



THG

SPA @ KSTH

Stage 4 Acoustic Report





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ACOUSTIC REPORT (FIRST ISSUE) CONFIDENTIAL

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CONTENTS

1	INTRODUCTION	1
1.1	PURPOSE OF THIS REPORT	1
1.2	BASIS OF THE DESIGN	1
1.3	ACOUSTIC RISK ITEMS	1
2	ACOUSTIC PERFORMANCE STANDARDS	1
2.1	BRAND STANDARDS	1
2.2	MCC PLANNING CONDITIONS	1
2.3	OTHER GUIDANCE DOCUMENTS REVIEWED	2
2.4	SUMMARY OF ACOUSTIC PERFORMANCE STANDARDS	2
2.5	DEMONSTRATING COMPLIANCE	3
3	NOISE SURVEY RESULTS	4
4	SOUND INSULATION TESTING RESULTS	5
5	OPERATIONAL NOISE	5
6	ACOUSTIC DESIGN	7
6.1	BUILDING ENVELOPE	7
6.2	PARTITIONS	8
6.3	INTERNAL DOORS	8
6.4	FLOORS	9
6.5	CEILINGS	11
6.6	ACCESS PANELS	11
6.7	BUILDING SERVICES	11
6.8	AUDIO VIDEO SYSTEMS	18

TABLES

Table 2-1 – Internal building services noise limits	2
Table 2-2 – External building services noise limits at noise sensitive receivers	2
Table 2-3 – Partition sound insulation performance standards	2
Table 2-4 – Limits for vibration from building services plant	3
Table 3-1 – Noise measurement equipment	4
Table 3-2 – Daytime and night time background sound levels	4
Table 3-3 – Octave band background sound levels at nearby noise sensitive receivers	4
Table 3-4 – Day and night time ambient noise levels	4
Table 4-1 – Sound insulation testing results	5
Table 5-1 – Typical gym noise levels	5
Table 5-2 – Comparison of gym operational noise break-out with daytime and night time background sound levels	6
Table 5-3 – Measure sound insulation performance of the existing floor	6
Table 5-4 - Increase in performance due to installation of a sound insulating ceiling	6
Table 5-5 - Calculated noise levels in apartments above	6
Table 5-6 – Expected music noise limits	7
Table 6-1 – Sound insulation specifications for new areas of glazing and door in the building envelope	8
Table 6-2 – Internal door sound insulation requirements	9
Table 6-3 - Screening corrections	12
Table 6-4 – External plant noise levels	12
Table 6-5 - Maximum recommended in-duct airflow velocities	13
Table 6-6 - Maximum airflow velocities at supply and return air openings	13
Table 6-7 – Stage 4 AHU noise data	14
Table 6-8 – Stage 4 extract fan noise data	14
Table 6-9 - Stage 4 FCU noise data	14
Table 6-10 – Stage 4 condensing unit noise data	15
Table 6-11 – Stage 4 attenuator insertion losses	16
Table 6-12 – Vibration isolation requirements	16



Table 6-13 – Live lengths for flexible pipe connectors

FIGURES

Figure 6-1 – Extent of sprung concrete floor	10
Figure 6-2 - Floating floor / partition junction detail	10
Figure 6-3 - Approximate locations of rooftop plant	11

APPENDICES

APPENDIX A
ACOUSTIC TERMINOLOGY
APPENDIX B
PARTITION AND DOOR SOUND INSULATION SPECIFICATIONS
APPENDIX C
LIMITATIONS

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

The purpose of this RIBA Stage 4 acoustic report is to:

- Finalise the acoustic performance standards for the development, these include:
 - Internal building services noise limits
 - External building services noise limits
 - Operational noise limits i.e. limits for noise from the gym to dwellings
 - Sound insulation performance standards for new partitions
 - Sound insulation performance standards for new floors
- Set out how the Contractor is required to demonstrate compliance with the acoustic performance standards. Testing to demonstrate compliance with the acoustic performance standards is the responsibility of the Contractor and shall be undertaken in sufficient time such that any failures can be rectified prior to handover.
- Co-ordinate the acoustic specifications with other disciplines
- Assessment of noise with respect to MCC requirements

This report does not cover sound system design or assessment of public address / voice alarm systems.

1.2 BASIS OF THE DESIGN

The acoustic design has been developed based on requirements / guidance included in the following documents:

- Manchester City Council (MCC) planning requirements relating to noise
- CIBSE Guide A – Environmental Design
- BS 6472-1: 2008 'Guide to Evaluation of Human Exposure to Vibration in Buildings'
- Building Regulations Approved Document E 'Resistance to the passage of sound'
- Various hotel design guides including Hilton Hotels, Crown Plaza and Four Seasons
- Other THG projects such as ICON, GJSH and The Hangar

1.3 ACOUSTIC RISK ITEMS

The key acoustic considerations at the stage are listed below.

- **Acoustics and planning** – MCC have raised concerns regarding noise transfer from the gym to the dwellings above. The mitigation measures included in this report (i.e. sprung concrete floor and sound insulating ceilings) will provide significant noise control and are expected to result in a scheme that can be operated reasonably (i.e. music at typical levels and free weights used considerably) but due to uncertainty within the calculation process it is expected that verification will have to be determined by testing prior to completion of the build.

2 ACOUSTIC PERFORMANCE STANDARDS

2.1 BRAND STANDARDS

There are no THG brand standards relating to acoustics for developments such as this.

2.2 MCC PLANNING CONDITIONS

The planning consent conditions which relate to acoustics are included below. Conditions 5 and 6 are both pre-occupation conditions and as such are the responsibility of the Contractor to discharge.

2.2.1 PLANNING CONDITION 5

The premises shall be acoustically insulated and treated to limit the break out of noise in accordance with a noise study of the premises and a scheme of acoustic treatment that has been submitted to and approved in writing by the City Council as local planning authority. The scheme shall be implemented in full before the use commences or as otherwise agreed in writing by the City Council as local planning authority.

Where entertainment noise is proposed the L_{Aeq} (entertainment noise) shall be controlled to 10 dB below the L_{A90} (without entertainment noise) in each octave band at the facade of the nearest noise sensitive location, and internal noise levels at structurally adjoined residential properties in the 63 Hz and 125 Hz octave frequency bands shall be controlled so as not to exceed (in habitable rooms) 47 dB and 41 dB, respectively.

Upon completion of the development a verification report will be required to validate that the work undertaken throughout the development conforms to the recommendations and requirements in the approved acoustic consultant's report. The report shall also undertake post completion testing to confirm that acceptable criteria has been met. Any instances of non-conformity with the recommendations in the report shall be detailed along with any measures required to ensure compliance with the agreed noise criteria.

Reason - To safeguard the amenities of the occupiers of nearby properties, pursuant to policy DM1 (Development Management) and policy SP 1 (Spatial Principles) within Manchester Core Strategy

A scheme of acoustic treatment is to be submitted to and approved in writing by the City Council as local planning authority.

Upon completion of the development a verification report will be required to validate that the work undertaken throughout the development conforms to the recommendations and requirements in the approved acoustic consultant's report.

2.2.2 PLANNING CONDITION 6

Externally mounted ancillary plant, equipment, servicing and louvres 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.

The scheme shall be submitted to and approved in writing by the City Council as local planning authority in order to secure a reduction in the level of noise emanating from the site. The approved scheme shall be completed before the premises is occupied.

Upon completion of the development a verification report will be required to validate that the work undertaken throughout the development conforms to the recommendations and requirements in the approved acoustic consultant's report. The report shall also undertake post completion testing to confirm that the noise criteria has been met. Any instances of non-conformity with the recommendations in the report shall be detailed along with any measures required to ensure compliance with the agreed noise criteria.

Reason - To minimise the impact of the development and to prevent a general increase in pre-existing background noise levels around the site, pursuant to policy DM1 (Development Management) and policy SP 1 (Spatial Principles) within Manchester Core Strategy.

A scheme of externally mounted ancillary plant, equipment, servicing and louvres is to be submitted to and approved in writing by the City Council as local planning authority.

Upon completion of the development a verification report will be required to validate that the work undertaken throughout the development conforms to the noise criteria identified.

2.3 OTHER GUIDANCE DOCUMENTS REVIEWED

Where acoustic performance standards are not covered by either THG brand standards or MCC requirements, then we have proposed acoustic standards based on our experience of other similar projects and those in the following:

- CIBSE Guide A – Environmental Design
- BS 6472-1: 2008 'Guide to Evaluation of Human Exposure to Vibration in Buildings'
- Various hotel design guides including Hilton Hotels, Crown Plaza and Four Seasons
- Other THG projects such as ICON, GJSH and the Hangar

2.4 SUMMARY OF ACOUSTIC PERFORMANCE STANDARDS

2.4.1 EXTERNAL NOISE INGRESS

Limits for external noise ingress are not proposed as the envelope is to remain largely as is.

2.4.2 INTERNAL BUILDING SERVICES NOISE LIMITS

Internal building services limits are included in Table 2-1. These are based on performance standards included in the CIBSE Guide A and design guides provided by various hotel chains. They are for all plant operating simultaneously at design duty.

Table 2-1 – Internal building services noise limits

Room	Building services noise limit (dB)
Treatment rooms	NR 30
Office, Staff room, Express room, Spa Lounge, Relaxation Area	NR 35
Gym, Changing Rooms, Finishing Kitchen, WCs	NR 40
Plant rooms	NR 70

2.4.3 EXTERNAL BUILDING SERVICES NOISE LIMITS

External building services noise are included in Table 2-2. These are in accordance with MCC requirements and are based on the background sound levels in Table 3-2.

Table 2-2 – External building services noise limits at noise sensitive receivers

Condition	Day / night	Limit
Normally operating plant	Daytime (07:00 – 23:00)	48 dB L _{A,r,Tr}
	Night-time (23:00 – 07:00)	47 dB L _{A,r,Tr}

It is understood that there is no emergency plant within the development and, therefore, emergency plant noise limits are not included in this report.

2.4.4 SOUND INSULATION

2.4.4.1 Partitions

Minimum levels of in-situ airborne sound insulation to be achieved by separating partitions are proposed following review of various hotel brand standards and our experience on other THG projects. The key performance standards are included in Table 2-3.

Table 2-3 – Partition sound insulation performance standards

Adjacency	Sound insulation performance standard
Acc changing / Male changing, Acc shower / Female change	D _w ≥ 40 dB
Office / Staff room, Treatment room / treatment room, Treatment room / circulation (no door), Treatment / Spa entrance, Sauna / Steam room, Clinical room / Circulation (no door), PH plant / accessible WC, Express room / circulation (no door)	D _w ≥ 45 dB
Gym / Spa entrance, HE plant room / Steam room, Plant / changing	D _w ≥ 50 dB

2.4.4.2 First Floor Construction

The floor (new ceiling and existing structure) which separates the gym from the dwellings above is required to control noise transfer as per MCC requirements i.e. music/activity noise within the gym shall not cause the level in dwellings to exceed 47 dB and 41 dB L_{Aeq} at 63 and 125 Hz respectively.

The floor also has to satisfy the requirements of Approved Document E of the Building Regulations, which sets out levels of airborne and impact sound insulation to be achieved between dwellings. Where dwellings are adjacent to spaces that are communal or non-domestic, then 'a higher standard of sound insulation may be required'. Therefore, in addition to satisfying the MCC requirements, it is proposed that the floor which separates the gym from the dwellings above also achieves a level of

airborne sound insulation of at least 55 dB $D_{nT,w} + C_{tr}$, which is 10 dB above the minimum Building Regulations requirement.

2.4.4.3 Ground Floor Construction

Noise from the gym shall not exceed NR 15 in the spa. However, it is recognised that the assessment of airborne and structure-borne noise from gym activities includes considerable tolerances and as such NR 15 is considered a target rather than an objective limit.

In addition to the above it is a requirement that a sprung concrete floating floor is provided to the ground floor as a means of controlling both airborne and impact noise, the minimum construction requirements for the floor are set out in section 6.4.4.

2.4.5 REVERBERATION TIME

Reverberation time performance standards are typically provided where speech intelligibility is important or where the reverberant build-up of noise might be an issue.

For the gym and studio, speech communication between occupants is expected to be face-to-face and increases in ambient noise levels in these environments are typically acceptable then reverberation time performance standards are not proposed.

For the spa areas, speech communication between occupants is expected to be face-to-face and as such speech intelligibility is not expected to be an issue and the combination of relatively quiet occupant communication and lower building services noise levels means that the reverberant build-up of noise should not be problematic. Therefore, reverberation time performance standards are not proposed.

2.4.6 VIBRATION

BS 6472 provides VDV limits for residential properties but also states that 'For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the vibration dose value ranges for a 16 hr day'. This allows for a more relaxed threshold in terms of vibration limits than is required for residential units.

Limits for vibration due to building services are included in Table 2-4 for the dwellings of the 2 – 4 Booth Street building and also for the spa and gym areas within the development.

Table 2-4 – Limits for vibration from building services plant

Space	Vibration limit
Dwellings	0.1 VDV $\text{ms}^{-1.75}$
Gym, Treatment rooms, etc	0.4 VDV $\text{ms}^{-1.75}$

2.5 DEMONSTRATING COMPLIANCE

The Contractor shall undertake acoustic testing to demonstrate that the specified acoustic criteria have been met. Tests shall include:

- Airborne sound insulation of internal partitions and floors
- Weight drop tests to determine the maximum permissible weight drops.
- Tests to determine music noise limits
- Internal and external building services noise levels.

Prior to undertaking any tests, the Contractor shall submit a schedule of testing to The Hut Group for approval and shall give them sufficient notice for their Acoustic Consultant to witness the measurements.

- Levels of airborne sound insulation across partitions and floors will be measured in general accordance with BS EN ISO 140-4:1998 'Acoustics – Measurement of sound insulation in buildings and of building elements - Part 4: Field measurements of airborne sound insulation between rooms'. The results of these tests will be weighted in accordance with BS EN ISO 717-1:2013 'Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation'.
- A methodology for weight drop tests shall be agreed with the Acoustic Consultant acting on behalf of The Hut Group and MCC environmental health.
- Internal building services noise levels will be determined in accordance with the Association of Noise Consultants June 2020 document 'Measurement of Sound Levels in Buildings Version 1.0'.
- External building services noise levels shall be determined in accordance with MCC environmental health.

3 NOISE SURVEY RESULTS

Unattended noise monitoring equipment was used to measure background sound levels between 18 and 27 March 2020 from an open window of the top floor apartment in 2 – 4 Booth Street. The microphone of the noise monitoring equipment extended approximately 1 m from the façade and was approximately 10 m above ground level. 3 dB has been subtracted from the measured levels as they are subject to reflections from the façade.

COVID-19 related lockdown officially started on 23 March 2020, therefore, all measurements completed on and after this date have been excluded from the data analysis.

Prior to lockdown, the dominant source of noise affecting the measurement location was road traffic noise from the surrounding roads, pedestrian movements and building services noise.

Details of the noise measurement equipment are included in

Table 3-1 – Noise measurement equipment

Equipment	Make/Model	Serial No.	Calibration due
Sound Level Meter	Sound Level Meter	01dB-METRAVIB Solo Master	08 September 2021
Pre-amplifier	Pre-amplifier	01dB-Stell PRE 21 S	08 September 2021
Microphone	Microphone	Microtech Gefell GmbH MCE212	08 September 2021
Calibrator	Calibrator	01dB-Stell Cal 21	05 September 2020

The weather is not expected to have had an impact on the measured background sound levels, with it being mostly dry and sunny and wind speeds generally below 5 m/s.

The nearest noise sensitive receivers to the development are as follows:

- Residential properties within 2 – 4 Booth Street
- Residential properties on Kennedy Street
- The outdoor terrace and pool and guest rooms in the King Street Townhouse Hotel (KSTH)

The background sound levels measured from the top floor apartment of the 2 – 4 Booth Street building are considered to be representative of the background sound levels at the residential properties on Kennedy Street.

The representative background sound levels ($L_{A90,T}$, dB) have been determined based the guidance in MCC's *Planning & Noise Technical Guidance (December 2015)* and are summarised in Table 3-2. These background sound levels shall be used for setting plant noise limits in accordance with MCC requirements.

Table 3-2 – Daytime and night time background sound levels

Noise sensitive receiver	Period	Background sound level, $L_{A90,T}$ (dB)
Residential properties on Booth and Kennedy Streets and Guestrooms in KSTH	Day (07:00 – 23:00)	53
	Night (23:00 – 07:00)	52

The minimum octave band background sound levels measured during the survey are included in Table 3-3. These background sound levels shall be used to set limits for entertainment noise.

Table 3-3 – Octave band background sound levels at nearby noise sensitive receivers

Noise sensitive receiver	Period	Octave band (Hz) background sound level, $L_{A90,T}$ (dB)							
		63	125	250	500	1000	2000	4000	8000
Residential properties on Booth and Kennedy Streets and Guestrooms in KSTH	Day	53	50	51	48	48	42	33	21
	Night	53	50	51	49	48	43	36	23

A summary of the ambient noise levels during the unattended measurements is provided Table 3-4.

Table 3-4 – Day and night time ambient noise levels

Position	Date	$L_{Aeq,16hrs}$ (dB) Daytime (07:00-23:00)	$L_{Aeq,8hrs}$ (dB) Night-time (23:00-07:00)
2 – 4 Booth Street	18/3/20	59	59
	19/3/20	60	60
	20/3/20	59	58
	21/3/20	58	56
	22/3/20	57	59
	23/3/20	59	57

4 SOUND INSULATION TESTING RESULTS

Sound insulation tests were undertaken by WSP on 18 March 2020 to provide detail of the acoustic separation currently achieved by the existing structure. The following tests were undertaken:

- Airborne sound insulation between the ground floor and the first floor
- Airborne sound insulation between the ground floor and the basement
- Impact sound insulation between the ground floor and the basement

The results of these tests are included in Table 4-1.

Table 4-1 – Sound insulation testing results

Source Room	Receive Room	Airborne sound insulation performance	Impact sound insulation performance
Ground floor (proposed gym)	First floor (communal corridor)	54 dB $D_{nT,w}$ 49 dB $D_{nT,w} + C_{tr}$	-
Ground floor (proposed gym)	Basement (proposed spa)	30 $D_{nT,w}$ 29 dB $D_{nT,w} + C_{tr}$	68 dB $L'_{nT,w}$

Commentary on the results and what they mean for the design going forward are included below:

- **Ground floor to first floor airborne sound insulation.** The floor achieves a relatively high level of airborne sound insulation and is compliant with the minimum requirements of Approved Document E of the Building Regulations. With respect to the performance standards set out in section 2.4.4.2, the sound insulation performance of the existing floor is not expected to undermine the use of the gym (i.e. music should be able to be played at a reasonable level for a gym) with upgrades or replacement of the existing ceiling at ground floor level.
- **Ground floor to basement airborne sound insulation.** The floor achieves a very low level of airborne sound insulation. Holes in the floor due to the removal of socket boxes were observed when on site and it is expected that the performance would improve significantly following closure of these penetrations and installation of a sprung concrete floor. No problematic flanking paths were identified during the test.
- **Ground floor to basement impact sound insulation.** The floor achieved a poor level of impact sound insulation. It is expected that this would improve significantly following installation of concrete floating floor.

5 OPERATIONAL NOISE

This section includes:

- Assessment of operational noise from typical gym activities breaking-out through the building envelope of the gym to the windows of the residential properties immediately above the gym to establish compliance with MCC requirements
- Assessment of operational noise transfer from typical gym activities to the dwellings above to establish compliance with MCC requirements
- The setting of music noise limits in the gym in accordance with MCC requirements

5.1.1 OPERATIONAL NOISE BREAK-OUT OF THE BUILDING ENVELOPE

The envelope is required to provide some control of noise breaking-out from the gym to the windows of nearby noise sensitive properties. As per MCC requirements, ambient noise (L_{Aeq}) from the gym shall be at least 10 dB below the background noise level (L_{90}) in each octave band, see Table 3-3.

Noise breaking-out of the gym has been assessed at the windows of the residential properties in 2 – 4 Booth Street as these are the closest noise sensitive receivers to the gym. This assessment is based on the following:

- The new and existing parts of the building envelope achieve levels of sound reduction as per Table 6-1. Table 6-1
- Typical ambient noise levels in the gym are expected to be comparative to those measured by members of the WSP acoustics team in a similar sized gym, see Table 5-1.
- Any windows within the building envelope of the gym are considered to be closed as the scheme is mechanically ventilated and does not rely on open windows for ventilation or cooling.
- The distance from the centre of the gym building envelope to the windows of the residential properties above is 4 m

Table 5-1 – Typical gym noise levels

Condition	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	A-weighted
Measured ambient noise level from typical gym activities including treadmills, weights machines and background music, L_{eq} (dB)	62	68	64	66	64	61	59	50	69

The calculated operational noise levels at the windows of the nearest noise sensitive receivers are included in Table 5-2 along with a comparison of the daytime and night time background sound levels, the results of the calculations are compliant with MCC requirements.

Table 5-2 – Comparison of gym operational noise break-out with daytime and night time background sound levels

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Ambient noise levels at 2 – 4 Booth Street, L_{eq} (dB)	36	37	36	34	21	12	15	6
Daytime background sound level, L_{90} (dB)	56	53	54	52	51	46	39	26
Difference between ambient and daytime background sound level	-20	-16	-18	-18	-30	-34	-24	-20
Night time background sound level, L_{90} (dB)	56	53	54	51	51	45	36	24
Difference between ambient and daytime background sound level	-20	-16	-18	-17	-30	-33	-21	-18

5.1.2 OPERATIONAL NOISE BREAK-OUT THROUGH THE FIRST FLOOR CONSTRUCTION

Operational noise from the gym to the dwellings above has been assessed as per MCC requirements and is based on the following:

- Ambient noise levels in the gym being comparative to those measured previously by WSP at a similar sized gym, see Table 5-1.
- The measured sound insulation performance of the existing floor, measured between the ground floor (proposed gym) and first floor circulation, see Table 5-3
- The calculated improvement in sound insulation performance of the existing floor due to installation of a sound insulating ceiling, see Table 5-4
- A reverberation time of 0.5 seconds in the apartments, as per the reference reverberation time included in Approved Document E of the Building Regulations, and a volume of 60 m³ in the apartment bedroom, which is the volume measured by WSP for a second floor apartment bedroom.
- The expected noise levels from gym activities in the apartment above have been calculated and these are included in Table 5-5.

Table 5-3 – Measure sound insulation performance of the existing floor

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Measured sound insulation performance of existing floor, D (dB)	34	35.6	42.8	50	56.5	58.5	60	60

Table 5-4 - Increase in performance due to installation of a sound insulating ceiling

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Calculated upgrade in sound insulation following installation of a sound insulating ceiling (dB)	16	19	15	15	20	20	20	16

Table 5-5 - Calculated noise levels in apartments above

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB(A) / NR
Ambient noise level in apartment due to typical gym activities, L_{eq} (dB)	14	12	5	0	-13	-19	-21	-30	2 / 0

The calculated octave band noise levels from typical gym activities are compliant with MCC's requirements for control of noise from entertainment venues i.e. no more than 47 dB L_{eq} at 63 Hz and 41 dB L_{eq} at 125 Hz. Whilst it is recognised that gyms might not necessarily be considered as entertainment venues, it is considered that compliance with the MCC criteria relating to noise from such venues is demonstration of a robust approach to noise control.

5.1.3 MUSIC NOISE LIMITS

Based on the sound insulation performance of the façade and the sound insulation performance of the existing floor plus sound insulating ceiling, music noise could be played at around the levels in Table 5-6. These limits are considered reasonable for gym activities. Activities with higher noise levels will take place in the studio, which is omitted from the design. The proposed limits are dependent on the performance of the sound insulating ceiling and may need to be reviewed as the building services design is developed.

Table 5-6 – Expected music noise limits

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB(A)
Limit for music noise in the gym, L_{eq} (dB)	72	74	72	73	84	84	70	58	88

It is recommended that the sound system installed to the gym be fitted with limiter in order that noise from the system does not exceed MCC's limits for noise from entertainment venues in the apartment above.

In-situ testing of the installed system is required to be undertaken by the Contractor to establish and limits established with respect to the MCC criteria.

6 ACOUSTIC DESIGN

6.1 BUILDING ENVELOPE

6.1.1 INSPECTION OF EXISTING ENVELOPE

The building envelope is to remain largely as is, with only the main door and a single glazed window being replaced.

The envelope has been inspected by WSP and is predominantly double glazed but the exact configuration could not be confirmed during the inspection. For the purpose of assessing external noise ingress and operational noise break-out, the glazing is assumed to have sound insulation performance 27 dB $R_w + C_{tr}$, which is typically the lowest level of sound insulation achieved by a thermal double glazed unit in reasonable condition.

6.1.2 DESIGN APPROACH

The building envelope is required to control external noise ingress to a suitable level and to also noise breakout, as required by MCC.

6.1.2.1 External noise ingress

As the majority of the building envelope is to remain as is, limits for external noise ingress have not be set. However, an assessment of external noise ingress has been undertaken gauge the capability of the existing glazing to provide a suitable environment. Typically, external noise ingress to a gym would be controlled to no more than 45 dB $L_{Aeq,1 \text{ hour}}$.

The resultant noise level in the gym, due to external noise ingress, was calculated to be 40 dB $L_{Aeq,1 \text{ hour}}$, which is comfortably below the limit that would normally be applied to a gym.

6.1.2.2 Noise break-out

As per MCC requirements, operational noise (L_{Aeq}) breaking out of the gym shall be at least 10 dB below the background noise level (L_{90}) in each octave band at the windows of nearby noise sensitive receivers, see Table 3-3.

Operational noise breaking out through the building envelope has been assessed, see Table 5-2, and providing that music noise is adequately controlled, see Table 5-6, is expected to be compliant with MCC requirements.

6.1.3 BUILDING ENVELOPE ACOUSTIC REQUIREMENTS

Minimum sound insulation specifications for the new glazing and door in the building envelope are included in Table 6-1. In this instance, the term glazing applies to the glass, seals, frame and any associated hardware.

Table 6-1 – Sound insulation specifications for new areas of glazing and door in the building envelope

Element	Minimum octave band (Hz) sound reduction index, R (dB)								Minimum $R_w + C_{tr}$ (dB)
	63	125	250	500	1000	2000	4000	8000	
New glazing and door in the building envelope	18	23	20	24	35	41	36	36	27

6.2 PARTITIONS

6.2.1 DESIGN APPROACH

Partitions have been designed taking into consideration the need to control noise transfer between adjacent spaces and the provision of privacy.

6.2.2 PARTITION ACOUSTIC REQUIREMENTS

Minimum sound insulation specifications (in terms of R_w) for partitions are included on the following EPR drawings:

- 1178-EPR-00-B1-DR-A-68-0001 Rev 3
- 1178-EPR-00-GF-DR-A-68-0002 Rev 3

These have been reviewed and the sound insulation specifications included on these drawings are considered capable of achieving the sound insulation performance standards, where necessary.

At ground floor level, all partitions shall be built from structural slab (i.e. **not** on the floating floor) and extend up to the underside of the soffit above.

At basement level, all partitions shall be built from structural slab up to the underside of the soffit above.

The installed partitions shall incorporate joint, head and base track details appropriate to the relevant on-site performance, as well as any other detail specified by the partition supplier. Plasterboard can be either skimmed or taped and jointed but this is required to the full height of the partition. Where there is more than one lining, the boards should be installed with staggered joints.

Where new partitions abut the existing envelope then these shall be fixed securely to envelope and joint sealed from bottom to top with mastic which does not set hard.

The curved partitions are included then these shall achieve the acoustic requirements shown on the EPR drawings in Appendix B. Where it is not practicable for the curved elements to achieve these, an alternative shall be presented to THG for approval further to any work being undertaken.

6.2.3 PARTITION DETAILING

Drylining constructions and typical head and base details are included in the following drawings prepared by EPR:

- 1178-EPR-00-B1-DR-A-22-2201 Rev 1
- 1178-EPR-00-GF-DR-A-22-2201 Rev 1

- 1178-EPR-00-XX-DR-A-22-2250 Rev 1
- 1178-EPR-00-XX-DR-A-22-2251 Rev 1
- 1178-EPR-00-XX-DR-A-22-2252 Rev 1
- 1178-EPR-00-XX-DR-A-22-2253 Rev 1

The constructions shown satisfy the sound insulation specifications.

The details included on these drawings are generally acceptable however, it is recommended that the gaps between partitions and the concrete floating floor are 25 mm and filled with dense isolation strip (approx. 100 kg/m³), see Figure 6-2.

Where new partitions specified with $R_w \geq 50$ dB butt up to the existing envelope or existing walls, then the partitions shall break any lining applied to the existing envelope / walls. The linings shall not be continuous across separating partitions.

6.3 INTERNAL DOORS

6.3.1 DESIGN APPROACH

The acoustic requirements for the internal doors have been developed with noise transfer between spaces (e.g. noise transfer via risers in the residential areas) and privacy in mind.

Where new riser doors are provided to communal corridors in the residential areas, then these are required to control building services noise break-out from the ducts in the riser and also to control noise transfer between the floors.

Noise from the ducts in the riser breaking out through the doors and into the communal corridors has been assessed. The calculated noise level in the communal corridor is 9 dB L_{Aeq} , which is considered acceptable however, this will need to be reviewed if the construction stage building services selections differ from those included at this stage of the design.

6.3.2 ACOUSTIC REQUIREMENTS

Acoustic strategy drawings prepared by EPR and reviewed by WSP which include sound insulation specifications for partitions are included in Appendix B.

Table 6-2 – Internal door sound insulation requirements

Location	Minimum sound insulation performance	Comment
WCs, Changing rooms, Steam room, Sauna	n/a	It is expected that doors to WCs will be undercut for ventilation purposes and it is recommended, therefore, that solid core doors which fit well within their frame are provided. Undercuts should be kept to a minimum. Acoustic doors are not included to the steam room and sauna as these are often glazed, frameless type units which typically achieve relatively poor levels of sound insulation.
Treatment rooms, Clinical room, electrical risers	30 dB R_w	Specification provided to provide a degree of privacy whilst balancing with functionality. Example construction included below.
Mechanical & public health riser	35 dB R_w	Specification provided to control noise breakout of risers and to control noise transfer between voids in floors. Example construction included below.
HE plant room, Pool plant room, PH plant room	40 dB R_w	These rooms open into patron occupied areas, therefore, high spec doors are included in the design. The specifications for these doors can be reviewed as the MEP design is developed

6.4 FLOORS

6.4.1 FIRST FLOOR

6.4.1.1 Design Approach

The first floor construction, which separates the gym from the dwellings above, is required to control noise from the gym as per MCC requirements.

The airborne sound insulation performance of the existing first floor construction was measured by WSP and achieved 49 dB $D_{nT,w} + C_{tr}$, which is a relatively high level of sound insulation. An assessment of noise transfer between the gym and dwellings above is included in section 5.1.2 of this report, the key findings are summarised below.

- When combined with the new ceiling to the gym, the floor is capable of controlling noise from typical gym activities to a level that is compliant with MCC requirements in the dwellings above.
- When combined with the new ceiling to the gym, the floor is expected to allow music noise to be played at a reasonable level for the types of activities expected to take place in the gym

6.4.1.2 Acoustic Requirements

Taking the above into consideration, additional sound insulation measures to the existing first floor construction, other than the new ceiling in the gym, are not considered necessary.

6.4.2 EXISTING GROUND FLOOR

6.4.2.1 Design Approach

The ground floor, when combined with the new floating floor and ceiling below, is required to control noise transfer between the gym and the spa as per the performance standards set out in section 2.4.4.3.

To identify any enhancements necessary to the existing floor, the airborne and impact sound insulation performance was measured by WSP. The airborne performance was measured to be 30 dB $D_{nT,w}$, which is a relatively low level of sound insulation, and was due to a number of holes in the floor.

6.4.2.2 Acoustic Requirements

To help achieve the performance standard in section 2.4.4.3, whilst bearing in mind a concrete floating floor is to be installed on top of the ground floor construction and ceiling below, it is recommended that any holes in the existing slab are tightly filled with material which has density at least 100 kg/m³.

6.4.3 NEW STRUCTURAL FLOOR

6.4.3.1 Design Approach

Part of the existing ground floor slab is to be replaced with a new slab on trapezoidal deck which is 150 mm thick at its deepest point. This new floor, when combined with new floating floor and ceiling below, is required to control noise transfer between the gym and the spa as per the performance standards set out in section 2.4.4.3.

6.4.3.2 Acoustic Requirements

To achieve the required level of sound insulation, the concrete shall achieve density at least 2200 kg/m³ and the slab shall achieve a surface density of at least 270 kg/m².

The void between the new structural floor and the building envelope, which has the potential to create a path for noise transfer between the gym and spa, shall be closed off as follows:

- 1.2 mm steel closer plate on top of the new slab
- Void fully and tightly filled with material which has density at least 100 kg/m³
- 1.2 mm steel closer plate to underside of new slab

6.4.4 NEW CONCRETE FLOATING FLOOR

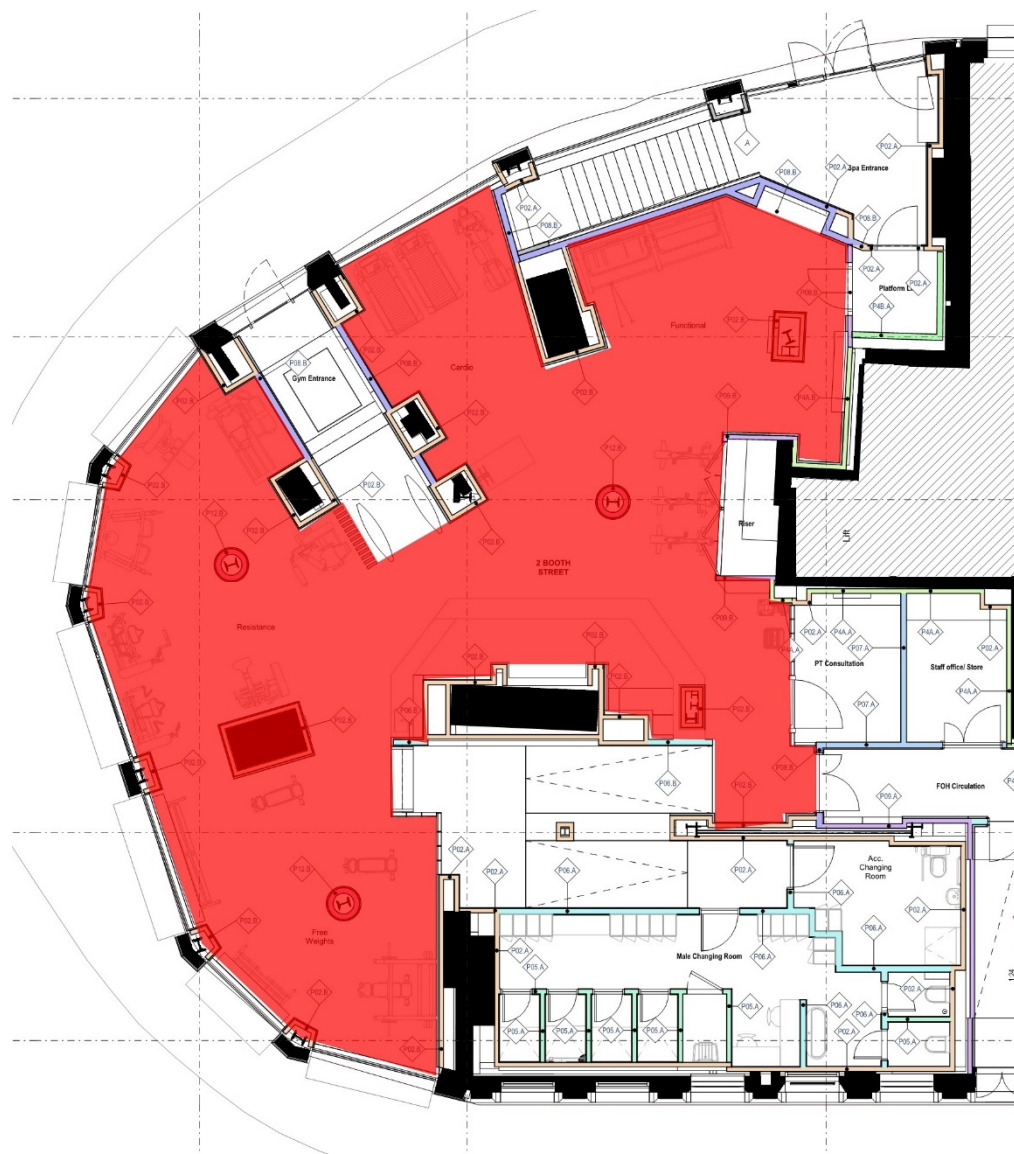
6.4.4.1 Design Approach

A sprung concrete floating floor is to be provided as these types of floors provide significantly improved control of impact noise / vibration from gym activities (e.g. weight drops and weight machine use) when compared with other types of floors and are generally regarded as being the most robust form of noise control available for gym activities.

The floor is required to provide a degree of structure borne noise control between the gym and the dwellings above and the spa below. It is also required to enhance the airborne sound insulation performance of the existing and new structural floors at ground floor level.

As future flexibility is a key consideration in the overall design of the gym, the floating floor will cover almost the entire floor area of the gym, see area highlighted in 'red' in Figure 6-1.

Figure 6-1 – Extent of sprung concrete floor



The combination of new structural floor, concrete floating floor and ceiling in the spa is expected to achieve R_w in excess of 70 dB and R at 63 Hz in the region of 45 dB. Based on the music noise being limited as per Table 5-6, noise levels in the spa have been calculated to be NR 12, which is comfortably below the building services noise limit of NR 30 in the treatment rooms and is compliant with the performance standard in section 2.4.4.3.

6.4.4.2 Acoustic Requirements

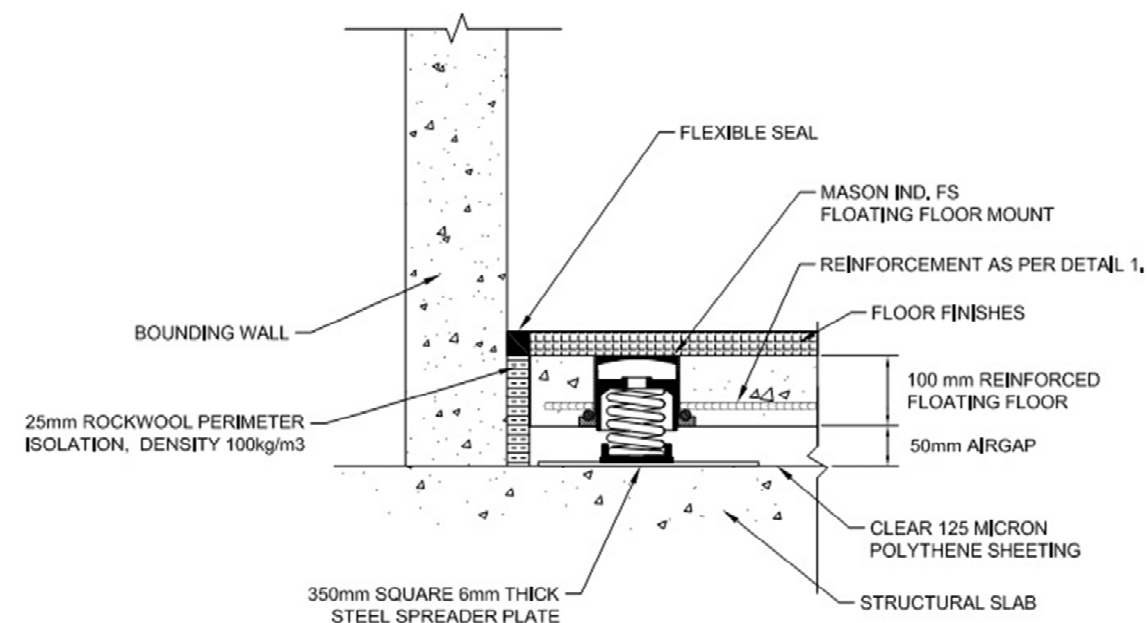
The various elements of the concrete floating shall achieve the following:

- 100 mm solid concrete ($\geq 2200 \text{ kg/m}^3$).
- 50 mm jack-up isolation springs selected to achieve a natural frequency in region of 4 Hz. Minimum deflection of 25 mm.

The floating floor shall not be in contact with any partitions (see indicative detail in Figure 6-2), the building envelope or cable trays around the perimeter.

It is acceptable to fix weights machines directly to the floating however, this will have to be coordinated between the equipment and floor installers to avoid clashes between fixing points and springs.

Figure 6-2 - Floating floor / partition junction detail



6.4.5 GYM FLOOR FINISH

It is recommended that the free weights area includes sports floor finish which achieves ΔL_w at least 25 dB. The current design includes Ecore Monster floor finish, which is compliant with this requirement.

Any changes to the floor finishes shall be reviewed by the Contractor's acoustic consultant and THG informed of any implications.

6.4.6 SPA FLOOR FINISH

There are no acoustic requirements for floor finishes in the spa.

6.5 CEILINGS

6.5.1 DESIGN APPROACH

The ceilings to the ground floor gym are required as part of the noise control strategy between the gym and the dwellings above.

The ceilings to the basement spa are required as part of the noise control strategy between the spa and the gym above.

6.5.2 ACOUSTIC REQUIREMENTS

The ceilings to the gym, treatment rooms and spa circulation areas shall achieve mass per unit area at least 20 kg/m² and shall be hung from spring hangers which have natural frequency in the region of 8 Hz.

Where moisture resistant boards are required then the mass per unit area shall be at least 19 kg/m².

In areas where space constraints mean that it is not practicable to achieve the above, then alternative approaches have been included in the design. These vary to suit but shall include two layers of board where practicable.

Ceilings to WCs and changing areas shall achieve mass per unit area at least 8 kg/m².

In areas where ceilings are required to achieve mass per unit area either 19 or 20 kg/m², all services shall be ducted to grilles (both supply and return air) or attenuators provided such that the sound insulation performance is not compromised.

Ceilings shall not span partitions that separate rooms.

6.5.3 CEILING CONSTRUCTION AND DETAILING

The following EPR ceiling type and ceiling detail drawings have been reviewed and the details and construction types are compliant with the acoustic requirements.

- 11178-EPR-00-B1-DR-A-35-3501 Rev 1
- 11178-EPR-00-GF-DR-A-35-3502 Rev 1
- 11178-EPR-00-XX-DR-A-35-3550 Rev 1
- 11178-EPR-00-XX-DR-A-35-3552 Rev 1
- 11178-EPR-00-XX-DR-A-35-3553
- 11178-EPR-00-XX-DR-A-35-3554
- 11178-EPR-00-XX-DR-A-35-3555

6.6 ACCESS PANELS

6.6.1 DESIGN APPROACH

Where access panels are included in ceilings to the gym and spa areas, then these are also required to form part of the noise control strategy.

6.6.2 ACOUSTIC REQUIREMENTS

Access panels shall have R_w at least 30 dB or achieve a mass per unit area at least 20 kg/m².

6.7 BUILDING SERVICES

6.7.1 DESIGN APPROACH

Noise from the building services shall be controlled such that the total internal and external noise levels, when operating at design duty, are compliant with the performance standards in Chapter 2 of this report. Vibration from building services shall be so that the limits in Table 2-4 are not exceeded.

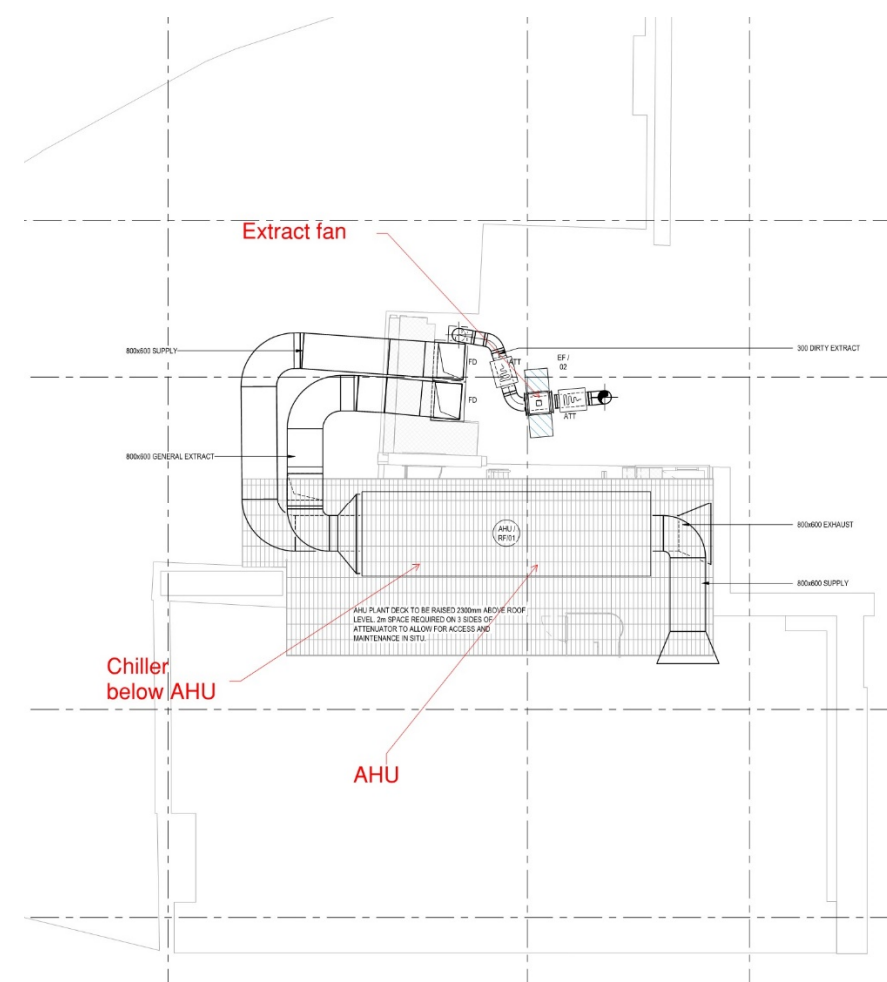
Where building services selections are reasonably fixed and noise data is available, assessments have been undertaken and design advice has been provided to the team. Where noise data has not been provided then generic design advice based on our experience of similar is provided.

6.7.2 EXTERNAL BUILDING SERVICES NOISE ASSESSMENT

External building services noise has been assessed using the Stage 4 plant and attenuator selections. The assessment is based on the items of plant listed below and plant locations shown in Figure 6-3.

- One air handling unit (AHU) on the roof
- One VRF chiller on the roof
- One extract fan on the roof

Figure 6-3 - Approximate locations of rooftop plant



The nearest noise sensitive receivers are as follows:

- The windows of residential properties within 2 – 4 Booth Street
- The windows of residential properties on Kennedy Street
- The outdoor terrace and pool and guest room windows in the King Street Townhouse Hotel (KSTH)

There is no direct line of sight between the plant items on the roof and these noise sensitive receivers due to either differences in height or screening by existing buildings. Therefore, the screening corrections included in Table 6-3 have been included in the assessment.

Table 6-3 - Screening corrections

Receiver	Octave band (Hz) screening reduction (dB)							
	63	125	250	500	1000	2000	4000	8000
2 – 4 Booth Street	9	11	13	16	18	21	24	27
Kennedy Street	7	9	11	14	16	19	22	25
KSTH	6	6	7	9	11	14	16	19

Attenuators have been included to the intake and exhaust of the AHU to help reduce external noise levels.

As required by MCC, plant noise has been assessed at the noise sensitive receivers taking into consideration distance losses, screening corrections and attenuator insertion losses. The assessment assumes that all plant operates during the day and night time at design duty however, it is understood that this is unlikely to be the case. The likely operation of the plant has been discussed with the building services engineer and no correction for intermittency has been applied and it is not expected to be either tonal or impulsive. The calculated external plant noise levels are included in Table 6-4 along with the plant noise limits for comparison.

Table 6-4 – External plant noise levels

Noise sensitive receiver	Period	External plant noise limit, $L_{A,r,Tr}$ (dB)	Calculated external rating level, $L_{A,r,Tr}$ (dB)
2 – 4 Booth Street	Daytime	48	37
	Night time	47	
Kennedy Street	Daytime	48	36
	Night time	47	
KSTH	Daytime	48	43
	Night time	47	

Any changes to the layouts and/or noise data could result in non-compliance with the performance standards and as such, the project acoustic consultant should be informed of any change.

6.7.3 RISER NOISE ASSESSMENT

Noise breaking out of the riser into the dwellings has been assessed. The assessment includes the following assumptions:

- The extract fan and AHU (both extract and supply sides) operating at maximum design duty
- The partition which separates the dwellings from the risers consists of only two layers of standard 12.5 mm plasterboard

Based on the above assumptions, the calculated noise level in the nearest apartment to the AHU and extract fan is NR 15, which is considered acceptable. It should also be noted that this a worst-case calculation and that the partition which separates the riser from the dwellings is likely to provide higher levels of sound insulation than achieved by two layers of plasterboard. Therefore, noise levels in the dwellings are expected to be lower than calculated.

6.7.4 GENERAL GUIDANCE

6.7.4.1 Demonstrating Compliance

Compliance with internal building services noise limits shall be demonstrated by measurement of building services noise in accordance with the Association of Noise Consultants *Guidelines Part 1: Noise from Building Services*.

Compliance with external building services noise limits shall be demonstrated by measurement or by calculation as required the Local Authority or BREEAM Assessor.

6.7.4.2 Air velocities

To minimise regenerated noise in ductwork, air velocities in ducts should generally be kept as low as possible throughout the system. Table 6-5 below, includes guidance on airflow velocities through ducts and Table 6-6 includes guidance on airflow velocities at supply and return air openings.

Table 6-5 - Maximum recommended in-duct airflow velocities

Duct location	NR limit	Maximum airflow velocity (m/s)					
		Rectangular duct			Circular duct		
		Main duct	Branch duct	Final runouts	Main duct	Branch duct	Final runouts
In shaft or above dry wall ceiling	45	17.8	14.2	8.9	25.4	20.3	12.7
	40	15.3	12.2	7.6	21.6	17.3	10.8
	35	12.7	10.2	6.4	17.8	14.2	8.9
	30	10.7	8.5	5.3	15.3	12.2	7.6
	25	8.6	6.9	4.3	12.7	10.2	6.4
	20	7.1	5.8	3.6	10.6	8.5	5.3
Above suspended ceiling	45	12.7	10.2	6.4	22.9	18.3	11.5
	40	10.8	8.6	5.4	19.1	15.2	9.5
	35	8.9	7.1	4.5	15.2	12.2	7.6
	30	7.5	6.0	3.8	12.7	10.2	6.4
	25	6.1	4.9	3.1	10.2	8.2	5.1
Duct in occupied space	45	10.2	8.2	5.1	19.8	15.8	9.9
	40	8.8	7.0	4.4	16.5	13.2	8.3
	35	7.4	5.9	3.7	13.2	10.6	6.6
	30	6.1	4.9	3.1	10.9	8.7	5.5
	25	4.8	3.8	2.4	8.6	6.9	4.3

Table 6-6 - Maximum airflow velocities at supply and return air openings

Opening	NR	Maximum airflow velocity (m/s)
Supply air outlet	45	3.2
	40	2.8
	35	2.5
	30	2.2
	25	1.8
Return air opening	45	3.8
	40	3.4
	35	3
	30	2.5
	25	2.2

6.7.4.3 Guidance on service routes

The routings of building services will need to be carefully considered to ensure it does not cause the specified sound insulation criteria to be reduced. Where they pass from plantrooms or through walls, floors or ceilings separating spaces, holes that are required to accommodate the duct, pipe, trunking or conduit should be designed with the minimum clearance that is practicable.

Wherever possible services should be routed along corridors and enter rooms above doors.

Where ducts pass through sound insulating elements (e.g. partitions, floors, etc), cross-talk attenuators may be required to maintain the recommended level of sound insulation.

6.7.4.4 Duct, pipe and cable tray penetrations

Ducts should be distributed along circulation areas with penetrations being made in the corridor wall as these partitions will generally be of a lower sound insulation performance.

In partitions which have $R_w < 50$ dB, gaps around penetrations should be kept small (< 15 mm) and the remaining void filled with mineral wool and sealed with mastic which does not set hard.

For lightweight and block partitions which have $R_w \geq 50$ dB the gap around penetrations should be kept small (< 15 mm) and the remaining void filled with mineral wool and sealed with mastic.

If the gap is any larger than 15 mm then the following applies:

- Lightweight partitions - gaps bigger than 15 mm will require a plasterboard pattress. The pattress should include the same number and type of plasterboard layers as the partition. The remaining gap (no greater than 5 mm) sealed with mastic which does not set hard.
- Block partitions - gaps bigger than 15 mm will require a plasterboard pattress. The pattress should be constructed from 2 layers of 15 mm dense (12.8 kg/m^2) plasterboard. The remaining void (no greater than 5 mm) sealed with mastic which does not set hard

6.7.4.5 Electrical conduit

Where electrical conduit passes through partitions then the penetration should be as small as possible with the gaps around the conduit being less than 5 mm. The remaining gap and open end of the conduit must be sealed with mastic that does not set hard.

6.7.5 PLANT ITEMS AND ATTENUATORS

Noise data for the plant items on which the Stage 4 acoustic design has been developed are included in the following sub-sections along with insertion losses for attenuators.

6.7.5.1 Air handling units

A single air handling unit (AHU) is to be installed on the roof of 2 – 4 Booth Street, this will provide ventilation for the spa and gym. It is necessary that noise from the AHU is compliant with the relevant performance standards set out in this document when operating at design duty and contributions from all other sources are taken into consideration.

In-duct sound power levels for the current selection is included in Table 6-7. The stated breakout sound pressure level for the unit at a distance of 5 m is 45 dB L_{Aeq} . It is recommended that the air handling unit procured has sound power levels no greater than these as exceedances may result in non-compliance with the project performance standards.

Table 6-7 – Stage 4 AHU noise data

Plant item		Octave band (Hz) sound power level (dB)							
		63	125	250	500	1000	2000	4000	8000
AHU	In-duct intake	67	78	76	72	69	68	65	60
	In-duct supply	72	83	80	80	78	74	70	65
	In-duct extract	66	76	72	68	66	65	61	55
	In-duct exhaust	70	79	75	75	74	70	65	61
	Breakout	See above							

6.7.5.2 Extract fan

A single extract fan is to be installed on the roof of 2 – 4 Booth Street, this will extract air from the basement spa area. It is necessary that noise from the extract fan is compliant with the relevant performance standards set out in this document when operating at design duty and contributions from all other sources are taken into consideration.

Noise data for the current selection is included in Table 6-8. It is recommended that the fan procured has sound power levels no greater than these as exceedances may result in non-compliance with the project performance standards.

Breakout sound power levels for the extract fan were not provided by the manufacturer. For compliance with the MCC requirements relating to plant noise, the extract fan shall have case radiated (breakout) sound power level no more than 72 dB L_{WA} .

Table 6-8 – Stage 4 extract fan noise data

Plant item		Octave band (Hz) sound power level (dB)							
		63	125	250	500	1000	2000	4000	8000
Extract fan	In-duct intake	55	67	78	81	83	87	82	81
	In-duct exhaust	55	67	78	81	83	87	82	81
	Breakout	See above							

6.7.5.3 Fan coil units

Fan coil units (FCUs) are to be installed to ceiling voids to provide heating / cooling to various areas throughout the gym and spa. It is necessary that the FCUs are compliant with the relevant performance standards set out in this document when operating at design duty and contributions from all other sources are taken into consideration.

Noise data for the current selections is included in Table 6-9 It is recommended that the fan coil units procured have sound power levels no greater than these as exceedances may result in non-compliance with the project performance standards.

FCUs shall be hung from the concrete slab on manufacturer approved anti-vibration mounts and shall be completely independent of ceilings or partitions.

Table 6-9 - Stage 4 FCU noise data

FCU		Octave band (Hz) sound power level, L_w (dB)							
		63	125	250	500	1000	2000	4000	8000
IU/00/01	Discharge In-duct	56	47	43	41	38	28	20	20
	Inlet / case radiated	58	43	43	40	39	32	25	21
IU/00/02	Discharge In-duct	50	49	45	44	44	33	24	19
	Inlet / case radiated	52	53	52	49	48	42	34	27
IU/00/03	Discharge In-duct	60	50	46	45	40	32	24	21
	Inlet / case radiated	57	49	49	46	45	38	30	23
IU/00/04	Discharge In-duct	49	45	40	39	36	29	21	19
	Inlet / case radiated	52	47	44	40	39	32	27	21
IU/00/05	Discharge In-duct	60	50	46	45	40	32	24	21

FCU		Octave band (Hz) sound power level, L_w (dB)							
		63	125	250	500	1000	2000	4000	8000
	Inlet / case radiated	57	49	49	46	45	38	30	23
IU/00/06	Discharge In-duct	Not provided							
	Inlet / case radiated	Not provided							
IU/00/07	Discharge In-duct	Not provided							
	Inlet / case radiated	Not provided							
IU/B/01	Discharge In-duct	49	47	45	43	40	32	22	18
	Inlet / case radiated	50	50	47	43	43	37	28	21
IU/B/02	Discharge In-duct	56	47	43	41	38	28	20	20
	Inlet / case radiated	58	43	43	40	39	32	25	21
IU/B/03	Discharge In-duct	49	45	40	39	36	29	21	19
	Inlet / case radiated	52	47	44	40	39	32	27	21
IU/B/04	Discharge In-duct	49	45	40	39	36	29	21	19
	Inlet / case radiated	52	47	44	40	39	32	27	21
IU/B/05	Discharge In-duct	56	47	43	41	38	28	20	20
	Inlet / case radiated	58	43	43	40	39	32	25	21
IU/B/06	Discharge In-duct	57	50	45	42	42	31	22	21
	Inlet / case radiated	51	46	47	43	42	36	28	22
IU/B/07	Discharge In-duct	56	47	43	41	38	28	20	20
	Inlet / case radiated	58	43	43	40	39	32	25	21

FCU		Octave band (Hz) sound power level, L_w (dB)							
		63	125	250	500	1000	2000	4000	8000
IU/B/08	Discharge In-duct	56	47	43	41	38	28	20	20
	Inlet / case radiated	58	43	43	40	39	32	25	21
IU/B/09	Discharge In-duct	49	45	40	39	36	29	21	19
	Inlet / case radiated	52	47	44	40	39	32	27	21

6.7.5.4 Outdoor condensing units

A condensing unit is to be installed on the roof of 2 – 4 Booth Street. It is necessary that the condensing unit is compliant with the relevant performance standards set out in this document when operating at design duty and contributions from all other sources are taken into consideration.

Noise data for the current selection is included in Table 6-10. It is recommended that the outdoor unit procured has sound pressure levels than these at the stated distance as exceedances may result in non-compliance with the project performance standards.

Table 6-10 – Stage 4 condensing unit noise data

Plant item	Octave band (Hz) sound pressure level (dB)							
	63	125	250	500	1000	2000	4000	8000
VRF chiller sound pressure level at 1 m, L_{eq} (dB) (heating)	86	71	71	69	63	61	56	51

6.7.5.5 Attenuators

Attenuators shall achieve at least the dynamic insertion losses in Table 6-11 when tested in accordance with BS EN ISO 7235: 2009 'Acoustics - laboratory measurement procedures for ducted silencers and air terminal units—insertion loss, flow noise and total pressure loss'.

The attenuator pressure drops shall not impede performance of the system and shall be in line with the requirements of the building services specification.

Table 6-11 – Stage 4 attenuator insertion losses

Plant ref	Attenuator location	Octave band centre frequency (Hz) dynamic insertion loss (dB)							
		63	125	250	500	1000	2000	4000	8000
AHU	Intake	5	7	13	27	37	25	17	13
	Supply	5	7	13	27	37	25	17	13
	Extract	5	7	13	27	37	25	17	13
	Exhaust	5	7	13	27	37	25	17	13
Extract fan	Inlet	0	2	13	20	25	30	22	20
	Exhaust	0	2	10	18	25	25	17	12
Gym ceiling	Extract	10	17	25	25	25	25	20	15

6.7.6 PLUMBING

Rainwater drainage pipework and other drainage routes should be located within self-contained risers where possible. If this is not possible then it is likely that one or all of the following mitigation measures will have to be implemented:

- Transitions by two 45 degree bends separated by a length of pipe at least 250 mm long
- Cast iron or low noise pipes used in place of plastic or HDPE
- Horizontal pipes lagged with mass loaded wrap
- Pipes boxed in with plasterboard

Where pipework runs through studwork in plasterboard walls, pipework must not be in contact with the surrounding plasterboard or studwork and should be supported from its own independent metal frame and held using rubber lined brackets.

6.7.7 LIFTS

A new lift is to be provided however, this will operate at very low speeds and is not expected to be a significant source of noise or vibration.

6.7.8 BUILDING SERVICES ANTI-VIBRATION

All systems shall be provided with appropriate vibration control measures so that noise levels are at least 10 dB below the internal building services noise limits and the vibration limits are not exceeded.

Base, isolator types and minimum static deflections are included in Table 6-12 Where integral anti-vibration measures are provided then alternatives may be acceptable. However, these would have to be reviewed and approved by the project acoustic consultant.

All pipes and ducts should be hung using spring hangers within the plant room and thereafter all hangers shall include resilient inserts within the pipe clamp.

Table 6-12 – Vibration isolation requirements

Plant		Isolator details		
Type	Plant ref	Base type	Isolator type	Min. static deflection (mm)
AHU	Roof	See note 2	3	15
Extract fan	Roof	B	3	20
Base types:		Isolator types		
A. No base, isolators attached directly to equipment		1. Pad, rubber, or glass fibre		
B. Structural steel rails or base		2. Rubber floor isolator or hanger		
C. Concrete inertia base		3. Spring floor isolator or hanger		
		4. Restrained spring isolator		
Note 1: To be Read in Conjunction with WSP Acoustics Specification for Noise and Vibration Control Products				
Note 2: All cased fans shall have the above specified isolators internally between fan and motor frame, and additionally isolated externally with neoprene pads having 2mm deflection				
Note 3: All pipework to be isolated between the plant and the first structural penetration using AV hangers/mounts with the above specified static deflection, and thereafter with brackets having neoprene inserts. CW booster pipework to be isolated on AV hangers throughout.				

6.7.8.1 Base Types

Base Type B (Structural bases) Steel plant bases shall comprise an all-welded steel framework of sufficient rigidity to provide adequate support for the equipment and fitted with isolator height saving brackets. The frame depth shall be approximately 1/10 of the longest dimension of the equipment with a minimum of 150mm. This form of base may be used as a composite A.V. Rail system.

Base Type B (Structural rails) Structural rails comprise a steel beam with two or more height-saving brackets. The steel sections must be sufficiently rigid to prevent undue strain in the equipment and if necessary, should be checked by the Structural Engineer.

Base Type C (Concrete inertia bases) These shall consist of an all-welded steel pouring frame-work with height saving brackets and a frame depth of approximately 1/12 of the longest dimension of the equipment, with a minimum of 100mm. The bottom of the pouring frame should be blanked off and concrete (2300 kg/m³) poured in over steel reinforcing rods positioned 35mm above the bottom. The inertia base should be sufficiently large to provide support for all parts of the equipment, including any

components which over-hang the equipment base, such as suction and discharge elbows on centrifugal pumps.

6.7.8.2 Isolator Types

Isolator Type 1 Pad or mat type isolators are usually required to items which include integral isolation, these shall normally be bonded to supported and supporting surfaces and shall be selected and loaded to avoid resonance. The resonant frequency of the assembly shall not lie between 2/3 and 4/3 of the disturbing frequencies of the supported equipment.

Isolator Type 2 (Floor isolator) Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant rubber/neoprene. Each mounting shall be capable of being fitted with a levelling device, have bolt holes in the base plate and have a threaded metal insert in the top plate so they can be bolted to the floor and equipment where required.

Isolator Type 2 (Hanger) The hanger shall incorporate a neoprene in shear element as per the floor isolator. The clearance hole in the bottom of the cage should allow a lateral movement of the lower hanger rod of at least 15°. Where hangers incorporate a positioning device, the adjustment system should incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration, or accidental/unauthorised tampering.

Isolator Type 3 (Floor isolator) Each mounting shall consist of one or more helical steel springs as the principal isolation elements and shall incorporate a built-in levelling device. The springs shall be fixed or otherwise securely located to cast or fabricated top and bottom plates having an outside diameter of not less than 75% of the operating height and shall be selected to have at least 50% overload capacity before becoming coil-bound. The bottom plate shall have bonded to it a rubber/neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

Isolator Type 3 (Hanger) The hanger shall incorporate a helical steel spring securely locate in a steel cage. The clearance hole in the bottom of the cage should allow a lateral movement of the lower hanger rod of at least 15° included angle. Where hangers incorporate a positioning device, the adjustment system should incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration, or accidental/unauthorised tampering.

Isolator Type 4 Each mounting shall consist of cast or fabricated telescopic top and bottom housings enclosing one or more helical steel springs as the principle isolation elements and shall incorporate a built-in levelling device. The housing should be designed to permit visual inspection of the springs after installation, i.e. the spring must not be totally enclosed. The springs shall have an outside diameter of not less than 75% of the operating height and be selected to have at least 50% overload capacity before becoming coil-bound. The bottom plate of each mounting shall have bonded to it a rubber/neoprene pad designed to attenuate any high frequency energy transmitted by the springs. Mountings incorporating snubbers or restraining devices shall be designed so that the snubbing, damping or restraining mechanism is capable of being adjusted to have no significant effect during the normal running of the isolated machine. All nuts, bolts or other elements used for adjustment of a mounting shall incorporate locking mechanisms to prevent the isolator going out of adjustment as a result of vibration or accidental or unauthorised tampering.

6.7.8.3 Pipework to Pumps, Chillers etc.

Where isolated equipment is 'piped up' after installation, it is imperative that associated pipework is independently supported and does not transfer any load to the isolated equipment. Pipework should also not cause any shearing force to be transmitted to the isolated equipment.

6.7.8.4 Pipework and Duct Isolation

Pipes, ducts and their contents, or other connected services, must be supported to avoid load on equipment items.

All ductwork connections to fans and AHUs should be flexible and at least 100 mm long but no more than 250 mm. These should be constructed from sound barrier mat having a minimum superficial density of at least 5 kg/m². These connections should be straight but not rigid, with no offset, in order to minimise turbulence.

Where services are jointed to isolated equipment by flexible connectors and the internal pressure in the connectors is 100 kPa or less, the first three service supports next to the equipment shall include vibration isolators giving at least 98 % efficiency at the fundamental forcing frequency of the equipment. The supports shall be designed to prevent movement of the connected pipe or duct from static or dynamic forces due to the fluid weight or velocity.

The first five supports for ductwork on either side of the vibration source shall also be provided with vibration isolators equal in static deflection to that of the source of vibration.

Electrical connections to equipment mounted on vibration isolation bases shall be made through flexible conduit which changes direction by at least 90° in a minimum length of 25 conduit diameters. Mineral insulated cables shall be looped through at least 360° at 75mm radius or double the permissible minimum radius, whichever is larger.

Within all mechanical plantrooms, all pipes connected to equipment installed on spring vibration isolators shall be suspended, supported and guided within the room by means of appropriate spring vibration isolators as described below. This includes domestic water, heating, compressed air, hydraulic fluid, steam and chilled water/glycol pipes, etc. The only exclusions are the roof and floor drains and sprinkler piping. Pipes shall be supported on spring mountings or hung from the structure on spring hangers.

The first isolator both upstream and downstream of equipment on springs shall have a static deflection equal to 1.5 times that of the equipment isolators, up to a maximum of 50mm. The static deflection of the remaining pipe isolators shall be 25mm. Piping in the mechanical plant rooms that is connected only to machinery installed on neoprene isolators shall be either supported by neoprene mounts or suspended from the structure on neoprene hangers.

The use of flexible connectors as an interface between plant and associated pipework cannot be considered as adequate vibration isolation. Their use as thermal and shock compensators is well known, but even under nominal line pressures the connectors become acoustically rigid. It is therefore recommended that all active pipework be isolated on resilient mountings/hangers either up to the structural penetration adjacent to the service shaft or up to 100 pipe diameters from the main plant (whichever is the shorter route). Thereafter, oversized brackets having neoprene inserts would be advisable for larger 'live' pipework (>50 mm O/D), but also for smaller pipework where friction losses exceed 280 Pa/m

6.7.8.5 Reinforced Flexible Pipe Connectors used for Vibration Isolation

Flexible pipe connectors made from corrugated metal, rubber, neoprene or other flexible liner with braided metal or other similar internal or external reinforcing, and intended for use without tie rods, shall have minimum live lengths when used for anti-vibration purposes as detailed in the following table.

Table 6-13 – Live lengths for flexible pipe connectors

Pipe Bore (mm)	Live length (mm)
0 – 28	230
32 – 80	340
90 – 133	455
150 – 200	570
250 - 300	690

The minimum internal bore of the flexible pipe shall not be less than the diameter of the rigid pipe to which it is attached.

These default values for optimum isolation may be reduced in specific cases where requirements other than vibration isolation take precedence. All such cases shall be approved by the acoustic consultant.

The axis of the connectors shall be perpendicular to the direction of vibration. Alternatively, where the design allows, the connectors shall be formed in 90° bends.

6.7.8.6 Expansion joints used for vibration isolation in pipework

Tie rod systems on expansion joints used for vibration isolation shall be designed to achieve vibration isolation across the joint. The tie rod fixings shall use rubber or neoprene based washers to prevent metal to metal contact throughout the normal range of movement of the joint.

6.7.8.7 Expansion tanks, Deaerators, Heat Exchangers and Water Heaters without pumps or motors

Each floor mounted unit shall be supported on 2mm static deflection neoprene waffle pads. Each suspended unit shall be supported on appropriate hangers. Where piping on isolators is connected to these units the connection shall be made with a neoprene flexible connector.

If an associated circulation pump or chemical feed pump is to be mounted on the unit and if the pump is 0.4kW or smaller then the pump shall be mounted on the unit through neoprene isolators. Such pumps larger than 0.4kW shall be supported from the building structure on neoprene mountings. Pumps larger than 1.1kW shall be supported on concrete inertia bases which are supported on spring mounts. All connections to these circulation pumps shall be with flexible connectors.

6.7.8.8 Ductwork Flexible Connectors

All ductwork connections to fans and AHUs should be flexible and at least 75 mm long and no more than 250 mm. These should be constructed from sound barrier mat having a minimum superficial

density of at least 5 kg/m² These connections should be straight but not rigid, with no offset, in order to minimise turbulence.

6.7.8.9 Electrical Connections

Electrical connections to plant should be made via looped flexible conduit, since it is important that isolated equipment is not mechanically bridged or 'shorted' by the installation of conduit or cable trays, etc. which are rigidly connected to the structure.

6.8 AUDIO VIDEO SYSTEMS

6.8.1 DESIGN APPROACH

The design of the AV is outside of the acoustic scope.

An assessment has been undertaken to establish noise limits for the system based on MCC requirements and the current design, see Table 5-6. The results indicate the audio from the AV systems can be played at a level that is considered appropriate for a gym that does not include dedicated fitness studio.

6.8.2 ACOUSTIC REQUIREMENTS

Noise from the AV systems shall be controlled such that it is compliant with the requirements of planning condition 6.

The system shall be tested and limits set prior to handover.

Where loudspeakers are installed to ceilings, these shall not degrade the sound insulation performance by more than 2 dB. It is currently proposed that Sonance Invisible Series loudspeakers (type IS4C) will be installed to the ceilings of the treatment rooms in the spa. As the ceilings are required to provide sound insulation between the spa and gym above, it is recommended that acoustic enclosures are installed to the rear (see <https://www.sonance.com/in-wall-in-ceiling/invisible-series/invisible-series/accessories/isenclosures>).

Appendix A

ACOUSTIC TERMINOLOGY



Noise is defined as unwanted sound. Human ears are able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble) and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting mechanism is used. This reduces the importance of lower and higher frequencies, in a similar manner to the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality or impulsiveness may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source.

The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or LAeq, LA90 etc., according to the parameter being measured.

The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB(A) is generally regarded as the minimum difference needed to perceive a change under normal listening conditions.

An indication of the range of sound levels commonly found in the environment is given in the following table.

Table A/1: Typical sound levels found in the environment

Sound level	Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 40 dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off

Table A/2: Acoustic Terminology relating to noise

Terminology	Description
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (Sound Level)	The sound level is the sound pressure relative to a standard reference pressure of 20µPa (20x10 ⁻⁶ Pascals) on a decibel scale.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1/s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.
A-weighting, dB(A)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
Leq,T	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
Lmax,T	A noise level index defined as the maximum noise level during the period T. Lmax is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall Leq noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L90,T	A noise level index. The noise level exceeded for 90% of the time over the period T. L90 can be considered to be the "average minimum" noise level and is often used to describe the background noise.
L10,T	A noise level index. The noise level exceeded for 10% of the time over the period T. L10 can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise.
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m.
Façade	At a distance of 1m in front of a large sound reflecting object such as a building façade.
Fast/Slow Time Weighting	Averaging times used in sound level meters.
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.

Appendix B

PARTITION AND DOOR SOUND INSULATION SPECIFICATIONS



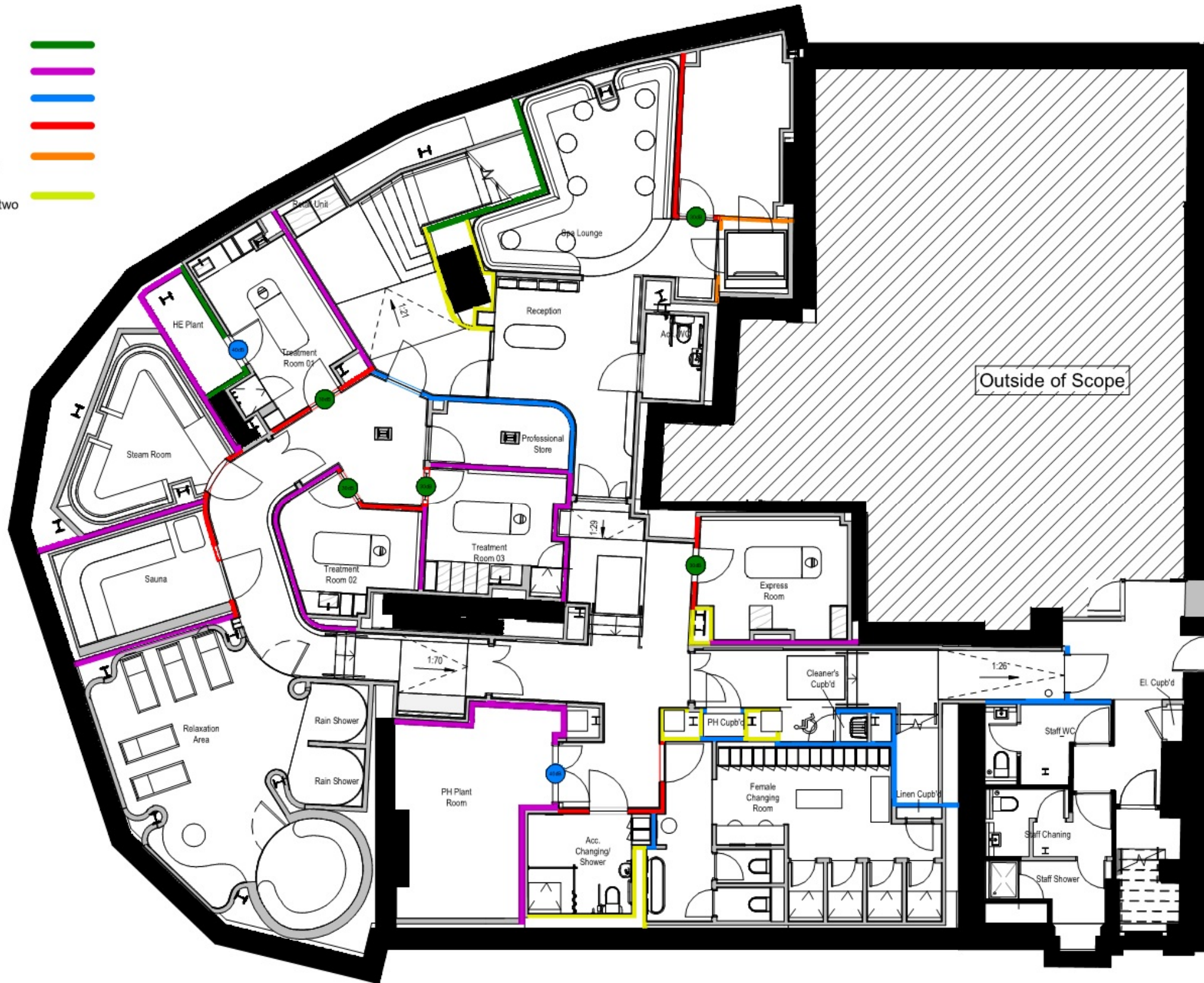
ACOUSTIC STRATEGY:

ACOUSTIC PARTITIONS:

- Rw = 55 dB
- Rw = 50 dB
- Rw = 45 dB
- Rw = 40 dB
- Rw = 39 dB
(Independent Shaft Wall)
- Rw = 36 dB
(Independent Lining with two layers of plasterboard)

ACOUSTIC DOORS:

- Rw = 40 dB
- Rw = 35 dB
- Rw = 30 dB



2 B1 Acoustic Strategy
1:100

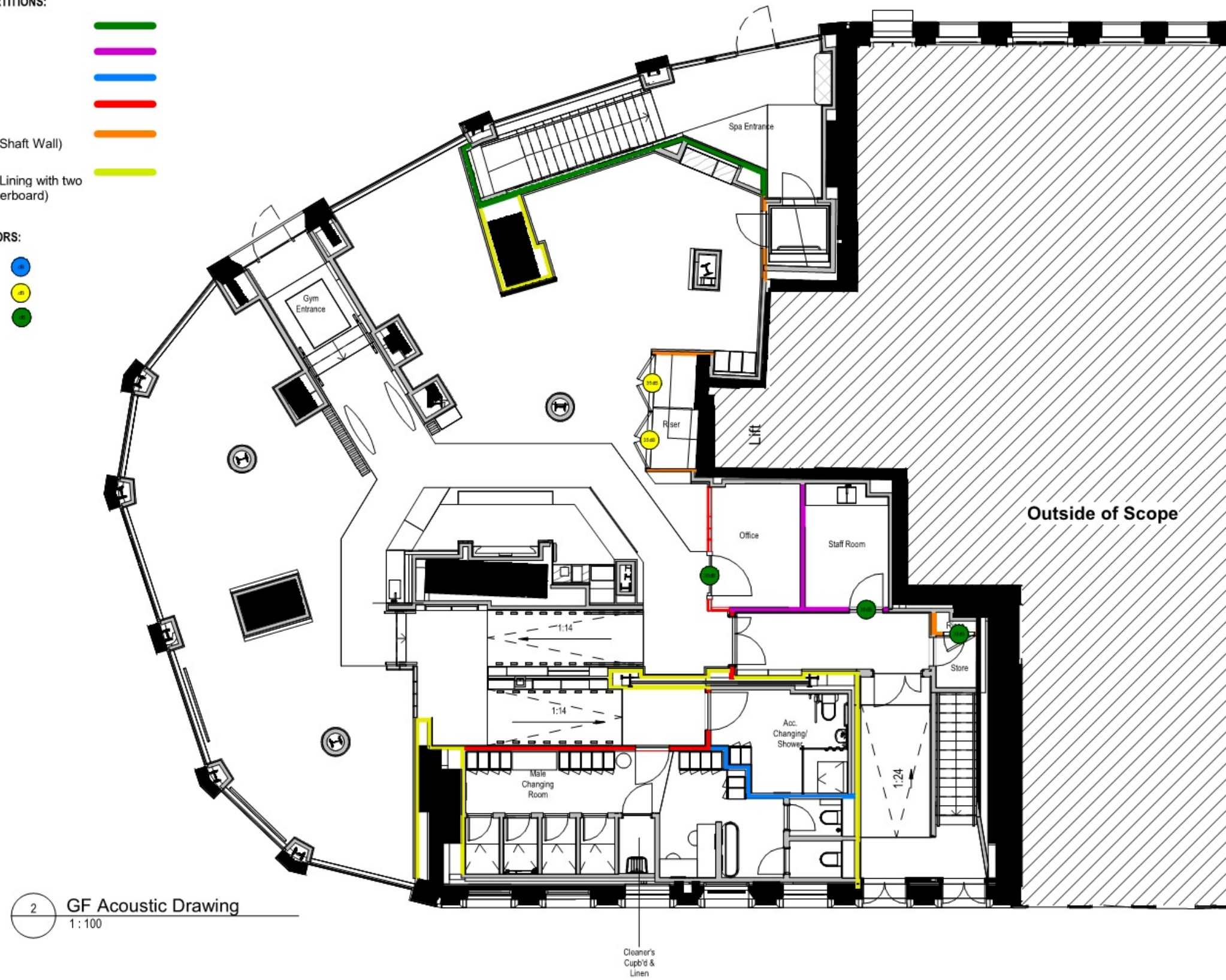
ACOUSTIC STRATEGY:

ACOUSTIC PARTITIONS:

- Rw = 55 dB
- Rw = 50 dB
- Rw = 45 dB
- Rw = 40 dB
- Rw = 39 dB
(Independent Shaft Wall)
- Rw = 36 dB
(Independent Lining with two layers of plasterboard)

ACOUSTIC DOORS:

- Rw = 40 dB
- Rw = 35 dB
- Rw = 30 dB



Appendix C

LIMITATIONS





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