62.4	64.6	56.0	53.0	52.5	48.6	46.4	46.2	41.1	37.2	33.1	33.4	29.1	22.6	



Table A4 Station to station unweighted one-third octave band L_{eq} at 1.6 m standing position (Elephant and Castle to Stonebridge Park)

	Centre Frequency (Hz)																														
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
EAC-LAN	80.1	83.6	78.3	76.1	75.5	73.6	77.4	76.4	77.3	74.8	78.1	75.1	74.6	72.7	79.8	73.5	72.4	68.9	64.3	59.8	62.5	74.4	54.1	50.1	51.6	44.3	40.5	37.7	37.8	34.6	27.7
LAN-WAT	79.9	84.1	79.9	77.9	77.5	75.6	77.9	75.1	76.0	71.7	74.7	71.0	71.4	73.0	88.3	80.7	70.9	70.4	65.3	62.3	59.7	60.0	55.2	54.7	48.0	44.8	41.5	38.1	37.7	34.7	28.4
WAT-EMB	78.5	83.6	78.8	78.8	80.3	75.5	79.8	80.7	79.3	75.8	79.1	77.5	79.1	78.0	79.0	78.4	77.5	72.9	70.3	64.0	61.8	64.4	57.5	53.4	50.8	47.0	41.7	39.9	41.3	38.2	31.7
EMB-CHC	76.3	83.5	79.7	75.0	75.5	76.7	77.4	80.1	79.0	73.9	75.1	71.9	71.6	69.6	70.8	69.3	68.8	64.7	60.6	58.0	56.1	55.2	51.5	48.4	45.4	41.1	36.8	33.5	32.9	30.2	24.5
CHC-PIC	77.8	83.7	78.1	77.4	76.6	74.0	77.1	76.3	77.0	75.3	79.1	76.1	75.7	74.2	77.1	73.4	72.3	68.0	78.5	66.3	57.6	66.3	53.9	50.7	48.2	44.0	39.1	36.5	36.4	33.1	26.9
PIC-OXC	79.7	84.6	80.0	78.3	77.2	75.6	78.7	79.2	78.5	76.5	79.7	76.5	76.3	74.5	77.0	74.4	73.6	70.0	80.4	69.7	61.8	68.9	58.3	55.7	51.5	46.0	42.6	39.7	40.1	37.9	30.7
OXC-REP	76.6	82.6	75.7	73.1	72.9	72.2	75.6	79.1	77.7	72.2	75.0	72.5	72.0	71.8	82.0	73.7	70.4	70.0	62.0	58.4	66.1	78.4	54.5	49.6	55.3	42.9	39.9	34.8	34.4	31.2	25.4
REP-BAS	78.5	83.3	79.5	78.9	76.4	77.4	79.1	82.6	81.6	78.4	83.2	82.0	83.1	80.3	82.9	82.8	80.0	75.1	70.4	66.3	66.0	75.9	58.2	54.3	56.0	47.9	42.5	40.6	40.4	36.8	30.2
BAS-MAR	79.1	83.2	79.5	80.8	77.7	77.1	76.6	74.7	75.6	71.4	75.1	72.1	72.9	71.5	72.5	71.6	72.3	67.8	63.6	60.1	59.1	58.1	55.3	51.1	47.9	44.3	40.4	39.1	38.5	34.4	27.8
MAR-EDR	77.3	83.7	78.6	78.0	75.4	75.1	80.1	79.9	80.0	76.1	77.8	75.8	74.8	73.3	73.2	73.0	68.4	64.9	61.6	60.2	60.0	56.1	52.0	49.8	45.4	40.8	38.4	38.0	34.7	28.8	
EDR-PAD	78.1	84.6	79.7	79.1	78.6	74.3	80.8	77.0	78.0	75.4	81.2	76.6	75.6	75.3	87.8	77.5	74.5	75.2	78.2	67.6	63.0	67.6	56.7	54.2	52.1	46.3	41.4	39.3	39.6	36.6	30.0
PAD-WAA	77.7	83.7	79.6	79.8	81.4	78.2	81.0	87.7	83.6	79.2	83.9	78.7	80.1	79.2	79.7	80.4	80.8	77.3	71.6	66.3	65.0	63.7	59.6	55.9	52.4	47.0	42.0	39.6	39.5	36.1	29.6
WAA-MAV	75.4	82.9	79.1	78.5	76.4	70.5	73.4	75.8	77.0	75.4	81.4	78.7	79.2	77.9	82.0	77.9	76.2	72.7	66.2	61.1	62.0	70.6	54.3	49.9	51.4	42.8	37.5	34.8	34.7	31.0	24.4
MAV-KIP	76.5	83.6	79.1	75.0	74.7	72.1	74.0	73.7	74.7	71.7	74.8	72.7	72.7	72.2	75.2	75.6	73.4	70.0	66.0	61.0	59.1	64.6	55.2	51.0	48.7	43.6	40.2	37.1	36.7	33.4	27.3
KIP-QUP	78.0	83.5	76.5	76.0	75.4	75.2	77.7	76.5	75.9	73.6	76.7	74.6	75.4	73.4	77.9	77.6	78.9	73.4	66.4	60.6	59.1	58.6	53.3	49.3	46.1	42.1	37.5	34.9	35.6	32.9	27.2
QUP-QPNJn	75.4	84.1	73.8	73.2	73.1	68.3	70.6	73.4	64.5	60.5	62.9	59.9	62.0	59.5	57.1	56.3	55.7	53.5	54.6	50.8	50.2	59.2	48.5	43.7	45.7	39.4	37.0	35.1	34.6	31.5	25.4
QPNJn-KEG	77.7	84.2	77.7	76.9	73.3	70.7	73.0	73.9	75.6	73.2	75.5	69.9	69.8	66.2	64.6	64.1	63.3	60.7	57.1	54.3	53.8	53.8	51.6	49.5	46.9	42.8	37.7	34.4	33.9	30.0	23.5
KEG-WIJ	79.7	85.5	80.8	82.2	77.1	76.8	82.4	80.4	74.8	72.8	75.5	73.5	73.7	71.5	69.3	68.6	68.3	64.3	60.6	57.9	57.5	57.9	56.0	54.2	51.2	47.1	41.5	38.4	38.8	35.5	28.7
WIJ-HAR	76.4	84.4	78.2	78.2	78.7	72.9	74.0	74.5	72.9	70.6	73.4	69.7	69.9	67.6	66.8	66.1	67.3	64.9	58.2	55.1	54.1	55.2	51.8	48.5	45.5	41.4	36.7	34.4	34.6	30.9	24.2
HAR-STP	70.5	83.2	73.4	69.8	67.8	64.0	64.9	64.1	58.2	58.4	64.1	62.4	64.9	63.1	60.6	58.5	57.1	54.3	50.0	48.5	46.9	48.9	47.2	42.3	39.9	36.0	31.7	30.0	29.8	27.8	21.2