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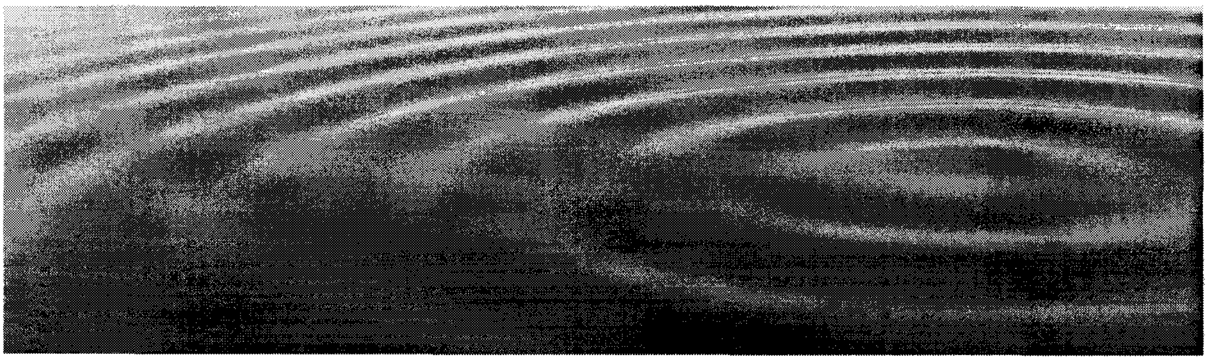
TENDER STAGE ACOUSTIC REPORT 9552/AR1

BENTLEY HOUSE, EUSTON ROAD
LONDON

For
THE WELLCOME TRUST



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One Discovery Place,
Columbus Drive,
Southwood West, Farnborough,
Hampshire, GU14 0NZ

T: +44 (0)1252 550 500
F: +44 (0)1252 550 501
www.hilsonmoran.com
info@hilsonmoran.com

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AUTHOR:	Mark Brightwell
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CONTENTS

1 INTRODUCTION

A new development, comprising a student hall of residence and associated amenity areas is proposed at Bentley House, 200 Euston Road, London.

This document proposes the various acoustic criteria to be achieved in the completed development along with guidance on achieving them.

Following this introductory section, Section 2 presents environmental noise break-in limits along with an acoustic specification for the proposed external glazing and guidance on the build-up of non-glazed façade areas, with calculations presented in Appendix B.

Section 3 presents a summary of the findings of the underground train vibration assessment, undertaken at planning stage, is provided.

Section 4 describes internal and atmospheric plant noise and vibration limits, along with plant noise specifications and attenuation requirements, with calculations presented in Appendix C.

Noise and vibration limits for the lifts are presented in Section 5.

The internal sound insulation performance of the various walls and floors throughout the development are presented in Section 6.

Finally, Section 7 presents sound absorption requirements throughout the development.

Appendix A presents an explanation of the acoustic terminology used in this report.

2 ENVIRONMENTAL NOISE INTRUSION

2.1 Internal Environmental Noise Intrusion Limits

Table 2.1 below presents internal environmental noise intrusion limits for occupied internal areas.

Table 2.1 Environmental Noise Break-in Limits

Area	Environmental Noise Break-in Limit
Bedrooms	35dB $L_{Aeq\ (23:00-07:00\ hours)}$ [1] 40dB $L_{Aeq\ (07:00-23:00\ hours)}$ [1]
Bathrooms & En-suites	40dB $L_{Aeq\ (24\ hour)}$
Common Areas/Study Areas	40dB $L_{Aeq\ (07:00-23:00\ hours)}$
Kitchens	40dB $L_{Aeq\ (07:00-23:00\ hours)}$

[1]*In accordance with planning condition 15 "internal noise levels based on the reasonable standards in BS 8233:1999 Sound insulation and noise reduction for buildings - Code of practice"*

In addition, in accordance with the guidance of British Standard (BS) 8233: 1999 "*Sound insulation and noise reduction for buildings*" in bedrooms at night (23:00-07:00 hours) "*individual noise events (measured with F time-weighting) should not normally exceed 45 dB L_{Amax}*".

The World Health Organisation document "*Guidelines for Community Noise*" (1999) advises that for a good sleep, 45 dB L_{Amax} should not be exceeded more than 10-15 times per night. We shall therefore base our design on not exceeding the limit of 45 dB L_{Amax} more than 10 times per night.

2.2 External Noise Levels Incident upon the Development

Our noise survey report dated 12 May 2010 presents noise levels incident upon the various facades of the development. Table 2.2 below presents a summary of the noise levels incident upon each façade.

Table 2.2 Noise Levels Incident Upon Development

Façade	Measured Noise Level, $L_{Aeq,T}$, dB	
	Daytime 07:00 – 23:00	Night-Time 23:00 – 07:00
Euston Road	73	72
Stephenson Way	61	56
Courtyards	60	55

In addition, typical worse case L_{Amax} noise levels during night-time periods were in the order of approximately 90dB overlooking Euston Road and 75dB overlooking Stephenson Way.

2.3 Acoustic Performance of Glazing

We have based our calculations on floor and façade dimensions detailed on the Tender drawings issued by TP Bennett in our meeting on 21st September 2012. Please advise if the façade/floor dimensions and glazed areas differ significantly from those detailed in the above drawings.

The level of external noise intrusion is affected by the amount of acoustic absorption within a space. The amount of acoustic absorption within a space is predominantly determined by the surface finishes within the space. We understand the room finishes throughout the development are likely to be as detailed in Table 2.3.

Table 2.3 Surface Finishes

Proposed Surface Finishes			
Floor	**Walls (Internal)**	**Walls (External)**	**Ceiling**
Carpet	Stud Partition	Stud Partition plus Brick/Block and Glazing	Plasterboard

Please advise if the proposed surface finishes differ significantly from those presented in Table 2.3.

2.3.1 Euston Road Façade

We understand the existing glazing to the façade overlooking Euston Road is to be retained and refurbished with new secondary glazing units. In addition we understand the non-glazed elements of the façade are of a masonry construction, approximately 300mm thick.

We understand that the existing external glazing shall be refurbished and made good to achieve good acoustic and thermal seals. In addition new 6mm glass shall be installed.

We also understand that the cavity between the external glass and a secondary glazing system would be of minimum 130mm.

We have interpolated sound reduction performance data received from selectaglaze (i.e. based on test data they have for similar scenarios as above).

Our calculations indicate that the based on a minimum 130mm cavity and 6mm external glazing (made good), a secondary glazing sash of 10.8mm stadip silence (type S80) should be suitable.

Open windows will cause exceedances of the proposed internal noise limits, however we understand ventilation/cooling shall be provided mechanically.

2.3.2 Stephenson Way and Courtyards

We understand new glazing is to be introduced to the façades overlooking Stephenson Way and the Courtyard. In addition, we understand the non-glazed elements of the façade overlooking Stephenson Way are to comprise brickwork, a Metsec frame (with insulation) and 2No layers plasterboard internal linings.

We understand the non-glazed elements of the façade overlooking the courtyards to comprise a Sto-type cladding, Metsec framing (with insulation) and 2No layers plasterboard internal linings.

Our calculations indicate that, upon incorporation of glazing providing the minimum sound reduction values specified in Table 2.5 below, the internal noise level limits detailed in Section 2.1 should be achieved.

Table 2.5 Minimum Sound Reduction Indices (Stephenson Way and Courtyards)

Façade Description	**Minimum Sound Reduction Index (dB) at Octave Band Centre Frequency (Hz)**					
	125	**250**	**500**	**1k**	**2k**	**4k**
Stephenson Way	26	27	34	40	38	36

Courtyards	24	20	25	34	34	34

To determine compliance with the sound reduction specifications, testing should be undertaken on fully representative test samples, comprising the correct proportion of glazing and any opaque panels in a representative bay, as well as fully representative frames, seals, etc.

The sound reduction performance of the proposed glazing shall be determined in accordance with BS EN ISO 140-3: 1995. This will involve testing in 1/3 octaves from at least 100 Hz to 5000 Hz inclusive.

The test results, together with suitably converted octave band results from 125 Hz to 4000 Hz, shall be provided for a fully representative curtain walling test sample – including representative glazing and any opaque panels, frames, seals, opening lights etc.

We would expect the non-glazed areas of the external façades to be commensurate with the glazing specifications in Table 2.5.

2.4 Internal Noise Level Prediction Calculations

We have undertaken calculations to predict the resultant internal noise levels due to measured external environmental noise levels.

Our calculations have been undertaken in accordance with the external-to-internal noise level calculation methodology described in BS8233: 1999.

Appendix C presents full details of our calculations for the worst case façade (Euston Road). Table 2.6 summarises the predicted internal noise levels during each period.

Table 2.6 Summary of Predicted Internal Noise Levels on Euston Road Façade

Period/Description	Predicted Resultant Noise Level	Environmental Noise Break-in Limit
Daytime $L_{Aeq\ (07:00-23:00\ hours)}$	**27dB**	40dB
Night-time $L_{Aeq\ (23:00-07:00\ hours)}$	**26dB**	35dB
Night-time L_{Amax}	**42dB**	45dB *(up to 15 events per night)*

It can therefore be seen that the predicted internal noise levels within rooms overlooking Euston Road (worst-case façade) should achieve the limits presented in Section 2.1 and should comply with Camden Council's requirements.

3 TRAIN VIBRATION AND RE-RADIATED NOISE

London Underground Lines run beneath Euston Road to the South of the site, and also to the North-West of the site. Subsequently, the potential exists for vibration and re-radiated noise due to underground trains to be perceptible in the new development.

We have previously undertaken a vibration survey to determine the level of vibration affecting the current site to enable predictions of vibration and re-radiated noise in the proposed development to be undertaken.

The measured vibration levels due to underground trains were found to be of satisfactory magnitudes at various positions around the site. In addition, the estimated Vibration Dose Values (e.V.D.V's) determined for daytime and night-time periods were found to be less than the limits presented within Camden Borough Council's UDP.

Predicted re-radiated noise levels within completed bedrooms due to nearby train movements were equal to or less than Camden Council's typical L_{Amax} criterion of 35dB at all positions throughout the proposed development.

We note that Table 1 of the World Health Organisation document *"Night Noise Guidelines for Europe"* 2009, cites a noise level limit associated with *"Waking in the night and/or too early in the morning"* at 42dB L_{Amax}, which is 7dB higher than the predicted re-radiated noise levels.

4 BUILDING SERVICES NOISE AND VIBRATION

4.1 Building Services Noise and Vibration Limits

4.1.1 Internal Building Services Noise Limits

Building services noise in internal areas shall not exceed the levels shown in Table 4.1.

Table 4.1 Internal Building Services Noise Limits

Area	Noise Limit	
	Systems Serving/Located In Actual Area	**All Other Systems**
Bedrooms	NR 25	NR 20
Bathrooms & en-suites	NR 35	NR 30
Common Areas/Study Areas	NR 35	NR 30
Kitchens	NR 50	NR 45
Plantrooms	So as not to exceed noise limits in adjacent areas	

In addition, building services plant shall not emit any audible tones or rattles.

4.1.2 External Building Services Noise Limits

Planning condition 16 states:

"Noise levels at a point 1 metre external to sensitive facades shall be at least 5dB(A) less than the existing background measurement (LA90) expressed in dB(A) when all plant/equipment (or any part of it) is in operation unless the plant/equipment will have a noise that has a distinguishable discrete continuous note (whine, hiss, screech, hum) and/or if there are distinct impulses (bangs, clicks, clatters, thumps) then the noise levels from that piece of plant/equipment at any sensitive façade shall be at least 10dB(A) below the LA90 expressed in dB(A)."

Based on the above requirements and the measured noise levels presented in our noise survey report dated 12 May 2010, we would propose the plant noise limits shown in Table 4.2. The plant noise limits are to be achieved during the relevant plant operating period, when measured 1m external to the nearest noise sensitive façade to the site.

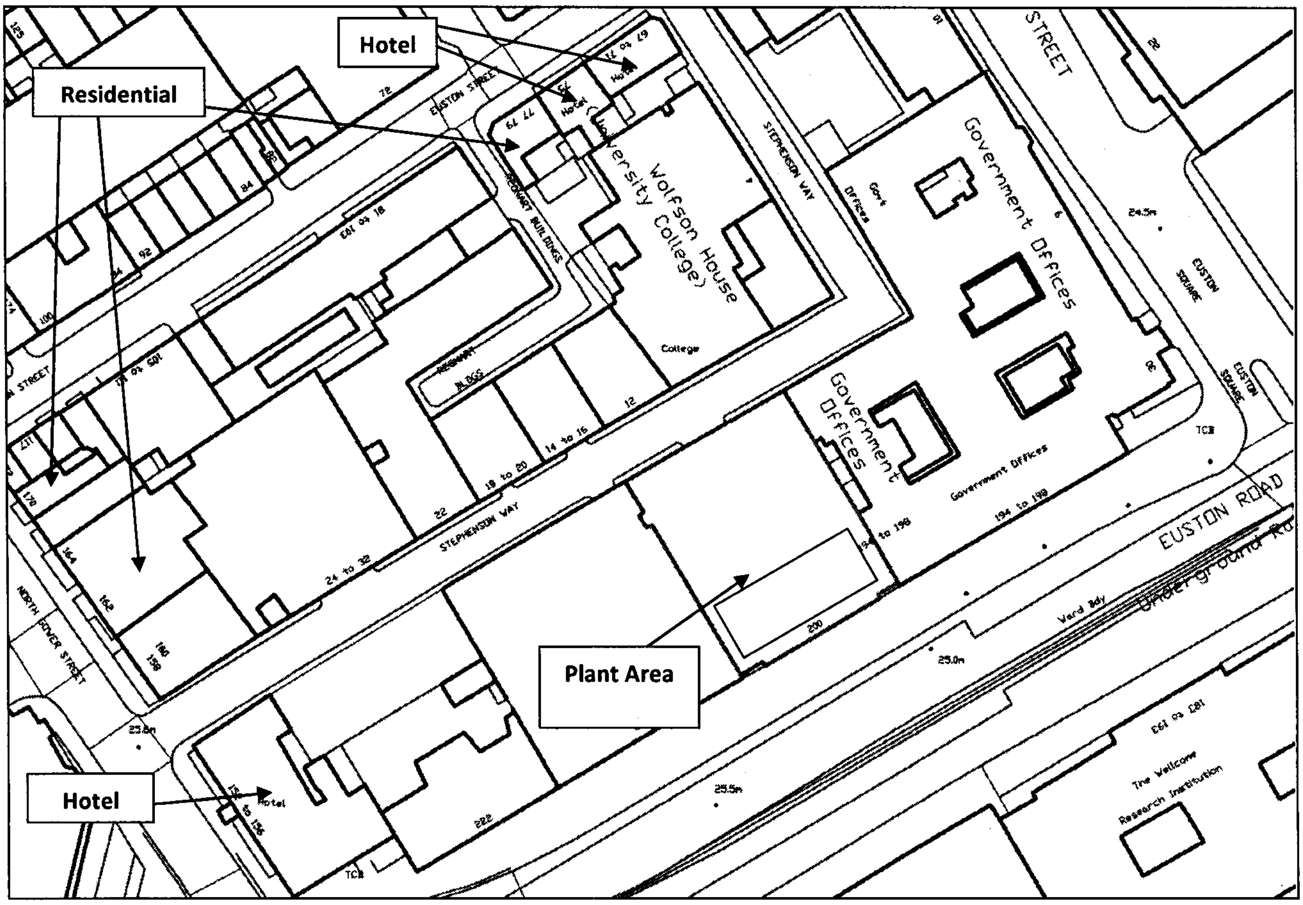
Table 4.2 Atmospheric Building Services Noise Limits

Measurement Position	External Plant Noise Limit during plant operating period (dBA)			
	Daytime (07:00 – 23:00 hours)		Night-time (23:00 – 07:00 hours)	
	Weekday	Weekend	Weekday	Weekend
A	59	58	51	52
B	47	47	46	46

The above external plant noise limits are subject to approval by Camden Council. In accordance with the requirements of Camden Council, if noise from the proposed plant has a distinguishable discrete continuous note (whine, hiss, screech, hum) and/or if there are distinct impulses (bangs, clicks, clatters, thumps) then the above plant noise limits should be reduced by 5 dBA.

The sketch plan in Figure 4.1 indicates the approximate proposed locations of the new plant items on the roof of Bentley House. The approximate locations of the nearest noise-sensitive (residential and hotel) properties are also shown.

Figure 4.1 Approximate Proposed Plant Locations and Nearest Noise Sensitive Properties



The nearest noise-sensitive properties to the proposed plant locations are noted to be the hotels and residential property on Euston Street, the hotel on the junction of Stephenson Way and North Gower Street, and the residential properties on North Gower Street.

4.1.3 Building Services Vibration Limits

The services installation shall be isolated from the structure to ensure that the frequency and amplitude of structure borne vibration shall not exceed 0.01 m/s^2 within any residential areas, in accordance with Clause 3.3 of BS 6472: 2008.

4.2 Building Services Acoustic Treatment

4.2.1 CHP Units

We understand the roof top plant room located immediately above 6^{th} floor bedrooms is to house Combined Heat and Power (CHP) Plant as well as boiler plant and pumps. We understand the roof slab is to be 250mm concrete.

We understand that 2No 20kW XRGI20 SAV Type CHP Units are proposed for locating within the CHP roof top plant room. We have undertaken an assessment of the noise level data for these units (as provided by SAV).

Our calculations indicate that suitable break-out noise levels should be achieved in the 6^{th} floor rooms with the 250mm roof slab plus acoustic absorptive lining to the walls of the CHP plant room. The CHP plantroom noise mitigation measures are described in the following sections.

4.2.1.1 CHP Plantroom Lining

The acoustic absorptive lining should:

a) occupy an area at least equal to the ceiling area;

b) be spread evenly around the room, ideally on the ceiling; and

c) consist of a material capable of achieving the minimum sound absorption coefficients presented in Table 4.3 below.

Table 4.3 Roof Top CHP Plant Room Acoustic Absorption Specification

Minimum Sound Absorption Coefficient at Octave Band Centre Frequency (Hz)					
125	250	500	1k	2k	4k
0.40	0.60	0.70	0.80	0.80	0.85

We would expect 75 mm thick mineral wool (100 kg/m^3 density) to be capable of achieving the minimum sound absorption coefficients shown in Table 4.3, although alternative proposals may be acoustically acceptable.

The acoustic absorption material should be held behind an acoustically transparent facing with a minimum 25% open area e.g. perforated steel.

4.2.1.2 CHP Plantroom Ventilation Attenuators

We understand the CHP room will be mechanically ventilated. We understand the ventilation fan will be of duty of approximately $0.4m^3/s$. The actual fan has not yet been selected, thus our assessment is based on empirically calculated noise levels for a fan of this duty, and assumes the fan will be selected so as not to exceed the limiting induct sound power levels presented in Table 4.4 below.

Table 4.4 CHP Ventilation Fan Limiting In-Duct Sound Power Levels

Maximum In-Duct Sound Power Level (dB re 10^{-12} Watts) at Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
81	77	70	65	64	61	58	53

Based on the above limiting in-duct sound power levels and the anticipated CHP plantroom noise levels, calculations have been undertaken to determine attenuator insertion losses which should achieve the external noise level limits presented in Section 4.1.1 and 4.1.2 above. Table 4.5 below presents minimum insertion losses to be achieved by the CHP ventilation attenuators.

Table 4.5 CHP Ventilation Attenuator Minimum Insertion Losses

System Description	Dimensions (mm)			Max Pd. (Pa)	Vol. (m^3/s)	Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
	H	W	L			63	125	250	500	1k	2k	4k	8k
Intake	750	750	1200	30	0.4	5	11	19	29	36	37	29	18
Discharge	750	750	1200	30	0.4	5	11	19	29	36	37	29	18

Should the in-duct sound power levels for the selected fan exceed those specified in Table 4.4, then we will need to review and possibly revise the attenuator specifications.

4.2.2 Roof Top Boiler/Pump Plant Room

In order to control atmospheric noise break-out from the Roof top boiler/pump plant room, we would advise that ventilation should be via an acoustic louvre and acoustic absorptive lining should be introduced to the plantroom.

4.2.2.1 Roof Top Boiler/Pump Plantroom Lining

The acoustic absorptive lining should:

a) occupy an area at least equal to the ceiling area;

b) be spread evenly around the room, ideally on the ceiling; and

c) consist of a material capable of achieving the minimum sound absorption coefficients presented in Table 4.6 below.

Table 4.6 Roof Top Boiler/Pump Plant Room Acoustic Absorption Specification

Minimum Sound Absorption Coefficient at Octave Band Centre Frequency (Hz)					
125	**250**	**500**	**1k**	**2k**	**4k**
0.40	0.60	0.70	0.80	0.80	0.85

We would expect 75 mm thick mineral wool (100 kg/m^3 density) to be capable of achieving the minimum sound absorption coefficients shown in Table 4.6, although alternative proposals may be acoustically acceptable.

The acoustic absorption material should be held behind an acoustically transparent facing with a minimum 25% open area e.g. perforated steel.

4.2.2.2 Roof Top Boiler/Pump Plantroom Acoustic Louvre

We understand ventilation would be via a louvre of approx 4m^2. The louvre should provide the minimum insertion losses presented in Table 4.7, when tested in accordance with British Standard (BS) EN ISO 7235: 2003.

Table 4.7 Roof Top Boiler/Pump Plant Room Louvre Insertion Losses

Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
6	7	10	12	18	18	14	13

We would anticipate that the above specification could be achieved by a 300mm acoustic louvre. The face velocity across the louvre should not exceed 2.5m/s.

4.2.3 Air Handling Units

We understand the proposed air handling units will be selected so as not to exceed the limiting in-duct sound power levels presented in Table 4.8 below.

Table 4.8 AHU Limiting In-Duct Sound Power Levels

System Description	**Maximum In-Duct Sound Power Level (dB re 10^{-12} Watts) at Octave Band Centre Frequency (Hz)**							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Fresh Air Intake (Atmospheric)	62	65	75	66	65	61	53	46
Supply Air (Roomside)	67	70	86	72	75	73	70	65
Extract Air (Roomside)	62	65	75	66	65	61	53	46
Exhaust Air (Atmospheric)	67	70	86	72	75	73	70	65

Based on the above limiting in-duct sound power levels, calculations have been undertaken to determine attenuator insertion losses which should achieve the external and internal noise level limits presented in Section 4.1.1 and 4.1.2 above. Table 4.9 below presents minimum insertion losses to be achieved by in-duct attenuators associated with the air handling units.

Table 4.9 AHU Attenuator Minimum Insertion Losses

System Description	Dimensions (mm)			Max Pd. (Pa)	Vol. (m^3/s)	Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
	H	W	L			63	125	250	500	1k	2k	4k	8k
Fresh Air Intake (Atmospheric)	Maximum face velocity not to exceed 3.2m/s		600	40	0.51	4	8	12	17	29	28	23	16
Supply Air (Roomside)			1800	40	0.51	9	17	29	46	50	50	49	34
Extract Air (Roomside)			1200	40	0.51	7	12	20	33	39	40	35	28
Exhaust Air (Atmospheric)			900	40	0.51	5	10	16	25	34	34	29	22

Should the in-duct sound power levels for the selected AHUs exceed those specified in Table 4.8, then we will need to review and possibly revise the attenuator specifications.

In addition, crosstalk attenuators shall be installed in ducts which pass through bedroom walls as described in Section 4.2.5 below.

4.2.4 MVHR Units

4.2.4.1 Individual Bedroom MVHR Units

We understand that generally an individual MVHR unit shall serve each bedroom. The units shall be located within the ceiling void of each bedroom.

We understand the proposed MVHR units are the Vent Axia Sentinel Kinetic V model operating at 21/s, sound power levels for which are presented in Table 4.10 below.

Table 4.10 MVHR Limiting In-Duct Sound Power Levels –Individual Bedroom Units

System Description	Maximum In-Duct Sound Power Level (dB re 10^{-12} Watts) at Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k

Fresh Air Intake (Atmospheric)	55	48	51	46	45	39	30	33
Supply Air (Roomside)	55	48	51	46	45	39	30	33
Extract Air (Roomside)	48	42	36	35	36	27	25	31
Exhaust Air (Atmospheric)	48	42	36	35	36	27	25	31

Based on the above limiting in-duct sound power levels, calculations have been undertaken to determine attenuator insertion losses which should achieve the external and internal noise level limits presented in Section 4.1.1 and 4.1.2 above. Table 4.11 below presents minimum insertion losses to be achieved by in-duct attenuators associated with the MVHR units.

Table 4.11 Individual MVHR Attenuator Minimum Insertion Losses

System Description	Dimensions (mm)			Max Pd. (Pa)	Vol. (l/s)	Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
	H	W	L			63	125	250	500	1k	2k	4k	8k
Fresh Air Intake (Atmospheric)	Maximum face velocity not to exceed 2.6m/s		600	10	21	2	4	8	12	13	13	9	8
Supply Air (Roomside)			600	10	21	2	4	8	12	13	13	9	8
Extract Air (Roomside)			600	10	21	2	4	8	12	13	13	9	8
Exhaust Air (Atmospheric)			600	10	21	2	4	8	12	13	13	9	8

The atmospheric attenuators should be located at the façade (i.e. immediately as the duct enters the building) to control noise break-in from outside.

The roomside attenuators shall be located as close to the MVHR unit as possible.

Should the in-duct sound power levels for the selected MVHR Units exceed those specified in Table 4.10, then we will need to review and possibly revise the attenuator specifications.

4.2.4.2 Cluster Bedroom MVHR Units

We understand in some instances an MVHR unit may serve multiple bedrooms. In these instances the units shall either be located within a riser or within the ceiling void of the kitchen.

We understand the proposed MVHR units are the Vent Axia Sentinel Kinetic V model operating at up to 48l/s, sound power levels for which are presented in Table 4.12 below.

Table 4.12 MVHR Limiting In-Duct Sound Power Levels – Cluster Bedroom Units

System Description	Maximum In-Duct Sound Power Level (dB re 10^{-12} Watts) at Octave Band Centre Frequency (Hz)

	63	125	250	500	1k	2k	4k	8k
Fresh Air Intake (Atmospheric)	66	55	48	51	52	45	36	35
Supply Air (Roomside)	66	55	48	51	52	45	36	35
Extract Air (Roomside)	66	63	66	63	62	57	50	48
Exhaust Air (Atmospheric)	66	63	66	63	62	57	50	48

Based on the above limiting in-duct sound power levels, calculations have been undertaken to determine attenuator insertion losses which should achieve the external and internal noise level limits presented in Section 4.1.1 and 4.1.2 above. Table 4.13 below presents minimum insertion losses to be achieved by in-duct attenuators associated with the MVHR units.

Table 4.13 Cluster Bedroom MVHR Attenuator Minimum Insertion Losses

System Description	Dimensions (mm)			Max Pd. (Pa)	Vol. (l/s)	Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
	H	W	L			63	125	250	500	1k	2k	4k	8k
Fresh Air Intake (Atmospheric)	Maximum face velocity not to exceed 2.6m/s		600	10	48	2	4	8	12	13	13	9	8
Supply Air (Roomside)			900	10	48	2	5	11	17	20	19	12	10
Extract Air (Roomside)			900	10	48	2	5	11	17	20	19	12	10
Exhaust Air (Atmospheric)			600	10	48	2	4	8	12	13	13	9	8

The atmospheric attenuators shall be located at the façade (i.e. immediately as the duct enters the building) to control noise break-in from out-side.

The roomside attenuators shall be located as close to the MVHR unit as possible.

Should the in-duct sound power levels for the selected MVHR Units exceed those specified in Table 4.12, then we will need to review and possibly revise the attenuator specifications.

In addition crosstalk attenuators shall be installed in ducts which pass through bedroom walls as described in Section 4.2.5 below.

4.2.5 Bedroom Crosstalk Attenuators

Crosstalk attenuators shall be installed in ducts which pass through bedroom walls (including toilets) and provide the minimum insertion losses presented in Table 4.14, when tested in accordance with British Standard (BS) EN ISO 7235: 2003.

Table 4.14 Bedroom Crosstalk Attenuator Insertion Losses

Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
2	5	11	17	20	19	12	10

The attenuators shall be 900 mm in length. The maximum pressure drop across the attenuators shall not exceed 10Pa under site operating conditions.

4.2.6 Plantrooms Crosstalk Attenuators

To control noise break-out from plant rooms, crosstalk attenuators shall be installed in ducts which pass through plant room walls and provide the minimum insertion losses presented in Table 4.15, when tested in accordance with British Standard (BS) EN ISO 7235: 2003.

Table 4.15 Plantroom Crosstalk Attenuator Insertion Losses

Minimum Insertion Loss (dB) at Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
4	9	17	28	34	32	21	14

The attenuators shall be 1500 mm in length. The maximum pressure drop across the attenuators shall not exceed 10 Pa under site operating conditions.

All crosstalk attenuators must comply with the Hilson Moran Partnership Standard Specification for Electrical and Mechanical Services.

4.2.7 All Other Plant

All other plant, including pumps, booster sets, etc, must be selected and/or attenuated so as to achieve the internal and external noise limits presented in Section 4.1.

4.3 Plant Noise Prediction Calculations

We have undertaken calculations to predict the total noise level due to the proposed plant, at a position 1 metre outside the nearest noise-sensitive windows to the plant, for comparison with the external plant noise limits proposed in 4.1.2.

Our calculations have considered reflections from the roof. As all of the nearest noise-sensitive windows are facing away from the plant locations and do not have line of sight to the plant locations our calculations have also considered acoustic screening due to intervening buildings. Appendix C presents full details of our calculations. Table 4.16 summarises the predicted noise levels due to each item of plant, as well as the total cumulative level due to all plant items.

Table 4.16 Summary of Plant Noise Prediction Calculations

Plant	Predicted Noise Level at 1m Outside Nearest Noise Sensitive Property (dBA)
CHP	8
Boiler & Pump Plantroom	33
AHUs (Fresh Air Intake)	10
AHUs (Exhaust Air)	13
MVHR Units	3
Total Predicted Noise Level	**33**
External Plant Noise Limit	**46***

** Plant may operate at any time, thus this worst case plant noise limit assumes operation during night-time periods on weekends*

It can therefore be seen that the total predicted plant noise levels 1m outside the nearest noise-sensitive properties should fall significantly below the external plant noise limit, hence the proposed plant items should comply with Camden Council's acoustic requirements.

4.4 Building Services Vibration Isolation

4.4.1 Preliminary Guidance for Plant Items

All plant shall be vibration isolated so as to achieve the building services vibration criteria described in Section 4.1 above. Detailed vibration isolation specifications will be determined once final plant selections are known, but in the meantime we would provisionally advise the following:

- The CHP Unit should be mounted on suitable steel spring vibration isolators.
- MVHR units should incorporate steel spring vibration isolators within the unit, as well as the unit casing being mounted externally on neoprene pads.
- Fans should be mounted on suitable steel spring or neoprene vibration isolators.
- Boilers should be mounted on suitable neoprene vibration isolation pads.
- Pumps/Boosters should be mounted on suitable concrete inertia bases which are in turn supported by suitable steel spring vibration isolators.

4.4.2 Pipework and Ductwork

Pipework connected to plant should be vibration isolated for 100 pipe diameters (or up to the first structural penetration, whichever is greater) using suitable vibration isolators which achieve at least the same vibration isolation performance as the plant vibration mounts (static deflection and isolation efficiency).

Ductwork and pipework connections to plant shall be by way of flexible connectors. Flexible connections shall be manufactured from high grade woven fire-resisting cloth with an impermeable coating applied by vacuum diffusion, and a minimum superficial density of 5 kg/m^2. A minimum distance of 50 mm shall be allowed between faces to be bridged by the flexible connection.

Flexible hose pipe couplings must be installed to flex transversely and therefore flexible pipe couplings shall be installed horizontally and parallel to the rotating shafts of the plant.

Flexible pipework connections shall be of rubber and butyl construction, with integral full faced rubber and butyl flanges. They shall be internally steel wire reinforced and be complete with steel retaining rings.

Rods and control cables shall be fitted to prevent excessive elongation and must be out of rigid contact or slack during normal operation.

The Mechanical Services Installer shall ensure that the pipe connections proposed are capable of withstanding the system operating temperatures and pressures.

5 LIFT NOISE AND VIBRATION

5.1 Ride Quality

Noise levels in the car in the cycle, when measured at a distance of 1.5 m from the centre of the floor and 1.0 m from the door face, should not exceed 55 dB $L_{Amax(fast)}$. Door noise, when measured accordingly, should not exceed 55 dB $L_{Amax(fast)}$. In-car announcement and arrival alarms, when measured as above, should not exceed 65 dB $L_{Amax(fast)}$.

Vibration levels must be measured in accordance with the methodology detailed within BS ISO 18738: 2003 *"Lifts (elevators), Measurement of lift ride quality"*.

The horizontal vibration within the lift should not exceed a maximum (peak-to-peak) acceleration level of 0.12 $m.s^{-2}$ in any 1/3 octave band over the frequency range of 1-80 Hz, during anytime in a complete cycle.

At maximum lift speed, the vertical vibration should not exceed a maximum (peak-to-peak) acceleration level of 0.15 $m.s^{-2}$ in any 1/3 octave band over the frequency range of 1-80 Hz.

During acceleration/deceleration and start/stop periods, the vertical vibration within the lift should not exceed a maximum (peak-to-peak) acceleration level of 1.2 $m.s^{-2}$ in any 1/3 octave band over the frequency range of 1-80 Hz. Lift jerk should not exceed 1.4 $m.s^{-3}$ (peak-to-peak).

5.2 Noise and Vibration Impact in Adjacent Areas

Lift noise, when measured at 1.5 m from the floor and 1.0 m from the door face should not exceed 50 dB $L_{Amax(fast)}$ at any time during the lift cycle.

Lift noise to all bedrooms should not exceed 30 dB $L_{Amax(fast)}$.

Lift noise to other occupied areas (e.g. study rooms, lounges etc) should not exceed 35 dB $L_{Amax(fast)}$.

The lift specialist is to assume that lift shaft walls achieve the Sound Reduction Indices, given in Table 5.1 (assuming 200mm concrete walls).

Table 5.1 Sound Reduction Indices for Lift Shaft Walls

Sound Reduction Index (dB) at Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
35	38	42	49	53	55	55	55

Noise levels within lift motor rooms shall not exceed the limits in Table 5.2.

Table 5.2 Maximum Lift Motor Room Noise Levels

Maximum Sound Pressure Level in Lift Motor Room (dB) At Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
76	76	72	71	66	64	69	66

Vibration from lifts, measured on residential floor slabs, should not exceed 0.01 m/s^2, in accordance with Clause 3.3 of BS 6472: 2008 "*Guide to evaluation of human exposure to vibration in buildings (1Hz to 80Hz)*".

6 INTERNAL SOUND INSULATION

6.1 Internal Sound Insulation Requirements

The level of airborne and impact sound insulation achieved between and within residential dwellings is specified in the Building Regulations Approved Document E 2003 (referred to hereafter as ADE 2003).

The proposed development falls under the description of *"Dwellings-houses and flats formed by material change of use"* as the completed development shall contain *"a greater of lesser number of dwellings than it did previously"* as defined by ADE 2003.

The ADE 2003 standards for the development are shown in Table 6.1.

Table 6.1 ADE 2003 Standards

Condition	On-Site Airborne Sound Insulation Performance, Minimum $D_{nT,w} + C_{tr}$ (dB)	On-Site Impact Sound Insulation Performance, Maximum $L'_{nT,w}$ (dB)
Walls between bedrooms	43	N/A
Floors between bedrooms	43	64
Method of Showing Compliance	On-Site Pre-Completion Testing	On-Site Pre-Completion Testing

We understand that although credits may be sought under the BREEAM requirements under BREEAM 2011 item Hea05 (which involves an improvement over ADE 2003), no credits are sought for this item. Therefore the advice contained in the following sections refers to achieving the minimum requirements of ADE 2003 outlined above.

In addition to the above minimum requirements of ADE 2003, internal constructions should also achieve suitable sound insulation such that noise break-out from ancillary areas (e.g. plant rooms, laundry rooms) is mitigated to a suitable level within bedrooms.

6.2 Separating Floors

6.2.1 Separating Floors Between Bedrooms

6.2.1.1 Main Area of Floor (Concrete slab)

We understand the current proposed floor build-up generally comprises a plasterboard suspended ceiling, a 250mm concrete slab (min 2350kg/m^3), an insulation layer (containing underfloor heating system) and a final floor finish.

At this stage we would recommend that the floor finish is separated from the concrete base a resilient layer with a maximum dynamic stiffness of 15 MN/m^3 and minimum thickness of 5mm under the load specified in the measurement procedure of BS EN 29052-1:1992, 1.8 kPa to 2.1 kPa. A product such as SoundLay in conjunction with the Regupol flanking Strips should be acceptable, (or similar products subject to our approval). These are available from CMS Acoustics (01206 216690).

Furthermore, the ceiling construction should comprise 1No layer 12.5mm plasterboard fixed using timber battens with minimum 50mm cavity.

We advise that the above construction should be capable of achieving the minimum requirements of ADE 2003 outlined in Table 6.1.

6.2.1.2 Retained Bay (Metsec)

We understand toward the front of the building, where the existing steel frame is being retained, it is proposed to use a Metsec flooring system comprising a plasterboard ceiling, a 75mm cavity (with insulation) a 130mm Metsec flooring system (with insulation in cavity), plywood, an insulation layer (containing underfloor heating system) and a final floor finish.

At this stage we would recommend that the floor finishes should be separated from the plywood layer by either 25mm thick mineral wool (minimum density of 36 kg/m^2) or an alternative resilient layer with a maximum dynamic stiffness of 15 MN/m^3 and minimum thickness of 5 mm under the load specified in the measurement procedure of BS EN 29052-1:1992, 1.8 kPa to 2.1 kPa.

Furthermore, the ceiling construction should comprise 2No layers 15mm Soundbloc (minimum total mass per unit area $20kg/m^2$) fixed on a separate joist system (i.e. isolated from the Metsec flooring). In addition, any penetrations of the ceiling (e.g. down lighting) should be treated with proprietary "acoustic hoods" or boxed in using 2No layers 15mm plasterboard.

The insulation within both the ceiling cavity and the metsec flooring cavity should be of minimum density $30kg/m^3$.

Finally, the final floor finish should achieve a minimum mass per unit area of $25kg/m^2$.

We advise that the above construction should achieve the minimum requirements of ADE 2003 outlined in Table 6.1.

6.2.2 Other Separating Floors

We would advise that in order to mitigate noise break-out from plant rooms, the lounge (ground floor) and the laundry room, the ceilings within the rooms should be up-rated by the following means:

- The ceiling construction should comprise 2No layers 15mm Soundbloc (minimum total mass per unit area $20kg/m^2$) fixed on a separate joist system (i.e. independent from the slab) or proprietary resilient hangers.
- 50mm mineral wool (minimum density $10kg/m^3$) in the cavity.
- Any penetrations of the ceiling (e.g. down lighting) should be treated with proprietary "acoustic hoods" or boxed in using 2No layers 15mm plasterboard.

6.3 Separating Walls

6.3.1 Separating Walls to Bedrooms

We understand staggered stud drylined partitions are proposed between bedrooms.

We advise that the following construction should achieve the minimum requirements of ADE 2003 outlined in Table 6.1:

- Staggered stud
- 2No Layers 15mm SoundBloc either side of two rows of 60I72 "I" in Gypframe 72 C 50
- Alternating studs staggered in channel at 300mm centres
- 50mm Isover APR 1200 in cavity
- Minimum laboratory sound insulation performance, R_w 61dB
- Approx overall thickness 132mm

The above constructions would apply to walls separating bedrooms from any other area of the building (e.g. bedroom to bedroom, bedroom to corridor, etc).

We would recommend that for lightweight frame walls the concrete slab or platform floor (on Metsec system) should be <u>discontinuous</u> across the wall cavity.

In addition doors to bedrooms should achieve a minimum laboratory sound reduction index of R_w 29 dB, when measured in accordance with BS ENO ISO 140-3: 1995 and rated in accordance with BS EN ISO 717-1: 1997.

6.3.2 Riser Walls within Bedrooms

Where risers pass through bedrooms, the linings to all sides of the risers should be as per the partition linings described in Section 6.3.1 above. Linings should maintain the separation achieved by the staggered stud construction of the main bedroom walls such that linings to the risers should not be continuous between bedrooms i.e. a break should be introduced in to the riser linings if this is the case.

6.3.3 Bedroom Walls to En-Suites

The ADE 2003 requirement for walls within a dwelling is a minimum laboratory sound insulation performance of R_w 40 dB. This requirement would apply to walls within the bedrooms to the en-suites. As a guide, wall constructions such as those described below should comply with the requirement:

- 2 x 12.5mm plasterboard, 50mm stud, 2 x 12.5mm plasterboard
- 1 x 12.5mm plasterboard, 50mm stud, with 25mm insulation, 1 x 12.5mm plasterboard

6.3.4 Separating Walls to Lounge

We understand a door lobby shall be introduced to the lounge, such that any bedrooms are separated by a minimum of 3No doors from the lounge. The doors to the lounge should achieve a minimum laboratory sound reduction index of R_w 29 dB *(that is, each door leaf independently)*, when measured in accordance with BS ENO ISO 140-3: 1995 and rated in accordance with BS EN ISO 717-1: 1997.

In addition to the above, we would advise that in order to mitigate noise break-out from the lounge, the lounge walls should be selected to achieve a minimum laboratory sound insulation performance of R_W69dB, typically this may comprise:

- 2No Layers 15mm SoundBloc
- Two independent rows of 92mm Gypframe C studs
- 100mm Isover APR 1200 in cavity
- Minimum laboratory sound insulation performance, R_w 69dB
- Approx overall thickness 300mm

Alternatively a similar sound insulation performance could be achieved with a blockwork construction with independent acoustic lining comprising:

- 140mm full density blockwork (minimum density 1,800kg/m^3), 12mm plaster to outer face,
- Independent framed 50mm stud (with minimum 10mm gap between frame and blockwork)
- 50mm Isover APR 1200 in cavity
- 2No Layers 15mm Sounbloc
- Approx overall thickness 240mm

6.3.5 Separating Wall Between Student Residential Reception and Bedroom

We would advise that in order to mitigate noise break-out from the residential reception to the adjacent bedroom, the separating wall should be selected to achieve a minimum laboratory sound insulation performance of R_W69dB, typically this may comprise:

- 2No Layers 15mm SoundBloc
- Two independent rows of 92mm Gypframe C studs
- 100mm Isover APR 1200 in cavity
- Minimum laboratory sound insulation performance, R_w 69dB
- Approx overall thickness 300mm

Alternatively a similar sound insulation performance could be achieved with a blockwork construction with independent acoustic lining comprising:

- 140mm full density blockwork (minimum density 1,800kg/m^3), 12mm plaster to outer face,
- Independent framed 50mm stud (with minimum 10mm gap between frame and blockwork)
- 50mm Isover APR 1200 in cavity
- 2No Layers 15mm Sounbloc
- Approx overall thickness 240mm

6.3.6 Separating Walls to Plant Areas

We would advise that in order to mitigate noise break-out from plant areas to adjacent bedrooms and/or corridors, the separating walls should be selected to achieve a minimum laboratory sound insulation performance of R_W69dB, typically this may comprise:

- 2No Layers 15mm SoundBloc
- Two independent rows of 92mm Gypframe C studs
- 100mm Isover APR 1200 in cavity
- Minimum laboratory sound insulation performance, R_w 69dB
- Approx overall thickness 300mm

Alternatively a similar sound insulation performance could be achieved with a blockwork construction with independent acoustic lining comprising:

- 140mm full density blockwork (minimum density 1,800kg/m^3), 12mm plaster to outer face,
- Independent framed 50mm stud (with minimum 10mm gap between frame and blockwork)
- 50mm Isover APR 1200 in cavity
- 2No Layers 15mm Sounbloc
- Approx overall thickness 240mm

6.4 Additional Notes on Separating Floors and Walls

In addition to the construction guidance provided in Sections 6.2 and 6.3 above we advise that:

- The eventual on-site performance is heavily dependent on both the selection of suitable separating constructions and appropriate junction detailing, which will need to be determined in liaison with TP Bennett architects.
- All walls are to be constructed full height (slab-to-soffit).
- Any steel columns between bedrooms should be wrapped with 50mm mineral wool (minimum density 10kg/m^2) then independent linings of 2No layers 15mm Soundbloc, should be either side of the column. The linings would be a continuation of the wall leaves, boxed out around the column ensuring full independence between the 2 leaves of the separating wall and column is maintained.
- Any services penetrations of separating wall and floors shall be boxed-in with an enclosure consisting of 25 mm mineral wool and 2 layers of 12.5 mm plasterboard; additionally, the service penetration should be well sealed and acoustically sleeved. Examples of suitable acoustic sleeving details are shown in Figures 6.1 & 6.2 below.

Figure 6.1 Typical Services Penetration Acoustic Sleeving Detail – Walls

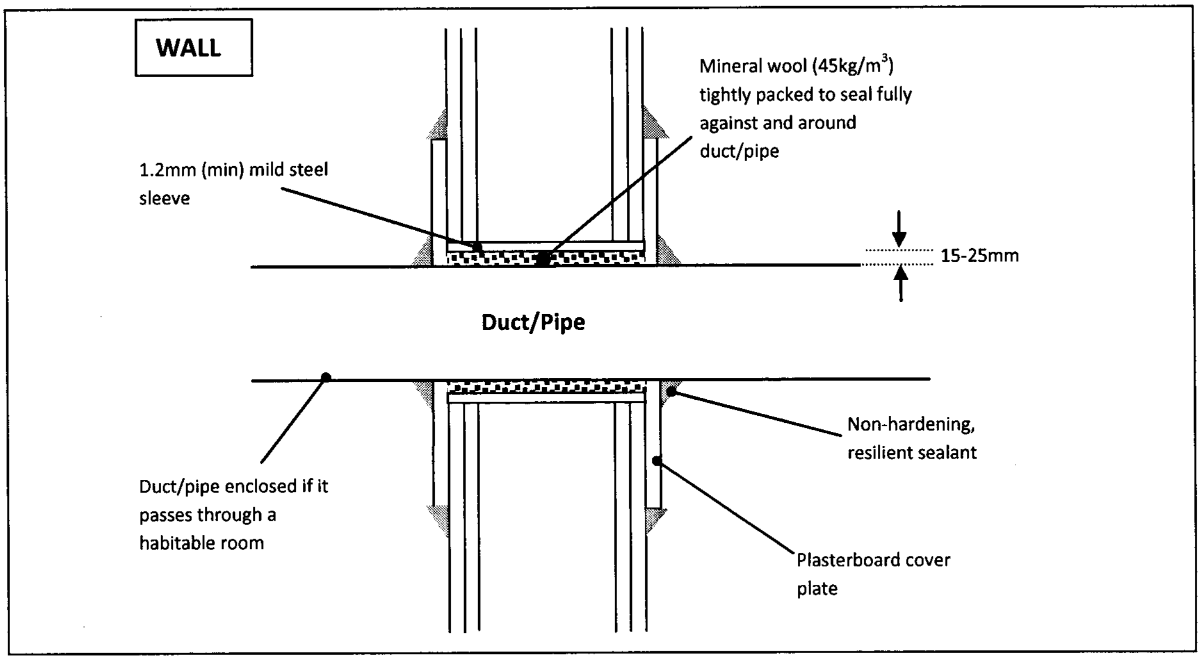
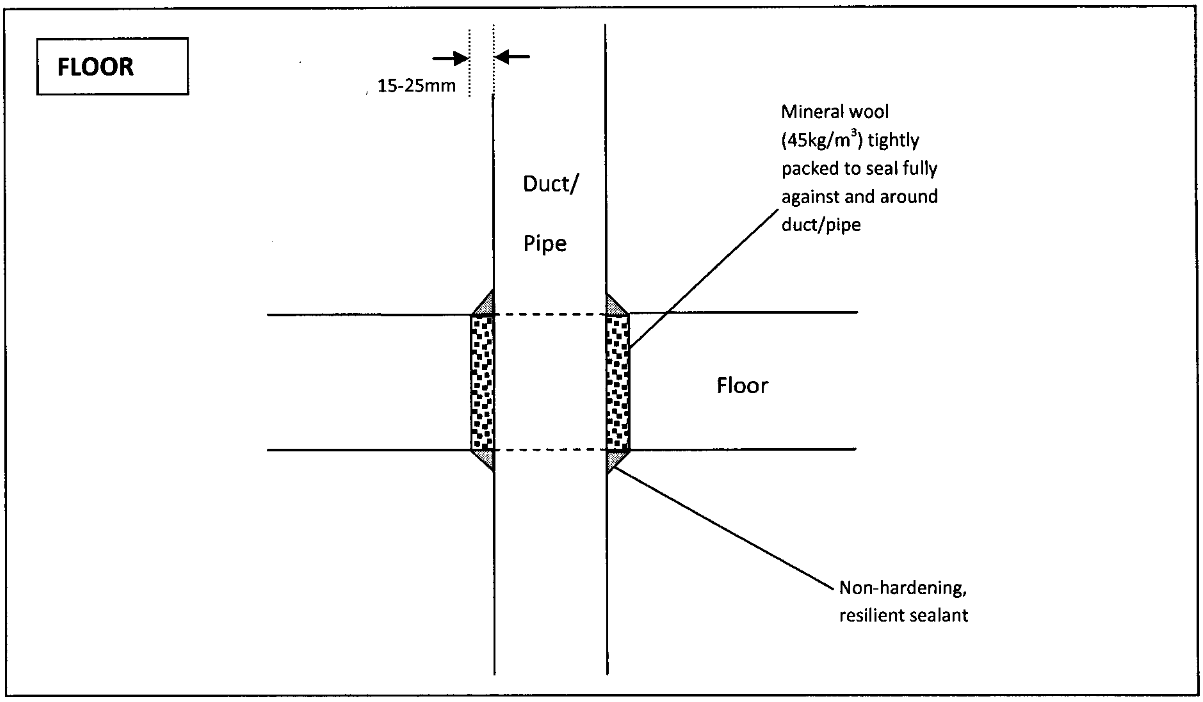


Figure 6.2 Typical Services Penetration Acoustic Sleeving Detail – Floors



- We understand that wiring shall be surface mounted. However we advise that sockets (if they penetrate the separating wall drylining) should not be located back-to-back (they should be separated by at least 600mm) and should be boxed in with 2No layers 12.5mm plasterboard or material of at least equal equivalent mass.

6.5 Internal Doors

Doors should be selected to achieve the minimum sound reduction performances presented in Table 6.2 below.

Table 6.2 Minimum Laboratory Sound Insulation Performance of Internal Doors

Location	Minimum Laboratory Sound Insulation Performance, R_w
Bedrooms	29 dB
Lounge	29dB
Laundry	29dB
Electrical PLantrooms	29dB
Mechanical Plantrooms (including roof top plantroom to stairwell)	34dB
Electrical Risers	29dB
Mechanical Risers	34dB

Doors should achieve the minimum laboratory sound reduction index presented in Table 6.2 above, when measured in accordance with BS ENO ISO 140-3: 1995 and rated in accordance with BS EN ISO 717-1: 1997.

7 SOUND ABSORPTION IN RESIDENTIAL COMMON PARTS

Requirement E3 of ADE 2003 states:

"The common internal parts of buildings which contain flats or rooms for residential purposes shall be designed and constructed in such as was as to prevent more reverberation around the common part than is reasonable."

In order to comply with this requirement, a minimum area of acoustic treatment is required to be included in the residential common parts.

Two methods are proposed for determining the area of acoustic absorption required:

Method A Cover an area at least equal to the floor area (e.g. the ceiling) with a Class C absorber or better.

Method B Determine the amount of absorption provided by non-acoustic surface finishes and calculate the additional absorption required to meet the requirement.

Note: sound absorption classes are defined in BS EN ISO 11654: 19974 "*Acoustics – Sound absorbers for use in buildings – Rating of sound absorption*".

In order to comply with Requirement E3 via Method A above, we would recommend that the ceilings/soffits of the residential common parts are covered with a finish capable of achieving the minimum Class C sound absorption coefficients, given in Table 6.2 below.

Table 6.2 Minimum Sound Absorption Coefficients

Minimum Suspended Ceiling Sound Absorption Coefficients at Octave Band Centre Frequency (Hz)					
125	**250**	**500**	**1k**	**2k**	**4k**
0.20	0.40	0.60	0.60	0.60	0.50

The above specification would be achievable using either a typical acoustic suspended ceiling (e.g. by Armstrong, Ecophon, SAS, etc.), a perforated plasterboard ceiling (e.g. by British Gypsum, Knauf, Lafarge, etc.) or a slatted timber system (e.g. by Decoustics).

Alternatively, a bespoke finish could be constructed, consisting of a suitable acoustically absorptive medium (e.g. 25 mm mineral wool or acoustic foam), behind an acoustically transparent facing (e.g. any open weave fabric, or perforated steel, timber, plasterboard etc. with a 23% (min) open area).

Under Requirement E3, acoustically absorptive treatments are required to all residential common parts, although it may be possible to agree with the local Building Control that acoustic treatment should only apply to common parts that provide direct access to residential dwellings (i.e. corridors immediately outside bedrooms). This approach will, however, require approval from Building Control.

APPENDIX A ACOUSTIC TERMINOLOGY

Parameter	Description
Decibel (dB)	A logarithmic scale representing the sound pressure or power level relative to the threshold of hearing ($20x10^{-6}$ Pascals).
Sound Pressure Level (L_p)	The sound pressure level is the sound pressure fluctuation caused by vibrating objects relative to the threshold of hearing.
A-weighting (L_A or dBA)	The sound level in dB with a filter applied to increase certain frequencies and decrease others to correspond with the average human response to sound.
$L_{Aeq,T}$	The A-weighted equivalent continuous noise level over the time period T. This is the sound level that is equivalent to the average energy of noise recorded over a given period.
Sound Reduction Index, R	A measure of the ability of a material to reduce the passage of sound through the material, usually measured in octave or 1/3 octave bands. The higher the value, the better the sound reduction performance.
$D_{nT,w}$	The weighted (w), standardised (nT) sound level difference (D), a single number indicator of the on-site airborne sound insulation performance of a construction, usually measured across the frequency range 100-3150Hz. The higher the value of $D_{nT,w}$, the greater the sound insulation, and the more onerous the requirement.
R_w	The weighted (w) sound reduction index (R), a single number indicator of the laboratory airborne sound insulation performance of a construction, usually measured across the frequency range 100-3150Hz. The higher the value of R_w, the greater the sound insulation, and the more onerous the requirement.
$L'_{nT,w}$	The weighted (w) standardised (nT) sound pressure level (L), a single number indicator of the on-site impact sound insulation performance of a construction, usually measured across the frequency range 100-3150Hz. $L'_{nT,w}$ is specified as a maximum sound pressure level in the receiving room. The lower the value, the quieter the received impact sound, and the more onerous the requirement.

APPENDIX B ENVIRONMENTAL NOISE BREAK-IN CALCULATIONS

The following presents a summary of our calculations to predict internal noise levels. The tables include the external daytime noise level, typical sound reduction indices of the glazed and masonry elements of the facades and the predicted resultant internal noise level. Our calculations have been undertaken in accordance with the external to internal noise level calculation methodology described in BS8233: 1999.

Highest Daytime L_{eq} Environmental Noise Break-in

Description	Octave Band Centre Frequency (Hz)						dBA
	125	250	500	1k	2k	4k	$L_{eq,}$
External Noise Level	72	67	67	69	66	59	73
Sound Reduction Performance Glazing (6mm / 130mm cavity/ 10.8mm Secondary Glazing)*	40	46	50	54	53	57	-
Typical Sound Reduction Performance Masonry	41	44	48	55	55	55	-
Predicted Internal Noise Level	**39**	**27**	**23**	**19**	**16**	**7**	**27**

Highest Night-time L_{eq} Environmental Noise Break-in

Description	Octave Band Centre Frequency (Hz)						dBA
	125	250	500	1k	2k	4k	$L_{eq,}$
External Noise Level	72	66	66	68	65	58	72
Typical Sound Reduction Performance Glazing (6mm / 130mm cavity/ 10.8mm Secondary Glazing)*	40	46	50	54	53	57	-
Typical Sound Reduction Performance Masonry	41	44	48	55	55	55	-
Predicted Internal Noise Level	**38**	**26**	**22**	**18**	**15**	**6**	**26**

Highest Night-time L_{max} Environmental Noise Break-in

Description	Octave Band Centre Frequency (Hz)						dBA
	125	250	500	1k	2k	4k	$L_{eq,}$
External Noise Level	75	69	85	87	84	66	90
Typical Sound Reduction Performance Glazing (6mm / 130mm cavity/ 10.8mm Secondary Glazing)*	40	46	50	54	53	57	-
Typical Sound Reduction Performance Masonry	41	44	48	55	55	55	-
Predicted Internal Noise Level	**42**	**29**	**40**	**37**	**35**	**14**	**42**

**Sound Reduction performance data provided by Selectaglaze, based on testing at Taylor Woodrow Laboratories*

APPENDIX C ATMOSPHERIC PLANT NOISE CALCULATIONS

Calculations of Predicted Noise Level at 1m Outside Nearest Window of Hotels and Residential Property on Euston Street (worst-case i.e. nearest noise sensitive properties).

CHP Ventilation	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dBA
In-duct Lw (+Rev LP CHP Room)	88	79	72	65	64	62	58	53	
Attenuator Insertion Loss	-5	-11	-19	-29	-36	-37	-29	-18	
Grille End Reflection Loss[3]	-6	-2	-1	0	0	0	0	0	
Distance attenuation[1] (65m)	-41	-41	-41	-41	-41	-41	-41	-41	
Quarter-spherical radiation	-5	-5	-5	-5	-5	-5	-5	-5	
Directivity[4] (worst case 0°)	+5	+5	+5	+6	+6	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
Resultant Lp at receiver	**31**	**20**	**6**	**0**	**0**	**0**	**0**	**0**	**8**

Boiler/Pump Plant Room	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dBA
Plant Room Internal Noise Level	70	71	71	69	64	61	57	53	
Area of Louvre, m²	4	4	4	4	4	4	4	4	
Acoustic Louvre Insertion Losses (dB) (300mm deep)	6	7	10	12	18	18	14	13	
Grille End Reflection Loss[3]	0	0	0	0	0	0	0	0	
Distance attenuation[1] (65m)	-26	-26	-26	-26	-26	-26	-26	-26	
Quarter-spherical radiation	-5	-5	-5	-5	-5	-5	-5	-5	
Directivity[4] (worst case 0°)	+4.5	+5	+5.5	+6	+6	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
Resultant Lp at receiver	**38**	**38**	**36**	**33**	**22**	**19**	**19**	**16**	**33**

AHU FA Intake Fan	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dBA
In-duct Lw	62	65	75	66	65	61	53	46	
Attenuator Insertion Loss	-4	-8	-12	-17	-29	-28	-23	-16	
Grille End Reflection Loss[3]	-7	-3	-1	0	0	0	0	0	
Distance attenuation[1] (65m)	-43	-43	-43	-43	-43	-43	-43	-43	
Quarter-spherical radiation	-5	-5	-5	-5	-5	-5	-5	-5	
Directivity[4] (worst case 0°)	+2	+2.5	+4	+5	+5.5	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
2No AHU units	+3	+3	+3	+3	+3	+3	+3	+3	
Resultant Lp at receiver	**6**	**9**	**16**	**4**	**0**	**0**	**0**	**0**	**10**

AHU Exhaust Fan	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	dBA
In-duct Lw	67	70	86	72	75	73	70	65	
Attenuator Insertion Loss	5	10	16	25	34	34	29	22	
Grille End Reflection Loss[3]	7	3	1	0	0	0	0	0	
Distance attenuation (65m)[1]	-43	-43	-43	-43	-43	-43	-43	-43	
Quarter-spherical radiation	-5	-5	-5	-5	-5	-5	-5	-5	
Directivity (worst case 0°)[4]	+2	+2.5	+4	+5	+5.5	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
2No AHU units	+3	+3	+3	+3	+3	+3	+3	+3	

Resultant Lp at receiver	**10**	**12**	**21**	**3**	**0**	**0**	**0**	**0**	**13**

MVHR (Individual Room) FA Intake Duct	**63Hz**	**125Hz**	**250Hz**	**500Hz**	**1kHz**	**2kHz**	**4kHz**	**8kHz**	**dBA**
In-duct Lw	55	48	51	46	45	39	30	33	
Attenuator Insertion Loss	-2	-4	-8	-12	-13	-13	-9	-8	
Grille End Reflection Loss[3]	-12	-7	-3	-1	0	0	0	0	
Distance attenuation (50m)[1]	-46	-46	-46	-46	-46	-46	-46	-46	
Hemi-spherical radiation	-8	-8	-8	-8	-8	-8	-8	-8	
Directivity (worst case 0°)[4]	+1	+1.5	+2.5	+3.5	+4.5	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
Resultant Lp at receiver	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

MVHR (Individual Room) Exhaust Duct	**63Hz**	**125Hz**	**250Hz**	**500Hz**	**1kHz**	**2kHz**	**4kHz**	**8kHz**	**dBA**
In-duct Lw	48	42	36	35	36	27	25	31	
Attenuator Insertion Loss	-2	-4	-8	-12	-13	-13	-9	-8	
Grille End Reflection Loss[3]	-12	-7	-3	-1	0	0	0	0	
Distance attenuation (50m)[1]	-46	-46	-46	-46	-46	-46	-46	-46	
Hemi-spherical radiation	-8	-8	-8	-8	-8	-8	-8	-8	
Directivity (worst case 0°)[4]	+1	+1.5	+2.5	+3.5	+4.5	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
Resultant Lp at receiver	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

MVHR (Cluster Unit) FA Intake	**63Hz**	**125Hz**	**250Hz**	**500Hz**	**1kHz**	**2kHz**	**4kHz**	**8kHz**	**dBA**
In-duct Lw	66	55	48	51	52	45	36	35	
Attenuator Insertion Loss	-2	-4	-8	-12	-13	-13	-9	-8	
Grille End Reflection Loss[3]	9	5	2	1	0	0	0	0	
Distance attenuation (50m)[1]	-43	-43	-43	-43	-43	-43	-43	-43	
Hemi-spherical radiation	-8	-8	-8	-8	-8	-8	-8	-8	
Directivity (worst case 0°)[4]	+1.5	+2	+3.5	+4.5	+5	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
Resultant Lp at receiver	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

MVHR (Cluster Unit) Exhaust	**63Hz**	**125Hz**	**250Hz**	**500Hz**	**1kHz**	**2kHz**	**4kHz**	**8kHz**	**dBA**
In-duct Lw	66	63	66	63	62	57	50	48	
Attenuator Insertion Loss	-2	-4	-8	-12	-13	-13	-9	-8	
Grille End Reflection Loss[3]	9	5	2	1	0	0	0	0	
Distance attenuation (50m)[1]	-43	-43	-43	-43	-43	-43	-43	-43	
Hemi-spherical radiation	-8	-8	-8	-8	-8	-8	-8	-8	
Directivity (worst case 0°)[4]	+1.5	+2	+3.5	+4.5	+5	+6	+6	+6	
Screening Loss[2] (no line of sight)	-5	-5	-5	-5	-5	-5	-5	-5	
Resultant Lp at receiver	**1**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**3**

Calculation Notes and References:

1. Correction from Sound Pressure Level (Lp) to Sound Power Level (Lw) has been calculated based on BS 3746: 1996 *"Acoustics – Determination of sound power levels of noise sources using sound pressure - Survey Method using an enveloping measurement surface over a reflecting plane"*

2. Correction for screening calculated in accordance with Maekawa Method. Note each receptor screened by edge of 200 Euston Road and intervening buildings.

3. Grille end losses based on CIBSE Guide B5 *'Noise and Vibration Control for HVAC'*

4. Grille directivity correction based on Flakt Woods *'Practical Guide to Noise Control'*

DOCUMENT HISTORY

ISSUE NO	DATE	DETAILS
0.1	12 September 2012	Document produced by Mark Brightwell and forwarded to Nicholas Jones for review.
0.2	13 September 2012	Document reviewed
1.0	13 September 2012	Document issued
1.1	26 October 2012	Document revised following comments from TP Bennett
1.2	29 October 2012	Document revised following comments from TP Bennett
1.3	3 January 2012	Document revised to include calculation details, following request from Camden Council