129-131 Grosvenor Street Manchester

Acoustic Planning Report
0492/APR1

7 February 2019

For:

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1.0 Introduction

Lighthouse Acoustics has been appointed by Index Investment Projects to undertake an environmental sound survey at 129-131 Grosvenor Street, Manchester and to undertake a detailed sound assessment for the proposed residential development.

The proposed residential development comprises an additional 2No. flats to the roof of the existing 5 storey block of flats.

The survey methodology, results and assessment for the proposed development are presented in this report.

2.0 Objectives

To establish the Local Authority's acoustic requirements for the proposed residential development.

To visit site to undertake a detailed environmental/entertainment sound survey in order to establish existing environmental/entertainment sound levels at the proposed residential development.

To undertake a detailed environmental/entertainment sound assessment of the proposed residential development to establish the acoustic specification for glazing/ventilation elements in order to achieve the acoustic requirements of the Local Authority.

To propose atmospheric plant sound emission limits at the nearest noise sensitive receptors for subsequent use in designing building services proposals in order to comply with the requirements of the Local Authority.

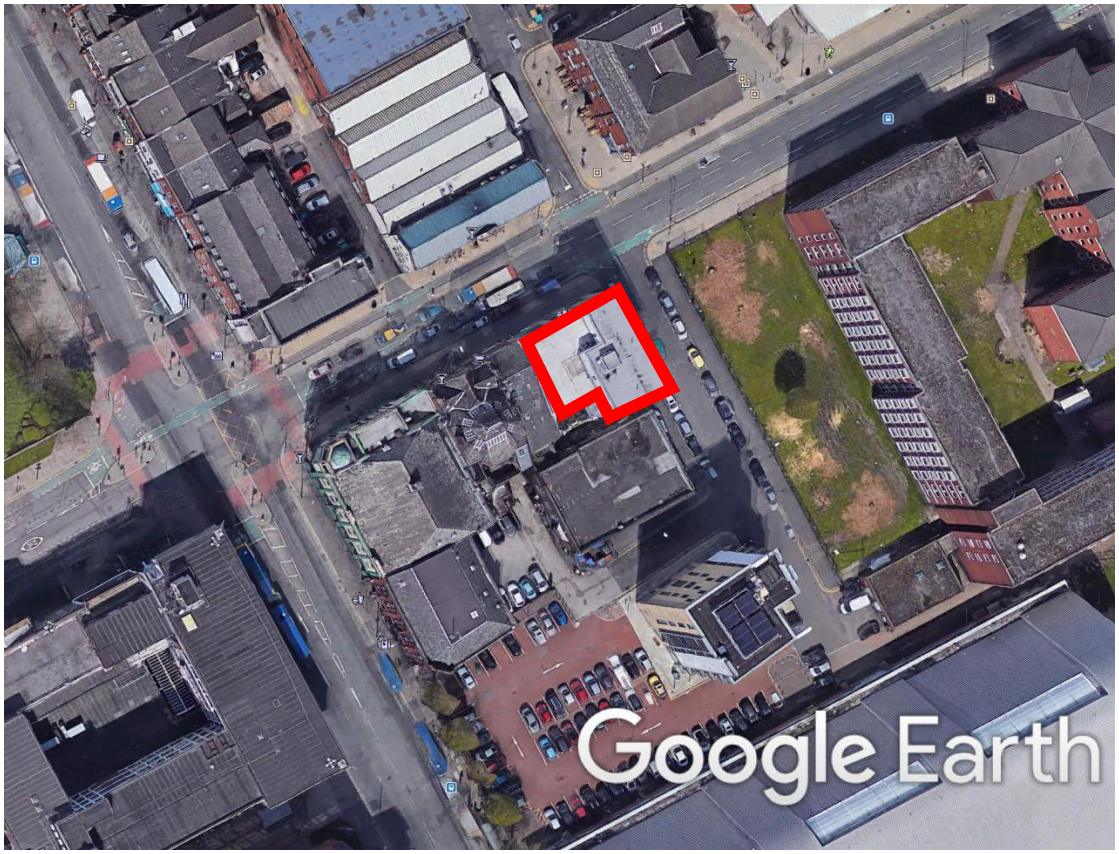
3.0 Site Description

The proposed residential development is at 129-131 Grosvenor Street, Manchester. The site comprises an existing 5 storey building with commercial units at ground floor and residential flats at 1st to 4th floors.

The site is bound by York Street to the north east, temporary site offices to the south east, commercial premises to the south west and Grosvenor Street to the north west.

A new university building is currently being constructed to the north east of the site opposite York Street. The Deaf Institute bar and music venue is situated to the south west of the site adjacent to the adjoining commercial property along Grosvenor Street.

The site plan overleaf indicates the extent of the site and the surrounding environment.



Site plan indicating the extent of the site and the surrounding environment

4.0 Local Authority Requirements

4.1 Residential Developments

With regard to residential developments, Section 3.6.1.1 of the Planning & Noise Technical Guidance document (dated December 2015) produced by Manchester City Council states the following:

> *"Manchester City Council has adopted the following internal noise limits for residential properties:*
>
> - ***Bedrooms (night time - 23.00 - 07.00) 30dB L_{Aeq} (individual noise events should not normally exceed 45dB $L_{Amax,F}$ by more than 15 times)***
> - ***Living Rooms (daytime - 07.00 - 23.00) 35dB L_{Aeq}***
> - ***Gardens and terraces (daytime) 55dB L_{Aeq}"***

4.2 Commercial Units

With regard to entertainment venues, Section 3.6.1.2 of the Planning & Noise Technical Guidance document (dated December 2015) produced by Manchester City Council states the following:

"Therefore a criterion that would achieve a condition of 'inaudible' / 'virtually inaudible' which is applicable for new residential developments that are structurally connected to entertainment venues (or vice versa) would be:

'Music noise levels in the 63Hz and 125Hz octave centre frequency bands (L_{eq}) should be controlled so as not to exceed (in habitable rooms) 47dB and 41dB (L_{eq}), respectively'.

This criterion may also be applicable for new residential developments that are structurally separate from an existing entertainment venue."

4.3 Building Services

With regard to noise and vibration from fixed plant/equipment, Section 3.6.1.5.1 of the Planning & Noise Technical Guidance document (dated December 2015) produced by Manchester City Council states the following:

"The noise assessment should be based on BS 4142: 2014 and any application for fixed plant, equipment or machinery must demonstrate that:

'Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5dB (L_{Aeq}) below the typical background (L_{A90}) level at the nearest noise sensitive location."

5.0 Environmental Sound Survey

5.1 Measurements

Automated environmental sound measurements were undertaken from 13:00 hours on Friday 18 January 2019 to 16:00 hours on Monday 21 January 2019. During this period the L_{Amax}, L_{Aeq} and L_{A90} sound pressure levels were measured continuously over 15 minute periods along with the corresponding octave band sound pressure levels.

5.2 Weather Conditions

At the start of the survey period there was a gentle south easterly breeze (<5m/s) and the sky was overcast. There was no rainfall and road surfaces were dry. The temperature was approximately 4°C.

At the end of the survey period there was a gentle southerly breeze (<5m/s) and the sky was overcast. There was no rainfall and road surfaces were dry. The temperature was approximately 5°C.

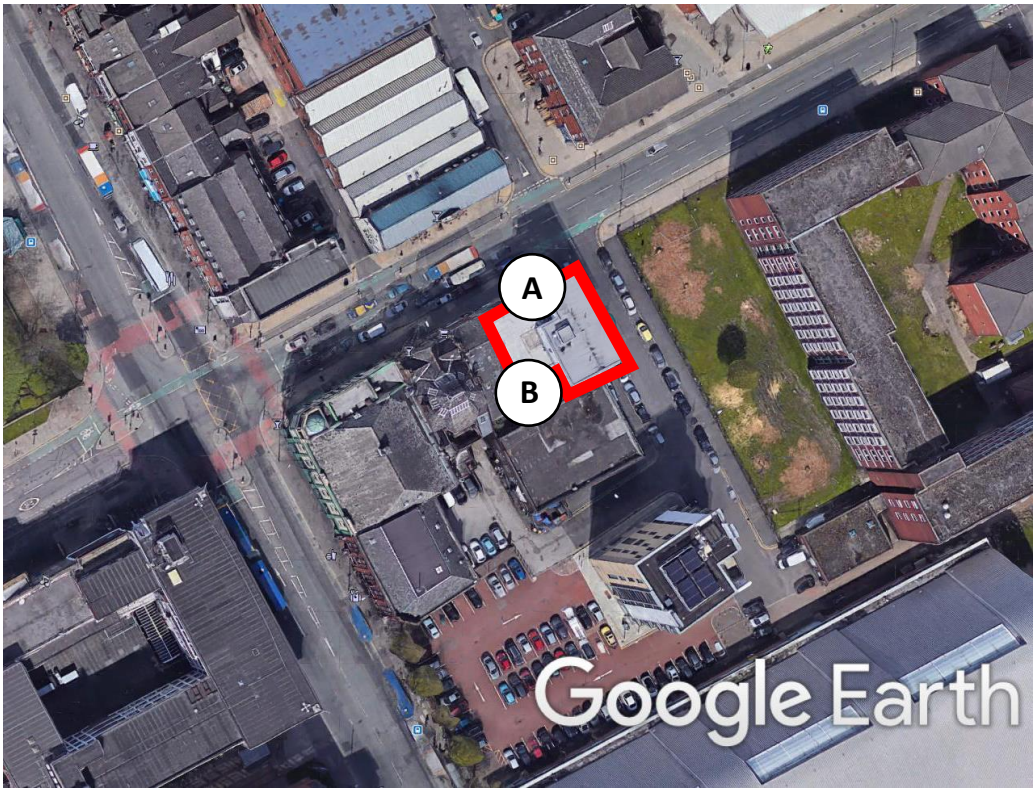
Based on publicly available weather data for the survey period we understand that weather conditions remained similar for the duration of the survey with no significant periods of rainfall or strong breezes. The weather conditions during the survey period are therefore considered to be suitable for undertaking measurements of sound levels.

5.3 Measurement Positions

Environmental sound levels were measured at 2No. positions on-site as described in the table below.

Position	Description
A	Microphone at 3rd floor roof level of existing flats in-line with the front facade of the building and proposed flats overlooking Grosvenor Street in free field conditions.
B	Microphone at 3rd floor roof level of existing flats in-line with the rear facade of the building and proposed flats overlooking the adjacent buildings in free field conditions.

The measurement positions are shown on the site plan below.



Site plan showing measurement positions

The measurement positions were selected in order to assess typical environmental/entertainment sound levels incident upon the front and rear facades of the proposed residential development.

5.4 Equipment

The following equipment was used to undertake the environmental sound survey.

Equipment	Manufacturer	Model	Serial No.	Calibration Date
Class 1 Sound Level Meter	Casella	633C	0721320	11/09/2017
Preamplifier	Casella	495	001414	11/09/2017
Microphone	Casella	251	1025	11/09/2017
Class 1 Sound Level Meter	Casella	633C	0721319	08/09/2017
Preamplifier	Casella	495	001446	08/09/2017
Microphone	Casella	251	1996	08/09/2017
Class 1 Sound Calibrator	Casella	120/1	3864878	13/11/2018
Environmental Noise Kits	Casella	6847	-	-
Microphone Extension Cables	Casella	C6717/5	-	-
Weather Protection Systems	Casella	6737	-	-

Field calibration checks were performed on the sound level meters prior to and on completion of the survey and were found to be within acceptable tolerance limits.

5.5 Results

5.5.1 Time History Graphs

The results of the environmental/entertainment sound survey are presented on Time History Graphs 0492/THG1 and 0492/THG2 enclosed at the rear of the report.

5.5.2 $L_{Aeq,T}$ Ambient Sound Levels

In order to compare the results of the environmental sound survey with the internal BS 8233: 2014 levels it is necessary to convert the $L_{Aeq,15min}$ sound levels into single figure daytime $L_{Aeq,16hour}$ and night-time $L_{Aeq,8hour}$ sound levels. This has been calculated using the following formula:

$$L_{Aeq,T} = 10\,log_{10}\left(\frac{1}{N}\sum_{i}^{N} 10^{L_{Aeq,15min}{}^{i}/10}\right)$$

The calculated daytime $L_{Aeq,16hour}$ and night-time $L_{Aeq,8hour}$ sound levels at each measurement position are presented in the table below.

Day	Position A		Position B	
	Daytime $L_{Aeq,16hour}$ (dB)	Night-time $L_{Aeq,8hour}$ (dB)	Daytime $L_{Aeq,16hour}$ (dB)	Night-time $L_{Aeq,8hour}$ (dB)
Friday	-	58	-	59
Saturday	60	57	58	56
Sunday	58	56	58	54

The highest daytime $L_{Aeq,16hour}$ and night-time $L_{Aeq,8hour}$ sound levels at each measurement position are presented in the table below along with the corresponding octave band sound pressure levels.

Position	Period	L_{eq} Sound Pressure Level (dB) at Octave Band Centre Frequency (Hz)								dBA
		63	125	250	500	1k	2k	4k	8k	
A	Daytime (16 hour)	66	59	57	55	57	53	46	35	60
	Night-time (8 hour)	74	65	57	54	54	49	40	30	58
B	Daytime (16 hour)	68	66	59	54	53	57	40	31	58
	Night-time (8 hour)	76	65	58	55	54	49	41	31	59

5.5.3 $L_{Amax,F}$ Sound Level Events

The highest 15No. individual $L_{Amax,F}$ sound level events measured during the night-time periods (23:00 to 07:00 hours) over the entire survey period at each measurement position are detailed in the table below.

Position	$L_{max,F}$ Sound Pressure Level (dB) at Octave Band Centre Frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8k	
A	79	83	88	91	87	80	70	58	90
	82	88	84	80	88	77	74	64	89
	82	78	82	81	79	74	66	55	83
	80	74	73	77	78	77	71	61	82
	78	69	65	72	78	76	76	68	82
	79	71	70	71	74	75	78	66	81
	77	70	74	65	81	62	64	49	81
	86	78	71	70	73	74	70	53	78
	84	80	73	74	75	70	67	53	77
	76	73	67	67	78	69	64	60	77
	78	83	74	74	73	69	60	51	77
	80	84	77	74	71	68	64	59	77
	85	79	78	80	68	64	62	57	77
	85	85	78	76	75	70	55	52	76
	73	64	58	61	75	71	60	51	76
B	81	80	82	81	80	81	85	76	89
	88	75	68	74	82	77	63	52	83
	77	74	81	84	75	68	58	53	81
	89	81	71	78	77	70	68	49	79
	92	79	71	70	76	74	64	47	77
	89	78	71	70	72	75	72	64	77
	91	80	75	78	72	68	58	47	77
	89	75	71	71	77	70	62	55	77
	79	81	63	66	72	72	64	57	76
	90	77	76	70	75	72	62	54	76
	80	77	75	75	72	63	56	49	76
	92	82	72	65	76	67	59	58	76
	74	74	71	72	74	71	62	60	76
	88	75	74	73	75	68	64	57	75
	93	78	71	69	74	67	58	49	74

5.5.4 L_{Aeq} Music Sound Levels

The typical highest $L_{eq,15min}$ music noise levels measured in the 63Hz and 125Hz octave band centre frequencies at each measurement position are presented in the table below.

Position	$L_{eq,15min}$ Sound Pressure Level (dB) at Octave Band Centre Frequency (Hz)	
	63	125
A	76	72
B	78	74

5.5.5 $L_{A90,T}$ Background Sound Levels

The lowest representative daytime and night-time $L_{A90,15min}$ background sound levels measured at each position during the survey period are detailed in the table below.

Position	Lowest Representative $L_{A90,15min}$ Background Sound Levels (dB)	
	Daytime	Night-time
A	57	51
B	56	51

5.6 Discussion of Sound Climate

At the start and end of the survey period the dominant sound sources at Position A were noted to be frequent road traffic along Grosvenor Street and frequent road traffic from the surrounding road network. Intermittent construction noise from the surrounding construction sites also contributed towards the measured noise climate.

At the start and end of the survey period the dominant sound sources at Position B were noted to be frequent road traffic from the surrounding road network and low level building services plant from the surrounding buildings. Intermittent construction noise from the surrounding construction sites also contributed towards the measured noise climate.

At Position B on Friday night, an increase in sound levels can clearly be seen from approximately 22:00 hours onwards with a sudden drop at approximately 03:00 hours. At Position B on Sunday night, an increase in sound levels can clearly be seen from approximately 21:00 hours onwards with a sudden drop at approximately 22:30 hours. The same can be seen at Position A to a lesser degree.

This is understood to be due to music breakout from the rear of The Deaf Institute bar and music venue.

6.0 Detailed Sound Assessment

6.1 Assessment Method

In order to establish the acoustic specification for glazing/ventilation elements required to achieve the internal daytime $L_{Aeq,16hour}$, night-time $L_{Aeq,8hour}$, night-time $L_{Amax,F}$ and music $L_{eq,63Hz}$ and $L_{eq,125Hz}$ requirements an assessment has been undertaken in accordance with the more rigorous calculation method detailed in BS 8233:2014, "Guidance on sound insulation and noise reduction for buildings".

This calculation method takes into account the external sound pressure level, the sound reduction indicies of the façade elements, the area of the facade and the absorption within the room at octave band centre frequencies.

Detailed calculation sheets for living/dining rooms and bedrooms are enclosed at the rear of the report.

6.2 Proposed Development

The assessment has been based on the following drawings.

Author	Drawing No.	Revision	Date
R.T.Lucas	PL-07	A	-
	PL-08	-	-
	PL-09	-	-
	PL-10	-	-
	PL-12	-	-

The proposals include the construction of 2No. 1 bed flats at 4th floor level of the existing block of flats.

6.3 Acoustic Requirements

The proposed flats comprise living/dining rooms and bedroom spaces. Based on the requirements of the Local Authority detailed in Section 4.0, the following internal sound limits have been assessed to.

Room Type	07:00 to 23:00	23:00 to 07:00
Living Room/Dining Room/Kitchen	35dB $L_{Aeq,16hour}$	-
Bedroom	35dB $L_{Aeq,16hour}$	30dB $L_{Aeq,8hour}$ 45dB L_{Amax}*

* should not be exceeded more than 15 times per night.

$L_{eq,T}$ Music Sound Pressure Level (dB) at Octave Band Centre Frequency (Hz)	
63	125
47	41

6.4 Room Assumptions

The following typical dimensions and finishes/furnishings have been assumed for the purpose of the assessment.

Room Type	Typical Room Dimensions	Typical Window Area	Typical Room Finishes / Furnishings
Living Room/ Dining Room	4m x 5m	3m^2	Wood/vinyl floor, curtains, sofa
Bedroom	4m x 3m	1.5m^2	Carpet & underlay, curtains, bed

Should the proposed dimensions/areas/finishes/furnishings differ from those detailed above a re-assessment may be required.

6.5 Construction Proposals

It is understood that the external walls and roof of the flats will comprise the following typical constructions.

Element	Typical Construction
Masonry Walls	Brickwork with cavity, insulation and 2No. layers internal plasterboard lining
Roof	Concrete slab with insulation in void and plasterboard ceiling

The following typical Sound Reduction Indicies have been assumed for the various elements.

Element	Sound Reduction Index (dB) at Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Masonry Walls	35	40	44	45	51	56	56	56
Roof	35	38	42	49	53	55	55	55

6.6 Glazing Specifications

In order to achieve the internal daytime, night-time and music requirements the glazing system as a whole including glass, frame, seals and openings shall provide the following minimum sound insulation performance when tested in accordance with BS EN ISO 10140-2: 2010.

Facade	Sound Reduction Index (dB) at Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Front (Grosvenor Street)	34	36	52	49	55	55	55	55
Rear	34	36	52	49	55	55	55	55

The table below presents typical configurations and R_w sound insulation values which may be expected to achieve the sound insulation performance specified above.

Facade	Typical R_w Sound Insulation Value (dB)	Typical Configuration
Front (Grosvenor Street)	55	6mm/10mm/6mm/ 300mm cavity with acoustically absorbent lined reveals/10mm
Rear	55	6mm/10mm/6mm/ 300mm cavity with acoustically absorbent lined reveals/10mm

Acoustic test data for the proposed glazing systems should be forwarded for review.

6.7 Ventilation Provision

6.7.1 Background Ventilation

In order to achieve the internal daytime, night-time and music requirements openable windows must remain closed. Background ventilation shall therefore be provided by alternative means.

Calculations indicate that acoustic trickle ventilators in the building façade are not sufficient for this development. As such, acoustically treated forced mechanical ventilation should be considered to provide continuous background ventilation. This may be in the form of separate fans serving individual rooms or a larger system which provides whole house ventilation.

The system should achieve noise levels of L_{Aeq} 30dB in living rooms and bedrooms and L_{Aeq} 35dB in bathrooms where providing continuous background ventilation.

A mechanical services engineer should be consulted to ensure that a suitable system is proposed. Detailed proposals should be forwarded for review acoustically.

6.7.2 Rapid/Summer Cooling Ventilation

In addition to background ventilation Manchester City Council require rapid/summer cooling ventilation in order to minimize the need for occupants to open windows during hot summer days.

In order to provide this, the acoustically treated forced mechanical ventilation should feature a user controllable 'boost' function which delivers increased air flow at the occupants discretion.

A mechanical services engineer should be consulted to ensure that a suitable system is proposed. Detailed proposals should be forwarded for review acoustically.

6.7.3 Purge Ventilation

Purge ventilation will be provided via openable windows at the occupants discretion. As such, the internal daytime and night-time requirements may potentially be exceeded during purge ventilation conditions. It is understood that this method of providing purge ventilation is deemed acceptable by Manchester City Council.

7.0 Building Services Sound Limits

Plant selections for the proposed residential flats have not been made at this stage of the development. As such, it is not possible to assess atmospheric building services sound to the nearest noise sensitive receptors.

Based on the requirements of Manchester City Council detailed in Section 4.3 and the lowest representative L_{A90} sound levels measured during the environmental sound survey detailed in Section 5.5.5, it is proposed that cumulative atmospheric plant sound emissions should be designed to achieve the following limits at the nearest noise sensitive receptors.

Nearest Noise Sensitive Receptor	L_{Aeq} Cumulative Atmospheric Plant Sound Emission Limits at Nearest Noise Sensitive Receptor (dB)	
	Daytime (07:00–23:00)	Night-time (23:00–07:00)
To the north east/ north west of the site	52	46
To the south east/ South west of the site	51	46

Plant sound emissions should be assessed in accordance with BS 4142:2014.

Plant sound limits for individual plant items will be dependent on the total number of plant items, the location of plant items in relation to nearest noise sensitive receptors and the proposed operational hours.

Once detailed design proposals are developed an assessment of atmospheric plant sound emissions from the proposed plant items to the nearest noise sensitive receptors should be undertaken. This will determine whether any attenuation measures are required in order to achieve the proposed limits.

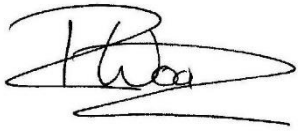
8.0 Conclusions

The Local Authority's acoustic requirements for the proposed residential development have been established.

A detailed environmental/entertainment sound survey has been undertaken in order to establish existing environmental/entertainment sound levels at the proposed residential development.

A detailed environmental/entertainment sound assessment of the proposed residential development has been undertaken and acoustic specifications for glazing/ventilation elements have been provided in order to achieve the requirements of the Local Authority.

Atmospheric plant sound emission limits have been proposed at the nearest noise sensitive receptors for subsequent use in designing building services proposals in order to comply with the requirements of the Local Authority.



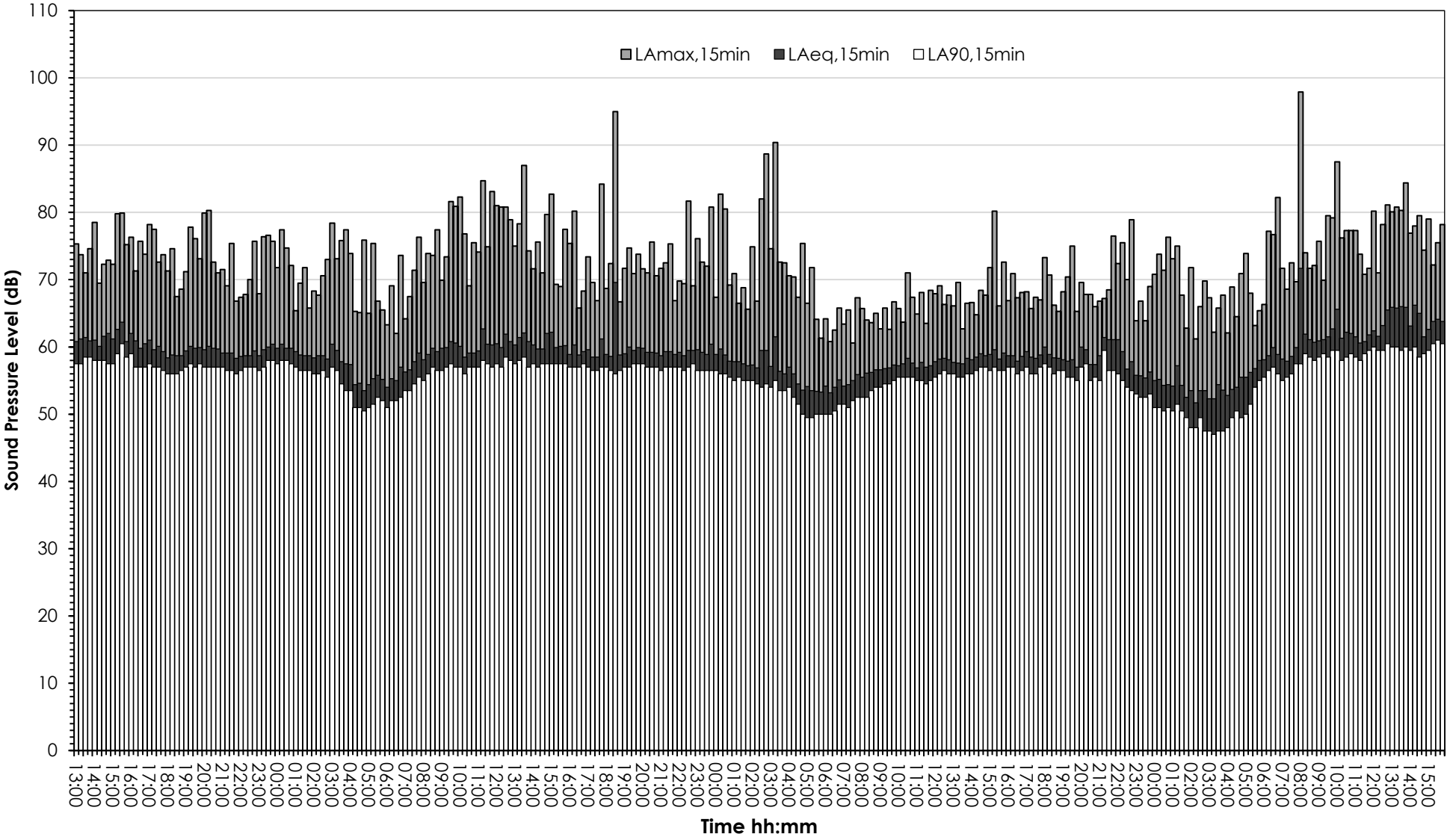
Robin Wood
LIGHTHOUSE ACOUSTICS

0492/THG1

129-131 Grosvenor Street, Manchester

Time History Graph -Friday 18 January 2019 to Monday 21 January 2019

$L_{Amax,15min}$, $L_{Aeq,15min}$ & $L_{A90,15min}$ Noise Levels at Position A

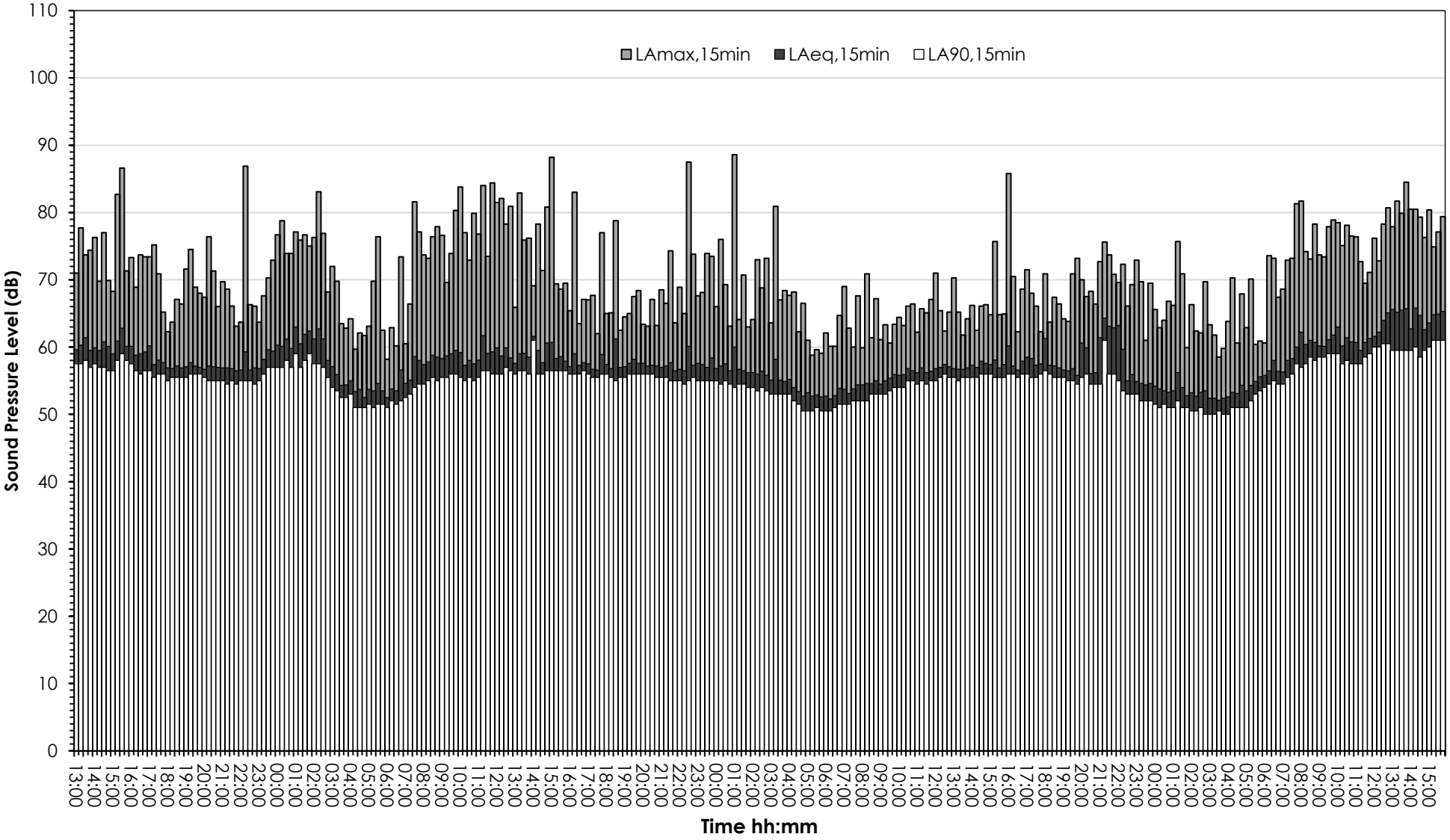


0492/THG2

129-131 Grosvenor Street, Manchester

Time History Graph -Friday 18 January 2019 to Monday 21 January 2019

$L_{Amax,15min}$, $L_{Aeq,15min}$ & $L_{A90,15min}$ Noise Levels at Position B



Term	Derivation	Value (m^2)
S_f	Facde Area (including window) S_{wi} + S_{ew}	7.2
S_r	Roof Area (exposed side)	0
S_{wi}	Window Area	1.5
S_{ew}	Wall Area S_f - S_{wi}	5.7
S_{rr}	Ceiling Area	0
S	Total Area S_f + S_{rr}	7.2
A_0	Ref. Absorption Area Given in BS EN ISO 10140-2	10
K	Correction Factor	3

BS 8233:2014 More Rigorous Calculation Method

Project:	129-131 Grosvenor Street, Manchester
Façade:	Front
Room:	Bedroom
Zone:	-

$$L_{p,in} = L_{p,out(ff)} + 10\,log_{10}\left(\frac{A_0}{S}\,10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}\,10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}\,10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}\,10^{\frac{-R_{rr}}{10}}\right) + 10\,log_{10}\left(\frac{S}{A}\right) + 3$$

Italic figures at 63Hz and 125Hz are music levels

Term	Description	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	Free Field External Daytime $L_{eq,16hour}$	*76*	*72*	57	55	57	53	46	35	60
$L_{p,out(ff)}$	Free Field External Night-time $L_{eq,8hour}$	*76*	*72*	57	54	54	49	40	30	58
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.1	79	83	88	91	87	80	70	58	90
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.2	82	88	84	80	88	77	74	64	89
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.3	82	78	82	81	79	74	66	55	83
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.4	80	74	73	77	78	77	71	61	82
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.5	78	69	65	72	78	76	76	68	82
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.6	79	71	70	71	74	75	78	66	81
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.7	77	70	74	65	81	62	64	49	81
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.8	86	78	71	70	73	74	70	53	78
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.9	84	80	73	74	75	70	67	53	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.10	76	73	67	67	78	69	64	60	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.11	78	83	74	74	73	69	60	51	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.12	80	84	77	74	71	68	64	59	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.13	85	79	78	80	68	64	62	57	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.14	85	85	78	76	75	70	55	52	76
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.15	73	64	58	61	75	71	60	51	76
$D_{n,e}$	None	99	99	99	99	99	99	*99*	*99*	
R_{wi}	6/10/6/300/10 +abs	34	36	52	49	55	55	55	55	
R_{ew}	Brick & block external wall	35	40	44	45	51	56	56	56	
R_{rr}	Concrete slab with insulation & ceiling	35	38	42	49	53	55	55	55	
A	Equivalent Absorption Area of Room (Calculated)	6	6	6	6	5	6	7	7	

Term From Equation	Reference Letter of Result	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	From Table Above	From Table Above								
$D_{n,e}$		99	99	99	99	99	99	99	99	
$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	B	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{wi}		34	36	52	49	55	55	55	55	
$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C	0.00008	0.00005	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{ew}		35	40	44	45	51	56	56	56	
$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D	0.00025	0.00008	0.00003	0.00003	0.00001	0.00000	0.00000	0.00000	
R_{rr}		35	38	42	49	53	55	55	55	
$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	E	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
10log(B + C + D + E)	F	-35	-39	-45	-46	-52	-56	-56	-56	
A (furnished)		6	6	6	6	5	6	7	7	
10 log S / A	G	1	1	1	1	1	1	0	0	
$L_{p,in}$	Free Field External Daytime $L_{eq,16hour}$ + F + G + 3	45	37	16	14	10	1	-7	-18	24
$L_{p,in}$	Free Field External Night-time $L_{eq,8hour}$ + F + G + 3	45	37	16	13	7	-3	-13	-23	23
$L_{p,in}$	Free Field External Night-time L_{max} No.1 + F + G + 3	48	48	47	50	40	28	17	5	48
$L_{p,in}$	Free Field External Night-time L_{max} No.2 + F + G + 3	51	53	43	39	41	25	21	11	44
$L_{p,in}$	Free Field External Night-time L_{max} No.3 + F + G + 3	51	43	41	40	32	22	13	2	39
$L_{p,in}$	Free Field External Night-time L_{max} No.4 + F + G + 3	49	39	32	36	31	25	18	8	36
$L_{p,in}$	Free Field External Night-time L_{max} No.5 + F + G + 3	47	34	24	31	31	24	23	15	34
$L_{p,in}$	Free Field External Night-time L_{max} No.6 + F + G + 3	48	36	29	30	27	23	25	13	33
$L_{p,in}$	Free Field External Night-time L_{max} No.7 + F + G + 3	46	35	33	24	34	10	11	-4	35
$L_{p,in}$	Free Field External Night-time L_{max} No.8 + F + G + 3	55	43	30	29	26	22	17	0	34
$L_{p,in}$	Free Field External Night-time L_{max} No.9 + F + G + 3	53	45	32	33	28	18	14	0	35
$L_{p,in}$	Free Field External Night-time L_{max} No.10 + F + G + 3	45	38	26	26	31	17	11	7	32
$L_{p,in}$	Free Field External Night-time L_{max} No.11 + F + G + 3	47	48	33	33	26	17	7	-2	35
$L_{p,in}$	Free Field External Night-time L_{max} No.12 + F + G + 3	49	49	36	33	24	16	11	6	36
$L_{p,in}$	Free Field External Night-time L_{max} No.13 + F + G + 3	54	44	37	39	21	12	9	4	37
$L_{p,in}$	Free Field External Night-time L_{max} No.14 + F + G + 3	54	50	37	35	28	18	2	-1	38
$L_{p,in}$	Free Field External Night-time L_{max} No.15 + F + G + 3	42	29	17	20	28	19	7	-2	29

Term	Derivation	Value (m^2)
S_f	Facde Area (including window) $S_{wi} + S_{ew}$	9.6
S_r	Roof Area (exposed side)	0
S_{wi}	Window Area	3
S_{ew}	Wall Area $S_f - S_{wi}$	6.6
S_{rr}	Ceiling Area	0
S	Total Area $S_f + S_{rr}$	9.6
A_0	Ref. Absorption Area Given in BS EN ISO 10140-2	10
K	Correction Factor	3

BS 8233:2014 More Rigorous Calculation Method

Project:	129-131 Grosvenor Street, Manchester
Façade:	Front
Room:	Livingroom
Zone:	-

$$L_{p,in} = L_{p,out(ff)} + 10\,log_{10}\left(\frac{A_0}{S}\,10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}\,10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}\,10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}\,10^{\frac{-R_{rr}}{10}}\right) + 10\,log_{10}\left(\frac{S}{A}\right) + 3$$

Italic figures at 63Hz and 125Hz are music levels

Term	Description	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	Free Field External Daytime $L_{eq,16hour}$	*76*	*72*	57	55	57	53	46	35	60
$D_{n,e}$	None	99	99	99	99	99	99	*99*	*99*	
R_{wi}	6/10/6/300/10 +abs	34	36	52	49	55	55	55	55	
R_{ew}	Brick & block external wall	35	40	44	45	51	56	56	56	
R_{rr}	Concrete slab with insulation & ceiling	35	38	42	49	53	55	55	55	
A	Equivalent Absorption Area of Room (Calculated)	8	8	7	4	3	3	4	4	

Term From Equation	Reference Letter of Result	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	From Table Above	From Table Above								
$D_{n,e}$		99	99	99	99	99	99	99	99	
$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	B	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{wi}		34	36	52	49	55	55	55	55	
$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C	0.00012	0.00008	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{ew}		35	40	44	45	51	56	56	56	
$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D	0.00022	0.00007	0.00003	0.00002	0.00001	0.00000	0.00000	0.00000	
R_{rr}		35	38	42	49	53	55	55	55	
$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	E	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
10log(B + C + D + E)	F	-35	-38	-45	-46	-52	-56	-56	-56	
A (furnished)		8	8	7	4	3	3	4	4	
10 log S / A	G	1	1	1	4	5	5	4	4	
$L_{p,in}$	Free Field External Daytime $L_{eq,16hour}$ + F + G + 3	45	37	16	16	13	5	-3	-14	24

Term	Derivation	Value (m^2)
S_f	Facde Area (including window) S_{wi} + S_{ew}	7.2
S_r	Roof Area (exposed side)	0
S_{wi}	Window Area	1.5
S_{ew}	Wall Area S_f - S_{wi}	5.7
S_{rr}	Ceiling Area	0
S	Total Area S_f + S_{rr}	7.2
A_0	Ref. Absorption Area Given in BS EN ISO 10140-2	10
K	Correction Factor	3

BS 8233:2014 More Rigorous Calculation Method

Project:	129-131 Grosvenor Street, Manchester
Façade:	Rear
Room:	Bedroom
Zone:	-

$$L_{p,in} = L_{p,out(ff)} + 10\,log_{10}\left(\frac{A_0}{S}\,10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}\,10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}\,10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}\,10^{\frac{-R_{rr}}{10}}\right) + 10\,log_{10}\left(\frac{S}{A}\right) + 3$$

Italic figures at 63Hz and 125Hz are music levels

Term	Description	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	Free Field External Daytime $L_{eq,16hour}$	*78*	*74*	59	54	53	57	40	31	58
$L_{p,out(ff)}$	Free Field External Night-time $L_{eq,8hour}$	*78*	*74*	58	55	54	49	41	31	59
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.1	81	80	82	81	80	81	85	76	89
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.2	88	75	68	74	82	77	63	52	83
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.3	77	74	81	84	75	68	58	53	81
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.4	89	81	71	78	77	70	68	49	79
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.5	92	79	71	70	76	74	64	47	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.6	89	78	71	70	72	75	72	64	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.7	91	80	75	78	72	68	58	47	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.8	89	75	71	71	77	70	62	55	77
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.9	79	81	63	66	72	72	64	57	76
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.10	90	77	76	70	75	72	62	54	76
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.11	80	77	75	75	72	63	56	49	76
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.12	92	82	72	65	76	67	59	58	76
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.13	74	74	71	72	74	71	62	60	76
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.14	88	75	74	73	75	68	64	57	75
$L_{p,out(ff)}$	Free Field External Night-time L_{max} No.15	93	78	71	69	74	67	58	49	74
$D_{n,e}$	None	99	99	99	99	99	99	*99*	*99*	
R_{wi}	6/10/6/300/10 +abs	34	36	52	49	55	55	55	55	
R_{ew}	Brick & block external wall	35	40	44	45	51	56	56	56	
R_{rr}	Concrete slab with insulation & ceiling	35	38	42	49	53	55	55	55	
A	Equivalent Absorption Area of Room (Calculated)	6	6	6	6	5	6	7	7	

Term From Equation	Reference Letter of Result	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	From Table Above	From Table Above								
$D_{n,e}$		99	99	99	99	99	99	99	99	
$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	B	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{wi}		34	36	52	49	55	55	55	55	
$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C	0.00008	0.00005	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{ew}		35	40	44	45	51	56	56	56	
$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D	0.00025	0.00008	0.00003	0.00003	0.00001	0.00000	0.00000	0.00000	
R_{rr}		35	38	42	49	53	55	55	55	
$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	E	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
10log(B + C + D + E)	F	-35	-39	-45	-46	-52	-56	-56	-56	
A (furnished)		6	6	6	6	5	6	7	7	
10 log S / A	G	1	1	1	1	1	1	0	0	
$L_{p,in}$	Free Field External Daytime $L_{eq,16hour}$ + F + G + 3	47	39	18	13	6	5	-13	-22	25
$L_{p,in}$	Free Field External Night-time $L_{eq,8hour}$ + F + G + 3	47	39	17	14	7	-3	-12	-22	25
$L_{p,in}$	Free Field External Night-time L_{max} No.1 + F + G + 3	50	45	41	40	33	29	32	23	41
$L_{p,in}$	Free Field External Night-time L_{max} No.2 + F + G + 3	57	40	27	33	35	25	10	-1	38
$L_{p,in}$	Free Field External Night-time L_{max} No.3 + F + G + 3	46	39	40	43	28	16	5	0	40
$L_{p,in}$	Free Field External Night-time L_{max} No.4 + F + G + 3	58	46	30	37	30	18	15	-4	38
$L_{p,in}$	Free Field External Night-time L_{max} No.5 + F + G + 3	61	44	30	29	29	22	11	-6	37
$L_{p,in}$	Free Field External Night-time L_{max} No.6 + F + G + 3	58	43	30	29	25	23	19	11	35
$L_{p,in}$	Free Field External Night-time L_{max} No.7 + F + G + 3	60	45	34	37	25	16	5	-6	38
$L_{p,in}$	Free Field External Night-time L_{max} No.8 + F + G + 3	58	40	30	30	30	18	9	2	35
$L_{p,in}$	Free Field External Night-time L_{max} No.9 + F + G + 3	48	46	22	25	25	20	11	4	32
$L_{p,in}$	Free Field External Night-time L_{max} No.10 + F + G + 3	59	42	35	29	28	20	9	1	36
$L_{p,in}$	Free Field External Night-time L_{max} No.11 + F + G + 3	49	42	34	34	25	11	3	-4	34
$L_{p,in}$	Free Field External Night-time L_{max} No.12 + F + G + 3	61	47	31	24	29	15	6	5	37
$L_{p,in}$	Free Field External Night-time L_{max} No.13 + F + G + 3	43	39	30	31	27	19	9	7	32
$L_{p,in}$	Free Field External Night-time L_{max} No.14 + F + G + 3	57	40	33	32	28	16	11	4	35
$L_{p,in}$	Free Field External Night-time L_{max} No.15 + F + G + 3	62	43	30	28	27	15	5	-4	37

Term	Derivation	Value (m^2)
S_f	Facde Area (including window) $S_{wi} + S_{ew}$	9.6
S_r	Roof Area (exposed side)	0
S_{wi}	Window Area	3
S_{ew}	Wall Area $S_f - S_{wi}$	6.6
S_{rr}	Ceiling Area	0
S	Total Area $S_f + S_{rr}$	9.6
A_0	Ref. Absorption Area Given in BS EN ISO 10140-2	10
K	Correction Factor	3

BS 8233:2014 More Rigorous Calculation Method

Project:	129-131 Grosvenor Street, Manchester
Façade:	Rear
Room:	Livingroom
Zone:	-

$$L_{p,in} = L_{p,out(ff)} + 10\,log_{10}\left(\frac{A_0}{S}\,10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}\,10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}\,10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}\,10^{\frac{-R_{rr}}{10}}\right) + 10\,log_{10}\left(\frac{S}{A}\right) + 3$$

Italic figures at 63Hz and 125Hz are music levels

Term	Description	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	Free Field External Daytime $L_{eq,16hour}$	*78*	*74*	59	54	53	57	40	31	58
$D_{n,e}$	None	99	99	99	99	99	99	*99*	*99*	
R_{wi}	6/10/6/300/10 +abs	34	36	52	49	55	55	55	55	
R_{ew}	Brick & block external wall	35	40	44	45	51	56	56	56	
R_{rr}	Concrete slab with insulation & ceiling	35	38	42	49	53	55	55	55	
A	Equivalent Absorption Area of Room (Calculated)	8	8	7	4	3	3	4	4	

Term From Equation	Reference Letter of Result	Octave Band Centre Frequency (Hz)								A-weighted Level
		63	125	250	500	1k	2k	4k	8k	
$L_{p,out(ff)}$	From Table Above	From Table Above								
$D_{n,e}$		99	99	99	99	99	99	99	99	
$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	B	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{wi}		34	36	52	49	55	55	55	55	
$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C	0.00012	0.00008	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
R_{ew}		35	40	44	45	51	56	56	56	
$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D	0.00022	0.00007	0.00003	0.00002	0.00001	0.00000	0.00000	0.00000	
R_{rr}		35	38	42	49	53	55	55	55	
$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	E	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	
10log(B + C + D + E)	F	-35	-38	-45	-46	-52	-56	-56	-56	
A (furnished)		8	8	7	4	3	3	4	4	
10 log S / A	G	1	1	1	4	5	5	4	4	
$L_{p,in}$	Free Field External Daytime $L_{eq,16hour}$ + F + G + 3	47	39	18	15	9	9	-9	-18	26