The Trevor Osborne Property Group

Buxton Crescent Hotel & Spa

Acoustic Strategy Report

R01

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Executive Summary

This report provides an initial acoustic review of the Buxton Crescent Hotel & Spa project. The acoustic design of this development will be a key factor in its overall quality and the guest's experience.

Acoustic standards have been proposed for three key acoustic elements; sound insulation, room acoustics and background noise levels. These standards are based on the acoustic standards of other 5* hotel operators (most particularly Hilton Hotels) and our extensive experience in the acoustic design of hotels. This project is also subject to Planning Condition 24 (relating to plant noise), Listed Building Consent Condition 12 (relating to internal sound insulation) and the requirements of the Building Regulations.

Since the buildings are listed, there will be a limit to the alterations that can be implemented and so achieving the proposed acoustic standards will be particularly challenging, and in some cases may not be feasible. The two key acoustic challenges are likely to be providing sufficient areas of acoustically absorbent finishes within the existing rooms to achieve the room acoustic requirements, and upgrading the existing constructions to achieve the proposed sound insulation standards. Initial guidance has been provided on these issues, and significant further investigation and design work is required to develop the acoustic design with the team.

From our initial review, the existing buildings appear to offer good potential to achieve high acoustic standards that will be a key factor in the success of this hotel.

1 Introduction

This report provides an initial acoustic review of the Buxton Crescent Hotel & Spa project, which will be formed by converting and extending a number of listed buildings to form a 5* Spa Hotel with Conference and Banqueting facilities. The existing buildings were built around 1780 and designed by the architect John Carr.

The acoustic design of this hotel will be a key factor in its overall quality and the guest's experience, and high acoustic standards will be required throughout. The three key acoustic factors are sound insulation, room acoustics and background noise levels; and acoustic design standards have been proposed for each. The standards proposed are typical of 5* hotels and so are relatively onerous.

Since the buildings are listed, the extent of alterations that can be made will be limited and so it may not be possible to achieve the proposed standards in all cases. At this stage detailed information is not available on the existing constructions or any limitations on upgrading measures, and so it is not possible to determine whether the proposed standards can be achieved. However, this will be considered further as the design progresses and we will advise accordingly.

We will provide separate detailed reports on each of the three key acoustic issues following further detailed design. Appendix A of this report provides an explanation of the acoustic terminology used, and Appendix B provides outline guidance on noise control of building services plant.

2 Acoustic design criteria

We are aware that Danubius is very familiar with Hilton hotels and so we have reviewed their latest acoustic design document "Brand Standards Section 2500.00: Design & Construction" (1/7/10). This document provides a comprehensive set of acoustic design criteria which are appropriate for 5* hotels, and so we have based the following criteria on this document together our extensive experience in this area.

It is also worth noting that the Building Regulations specify minimum acoustic standards for hotels, and so these will need to be achieved wherever possible. However, in many cases the standards required by the Building Regulations are significantly lower than the Hilton and other 5* hotel standards, and so should not be considered as acceptable design targets for this project.

2.1 Planning Conditions & Listed Building Consent

We understand that there are Planning and Listed Building conditions which are reproduced as follows:

- Listed Building Consent Condition 12 – "Details of sound proofing shall be agreed in writing with Local Planning Authority."
- Planning Condition 24 – "All inlet and extract ventilation systems shall be fitted with effective silencers in accordance with an acoustic specification to be agreed in writing by the Local Planning Authority. The approved silencers shall be installed prior to the commencement of the use of the development and maintained thereafter."

The Listed Building condition relates to sound insulation standards, and will most likely involve achieving the acoustic standards of Approved Document E (discussed later in this report). We will make contact with the Local Authority to discuss this when further details of the existing constructions and limitations of upgrading measures are available.

We have made initial contact with the Environmental Health department (Peter Hollingsworth) regarding planning condition 24, and understand that they require the plant noise specification to be based on a BS4142 assessment. They require that the Rating noise level of the new plant at the nearest noise sensitive building (dwellings etc) does not exceed the existing background noise levels. In order to determine the typical background noise levels it will be necessary to carry out a noise survey of the site, and we will advise further on this planning condition when the results of this survey are available.

2.2 Room acoustics

Generally the most important and measurable room acoustics parameter is the Reverberation Time (RT). The RT of a room relates to the time it takes for a sound to decay, once the source has stopped. 'Live' spaces such as churches have long RT's, whilst 'dead' spaces such as TV studios have short RT's. The RT of a space is a function of a number of factors, the most important being the physical volume of the room and the acoustic absorption provided by its finishes. Since the room volumes are fixed the main method of controlling the RT is by adding acoustically absorbent finishes.

The RT needs to be appropriate for the use of the space, and rooms intended to be used for speech based events (conference rooms etc) require a short and controlled RT to achieve good standards of speech intelligibility.

2.2.1 Public areas

Based on the Hilton design standards and our experience we would propose the following RT criteria.

Room	Maximum RT, seconds
Conference rooms 1 to 3	0.8
Reception	1.5
Assembly room (speech/amplified music based events)	1.0
Bar, Restaurant, Reception/Card room, Drawing / Living room	1.0

Table 1: RT criteria, average of the octave band values between 500Hz to 2kHz

These criteria apply to unoccupied and fully furnished rooms.

2.2.2 Common areas

Another important factor will be controlling noise within common areas of the hotel (stairwells, corridors etc) particularly for common areas directly adjacent to guest rooms. Both the Building Regulations and the Hilton design guide have a requirement for including acoustic absorption in these areas. The simplest way to achieve this requirement would be to provide an area of acoustic absorption to the space which is at least equivalent to its plan area, and this area can be applied to its floor, ceiling or walls. The most effective method to achieve this is to carpet these areas (eg by using a thick carpet on underlay), which is also strongly recommended since it can significantly reduce footfall noise.

2.3 Sound insulation

2.3.1 Building Regulations

As discussed above, hotels are covered by the current Building Regulations as they are classed as containing 'rooms for residential purposes'. The relevant performance standards from Approved Document E for 'rooms for residential purposes' and assuming the buildings will be undergoing a 'material change of use' are as follows:

Airborne sound insulation	
Party Walls/Floors/Stairs	$\geq$ 43dB$D_{nT,w+Ctr}$
Walls within rooms	$\geq$ R_w40
Doors	Minimum weight of 25 kg/m², or a minimum sound insulation of R_w29
Impact sound insulation	
Party Floors	$\leq$ 64dB$L'_{nT,w}$

Table 2: Approved Document E sound insulation criteria

Approved Document E acknowledges that achieving these standards may not always be possible in historic buildings and suggests the following:

- "the aim should be to improve sound insulation to the extent that it is practically possible, always provided that the work does not prejudice the character of the historic building, or increase the risk of long-term deterioration to the building fabric or fittings."
- "In arriving at an appropriate balance between historic building conservation and improving sound insulation it would be appropriate to take into account the advice of the local planning authority's conservation officer. In such cases it will be reasonable to improve the sound insulation as is practical, and to affix a notice showing the sound insulation value(s) obtained by testing in accordance with Regulation 20A or 12A, in a conspicuous place inside the building."

2.3.2 Proposed sound insulation standards

The Hilton design guide provides a matrix for defining sound insulation standards between adjacent areas, and the relevant standards for the Buxton adjacencies are proposed as follows. We will update this table as the design develops and further details of the adjacencies become available.

Airborne sound insulation (walls & floors)	
Guestroom to Guestroom (walls and floors)	≥ 55dBR'_w
Guestrooms to all other rooms (bar, meeting rooms, offices etc)	≥ 60dBR'_w
Walls within Guestrooms (to ensuite)	≥ R_w45
Conference room to Conference room	≥ 55dBR'_w
Airborne sound insulation (doors)	
Guestrooms, Conference rooms (and adjacent lobbies), Assembly room	≥ R_w35
Executive lounges, offices	≥ R_w30
Impact sound insulation (floors)	
Guest room to Guest room	≤ 50dB$L'_{nT,w}$
Guest room to Conference rooms	≤ 55dB$L'_{nT,w}$
Conference rooms to Living/drawing room	≤ 55dB$L'_{nT,w}$

Table 3: Proposed sound insulation criteria

2.4 Background noise

The background noise within internal spaces will be dictated by two key factors: building services noise (ventilation etc) and intrusive external noise (road traffic noise entering the rooms via windows etc). It is important that background noise levels are suitably controlled as they can have a significant impact on a guest's experience of the hotel and are a key factor in the use of some spaces.

2.4.1 Building services noise

Based on the Hilton design guide and our experience, we propose the following criteria for services noise:

Room	**Maximum building services noise level (NR)**
Guestroom (at bedhead)	NR25
Guestroom bathroom	NR35
Conference rooms 1 to 3	NR30
Assembly room	NR25*
Drawing/living room	NR35
Lobbies, reception, guest corridors, public toilets	NR40
Bar, restaurant, retail units	NR35
Staff toilets/changing	NR45
Back of house / service areas	NR45
Kitchens	NR45
Offices	NR35

Table 4: Building services noise criteria

* Further guidance on the likely use of this space is required. NR25 should be suitable for conferences etc, although NR20 would be more desirable for classical music recitals. Please refer to Section 3.1.1.

As discussed in Section 2.1, there is a planning condition relating to the external noise of plant and we will provide the relevant noise limits when the results of the noise survey are available. Also the design of the plant needs to consider external noise transfer to the hotel, and ensure that the noise limits in Table 4 are not exceeded (eg external chiller noise intrusion in a guestroom via an open window etc).

2.4.2 Intrusive noise

From our initial site visit the existing buildings appear to be located in an area with relatively low external noise levels, and so intrusive noise is not anticipated to be a major concern. However, based on our experience and the guidance presented in BS8233 for intrusive noise to bedrooms it would be prudent to consider this in more detail, and assess whether the current constructions are capable of achieving internal noise levels suitable for a 5* hotel, which would be as follows:

- Daytime (07:00-23:00): 35dB$L_{Aeq,16h}$
- Night-time (23:00-07:00): 30dB$L_{Aeq,8h}$ / 45dB$L_{Amax(fast)}$

In order to advise on this it would be necessary to carry out a noise survey at the site, to determine typical external noise levels. From our site visit we would expect that the building façades and roof structure will achieve a high degree of reduction to intrusive noise and that their weakest element will be the windows.

3 Initial review of the scheme

3.1 Room acoustics

Acoustically absorbent finishes will be required in most spaces within the building, and it is important to consider this early in the design. The heritage constraints are likely to limit the type and amount of these finishes that can be integrated into the design and so achieving an appropriate room acoustic in all spaces will be challenging, and needs to be considered in conjunction with architect and interior designer. However, there is a vast range of acoustically absorbent finishes available dependent on the required aesthetic, the following lists a few examples:

- Finishes that look like painted plaster: Fellert, Sonacoustic, Baswaphon, Monoacoustic. These types of finish can also be obtained in board form, eg Claro and Mikropor M.
- Fabric / Felt finishes: Fabritrak, Acousticpearls, Soft-cells, Fibreline.
- Perforated timber finishes: Decoustics, Gustafs, Topakustik.
- Perforated plasterboard: British-Gypsum.
- ‘Acoustic pictures’: AcousticArtPanels.

3.1.1 Assembly room

At this stage it has not been possible to carry out acoustic measurements in this space, and the following comments are based on our initial inspection. The hall has a large volume and predominantly 'hard' and acoustically reflective surfaces, which are likely to provide a high degree of reverberance (a long RT). Also, many of the surfaces are profiled with cornicing, ornate plasterwork etc, which will provide a significant degree of sound diffusion (ie achieve a good quality 'warm' sound). These factors should provide good room acoustics for chamber music (string quartet, solo instrument recitals etc) and so these types of events would be the most appropriate use for the natural acoustic of the hall (perhaps in conjunction with the Opera House).

At this stage detailed information is not available regarding the proposed uses of this hall, although we understand that typical events might be wedding receptions, banqueting etc. These types of event greatly benefit from the space having a short reverberation time to provide good speech intelligibility, enhance the quality of amplified music, reduce occupational noise etc. A suitable criterion for these types of use would be 1second (please refer to Section 2.2) and it would be necessary to incorporate significant areas of acoustically absorbent finishes in to the space to achieve this.

However, we very much doubt whether the aesthetic/heritage constraints would allow the required areas of acoustically absorbent finishes to be integrated into this space to achieve the proposed RT. One option that might be considered would be to provide acoustic drapes, which can be deployed in the hall for these types of event and then retracted/removed for classical music recitals (ie they would allow the acoustic of the hall to be tailored to the particular event).

This issue needs to be discussed further to determine what options are available, and of course this will be driven by the business model for the operator's proposed use of the hall.

3.1.2 Spa areas

Since many of the surfaces in the spa will need to be 'hard' for hygiene reasons, they are intrinsically acoustically reflective. This will lead these spaces to become overly reverberant and noisy, without the introduction of additional absorption, which is not conducive to a relaxing environment. Therefore, to reduce occupational noise levels and 'soften' the acoustic of these spaces we strongly recommend that they are provided with acoustically absorbent finishes. Initial recommendations are as follows:

- Large open plan areas (including pool areas, circulation, reception etc) – acoustic absorption to their full ceiling area. Factors such as humidity need to be considered in the selection of the acoustic finish, however there are options that appear to be suited to these types of environment. In particular the Fellert acoustic plaster appears to be suitable, please refer to this case study: Fellert. Another option might be a suspended absorber such as: Fabrasorb or Microsorber.
- Cellular rooms (treatment rooms, offices etc) – generally these rooms should have an acoustically absorbent ceiling or suspended acoustic rafts achieving a minimum α_w of 0.7. Options might be: Ecophon and SAS.

3.1.3 Conference rooms

The room acoustic of these rooms will be critical to their use, particularly for speech based events. Generally, they will require a carpeted floor and large areas of acoustic absorption to their ceiling with strategically placed wall absorption to achieve the RT criteria proposed in Section 2.2. The achievement of the proposed criteria is important to maximise speech intelligibility (ie speech intelligibly reduces with increasing RT).

Heritage considerations may limit the extent of acoustic finishes that can incorporated into these rooms, and this needs to be considered further. One option might be to replace the existing plaster with ‘acoustic plaster’ (refer to Section 3.1), which could have the same appearance as the existing plaster. Also, drapes / tapestries can provide useful acoustic absorption. Once initial decisions have been made regarding finishes we will carry out detailed calculations to assess compliance with the proposed RT criteria, and advise further.

A carpeted floor and acoustically absorbent ceiling is strongly recommended in the circulation areas directly adjacent to these rooms.

3.1.4 Other hotel areas

As discussed in Section 2.2, the Building Regulations require that common areas of the hotel (stairwells, corridors etc) are provided with acoustic absorption, and the simplest way to achieve this requirement is to carpet these areas (eg by using a thick carpet on underlay), which is also strongly recommended to minimise footfall noise. Generally, acoustic treatments to other areas will need to be:

- Offices – carpeted floor with acoustically absorbent ceiling or suspended acoustic rafts.
- Guestrooms - carpeted floor.
- Bar, Restaurant, Reception/Card room, Drawing / Living room - carpeted floor with acoustically absorbent ceiling or suspended acoustic rafts.
- Reception - acoustically absorbent ceiling or suspended acoustic rafts.

Please refer to Section 3.1.2 for details of the acoustic ceilings etc. Section 2.2 provides RT criteria for the Bar, Restaurant, Reception/Card room, Drawing / Living room and Reception (based on the Hilton design guide) and we will carry out calculations to determine whether the proposed finishes are capable of achieving these criteria.

3.2 Sound insulation

The existing buildings are of a traditional masonry construction with substantial masonry walls and timber floors. From our initial site inspection and discussions with the team, there appear to be various different types of wall and floor construction within the buildings. Some of the floors have a layer of ‘pugging’ which is a traditional method to improve their sound insulation by increasing the overall mass of the floor. However, in many cases the walls and floors appeared to be in poor condition with large areas of the pugging missing, holes through floors, missing floor boards etc.

Ideally we would measure the sound insulation of each type of wall and floor construction onsite, but from our initial site visit, this does not appear to be possible with the buildings in their current condition. However, there may be other areas within the buildings that are in better condition, and it would be worth investigating this further. If it is not possible to carry out tests during the design stages we strongly recommend that they are carried out as early in the construction phase as possible (ie by testing a pair of mockup rooms).

3.2.1 Floors

From Section 2.3 it can be seen that the airborne sound insulation standards required for floors will generally be R'_w55 (between guestrooms) and the highest standard will be R'_w60 between guestrooms and other areas (ie the retail units). These are high standards and consideration will need to be given to both the direct (ie sound passing through the floor) and indirect sound paths (sound flanking around the floor via walls, cavities etc).

A key aspect of the indirect sound transmission will be sound flanking via the walls common to the rooms above and below the floor. Generally the main factors that control a wall's flanking are its mass (flanking transmission reduces with increasing mass) and whether it has any linings (lath and plaster, plasterboard etc).

For initial guidance, if the flanking walls do not have linings or achieve a mass equivalent to around 300mm brickwork, then they will most likely require plasterboard linings to control their flanking transmission (ie ensure that they do not compromise the floor sound insulation). However, this is highly dependent on the construction and integrity of the existing flanking walls and so needs to be reviewed in detail when further information is available.

The most effective method to determine the flanking of these existing walls (and gain certainty on the need for additional linings) would be to test a pair of rooms onsite. As discussed above, these tests would ideally be carried out as soon as possible if a suitable pair of rooms can be found. However, if suitable rooms are not currently available, then it may be possible to achieve suitable test conditions with some simple remedial works (temporarily fixing sheets of plasterboard/MDF over doors, windows etc).

We will carry out a detailed review of the actual floor constructions, however, a typical dry construction that is capable of achieving around R'_w60 (with suitable flanking control) is:

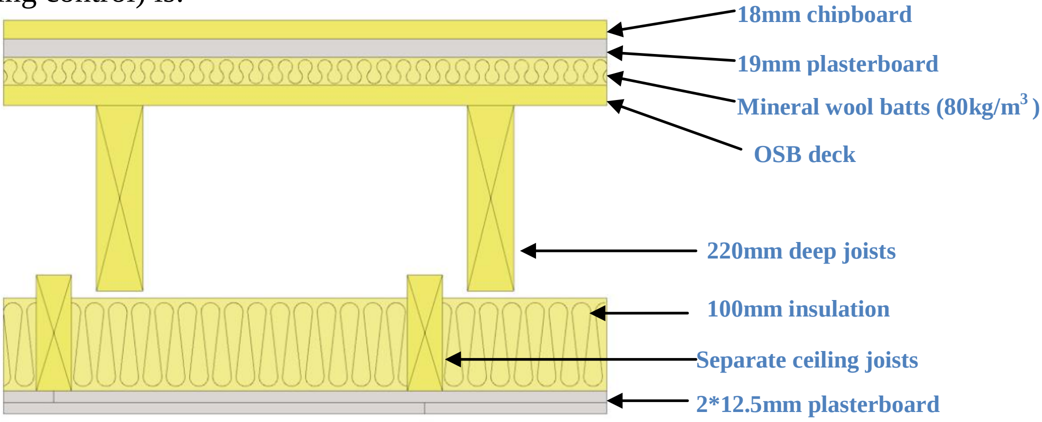


Figure 1: Typical construction capable of achieving R'_w60

The key elements of this construction are the mass provided by the upper boards and the fact that they are isolated from the floor (by 'floating' them on the mineral wool), the large cavity between the upper and lower boards, and the mass provided by the lower boards and their isolation from the main construction (ie supported on separate joists). Generally the existing floors will need to be developed to achieve this type of double construction principle.

There are many ways to achieve this, such as: adding floating floors, removing the existing floor boards and replacing them on resilient clips (eg BritishGypsum_Gypfloor_Silent), adding new plasterboard ceilings on resilient hangers or separate joists etc. Since there is not likely to be sufficient space available above the existing floors to accommodate floating floors, other innovative measures will be developed to achieve the required degree of isolation.

From our initial review of the AECOM drawings, many of the floor constructions offer good potential to achieve the above requirements (eg have large cavities, separate joists etc). In addition to the above it will be necessary to determine if any other specific weaknesses exist which could compromise the sound insulation of the floors such as chimney flues, flanking via the windows etc.

The above discussion focuses on airborne sound and the floors will also need to achieve the proposed standards for impact sound insulation. Generally, if the floors have a carpet on underlay and are developed to achieve the above principles then they are likely to be able to achieve the impact sound insulation requirements.

Carpets have other significant acoustic benefits (controlling reverberant noise etc) and so are strongly recommend wherever possible. In cases where carpets are not possible (bathrooms etc) then some form a resilient layer will need to be incorporated below the walking surface (below the bathroom tiles etc) a typical product might be: Regupol4515.

In particular, there are circulation areas on upper floors that are directly above bedrooms. It is very important that these circulation areas are carpeted with underlay, and that the ceilings to the bedrooms below are supported on separate joists.

3.2.2 Walls

From our initial review of the adjacencies, the highest standard of wall sound insulation required is R'_w55. Generally it should be possible to achieve this standard with 300mm thick dense masonry, assuming that indirect transmission is suitably controlled (as discussed above). Controlling these indirect sound paths will be a key issue, as factors such as back to back fireplaces, flanking via external walls common to both rooms etc could significantly compromise the wall performance onsite.

As discussed in relation to floors, any flanking walls adjacent to the party walls (ie common to rooms both sides of them) will either need to achieve a mass equivalent to around 300mm brickwork, or will require plasterboard linings (which may also be achieved with existing lath and plaster linings). From our initial review, the party walls generally appear to be around 300mm thick brickwork, but the walls to corridors, stairwells etc have a thinner brickwork construction. This requires further consideration when further details of the existing constructions are available.

In some cases the drawings show separating walls that are less than 300mm thick masonry, and so these will need to be upgraded to achieve R'_w55. A typical option to achieve this might be to add an independent plasterboard lining to the wall (eg British-Gypsum-IWL), and we will advise on specific constructions when further details of the existing constructions are available.

We have recommended a sound insulation standard of R_w45 for walls between guestrooms and their ensuites etc, and it should be possible to achieve this standard with: 2x12.5mm plasterboard both sides of a 70mm metal stud.

3.2.3 Assembly room kitchen

The new location of this kitchen is advantageous as it is no longer directly below the hall, however, it is now located directly below a guest bedroom. Due to the limitations of the existing constructions it is not likely to be possible to reduce the kitchen noise to provide acceptable levels in this guestroom, and so we recommend that this room is classified for a non-noise sensitive use (eg a store, maid's room, heritage bedroom etc).

3.2.4 Doors

Wherever possible, we recommend that acoustically rated doors (ie those identified in Table 3 above) are procured as an acoustic doorset (frame, acoustic seals, leaf) from a specialist supplier, who can provide acoustic test data demonstrating their performance. We understand that various suppliers can provide 'heritage' doors with acoustic ratings, for example: Longdendoors. Generally, all acoustically rated doors should be at least 54mm thick solid core timber doorsets and will require effective acoustic seals to their head, jambs and threshold.

We understand that some of the existing heritage doors need to be retained and so it is unlikely that they will be able to achieve the proposed sound insulation standards. We will advise further on this as the design progresses.

3.2.5 Retail units

There are small retail units shown directly below guestrooms and it will be important to ensure that noise associated with these units does not disturb the guests. We understand that the units will be used as boutique shops and so their operational noise levels will not be excessive, and will mostly likely be due to speech and possibly some low level background music.

The Hilton design guide does not specifically cover this adjacency, however it does cover similar spaces (for which it suggests a sound insulation of R'_w60) and also suggests that noise intrusion to the guestrooms from adjacent demises must not exceed $25dBL_{Aeq,5min}$ and $35dBL_{Amax(fast)}$. We therefore propose:

- Target R'_w60 for the separating floors.
- Include noise criteria in the tenancy agreements based on achieving the above noise criteria. We will provide suitable clauses when appropriate.

3.2.6 Assembly room

The hall is fairly well separated/buffered from the rest of the crescent buildings which should provide a good degree of sound reduction and flexibility in its use. However, there are paths for structureborne noise to transfer to the nearby guestrooms (ie structural connections), and so a degree of management will be required over the use of the hall (and in particular its noise levels) to avoid disturbing these guestrooms. A similar consideration applies to the nearby residential areas. Since it is unlikely to be possible to significantly upgrade the sound insulation of the hall's windows, it will be necessary to manage its noise levels to avoid disturbing these areas. These weaknesses could result in noise limits that would render it unsuitable for parties and receptions with high amplified sound levels.

Ideally all entrances to the hall from circulation spaces and the kitchen would be via sound lobbies, ie acoustic door – short lobby with acoustically absorbent finishes – acoustic door. This is particularly important in the case of the kitchen, although it may be difficult to add lobbies to the doors to other areas.

3.2.7 Conference rooms

The current drawings show single doors between the conference rooms and these will significantly limit the sound insulation that can be achieved between these rooms, which will significantly limit their simultaneous use. It is worth noting the Hilton standard between Meeting/Board/Training rooms which is R'_w50, and it would not be possible to even approach this with single doors (particularly if existing doors need to be used). We strongly recommend that these doors are reconsidered and that these openings are in-filled with a similar construction to the surrounding wall. Failing this, back-to-back acoustic doorsets are recommended.

Also the conference rooms have grilles in their ceilings which we understand are likely to be part of a previous natural ventilation system (which possibly exhausted air to the roof via the ceiling plenum and a duct that is now a lift shaft). These grilles/openings will seriously compromise the sound insulation performance of the ceiling/floor to the guestrooms above and so will need to be made good with a similar construction to the ceiling. Any other openings in the sound insulating constructions of these rooms (walls etc) will also need to be identified and made good. We will advise further on this as further details become available.

3.2.8 Spa

We understand that none of the rooms within the Spa are particularly acoustically sensitive and generally have no specific sound insulation requirements. The consulting room and office are likely to require some degree of speech privacy from adjacent areas (although both benefit from being fairly isolated) and so we recommend that they have R_w30 doors, the walls containing their doors are rated at R_w45 and that their other walls (to adjacent internal spaces) are rated at R_w50. Typical drywall constructions to achieve these standards are as follows:

- R_w45 – 2x12.5mm plasterboard both sides of a 70mm metal stud.
- R_w50 – 2x12.5mm plasterboard both sides of a 70mm metal stud, with 50mm mineral wool in the cavity.

3.3 Building services noise

Controlling building services noise will be critical to the success of the building and achieving the noise criteria proposed in Section 2.4.1. Outline guidance on key issues relating to building services noise and vibration control is provided in Appendix B. There is a planning condition relating to the external noise levels due to building services plant, and we will advise on suitable noise limits when the results of the noise survey are available.

Appendix A

Acoustic terminology

A1 Acoustic terminology

A1.1 Decibel

The ratio of sound pressures which we can hear is a ratio of 106 (one million:one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the ‘sound pressure level’ (Lp) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

A1.2 dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. It is worth noting that an increase or decrease of approximately 10dB corresponds to a subjective doubling or halving of the loudness of a noise, and a change of 2 to 3dB is subjectively barely perceptible.

A1.3 Equivalent Continuous Sound Level

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

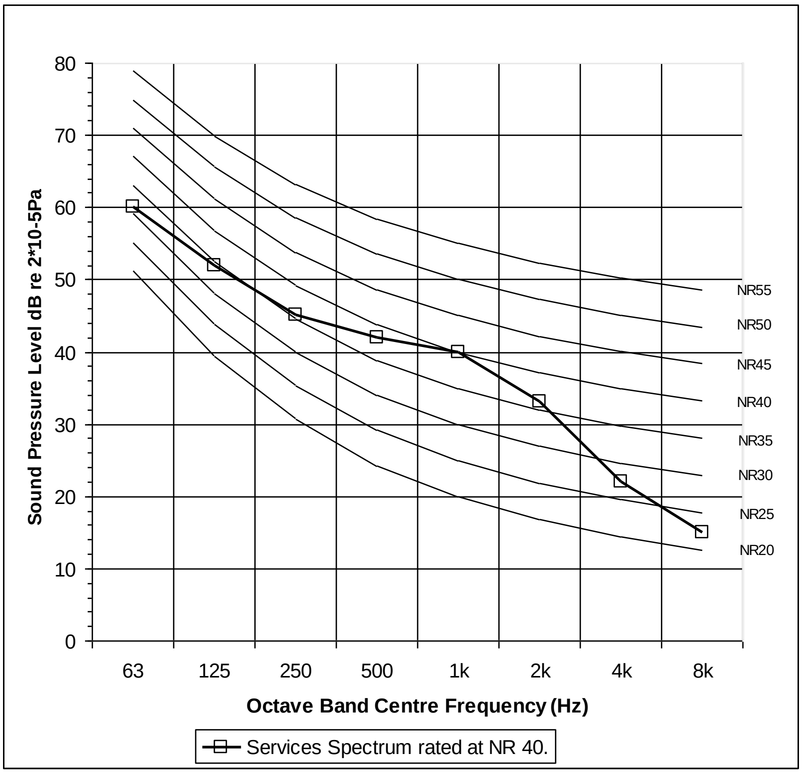
A1.4 Frequency

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kHz, eg 2kHz = 2000Hz. Human hearing ranges approximately from 20Hz to 20kHz. For design purposes, the octave bands between 63Hz to 8kHz are generally used. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For more detailed analysis, each octave band may be split into three one-third octave bands or in some cases, narrow frequency bands.

A1.5 Noise Rating (NR) Curves

Noise rating (NR) curves are a set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The NR value of a noise is obtained by plotting the octave band spectrum on the set of standard curves.

The highest value curve which is reached by the spectrum is the NR value. Shown below is a plant noise spectrum that is equivalent to NR40.



A1.6 Reverberation Time (RT60)

The time, in seconds, taken for a sound within a space to decay by 60dB after the sound source has stopped. An important indicator of the subjective acoustic within an auditorium.

A1.7 Sound Level Difference (D)

The sound insulation required between two spaces may be determined by the sound level difference needed between them. A single figure descriptor, the weighted sound level difference, Dw, is sometimes used (see BS EN ISO 717-1).

A1.8 Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, ie its attenuation properties. It is a property of the component, unlike the sound level difference which is affected by the common area between the rooms and the acoustic of the receiving room. The weighted sound reduction index, R_w , is a single figure description of sound reduction index which is defined in BS EN ISO 717-1: 1997. The R_w is calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site (which are invariably lower than the laboratory figures) are referred to as the R’w ratings.

A1.9 Statistical Noise Levels

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index which allows for this variation. The L_{10} , the level exceeded for ten per cent of the time period under consideration, has been adopted in this country for the assessment of road traffic noise. The L_{90} , the level exceeded for ninety per cent of the time, has been adopted to represent the background noise level. The L_{1} , the level exceeded for one per cent of the time, is representative of the maximum levels recorded during the sample period. A weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, eg $dBL_{A10,\ 5min}$ or $dBL_{A90,\ 8hr}$.

A1.10 Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, ie expansion joints and floating floors.

Appendix B

Guidance on building services noise control

B1 Guidance on Building Services Noise Control

B1.1 Introduction

Control of building services noise will be essential to the success of this development. The following report gives general guidance on noise control for the building services installations.

B1.2 Criteria

Target noise criteria for various spaces within the building are given in Section 2.4.1 above.

B1.3 Plantrooms & plant spaces

All Air Handling Units (AHUs), fans, pumps, and other rotating and reciprocating plant should be fitted with efficient anti-vibration mountings (AVMs).

Plant mounted on AVMs should be isolated by flexible connections from ducts, pipes and conduits.

Ideally, plantrooms should be located as far away as possible from noise sensitive spaces (eg seminar rooms etc).

Ducts between the AHU and associated primary attenuator (where this is duct mounted) should be externally acoustically lagged. Ductwork lagging will be required in other situations, especially where crosstalk could be an issue.

Ductwork and pipework in the plantroom / plant space, and ductwork and pipework in contact with structures bounding noise sensitive areas will need to be supported on anti-vibration hangers.

Riser shafts to and from plantrooms should be sealed so that they do not become noise transmission paths to other parts of the building.

B1.4 Attenuators

Primary attenuators should be fitted in the AHUs or in the ductwork before it leaves the plantroom. Acoustic ductwork lagging will be required as noted above.

Secondary attenuators will most likely also be required on systems serving noise sensitive spaces (seminar rooms etc). Crosstalk attenuators will also be required in certain situations in order to maintain the sound insulation integrity of acoustic structures, if secondary attenuators do not fulfil this function.

Acoustic lagging will be required to ductwork between secondary attenuators and the point of entry to a noise sensitive space. Similar provision will be required to ductwork associated with crosstalk attenuators (if any).

It is particularly important that there is sufficient space between AHUs / fans and the noise sensitive area served to accommodate the required attenuation, and to allow space between duct fittings to minimise regenerated noise.

Outline indications of attenuator sizes are given in Figure B1.

B1.5 Regenerated noise

Noise in ventilation systems is generated by the flow of air past diffusers, grilles, dampers, sound attenuators, turning vanes and duct fittings, as well as by the fan. The noise level generated at each location in the system depends on the air velocity and the local geometry and fittings. The ventilation systems need to be effectively designed to minimise airflow regenerated noise as far as possible.

Guidelines for air velocities are given in Figure B1.

Grilles and terminals should be carefully selected having regard to their noise characteristics.

If at all possible balancing dampers should not be used on systems serving acoustically critical spaces (eg seminar rooms etc). However, if these are absolutely necessary they must only be located on the fan side of the secondary / crosstalk attenuator, and only be used to provide a slight balancing resistance.

B1.6 Service penetrations

Service penetrations (ducts, pipes and electrical services) through walls, floors, and ceilings must be sealed in such a way that the acoustic integrity of the structure is maintained and vibration transfer is eliminated. Suitable details for sealing penetrations need to be developed at the appropriate stage.

This is of critical importance at the plantroom penetrations and penetrations to studios, control rooms, music practice rooms etc, and other areas where a high level of sound insulation is required.

B1.7 Routing of services in or near acoustically sensitive spaces

The routing of building services should be considered carefully by the design team early in the design. Services serving acoustically sensitive spaces must not be routed through noisy spaces or through other acoustically sensitive spaces. Services serving (only) other areas must not be routed through acoustically sensitive spaces. Noise can enter a duct or pipe in one space and be transmitted down the duct or pipe to another.

Rainwater pipes transmit noise from outside and radiate flow noise in storms. They should be routed outside acoustically sensitive spaces, and should not be attached to the structure of acoustically sensitive spaces. Similar care must be taken in routing of drainage pipes from showers, washbasins and toilets.

The use of 'low noise' pipework throughout the development should be considered eg Geberit.

B1.8 Crosstalk attenuation

Control of ‘crosstalk’ (noise from one room entering a duct and being transmitted through the duct to another room), will be needed between spaces that require acoustic separation but are served by a common air system, and also where ductwork passes through high performance structures. In many cases attenuators and areas of external acoustic lagging will be required (as discussed in section B1.4). Ducts serving adjacent acoustically sensitive rooms should be routed via the circulation spaces and not directly room-to-room, to reduce the requirements for crosstalk attenuation.

B1.9 External noise

Environmental attenuators, and possibly other means (such as acoustic louvres) will be required to control noise emanating from the plantrooms, air intake and discharge points or from externally mounted plant.

B1.10 Fan coil units

Many of the rooms within the building are noise sensitive (ie NR30 conference rooms, NR25 guestrooms) and it will be difficult to achieve such low noise levels if the fan coil units are located within the space they serve. If fan coil units are necessary, then they will need to be located outside of the space they serve and ducted-in via suitable attenuators. This needs to be considered early in the design to ensure that suitable space and cost allowances are made.

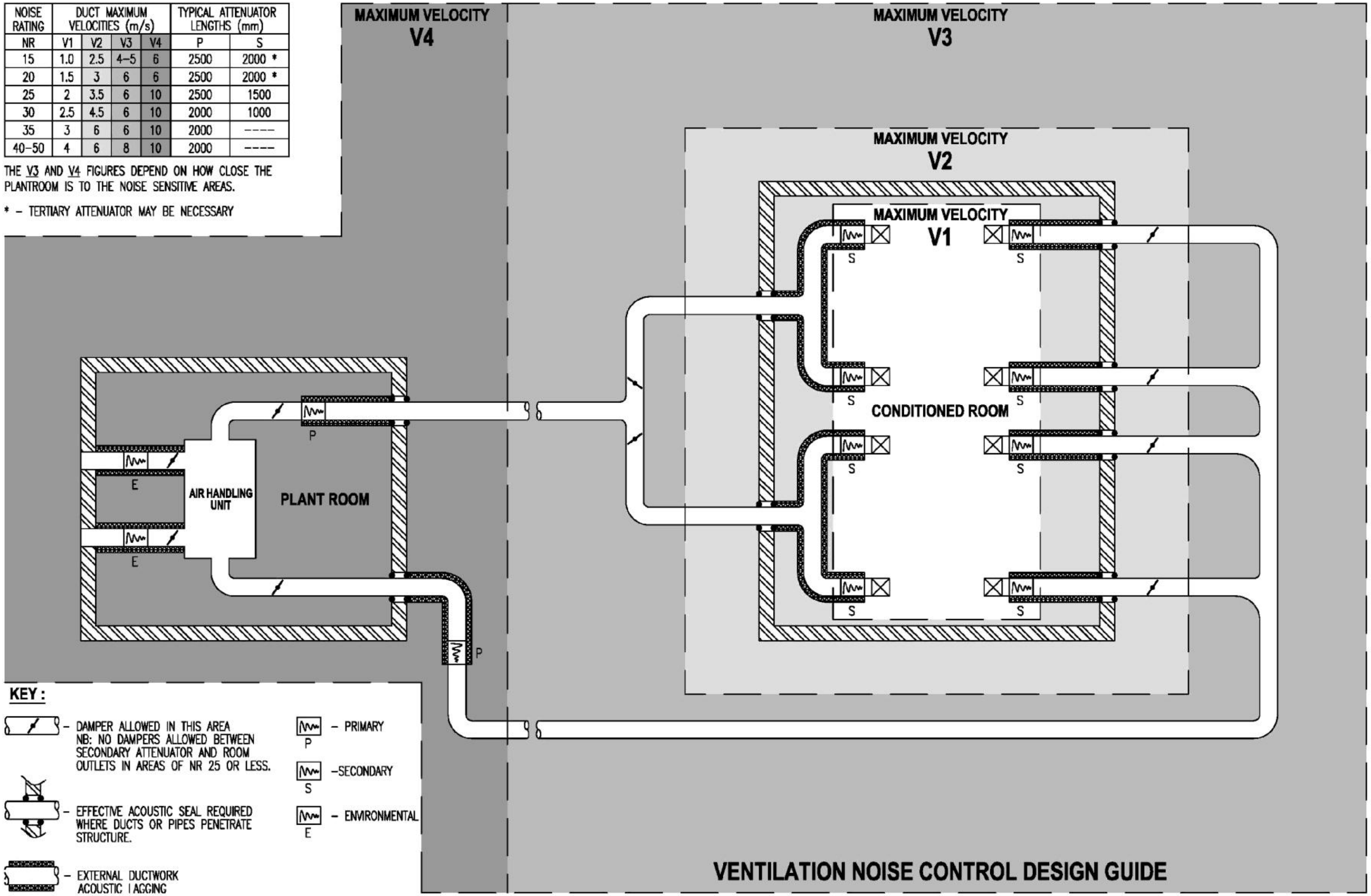
B1.11 Handriers

Due to the high levels of noise and vibration that some types of handrier can make, we recommend that they are not located on walls adjacent to noise sensitive spaces (guestrooms etc).

B1.12 Electrical

Mains transformers, dimmer racks and voltage regulators may have to be mounted on proprietary resilient pads if these items are in close proximity to noise sensitive areas.

It may be necessary to use surface mounted light fittings in acoustically critical spaces (eg recessed fittings could compromise the sound insulation of their ceilings etc). Also, light fittings in these critical spaces should be selected to be silent in operation.



NOISE RATING	DUCT MAXIMUM VELOCITIES (m/s)				TYPICAL ATTENUATOR LENGTHS (mm)	
NR	V1	V2	V3	V4	P	S
15	1.0	2.5	4–5	6	2500	2000 *
20	1.5	3	6	6	2500	2000 *
25	2	3.5	6	10	2500	1500
30	2.5	4.5	6	10	2000	1000
35	3	6	6	10	2000	----
40–50	4	6	8	10	2000	----

Figure B1: Guidelines for attenuators (location and typical sizes) and duct velocities