BUROHAPPOLD ENGINEERING

0046912 Marketing Suite, NOMA, Manchester

Noise Impact Assessment - Acoustics

0046912

16 December 2021

Revision 01

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved.

Revision	Description	Issued by	Date	Checked
00	For Issue	AM	18/02/21	BFB
01	Relocation of condensing unit	PL	16/12/21	PL

\\srv-manc02\Project Filing\0042512 NOMA Plot P\F41 Acoustics\03 Reports\05 Marketing Suite\0 Planning Report\211221 NOMA Marketing Suite Acoustics 01.docx

This report has been prepared for the sole benefit, use and information of NOMA (GP) Ltd. for the purposes set out in the report or instructions commissioning it. The liability of Buro Happold Limited in respect of the information contained in the report will not extend to any third party.

author	**Aaron Moroney**
date	**18/02/21**
approved	**Ben F Burgess**
signature	[redacted]
date	**18/02/21**

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Contents

1 Introduction **5**

1.1 Overview 5

1.2 Content 5

1.3 Reference Codes & Standards 5

2 Site and External Noise Survey Results **6**

2.1 Introduction 6

2.2 Site Description 6

2.3 Proposed Development 6

2.4 Survey Details 6

2.5 Survey Results 7

2.5.1 Unattended noise survey 7

2.5.2 Attended noise survey 8

2.6 Measurement Summary 8

2.7 Discussion 9

3 Plant Noise Break-Out **10**

3.1 Introduction 10

3.2 Noise Sensitive Receptors 10

3.3 External Plant Noise Limits 10

3.4 NOMA Marketing Suite 10

3.5 Calculation Methodology 11

3.6 Assessment Method 11

3.6.1 Rating level – tonality 11

3.6.2 Rating level – impulsivity 11

3.6.3 Rating level – intermittency 11

3.6.4 Summary table – Rating level 12

3.7 Local Planning Authority Criterion 12

4 Modelling **13**

4.1 Introduction 13

4.2 Methodology 13

4.3 Limitations 13

4.4 Results 13

5 Façade Noise Break-in **14**

5.1 Introduction 14

5.2 IANL Criteria 14

5.3 Ventilation Strategy 14

5.4 Drawings 14

5.5 Façade Noise Levels 14

5.6 Break-in Calculation Methodology 15

5.7 Calculation Assumptions 15

5.8 Glazing Requirements 15

6 Conclusions **16**

6.1 Plant Noise Break-out 16

6.2 External Noise Break-in 16

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Table of Tables

Table 2—1 Unattended noise measurements with façade corrections at Location 1 (22/01/18 – 23/01/18) 7

Table 2—2 Unattended noise measurements with façade corrections at Location 1 (22/01/18 – 23/01/18) 8

Table 2—3 Attended noise measurements at Location 2 8

Table 2—4 Attended noise measurements at Location 3 8

Table 2—5 Attended noise measurements at Location 4 8

Table 3—1 External plant noise limits at NSRs 10

Table 3—2 Items of proposed plant 10

Table 3—3 Octave-band sound power/pressure data for selected plant units 11

Table 3—4 Sound pressure levels impacting on nearest NSR 11

Table 3—5 Rating level at worst-case receptor (NSR1) 12

Table 3—6 Assessment of Rating level vs target 12

Table 5—1 BS 8233:2014 IANL Criteria 14

Table 5—2 Marketing suite façade glazing sound insulation requirements (with mechanical ventilation) 15

Table of Figures

Figure 1—1 Site plan showing the area associated with the planning application 5

Figure 1—2 Site plan of marketing suite within the planning application boundary 5

Figure 2—1 Site plan showing measurement locations, NSRs and site boundary 7

Figure 2—2 Site plan showing noise measurement summary 8

Figure 3—1 Site plan showing measurement locations, NSRs and site boundary 10

Figure 4—1 Plan view of predicted site wide noise levels during office hours ($L_{Aeq,T}$ dB) 13

Figure 4—2 Marketing suite predicted façade incident noise levels during office hours ($L_{Aeq,T}$ dB) 13

Figure 5—1 Plan of marketing suite, showing internal layout and external façade 14

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

1 Introduction

1.1 Overview

Buro Happold (acoustics) have been appointed by NOMA (GP) Ltd. to provide acoustics consultancy on a proposed new marketing suite at the Angel Square / NOMA site, Manchester.

Buro Happold have been involved with the wider site, having provided building acoustics design works for many of the adjacent plots.

Where a planning application involves the proposal for installing fixed plant, the Local Planning Authority (LPA) require a noise assessment with regards to plant noise emissions. As stated in *Planning and Noise - Technical Guidance* (Manchester City Council, 2015):

'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'.

This report is concerned with providing sufficient design information to show that the above criterion can be met with regards to the operation of the marketing suite.

Furthermore, details involving the assessment of the sound insulation performance of the external building façade is provided. In order to achieve suitable internal noise levels in the proposed space, recommendations regarding the sound insulation requirement of glazed elements are outlined.

1.2 Content

This report covers the following elements:

- Environmental noise levels from the noise survey
- Calculations of noise break-out (mechanical plant associated with the marketing suite, and its impact on existing noise sensitive receptors)
- Comparison of the above two elements with reference to LPA requirements
- External building façade assessment.

1.3 Reference Codes & Standards

This acoustic design report refers to the following list of codes and standards:

- Manchester City Council (MCC) – *Planning and Noise - Technical Guidance* (December 2015)
- NOMA Plot P Planning Conditions Schedule, 26 July 2019 and NOMA Primary Substation Planning Conditions Schedule, 31 July 2019
- British Standard (BS) 4142:2014+A1:2019 – *Methods for rating and assessing industrial and commercial sound*.
- British Standard (BS) 8233:2014 – *Guidance on sound insulation and noise reduction for buildings.*

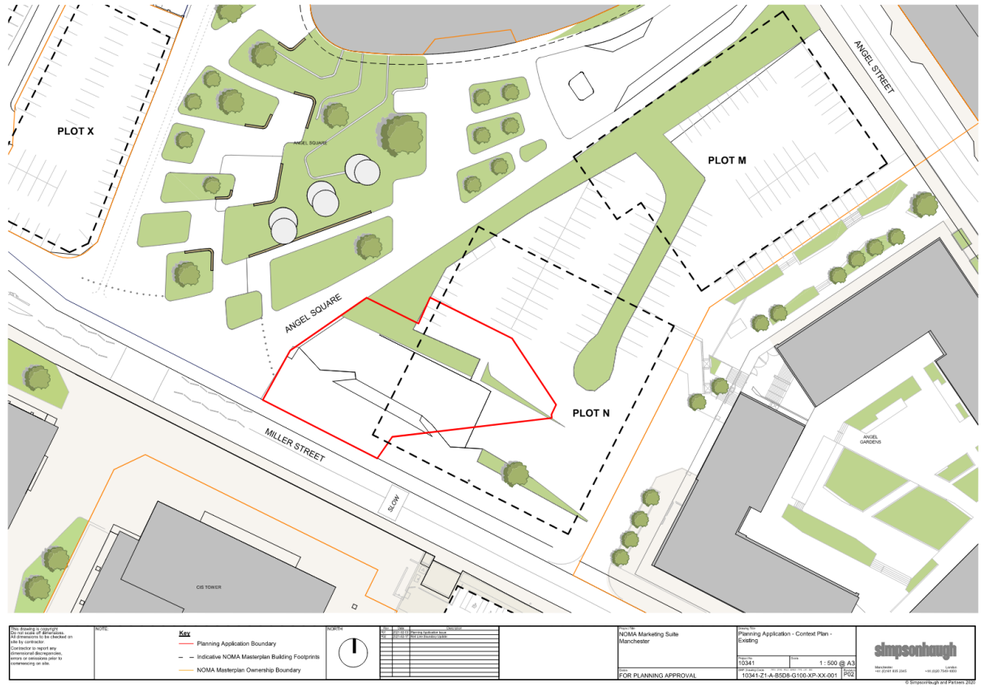


Figure 1—1 Site plan showing the area associated with the planning application

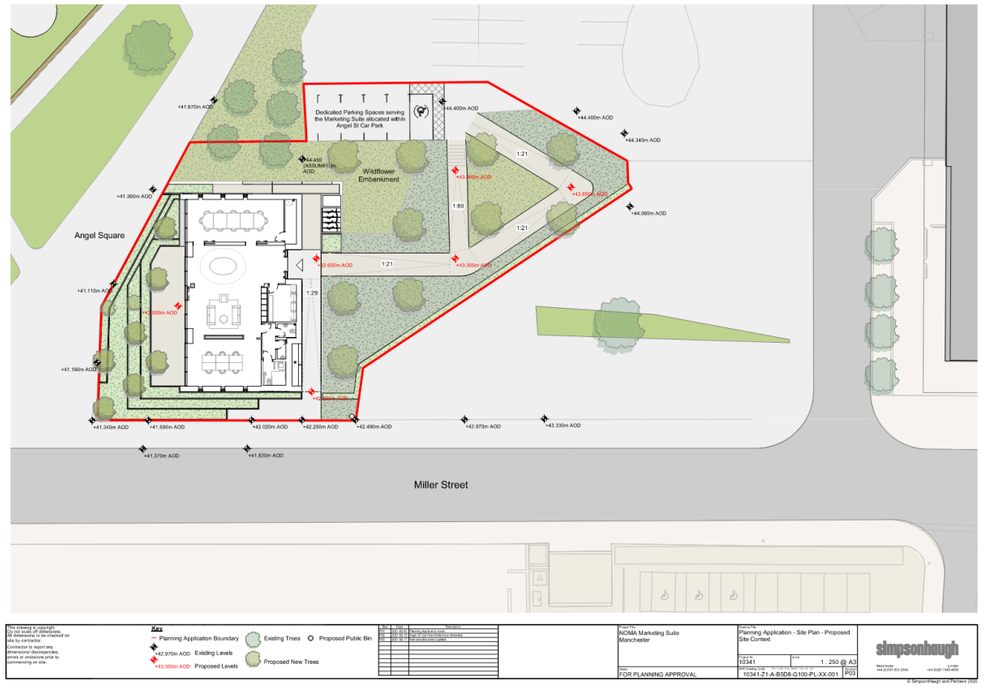


Figure 1—2 Site plan of marketing suite within the planning application boundary

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

2 Site and External Noise Survey Results

2.1 Introduction

Buro Happold (acoustics) previously conducted an external noise survey at Angel Square, NOMA, primarily for two purposes, relating to both the design as a whole and the requirements of planning:

- To capture the noise impact from surrounding environmental noise sources (e.g. roads) on the proposed façades. This allows the specification of external building envelope attenuation (i.e. glazing and ventilation) to see that internal ambient noise levels within noise-sensitive rooms can be compliant with appropriate criteria (as a minimum)
- To capture the existing background noise levels at nearby noise-sensitive (i.e. residential) receivers. This allows the specification of limiting noise levels for any externally located (or external terminations of) services plant, to see that the installation will not unduly increase existing noise levels in the vicinity of the site.

Buro Happold Engineering staff visited site to undertake an attended noise survey between Tuesday 22 and Wednesday 23 January 2019 to obtain the required data as described above.

This section details the methodology and results of the environmental noise survey, which is also applicable for the new NOMA marketing suite to be assessed in this report.

2.2 Site Description

The Site is shown in Figure 2—1 and comprises circa 0.2 hectares and includes circa 20 surface car parking spaces on an area of hardstanding to the north of the Site. The land to the south of the Site also comprises of hardstanding, which is currently secured by wooden fencing. The Site includes areas of overgrown shrubbery and grassland.

The Site comprises the southern section of the Site of 3 Angel Square, which received planning permission in February 2020 alongside 2 Angel Square for two office buildings of 10 and 11 storeys respectively (Ref: 124973/FO/2019).

The Application Site is located to the northern edge of Manchester City Centre. The Site occupies a prominent plot within the NOMA Strategic Regeneration Framework area and is located immediately to the north of Manchester's Inner Ring Road, Miller Street, which joins Great Ancoats Street to become the main route around the north of the City Centre.

To the north of the Site is a surface level car park and the landscaping surrounding One Angel Square.

To the east of the Site and the adjacent Angel Mews road, is Angel Gardens, which comprises a part seven, part 35 storey tall development of 466 residential apartments, which received planning permission in March 2015 under Ref. 107722/FO/2014/N2, and recently completed construction in 2020.

Construction has recently started on the next phase of development at NOMA; 4 Angel Square, which achieved planning permission in July 2019. This is set to be an 11 storey, office-led development with ground floor retail and leisure units alongside the creation of a new public square and landscaping (Ref. 123437/FO/2019).

The area to the south of Miller Street also forms part of the NOMA Masterplan as it relates to The Co-operative Group's former estate. This area contains a number of Listed and unlisted commercial and warehousing buildings, including the 25 storey, 118 metres high Grade II Listed CIS Tower, which fronts directly onto Miller Street.

The local road network is considered the primary noise source in the area.

The nearest noise sensitive receivers (NSRs) are considered to be the Co-op Insurance Tower (to the south-west across Miller Street), Angel Gardens residential properties (to the south-east) and the Co-op headquarters, 1 Angel Square (to the north).

2.3 Proposed Development

The Proposed Development comprises a temporary building providing an on-site base to enable the marketing of existing and proposed buildings within the NOMA estate to prospective occupiers.

The Proposed Development comprises:

- a one storey marketing suite building positioned to look towards the NOMA estate, comprising office and lounge space, a meeting room, WC and shower facilities, kitchen space and a PPE store, with a private external terrace accessed only through the building and photovoltaic cells on the roof;
- the creation of a new public realm accessible to all, including planters, and the provision of new green infrastructure, including wildflower meadows and tree planting and nurseries to grow trees to be used in future development phases at NOMA; and
- Four secure cycle parking spaces.

The building has been designed to be highly sustainable and to also be easily deconstructed and relocated elsewhere within the NOMA estate. The intention being that at the time where there is no longer a need for the Marketing Suite as a stand-alone building, it will be gifted, or its use redefined, so as to continue the lifetime of the building.

2.4 Survey Details

The survey methodology, timings and positions were agreed in principle with Laura Miller (Environmental Protection Specialist) at Manchester City Council (MCC) prior to attending site[1]. MCC are interested in the results from measurements taken during the absolute quietest period of a typical week, and also from some of the noisiest periods of a typical week (agreed to be adequately represented by the morning rush hour). As such, the noise survey methodology provides a comprehensive and complete picture of how noise levels change around the site throughout various times of the day and night-time.

Long-term (24-hours) unattended noise measurements were made at one location on site with concurrent short-term (15 minute) attended noise measurements undertaken during day and night-time periods at three locations around the site.

Measurement locations are described below, and marked on an annotated aerial image in Figure 2—1.

- **Location 1** – (Lat.: *53.4878*, Long.: *-2.2398*) – This is a long-term unattended measurement position which is subject to façade corrections. Noise measurements were undertaken at the south-west corner of the site at Level 2 of The Ducie Bridge building overlooking the Miller Street. This measurement location was set back at a distance of approximately 15 m from Miller Street at a height of approximately 8 m. This measurement location is considered representative of noise levels along the proposed south-western site boundary
- **Location 2** – (Lat.: *53.4880*, Long.: *-2.2387*) – Short-term attended noise measurements were undertaken at the north-east corner of the proposed development site approximately 1 m from Beswick Row in free field conditions. This measurement location is approximately 45 m from the Coop Building to the east, and approximately 1.5 m above ground level. This measurement position is considered representative of noise levels along the proposed north-eastern site boundary

[1] In a telephone conversation on 22 January 2019.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

- **Location 3** – (Lat.: 53.4882, Long.: -2.2393) – Short-term attended noise measurements were undertaken at the north-west corner of the proposed development site approximately 10 m from the Corporation Street in free-field conditions. This measurement location was set approximately 17 m from the nearest noise sensitive receptor to the west (Parkers Hotel Apartment) of the development, and 1.5 m above ground level. This measurement position is considered representative of noise levels along the proposed western site boundary and background noise levels at the nearby noise sensitive receptors.
- **Location 4** – (Lat.: 53.4875, Long.: -2.2391) – Short-term attended noise measurements were undertaken at the south-west corner of the proposed development site, in free-field conditions, approximately 8 m from the entrance to Beswick Row, 10 m from the Miller Street, and 1.5 m above ground level. This measurement location is considered representative of noise levels along the proposed south-eastern site boundary.



Figure 2—1 Site plan showing measurement locations, NSRs and site boundary

Weather conditions during the noise survey were generally appropriate, being mostly dry with light winds (i.e. ≤5 m/s).

Unattended noise measurements were made generally in accordance with BS EN 61672-2:2013+A1:2017, BS EN 61672-1:2003, BS EN 61672-2:2003 and BS 7445:2003 using the following equipment:

- Rion NL-52 Class 1 sound level meter (serial number: 01265411)

Attended noise measurements were made generally in line with the above using the following equipment:

- Class 1, Brüel & Kjær sound level meter (serial number: 3008216)

On site calibration checks were performed on all the meters before and after the measurements and were found to be within the permitted tolerance of BS EN 61672-1: 2013+A1:2017. All equipment had a valid calibration certificate at the time of the survey. Calibration certificates are available under request.

Sources of significant vibration such as over-ground rail and tram lines are located more than 65 m away from the development site. Therefore, baseline vibration monitoring was not conducted as it is generally considered that at a distance of 10 m or more the effects of ground borne vibration should be minimal.

2.5 Survey Results

A summary of the results is detailed in subsections below.

The included descriptors are as follows:

- $L_{Aeq,15min}$ – the continuous equivalent A-weighted sound pressure level over a 15-minute period. The steady state noise level, which over the period under consideration contains the same amount of sound energy as the time-varying noise
- $L_{AF,max}$ – the maximum instantaneous A-weighted sound pressure level measured during a 15-minute period. Typically corresponding to a short-duration event with a very high sound pressure level
- $L_{A90,15min}$ – the A-weighted sound pressure level exceeded for 90% of the measurement period. A level, which would be perceived as a constant, background noise level. Typically, largely unaffected by local traffic pass-by or by transient events. More usually attributable to constantly running building services plant or distant road traffic. What one would hear when there is no local traffic present (or other readily identifiable noise source).

2.5.1 Unattended noise survey

Results of the unattended noise survey, including a - 3 dB façade correction are shown in the table below. The presented noise levels are as follows:

- The façade corrected logarithmic average of $L_{Aeq,T}$ values
- The lowest measured $L_{A90,15min}$
- The 75th percentile of logged (15min) façade corrected night-time $L_{AF,max}$ events.

Table 2—1 Unattended noise measurements with façade corrections at Location 1 (22/01/18 – 23/01/18)

Period (HH:MM)	Elapsed time (HH:MM)	$L_{Aeq,T}$ dB(A)	$L_{A90,15min}$ dB(A)	$L_{AF,max}$ dB(A)
Daytime (07:00 – 23:00)	16:00	69	58	-
Office hours (09:00 – 17:00)	07:00	72	63	-
Night-time (23:00 – 07:00)	08:00	64	46	77

In order to compare unattended and attended measurements the following table provides the approximate concurrent noise measurements from the unattended position.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Table 2—2 Unattended noise measurements with façade corrections at Location 1 (22/01/18 – 23/01/18)

Date	Start time (HH:MM)	Elapsed time (MM:SS)	$L_{Aeq,T}$ (dBA)	$L_{A90,T}$ (dBA)	$L_{AF,max}$ (dBA)
23/01/19	08:15	15:00	68	62	84
	08:30	15:00	67	62	83
	08:45	15:00	68	62	83
23/01/19	06:00	15:00	65	58	74
	06:15	15:00	67	60	77
	06:30	15:00	69	63	92
	06:45	15:00	68	63	77

2.5.2 Attended noise survey

Measured noise levels at each attended monitoring location are reproduced in Table 2—3 to Table 2—5. The presented noise levels are the period $L_{Aeq,15min}$, $L_{A90,15min}$ values, and typically occurring $L_{AF,max}$ event (i.e. road traffic events) during the period.

Table 2—3 Attended noise measurements at Location 2

Date	Start time (HH:MM)	Elapsed time (MM:SS)	$L_{Aeq,T}$ (dBA)	$L_{A90,T}$ (dBA)	$L_{AF,max}$ (dBA)
23/01/19	08:16	15:00	62	56	76
23/01/19	06:00	15:00	59	51	77

Table 2—4 Attended noise measurements at Location 3

Date	Start time (HH:MM)	Elapsed time (MM:SS)	$L_{Aeq,T}$ (dBA)	$L_{A90,T}$ (dBA)	$L_{AF,max}$ (dBA)
23/01/19	08:32	15:00	69	59	84
23/01/19	06:23	15:00	68	54	79

Table 2—5 Attended noise measurements at Location 4

Date	Start time (HH:MM)	Elapsed time (MM:SS)	$L_{Aeq,T}$ (dBA)	$L_{A90,T}$ (dBA)	$L_{AF,max}$ (dBA)
23/01/19	08:49	15:00	69	60	84
23/01/19	06:45	15:00	70	58	85

2.6 Measurement Summary

A summary of typical, measured noise levels to be used for the assessment are overlaid onto an aerial site image in the image below.

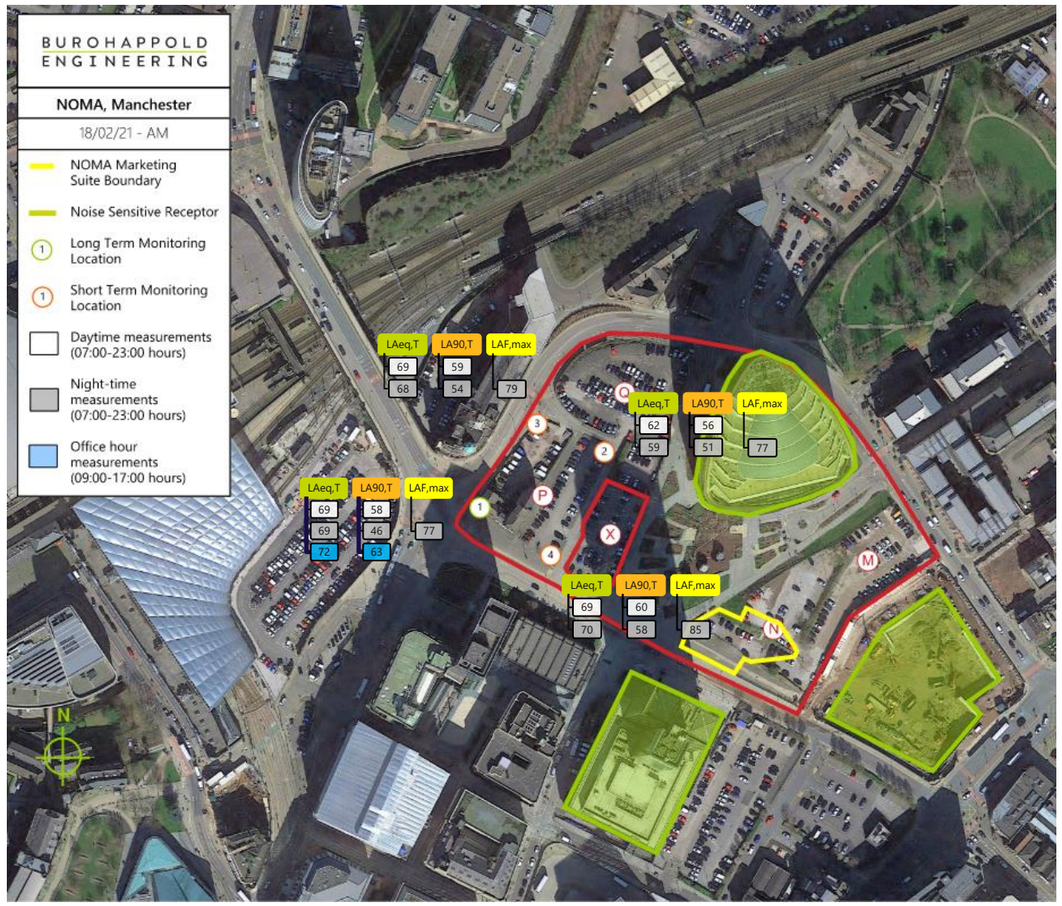


Figure 2—2 Site plan showing noise measurement summary

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

2.7 Discussion

The prevailing noise source at all locations was perceived to be traffic on the surrounding road network, particularly on Corporation Street (north-west) and Miller Street (south-west). This is evident in the survey results, which show higher noise levels at locations that are closer to Corporation Street and Miller Street. Furthermore, it is noted that worst-case noise levels were measured at Location 1 during office hours (09:00-17:00 hours).

During attended noise measurements up to 15 cars, in 15 minutes, entered surrounding car parks via Beswick Row and Munster Street. These movements affected attended noise measurements and have been included in the presented results. Other audible noise sources included construction to the east of the site, and tram and train movements to the north above Red Bank road. However, it was noted, that these did not significantly contribute to measured noise levels.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

3 Plant Noise Break-Out

3.1 Introduction

This section outlines mechanical plant noise limits to meet the requirements of the LPA, and provides an assessment showing the effect that the plant associated with the marketing suite is calculated to have on existing NSRs

3.2 Noise Sensitive Receptors

The following noise sensitive receptors (NSRs) have been identified, which have been outlined in green on an annotated aerial image in Figure 3—1. The distances to the nearest NSRs from the marketing suite are taken as space between the respective nearest edges of the proposed marketing suite building and the NSR. This has been taken to represent the worst-case scenario for the following assessment. The nearest NSRs are:

- 1 – Co-op Insurance Tower (to the south-west, across Miller Street);
- 2 – Angel Place residential properties (to the south-east); and
- 3 – Co-op headquarters, 1 Angel Square (to the north).

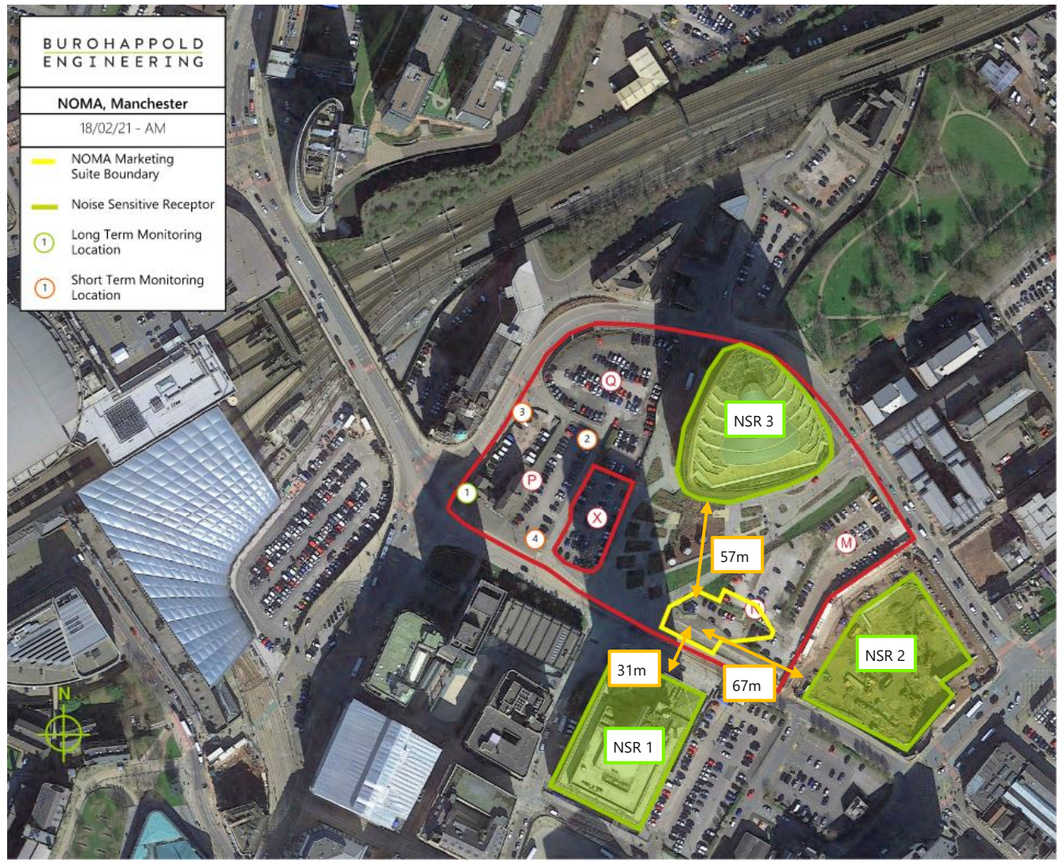


Figure 3—1 Site plan showing measurement locations, NSRs and site boundary

3.3 External Plant Noise Limits

As stated in the LPA criterion, the plant noise emissions should be limited to a Rating level ($L_{Ar,Tr}$ dBA) that is, as a minimum 5 dB below the representative background noise level. Where this Rating level is achieved, the requirements of planning will be met. Of the four survey measurement locations, it is considered that Measurement Locations 2 and 4 are most representative of the noise climate at the nearest NSRs to the proposed marketing suite.

In order to model the worst-case scenario, the lower of the two locations' daytime $L_{A90,15min}$ values has been used for assessment, measuring 56 dB $L_{A90,15min}$ at Measurement Location 2. As shown in Section 2.5, the measurement at Measurement Location 1 (long term, unattended) recorded 62 dB $L_{A90,15min}$ over the same period of time and recorded a minimum of 63 dB $L_{A90,15min}$ throughout the whole period for office hours (09:00-17:00). Thus, it is considered that the assumed background level of 56 dB $L_{A90,15min}$ is indeed a worst-case level and would likely be higher during office hours (during which the marketing suite plant will be operational). As such, cumulative plant noise emissions should be designed to not exceed the limit shown in Table 3—1.

Table 3—1 External plant noise limits at NSRs

Value	Level dB(A)
Baseline background sound level	$L_{A90,15min}$ 56 dB
Most onerous maximum level for plant under LPA criterion (baseline -5 dB)	$L_{Aeq,T}$ 51 dB

3.4 NOMA Marketing Suite

The proposed single storey marketing suite is to be served by a selection of mechanical plant, as shown in Table 3—2:

- 1 No. internally located MVHR unit, ducted to terminate externally at roof level;
- 1 No. VRF condenser unit, located at ground level in a timber enclosure adjacent to the bicycle store.

Table 3—2 Items of proposed plant

Plant type		Reference	Manufacturer/Model
MVHR unit	Intake fan	MVHR.IF	Zehnder ComfoAir Q 600
	Exhaust fan	MVHR.EF	
Outdoor VRF condenser unit		CU	Mitsubishi PUMY-P140VKM5

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

3.5 Calculation Methodology

The calculation methodology is as follows:

- The relevant octave-band sound power/pressure data for each of the units have been obtained from the product manufacturers and are shown in Table 3—3.

Table 3—3 Octave-band sound power/pressure data for selected plant units

Unit ref.	Parameter	Sound level (dB) at octave-band centres (Hz)								dB(A)
		63	125	250	500	1k	2k	4k	8k	
MVHR.IF	**In-duct sound power level**	67[2]	67	65	61	48	43	43	29	61
MVHR.EF	**In-duct sound power level**	72[3]	72	78	75	67	66	66	61	76
CU	**Sound pressure level at 1m**	59	60	51	52	47	42	37	31	53

- Inherent in-duct attenuation and grille end reflection have been calculated based on duct runs/dimensions in order to calculate a sound pressure level one metre from the respective atmospheric-side terminations.
- Distance loss and directivity (as a result of the adjacent reflecting roof) have been accounted for to calculate the level of each item of plant at the identified NSRs.
- The cumulative sound pressure levels impacting on each of the nearest NSRs are calculated and shown in Table 3—4. An example calculation for the MVHR exhaust fan is provided in Appendix A.

Table 3—4 Sound pressure levels impacting on nearest NSR

NSR	Sound pressure level (dB) at octave-band centres (Hz)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
1	4	15	26	35	33	34	34	27	41
2	0	8	19	28	26	27	27	20	34
3	0	10	20	29	27	29	29	22	35

The calculations assume the following:

- Ground floor plant items are located in a wooden enclosure
- The plant items are mounted on/terminates at the roof against 1 reflecting surface (Q = 2)

3.6 Assessment Method

As shown above, the marketing suite plant is calculated to generate a worst-case noise level of $L_{Aeq,T}$ 41 dB. The Local Planning Authority requires plant to be designed to a Rating level of at least 5 dB below the typical background level. A method for assessing the Rating level is given in BS 4142, where the specific sound (i.e. the noise impact generated by the marketing suite plant, as calculated above) is corrected for acoustically distinguishable features, as described below.

Once the specific sound level has been determined, this must be corrected in terms of the need to consider the subjective prominence of the impact of the sound at noise-sensitive receivers, and the extent to which acoustically distinctive characteristics will attract attention.

BS 4142 states that this is normally possible to carry out a subjective assessment of characteristics, based on the following correction guidelines:

- **Tonality**: +2 dB for a 'just perceptible' tone, +4 dB for 'clearly perceptible', and rising to +6 dB for 'highly perceptible' tones
- **Impulsivity** (rapidity of change and overall chance in level): +3 dB for 'just perceptible' impulsivity, +6 dB for 'clearly perceptible', rising to +9 dB for 'highly perceptible' impulsivity
- **Intermittency**: if the on/off-time of the specific sound is readily distinctive at the noise-sensitive receivers, +3 dB
- **Other sound characteristics**: where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a +3 dB penalty can be applied.

It should be noted that where one feature is clearly perceived as dominant, it may be applicable to correct for that feature only. Where multiple features are likely to affect perception and response, each should be added arithmetically. Buro Happold have considerable experience of mechanical plant, and all Buro Happold staff are (minimum) degree-qualified engineering consultants in acoustics or a related discipline. All (acoustics) staff members involved in this scheme are corporate members of the Institute of Acoustics and are therefore considered suitably qualified to make the following assessments.

3.6.1 Rating level – tonality

Noise associated with MVHR and condensers is typically associated with the movement of air, which generally produces a largely broadband sound. From examination of the octave-band spectrum of noise impact given above, it can be seen that no single octave-band frequency dominates, and the impact is comprised of a relatively equal contribution from the 500Hz-4kHz octave bands. No corrections for tonality are therefore considered to be required.

3.6.2 Rating level – impulsivity

MVHR units and condenser units do not have steep 'ramp up' levels, nor any features which rapidly interrupt the sound generation. On this basis, no corrections for impulsivity are considered to be required.

3.6.3 Rating level – intermittency

Fans can ramp down and up in response to load demands, however this is typically a slow response and the worst-case absolute level of noise generated ($L_{Aeq,T}$ 41 dB) should mean that any variation is imperceptible regardless. On this basis, no corrections for intermittency are considered to be required.

[2] The level at 63Hz is not available and is assumed identical to 125Hz.

[3] The level at 63Hz is not available and is assumed identical to 125Hz.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

3.6.4 Summary table – Rating level

Table 3—5 shows the specific sound level, corrected for the various features given above to obtain the Rating level required in BS 4142.

Table 3—5 Rating level at worst-case receptor (NSR1)

Value	Correction (dB)	Level dB(A)
Baseline specific sound level	-	41
Tonality correction	+ 0	41
Impulsivity correction	+ 0	41
Intermittency correction	+ 0	41
Rating level $L_{Ar,Tr}$ dB(A)		**41**

As can be seen, the cumulative corrections add up to a Rating level of 41 dB(A), which will be compared against the background sound level in the following assessment.

3.7 Local Planning Authority Criterion

Table 3—6 compares the typical background noise level at the worst-affected NSR (i.e. that measured at Position 2) to the Rating level calculated to be incident upon the worst-affected NSR from the marketing suite.

Table 3—6 Assessment of Rating level vs target

Value	Level (dB)
Baseline background sound level – office hours	$L_{A90,T}$ 56
Target – most onerous maximum level for plant under LPA criterion (baseline -5 dB)	$L_{Aeq,T}$ 51
Marketing suite plant Rating level at worst-affected NSR (NSR1)	$L_{Aeq,T}$ 41
Rating level VS target	**-10 dB**

As can be seen from the table above, the predicted Rating level of the noise produced by proposed marketing suite plant is 10 dB below the target required for compliance with LPA criterion (which stipulates that the rating level must be at least 5 dB below the background level).

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

4 Modelling

4.1 Introduction

A noise modelling exercise has previously been undertaken by Buro Happold (acoustics) for other parts of the NOMA development to estimate what the likely noise levels are at the façades of the proposed development. In addition, the NOMA development as a whole has been modelled according to Simpson Haugh architects Plot P – Planning Application Boundary drawing 10257-SHP-ZZ-XX-SK-A-G100-107 rev. P03 dated 6 March 2019. This includes the proposed sub-station building to the north on NOMA Primary Sub-station, and the removal of Munster Street to the north and Oswald Street to the east. The plans for the whole of the NOMA development include pedestrianised areas between the proposed commercial buildings which will replace access roads that currently serve the car parks on site. The key outcome of this exercise is the assessment of required glazing specification for the proposed marketing suite on Miller Street, which has been added to the model.

4.2 Methodology

In order to determine noise propagation across the development site, a noise model has been produced using CadnaA 4.3 acoustic modelling software. The noise model has been constructed based upon detailed Google Earth and OpenStreetMap mapping data. Local roads were added into the model to simulate noise sources that were measured during the on-site noise surveys.

The model predicts and maps the noise impacts on the proposed façades, considering factors such as distance attenuation, natural and man-made barrier attenuation, reflections and source directivity.

It has been established that the dominant, continuous noise source affecting the marketing suite area during office hour periods is the adjacent Miller Street road to the south-west. The constructed noise model has therefore been calibrated, based upon the measurement results summarised in Figure 2—2 to represent the noise climate on site as closely as possible. Furthermore, it is noted that worst-case noise levels were measured at Location 1 during office hours (09:00-17:00 hours) and, in-line with MCC recommendations (see Section 2.4), these noise levels have been used in the noise model to provide a worst-case assessment of predicted façade incident noise levels.

4.3 Limitations

The assessment has been based on the results produced through a noise modelling exercise, which provides predictions on the likely future noise levels. In order to increase the reliability of the results, the models have been calibrated to the noise levels measured on site during worst case time periods, as described in Section 2.5. However, this does not guarantee full accuracy of the predicted noise levels. Typically, an uncertainty within a range of approximately +/- 3 dB could be expected from computer noise modelling software. However, this uncertainty has been controlled as far as practicable by cross-referencing the levels of predicted noise impact against the measurements captured on site.

4.4 Results

The following noise map in Figure 4—1 shows how noise is predicted to impact the site during office hours (09:00 – 17:00 hours). As can be seen from predicted noise levels presented in Figure 4—2, the south-west and north-west elevations of the proposed marketing suite building are likely to be exposed to moderate levels of traffic noise, up to approximately 67 dB $L_{Aeq,T}$, whilst the rear of the building is subject to much lower levels of noise due to the natural screening provided by the building itself and the increased distance from Miller Street.

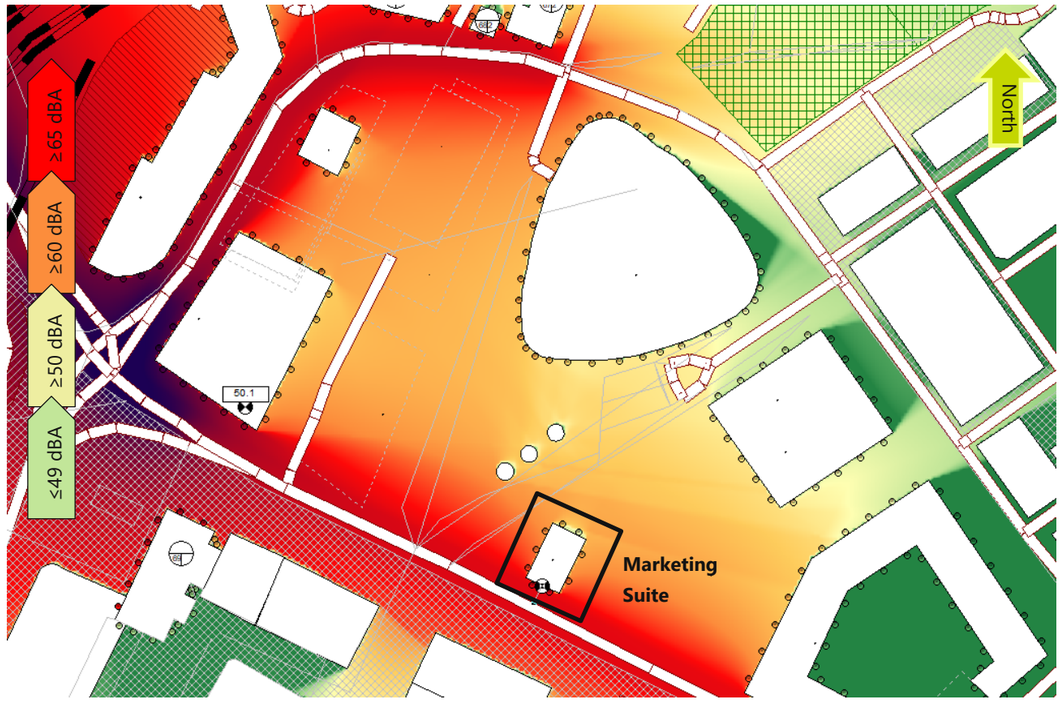


Figure 4—1 Plan view of predicted site wide noise levels during office hours ($L_{Aeq,T}$ dB)



Figure 4—2 Marketing suite predicted façade incident noise levels during office hours ($L_{Aeq,T}$ dB)

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

5 Façade Noise Break-in

5.1 Introduction

The internal ambient noise level (IANL) should be controlled to within acceptable noise levels to provide suitable internal acoustic amenity. The IANL is made up of contributions from external noise sources such as road and air traffic as well as internal building services noise. However, it does not include noise generated by the occupants and their activities. The aim of this section is to acoustically assess the external building façade to specify sufficient sound insulation, such that IANL requirements are not exceeded as a result of noise break-in from external sources.

5.2 IANL Criteria

'British Standard (BS) 8233:2014 – *Guidance on sound insulation and noise reduction for buildings*' is often used to set appropriate IANL design criteria for a variety of spaces and can be done so for office spaces. The recommended levels for office spaces are provided in Table 5—1. Considering the marketing suite is to comprise office, lounge and meeting room spaces, it is considered that an IANL of 40 dB $L_{Aeq,T}$ would be appropriate across all spaces.

Table 5—1 BS 8233:2014 IANL Criteria

Use of space	Design range (dB $L_{Aeq,T}$)
Staff/meeting room, training room	35-45
Executive office	35-40
Open plan office	45-50

5.3 Ventilation Strategy

Following discussion with BuroHappold (MEP), it is understood that the marketing suite is proposed to be provided with full supply and extract mechanical ventilation via an MVHR unit. Therefore, there is no requirement for operable windows to achieve the background ventilation requirements. The acoustic sound insulation performance of the sealed façade is discussed herein.

5.4 Drawings

The following assessment has been based on sub-station layout, elevation, section and site plan drawings as detailed in the following drawings by SimpsonHaugh architects:

- 10341-Z1-A-B5D8-G100-PL-00-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G100-PL-00-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G100-XP-XX-002 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-EL-EE-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-EL-EN-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-EL-ES-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-EL-EW-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-PL-00-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-PL-RF-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G200-SE-XX-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G251-DE-XX-001 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G251-DE-XX-002 Rev. P01 dated 2020
- 10341-Z1-A-B5D8-G251-DE-XX-003 Rev. P01 dated 2020

5.5 Façade Noise Levels

As seen in Figure 5—1, the majority of the north-western façade is proposed to be glazed and is thus considered vulnerable to external noise break-in, as glazing is commonly considered the weakest part of the external building façade, especially as the façade is proposed to be sealed. As demonstrated in Figure 4—2, the south-western façade is subject to the highest levels of noise exposure, although features a smaller area of glazed elements. Overall, these two façades are considered the biggest contributors to noise break-in to the marketing suite and an average 65 dB $L_{Aeq,T}$ is expected to be incident across the two façades, which will be used for assessment.

The design spectra is derived (based on a typical traffic noise spectrum) from the measured and subsequently calculated noise levels, in the CadnaA model to provide octave band design values.

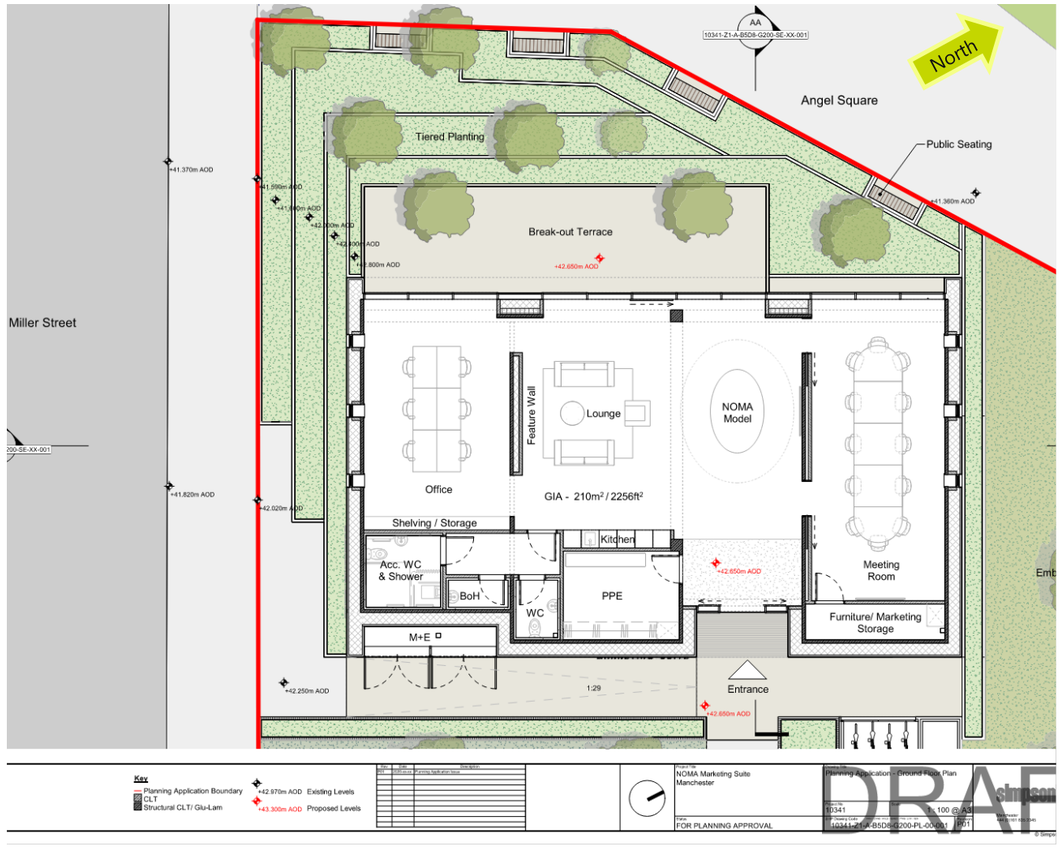


Figure 5—1 Plan of marketing suite, showing internal layout and external façade

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

5.6 Break-in Calculation Methodology

Calculation procedures follow the "more rigorous calculation method" outlined in BS 8233:2014, based on the following equation:

$$L_{eq,2} = L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{ne}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

$L_{eq,ff}$	*is the equivalent continuous sound pressure level outside the room elements under consideration*[4]
A_0	*is a reference absorption area of 10 m² and is independent of frequency*
S_f	*is the total façade area in square metres (m²) of the room in question*
S_{wi}	*is the area in square metres (m²) of the windows of the room*
S_{ew}	*is the area in square metres (m²) of the external wall of the room*
S_{rr}	*is the area is square metres (m²) of the ceiling of the room*
S	*is the total area in square metres (m²) of elements through which sound enters the room, i.e $S_f + S_{rr}$*
$D_{n,e}$	*is the insulation of the trickle ventilator measured according to BS EN ISO 10140*
R_{wi}	*is the sound reduction index (octave band value) of the window*
R_{ew}	*is the sound reduction index (octave band value) of the external wall*
R_{rr}	*is the sound reduction index (octave band value) of the roof/ceiling*
A	*is the equivalent absorption area of the receiving room being considered*
3	*is a correction factor*

5.7 Calculation Assumptions

The methodology has been carried out using the exterior noise levels outlined in Section 5.5 and the following indicative typical dimensions taken from Simpson Haugh architect drawings of the marketing suite:

- Approx. 20m x 7.5m floor space for office, lounge and meeting room;
- 82 m² (total) façade area (south-western and north-western façades);
- 48 m² of glazing (within the south-western and north-western façades);
- Mechanical ventilation; and
- 0.8 s reverberation time.

It is understood that designs are still subject to further development, therefore the glazing specification provided in this report are for guidance purposes only.

5.8 Glazing Requirements

As previously mentioned, it is expected that the weakest elements of the external elevation will be the glazing systems. The specification of these elements will be the primary factor in determining the internal ambient noise level within the marketing suite due to noise ingress from outside. Therefore, a glazing specification that would allow the marketing suite to achieve an IANL of ≤$L_{Aeq,T}$ 40 dB (Section 5.2) is outlined below.

The acoustic requirements of the glazing are given in terms of R, at each octave band centre frequencies and $R_w + C_{tr}$. These are defined as:

- **Sound Reduction Index, R** – is a measure of the sound insulating properties in a particular frequency band. In this case, the sound reduction index is given at each octave band centre frequency between 125 and 4000 Hz.
- **Weighted Sound Reduction Index, R_w** – is a single figure value which describes the standardised performance of partitions when measured in a laboratory.
- **Correction Traffic, C_{tr}** – is a single correction value applied which takes into account the urban traffic noise spectrum.

The glazing should achieve sound reduction values, at each octave band centre frequency, equal to or greater than the values given in Table 5—2. Details of the calculations undertaken to reach this specification are outlined in Appendix B.

Table 5—2 Marketing suite façade glazing sound insulation requirements (with mechanical ventilation)

Sound Reduction, R, (dB) at Octave Band Centre Frequencies (Hz)						$R_w + C_{tr}$ dB	Example glazing Construction
125	250	500	1k	2k	4k		
21	20	26	38	37	39	28	Typical double glazing performance for 6 mm glass / 20 mm air gap / 4 mm

[4] It is the free-field sound level (i.e. in the absence of the façade), measured or estimated at the intended position of the element under consideration. It is related to the level $L_{eq,1}$ measured within a few millimetres of the actual façade by the relation $L_{eq,ff} \approx L_{eq,1} - 6$, and to the level $L_{eq,2m}$ measured 2 m away from the façade by the relation $L_{eq,ff} \approx L_{eq,2m} - 3$

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

6 Conclusions

6.1 Plant Noise Break-out

The Local Planning Authority requires the Rating noise level of plant associated with the development to be at least 5 dB below the existing background level at nearby NSRs. A survey of the existing background noise levels has been undertaken on site, and representative levels captured.

With regards to the marketing suite, an assessment of the likely Rating noise impact has demonstrated that this is likely to be 15 dB lower than the existing background noise level when assessed at the worst-affected NSR, and therefore 10 dB lower than the target criterion.

It is therefore considered that noise is not a barrier to development and the LPA criterion should be met.

6.2 External Noise Break-in

It is concluded from this document that the NOMA marketing suite should be acoustically suitable in terms of internal acoustic conditions, should the guidance outlined throughout the report be followed.

Data obtained from a previous noise survey conducted by Buro Happold (acoustics) have been used to inform the calibration of noise sources within a 3D acoustic model of the site.

The required sound insulation performance of the proposed marketing suite's external glazing has been calculated from façade incident noise levels predicted in the 3D acoustic model.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Appendix A Example External Plant Noise Calculation

CALCULATING SOUND POWER TO THE OUTLET

m^3/s				SWL	63	125	250	500	1k	2k	4k	8k
1				Spectrum	72.4	72.4	77.7	74.7	66.6	66.2	66.2	61
Index	Mtrs/No. off		Dimension									
RECT DUCT	1		200		0	0	1	0	0	0	0	0
CIRC DUCT	0		100		0	0	0	0	0	0	0	0
M.BEND	0		100		0	0	0	0	0	0	0	0
RADIUS BEND	0		100		0	0	0	0	0	0	0	0
FILTER(NORM)	0		100		0	0	0	0	0	0	0	0
FILTER(ABS)	0		0		0	0	0	0	0	0	0	0
TERM. EQP.	0		0		0	0	0	0	0	0	0	0
#N/A	0		0		0	0	0	0	0	0	0	0
#N/A	0		0		0	0	0	0	0	0	0	0
#N/A	0		0		0	0	0	0	0	0	0	0
#N/A	0		0		0	0	0	0	0	0	0	0
#N/A	0		0		0	0	0	0	0	0	0	0
att'r					0	0	0	0	0	0		
Grille size:	200	mm X	200	mm	Grille location:		2	Flush				
End Reflection Loss:		0.04		m^2	14	10	6	2	0	0	0	0
Sound Power Leaving:					58	62	71	72	66	66	66	61
Sound Power to Outlet:	1	m^3/s	100	%	0	0	0	0	0	0	0	0
Distance to Listener:	30			m	-41	-41	-41	-41	-41	-41	-41	-41
Directivity Factor:		0.04		m^2	3	3	4	6	7	8	8	8
Direct SPL:					21	25	35	38	33	33	33	28
Resultant SPL:					**21**	**25**	**35**	**38**	**33**	**33**	**33**	**28**
NR Level Required:				NR50	75	65	59	53	50	47	45	43
Attenuation Required:					**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
dBA Correction:					-26	-16	-9	-3	0	1	1	-1
A-Weighted Equivalent:					-5	9	26	35	33	34	34	27
Resultant dBA Level (with no attenuation):					**40**							**dBA**

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Appendix B Façade Noise Break-in Calculations

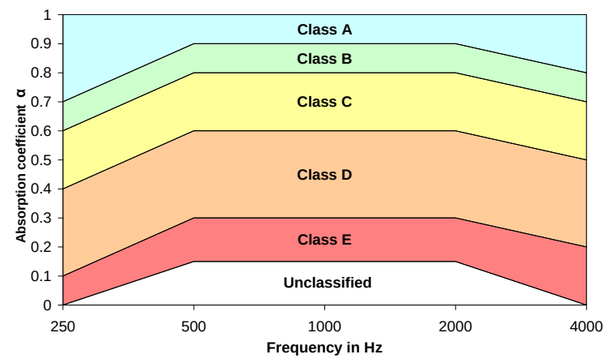
FAÇADE BREAK-IN CALCULATION													
Project Name	Marketing Suite, NOMA, Manchester												
Room or space	Just office												
Date	27/01/21												
ROOM CONSTANT & FAÇADE AREA													
Façade area (incl. window)	*37.2 m2*	**Area of the external wall**	21 m2	**Room reverberation time (s)**									
Area of the louver	*0.0 m2*			Tmf	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
Area of the windows	*15.8 m2*			0.8	0.8	0.8	0.8	0.8	0.8	0.8			
Area of the roof/ceiling	*36.5 m2*	**Area of exposed envelope**	74 m2										
Room Depth (x)	*7.6 m*												
Room Width (y)	*4.8 m*	**Room Volume**	####										
Ceiling height (z)	*3.0 m*												
DISTANCE ATTENUATION CALCULATION													
Distance correction	*No*	**Calculated Distance Attenuation**	-										
Type of distance correction	*Line source*												
Distance from source to microphone	-												
Distance from source to receiver	-												
FREE FIELD LEVELS AT 1m FROM THE NOISE SENSITIVE FAÇADE													
				dB(A)	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
LAeq	Free Field Leq in octave bands (dB)			66	68	64	62	62	58	53			
	Resultant Free-Field Leq with distance attenuation (dB(A))			66	68	64	62	62	58	53			
				dB(A)	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
LAmax (if applicable)	Free Field Lfmax in octave bands			-	-	-	-	-	-	-			
	Resultant Free-Field LAmax with distance			-	-	-	-	-	-	-			
SOUND REDUCTION PROPERTIES OF BUILDING ELEMENTS													
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	R_w	R_w+C_{Tr} (dB)		
Window (R_w)	*Rw+Ctr 28dB BS12354 6/20/4*			21	20	26	38	37	39	32	28		
Louver (Rw)	*No Louver*			0	0	0	0	0	0	0	0		
External wall Construction (Rw)	*Typical external wall construction*			46	44	46	54	62	67	52	49		
Roof Construction (Rw)	*Typical roof construction*			46	44	46	54	62	67	52	49		
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	$D_{n,ew}$ (dB)			
Trickle Vent ($D_{n,e,w}$)	*No Vent*	0 Units		200	200	200	200	200	200	-			
CALCULATED INTERNAL LAeq AND LAF,max LEVELS													
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz				
Calculated LAeq in the receiver room (dB)				49	46	38	26	23	16				
Calculated LAFmax in the receiver room (dB)				-	-	-	-	-	-				
				L_{Aeq} (125-4000Hz)				**L_{Amax} (125-4000Hz)**					
				40 dB(A)				**-**					

FAÇADE BREAK-IN CALCULATION													
Project Name	Marketing Suite, NOMA, Manchester												
Room or space	Lounge area												
Date	27/01/21												
ROOM CONSTANT & FAÇADE AREA													
Façade area (incl. window)	*27.6 m2*	**Area of the external wall**	7 m2	**Room reverberation time (s)**									
Area of the louver	*0.0 m2*			Tmf	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
Area of the windows	*20.3 m2*			0.8	0.8	0.8	0.8	0.8	0.8	0.8			
Area of the roof/ceiling	*69.9 m2*	**Area of exposed envelope**	98 m2										
Room Depth (x)	*7.6 m*												
Room Width (y)	*9.2 m*	**Room Volume**	####										
Ceiling height (z)	*3.0 m*												
DISTANCE ATTENUATION CALCULATION													
Distance correction	*No*	**Calculated Distance Attenuation**	-										
Type of distance correction	*Line source*												
Distance from source to microphone	-												
Distance from source to receiver	-												
FREE FIELD LEVELS AT 1m FROM THE NOISE SENSITIVE FAÇADE													
				dB(A)	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
LAeq	Free Field Leq in octave bands (dB)			61	63	59	57	57	53	48			
	Resultant Free-Field Leq with distance attenuation (dB(A))			61	63	59	57	57	53	48			
				dB(A)	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
LAmax (if applicable)	Free Field Lfmax in octave bands			-	-	-	-	-	-	-			
	Resultant Free-Field LAmax with distance			-	-	-	-	-	-	-			
SOUND REDUCTION PROPERTIES OF BUILDING ELEMENTS													
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	R_w	R_w+C_{Tr} (dB)		
Window (R_w)	*Rw+Ctr 28dB BS12354 6/20/4*			21	20	26	38	37	39	32	28		
Louver (Rw)	*No Louver*			0	0	0	0	0	0	0	0		
External wall Construction (Rw)	*Typical external wall construction*			46	44	46	54	62	67	52	49		
Roof Construction (Rw)	*Typical roof construction*			46	44	46	54	62	67	52	49		
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	$D_{n,ew}$ (dB)			
Trickle Vent ($D_{n,e,w}$)	*No Vent*	0 Units		200	200	200	200	200	200	-			
CALCULATED INTERNAL LAeq AND LAF,max LEVELS													
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz				
Calculated LAeq in the receiver room (dB)				42	39	31	19	16	9				
Calculated LAFmax in the receiver room (dB)				-	-	-	-	-	-				
				L_{Aeq} (125-4000Hz)				**L_{Amax} (125-4000Hz)**					
				33 dB(A)				**-**					

FAÇADE BREAK-IN CALCULATION													
Project Name	Marketing Suite, NOMA, Manchester												
Room or space	Office, lounge and meeting room												
Date	27/01/21												
ROOM CONSTANT & FAÇADE AREA													
Façade area (incl. window)	*81.9 m2*	**Area of the external wall**	34 m2	**Room reverberation time (s)**									
Area of the louver	*0.0 m2*			Tmf	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
Area of the windows	*48.2 m2*			0.8	0.8	0.8	0.8	0.8	0.8	0.8			
Area of the roof/ceiling	*146.0 m2*	**Area of exposed envelope**	####										
Room Depth (x)	*7.3 m*												
Room Width (y)	*20.0 m*	**Room Volume**	####										
Ceiling height (z)	*3.0 m*												
DISTANCE ATTENUATION CALCULATION													
Distance correction	*No*	**Calculated Distance Attenuation**	-										
Type of distance correction	*Line source*												
Distance from source to microphone	-												
Distance from source to receiver	-												
FREE FIELD LEVELS AT 1m FROM THE NOISE SENSITIVE FAÇADE													
				dB(A)	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
LAeq	Free Field Leq in octave bands (dB)			65	67	63	61	61	57	52			
	Resultant Free-Field Leq with distance attenuation (dB(A))			65	67	63	61	61	57	52			
				dB(A)	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz			
LAmax (if applicable)	Free Field Lfmax in octave bands			-	-	-	-	-	-	-			
	Resultant Free-Field LAmax with distance			-	-	-	-	-	-	-			
SOUND REDUCTION PROPERTIES OF BUILDING ELEMENTS													
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	R_w	R_w+C_{Tr} (dB)		
Window (R_w)	*Rw+Ctr 28dB BS12354 6/20/4*			21	20	26	38	37	39	32	28		
Louver (Rw)	*No Louver*			0	0	0	0	0	0	0	0		
External wall Construction (Rw)	*Typical external wall construction*			46	44	46	54	62	67	52	49		
Roof Construction (Rw)	*Typical roof construction*			46	44	46	54	62	67	52	49		
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	$D_{n,ew}$ (dB)			
Trickle Vent ($D_{n,e,w}$)	*No Vent*	0 Units		200	200	200	200	200	200	-			
CALCULATED INTERNAL LAeq AND LAF,max LEVELS													
				125Hz	250Hz	500Hz	1kHz	2kHz	4kHz				
Calculated LAeq in the receiver room (dB)				46	43	36	24	20	13				
Calculated LAFmax in the receiver room (dB)				-	-	-	-	-	-				
				L_{Aeq} (125-4000Hz)				**L_{Amax} (125-4000Hz)**					
				38 dB(A)				**-**					

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Glossary

Term	Definition
α (α_w)	Sound Absorption Coefficient (Weighted Sound Absorption Coefficient) is a measure of the effectiveness of materials as sound absorbers as defined in BS EN ISO 11654:1997. It is the ratio of the sound energy absorbed or transmitted (i.e. not reflected) by a surface to the total sound energy incident upon that surface. The value of the coefficient varies from 0 (perfect reflector) to 1 (perfect absorber).
A (A_T)	Absorption Area (Total Absorption Area) is equal to the product of multiplying the surface area of a construction (in m^2) and its Sound Absorption Coefficient (α).
Ambient Noise (as defined in BS 4142:2014+A1 2019)	Totally encompassing noise in a given situation at a given time; it is usually composed of noise from many sources, near and far.
Background Noise (as defined in BS 4142:2014+A1 2019)	A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90% of a given time interval, T, measured using the Fast time weighting and quoted to the nearest whole number of decibels.
C_{tr}	Spectrum adaptation term calculated using traffic noise as described in BS EN ISO 717-1:2013. This term is provided with weighted single values such as $D_{nT,w}$ or R_w to match with particular requirements (building acoustic or traffic noise spectrum).
Decibel, dB	Decibel (dB) is a dimensionless unit commonly used to demonstrate sound levels. It is derived from the logarithm of the ratio between the measured level and the reference value. For sound pressure level (L_p) the reference value is $2x10^{-5}$ pascals. For sound power (L_w) reference value is $1x10^{-12}$ Watts.
$D_{n,f,w}$	The weighted transmission of sound energy from a source room to a receiving room via structural (vibrational) paths in the construction mainly, e.g. walls, floors, ceilings.
$D_{nT,w}$	The Weighted Standardised Level Difference ($D_{nT,w}$) is defined in BS EN ISO 140-4:1998 (superseded by BS EN ISO 16283-1:2014+A1:2017 but still cited in The Building Regulations) BS EN ISO 717-1:2013. This performance describes the installed site performance of the composite separating constructions, including the partition element performance, the flanking path transmission and the reception room reverberation time factors. $D_{nT,w}$ target leads to a selection of adequate construction elements and methods to build the partition that are rated using weighted sound reduction index R_w. It is typically standardised to a reverberation time (T_0) of 0.5 seconds. In the instance of testing in schools, T_0 is taken as the room's T_{mf}.
D_w	Weighted Level Difference: Single-number quantity that characterizes airborne sound insulation between rooms, but which is not adjusted to reference conditions
Flanking Noise	The transmission of sound around the perimeter or through holes within partitions (or barriers) that reduces the otherwise obtained sound transmission loss of a partition. Examples of flanking paths within buildings are ceiling plenum above partitions or raised floor cavities, ductwork, piping, and electrical conduit penetrations through partitions, back to back electrical boxes within partitions, window mullions, etc.
Frequency	Number of cycles per second, measured in hertz (Hz), related to sound pitch.
IANL	Indoor Ambient Noise Level. For schools Table 1 in BB93 (2015) specifies the upper limit for indoor ambient noise levels within teaching areas. The design criteria is set for a 30-minute average level (i.e. $L_{Aeq,30mins}$). However, where there is negligible change in the noise level, BB93 states that a much shorter time period (e.g. $L_{Aeq,5min}$) can be used. BB93 also states that for rooms identified having limits of $L_{eq,30min}$ 35 dBA or less, the noise should not regularly exceed $L_{1,30min}$ 55 dBA.
$L_{90,T}$ ($L_{A90,T}$)	Sound pressure level exceeded for 90% of the measurement period. Referred to as background noise level.
$L_{Ar,T}$	Rating Noise Level (as defined in BS 4142:2014+A12019), the specific noise level plus any adjustment for the characteristic features of the noise.
$L_{eq,T}$ ($L_{Aeq,T}$)	The equivalent continuous noise level of a time-varying noise. It is the steady noise level which, over the period of time under consideration, contains the same amount of sound energy as the time-varying noise over the same period of time.
$L_{Fmax,T}$ ($L_{AFmax,T}$)	The maximum sound pressure level measured during the measurement period T using the fast time constant.
$L'_{nT,w}$	Weighted Standardized Impact Sound Pressure Level: a single-figure value of impact sound insulation performance. This European index is described in BS EN ISO 140-7:1998 (superseded by BS EN ISO 16283-2:2015 but still cited in The Building Regulations) and BS EN ISO 717-2:2013, used for comparing and rating floors and based on the values of L'_{nT} at different frequencies. L'_{nTw} target leads to a selection of adequate construction elements and methods to build the floor that are rated using weighted normalized impact sound pressure level $L_{n,w}$. The lower the $L'_{nT,w}$ the better the performance
$L_{n,w}$	Weighted Normalized Impact Sound Pressure Level: European single figure rating for transmission loss of impact sound through building elements as described in BS EN ISO 10140-3:2010+A1:2015 and BS EN ISO 717-2:2013. The lower the $L_{n,w}$ the better the performance.
L_p	Sound pressure level, in decibels, of a sound is 20 times the logarithm to the base of 10 of the ratio of the sound pressure to the reference pressure ($2x10^{-5}$ pascals). The reference pressure shall be explicitly stated and is defined by standard.
Noise Rating (NR)	Curves developed by the International Organization for Standardization (ISO) to determine the acceptable indoor environment for hearing preservation, speech communication and annoyance. These can be compared to NC curves and also can be approximated to equivalent dBA levels.
Reverberation Time (RT)	Time required for the steady sound pressure level in an enclosed space to decay by 60 dB, measured from the moment the sound source is switched off. Reverberation time is described in ISO 354:2003.
R_w (C, C_{tr})	Weighted Sound Reduction Index: Single-figure value of sound reduction according to BS EN ISO 10140-2:2010 used for rating partition systems, door-sets or glazing, based on the values of sound reduction index R at different frequencies. The higher the R_w the better the performance.
SEL (L_{AE})	Single Event Level: The sound level over one second which would have the same energy content as the whole event.
Sound absorption classes	Sound absorption performance characteristics are defined by a class. Below is a diagram of the different classes of absorption available, taken from BS EN ISO 11654:1997. The y-axis is the absorption coefficient of the material with one being total absorption and zero being no absorption. The x-axis is the frequency of the sound. 
Specific Noise Level (as defined in BS 4142:2014+A1 2019)	The equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval.
T_{mf}	Mid Frequency Reverberation Time: Within BB93, the reverberation time criteria are set in terms of the averaged value of the 500 Hz, 1000 Hz and 2000 Hz frequency bands. The various levels for T_{mf} are specified within Table 6 of BB93 (2015) and are generally upper limits. Usually the specified mid-frequency reverberation times are for 'finished but unoccupied and unfurnished rooms'.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Vibration	Force which oscillates about some specified reference point. Vibration is commonly expressed in terms of frequency such as cycles per second (cps), Hertz (Hz), cycles per minute (cpm) or (rpm) and strokes per minute (spm). This is the number of oscillations which occurs in that time period. The amplitude is the magnitude or distance of travel of the force.
Weightings (as defined in BS EN 61672:2013):	A-Weighting: Frequency weighting devised to attempt to take into account the fact that human response to sound is not equally sensitive to all frequencies; it consists of an electronic filter in a sound level meter, which attempts to build in this variability into the indicated noise level reading so that it will correlate, approximately, with human response.). C-Weighting: One of the frequency weightings corresponding to the 100-phon contour and the closest to the linear or un-weighted value.

Copyright © 1976 - 2021 BuroHappold Engineering. All Rights Reserved

Aaron Moroney
Buro Happold Limited
17 Newman Street
London
W1T 1PD
UK

T: +44 (0)207 927 9700
F: +44 (0)870 787 4145
Email: ben.burgess@burohappold.com