- Private & Confidential -

White Mark Limited

Fryderyk Chopin University of Music
Warsaw, Poland

- Acoustic Design Commentary Phase 1-

Our reference;
WML/2755 ADC

Suffolk, England

November 2013

- FRYDERYK CHOPIN UNIVERSITY OF MUSIC, WARSAW, POLAND –

Acoustic Design Commentary Document

This document has been created to answer the specific points raised in Annex No. 1, points 1 to 7. A number of assumptions have to be made about the final equipment selection and, where this has a material affect on the comments made, this will be specified.

1.0 Subject and scope of the study

This document outlines in general terms the approach to the acoustic design of the studio facilities, based on our entry to the concept design competition, as modified following initial discussions with representatives of the University. It covers the nature of treatments proposed and the design adopted to tailor the room performance from isolation and background noise level specification to operational level estimation and acoustic environment..

2.0 Formal basis for development of the design

The acoustic designs for the rooms, and for the facility as a whole, are intended to reflect both current best practice in the commercial recording and post-production studio marketplace and the specific needs of the university as an educational establishment. The design will draw upon the wide range of experience of the design team in recording, mixing and dubbing studios for music, broadcast and feature films. The solutions proposed will be based upon those described in WML's winning competition entry, modified in light of subsequent discussions. Levels of isolation achievable are based on current operating levels within studios and accepted noise floors for each operational class of room.

3.0 Characteristics of the facility

The current technical facilities have evolved in a piecemeal manner over the 50 years that the facility has been in use. Mechanical systems for ventilation and isolation elements such as the doors have deteriorated, in many cases broken altogether, and, together with cracking in the isolation structures due to subsidence of the structure, the acoustic separation of the rooms has inevitably deteriorated significantly. Monitoring levels and spatial distribution within Control Rooms have changed and, while the isolation performance of the spaces has reduced over time, both the dynamic range of the recording process and the higher monitoring levels expected have both combined to render the studios unsuitable for modern use.

4.0 General issues

The facilities as now proposed meet all of the current requirements for noise floor in the technical areas, all current standards for monitoring and can support the dynamic ranges of both the recording process and of the monitoring requirement of all current genres of output. It is unlikely that the dynamic range of either aspect of recording can change significantly as time progresses and thus the core structure of the facility should have an excellent life time looking into the future.

The rooms would cope with even the extreme requirements of Hip-Hop recording and monitoring but may need additional sub-bass units to meet market expectations. New standards of image related sound monitoring systems may be proposed as time passes but the main dubbing space (005) is being readied for Atmos, which is the very latest proposed 3D standard from Dolby. Future 3D standards may emerge based on Ambisonic sound-field creation but these must, of necessity, be mapped onto a conventional loudspeaker array and, commercially, this will need to be compatible with that set out by Dolby with Atmos. Structurally, the acoustic treatment of the rooms is based on an structurally sound method of creating the acoustic shell within each space and so, ultimately, this could be modified with little difficulty to accommodate most foreseeable changes that could be required.

The noise floors to be specified are close to the minimum that can be technically achieved given the need to cool and ventilate the occupancy figures that are understood to be required. There would, therefore, be no future improvement possible in this area of the design assuming maintenance regimes are correctly followed.

5.0 Utility and function description

The rooms to be included within the technical designs and their functions are listed, using the updated room numbering shown on WML drawings 2755-04 and 2755-05.

Room 002	Central Machine Room
Room 004	Main Live Room / Multimedia Space
Room 004A	Main 7.1 Music Control Room
Room 005	Film Mixing Room
Room 007	Secondary Stereo Music Control Room / E-Learning Control Room
Room 007A	Voice Over Booth
Room 008	Foley/ADR Control Room / Sound Design and Editing Room
Room 008A	Foley Recording Stage
Room 001	Projection Booth
Room 003	7.1 Mixing Room
Room 009	Anechoic Chamber

Various lobbies, cupboards and service voids will be formed in the course of the re-development, some of which will house local equipment racks or connection panels. These areas have not been allocated room numbers, but are identified according to whichever primary room they are associated with.

6.0 Design basis

This section offers a list of acoustic characteristics of each space with reference to the types of construction either existing or proposed in each area. The data offered here is based on the design target figures for reverberation time and isolation performance for each technical space. This is based on the currently understood construction methods to be undertaken and cannot take account of limitations subsequently imposed because of structural analysis, existing structure detail or substituted construction detail introduced as part of later design review or as a result of detailed examination made possible by demolition or other opening up of the existing building.

6.1 Soundproofing

6.1.1 Prediction of parameters of the rooms

The acoustic parameters that relate to sound proofing, or acoustic isolation, of each space are principally the anticipated noise floors within each space and the operating level anticipated. Later sections (principally 7.1 and 7.2) will deal with the sound leakage from each room into its neighbouring spaces and from the general circulation space into each room. To this end, each room is listed here with a tabulated operational sound level and a background noise level that will be used as a basis for design. Whilst many rooms will perform satisfactorily at higher sound levels it would appear wasteful to expend resources keeping the acoustic level high enough to contain unreasonable working sound levels. The figures tabulated below are offered for comment as a basis for design and are based on measurements made in operational studios by White Mark. The later section on room performance either uses these levels or higher as set out in each individual instance.

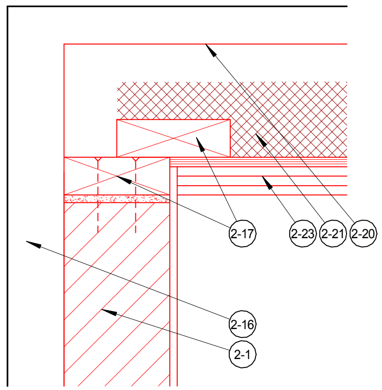
Room designation	**Background**	**Operational level (L_{max})**						
		31.5	**63**	**125**	**250**	**1k**	**2k**	**4k**
Main Control Room 004A	NC25	93	104	102	101	96	94	76
Atmos Room 005	NC25	100	105	105	102	100	98	96
Booth 007A	NC20	61	58	64	67	75	65	63
Control Room 007	NC25	93	104	102	101	96	94	76
Foley CR 008	NC25	82	92	92	88	91	91	91
Foley Studio 008A	NC15*	82	92	92	88	91	91	91
Control Room 003	NC 25	93	104	102	101	96	94	76
Corridor noise	NC35	88	76	78	73	77	82	73
Central Machine Room 002	NC40	88	76	78	73	77	82	73

* **Note:** The noise floor in the Foley Studio area is nominally set to NC15 as a specification for mechanical systems design; a review of the ground slab vibration noise generation needs to be undertaken and the operating level of the a/c system specified appropriately. This is based on the installation of a floating floor element being inappropriate in the case of Foley spaces, because of their function.

The ingress of operational noise into a quiet working environment should be judged against the anticipated noise level in the receiving space. Generally a disturbing noise level will only be noticed if it is above the ambient noise floor of the room. It should be noted, however, that low frequency rhythmic noises, such as the beats of loud music bass lines, should be attenuated to a level at least 5dB below the noise floor and ideally 10dB to remain inconspicuous.

6.1.2 Soundproofing parameters of building partitions

The following pages offer illustrations of the proposed partition types to be used in the development. Each type is analysed for isolation performance and this data is tabulated.



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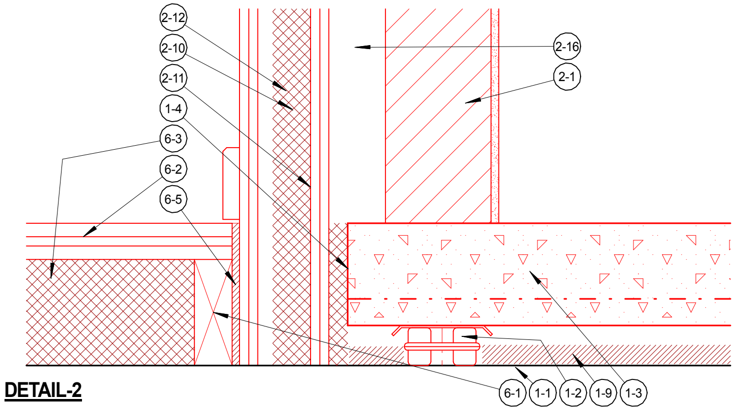
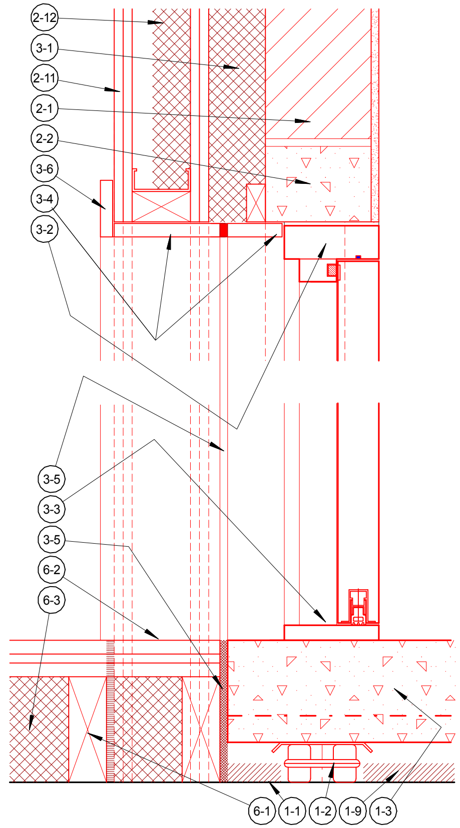
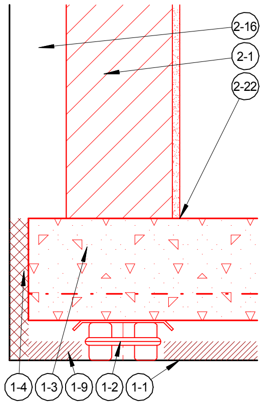


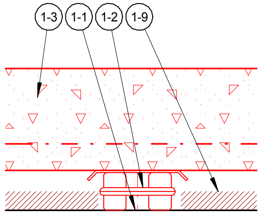
DETAIL-2



DETAIL-6



DETAIL-3



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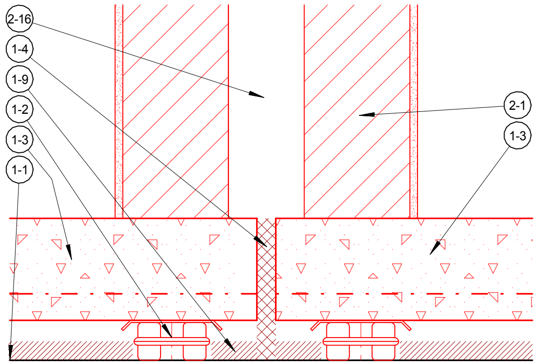

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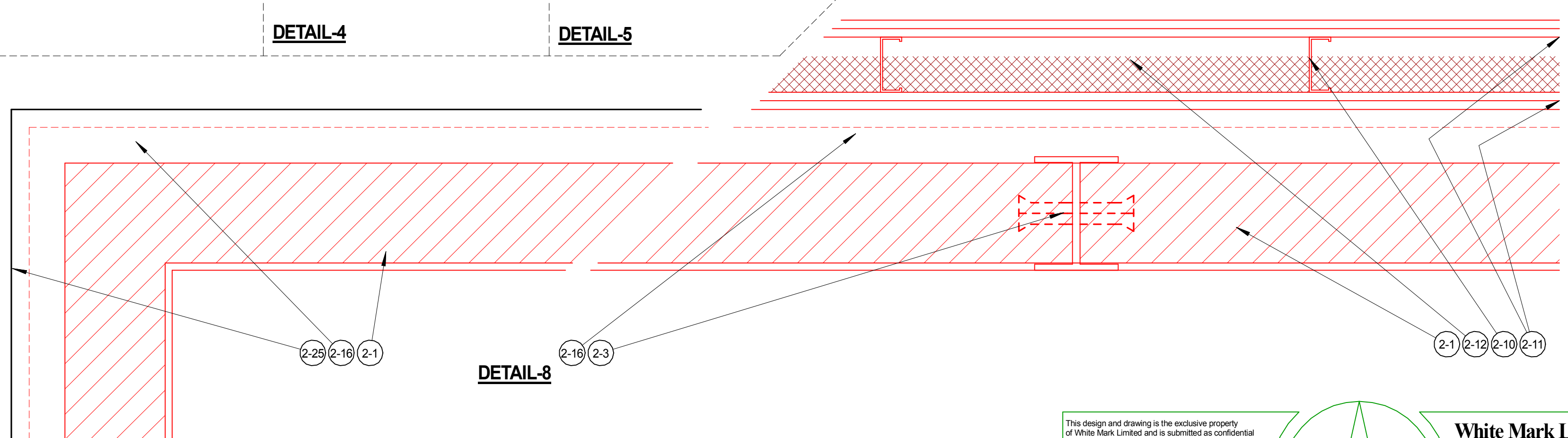

DETAIL-8

DETAIL-7

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Project: Fryderyk Chopin University of Music, Warsaw	Project No: 2755
	Drawing No: 200 / Revision: -
Title: Isolation Shell Details 140mm concrete block wall with concrete floor	Scale: 1:5 @ A2 / Date: Nov 2013

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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **27/11/2011**

Isolation Shell: 140mm Concrete Block wall WML -200 detail drawing

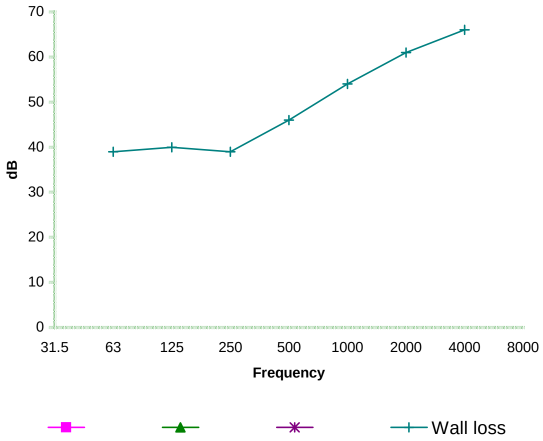
Fixed element: None

Studio wall: 140mm concrete block wall

Rw: 51

M-A-M resonance: NA

	Frequency	Wall loss
0	31.5	
1	63	39
2	125	40
3	250	39
4	500	46
5	1000	54
6	2000	61
7	4000	66
8	8000	



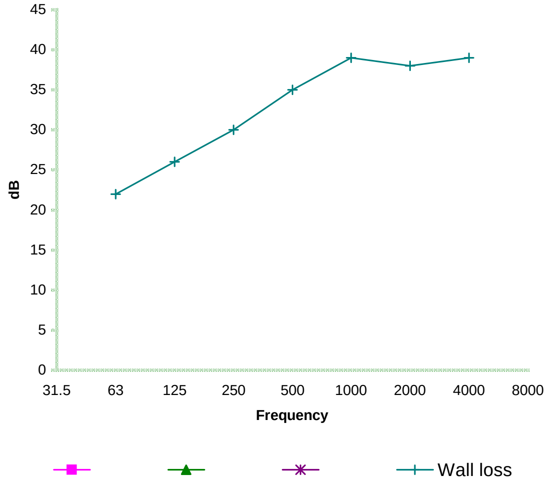
Fixed element: None

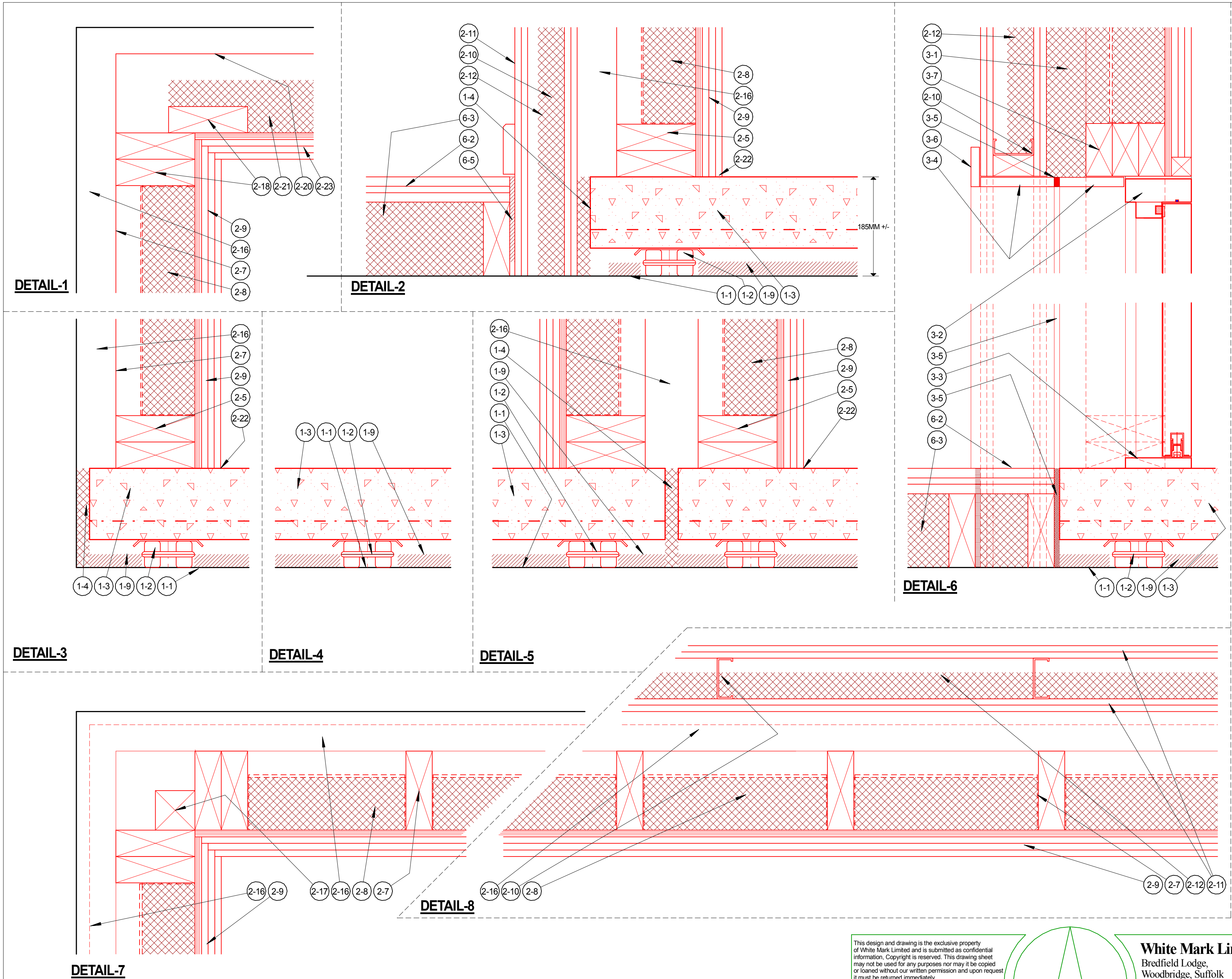
Studio Isolation Cap: One layer sheathing ply and three layers of plasterboard

Rw: 38

M-A-M resonance: NA

Frequency	Wall loss
31.5	
63	22
125	26
250	30
500	35
1000	39
2000	38
4000	39
8000	





Please note this drawing must be read in accordance
with the specification and any other related drawings.

Do not scale from this drawing, check and notify
White Mark Limited of any incorrect site dimensions.

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Project:	Fryderyk Chopin University of Music, Warsaw
Title:	Isolation Shell Details 150mm stud wall with concrete floor
Project No:	2755
Drawing No:	201
Revision:	-
Scale:	1:5 @ A2
Date:	Nov 2013

White Mark Limited

Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **27/11/2011**

Isolation Shell: Laminate wall WML -201 detail drawing

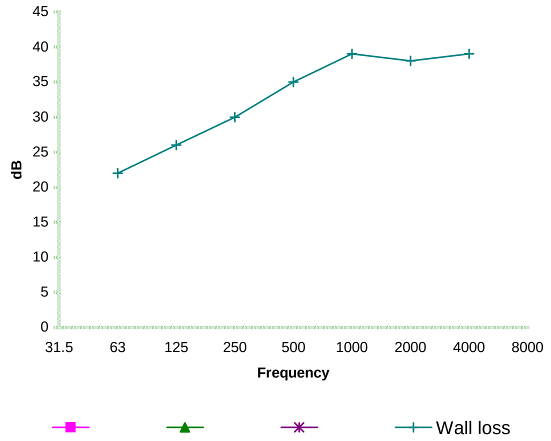
Fixed element: None

Studio wall: One layer sheathing ply and three layers of plasterboard

Rw: 51

M-A-M resonance: NA

	Frequency	Wall loss
0	31.5	
1	63	22
2	125	26
3	250	30
4	500	35
5	1000	39
6	2000	38
7	4000	39
8	8000	



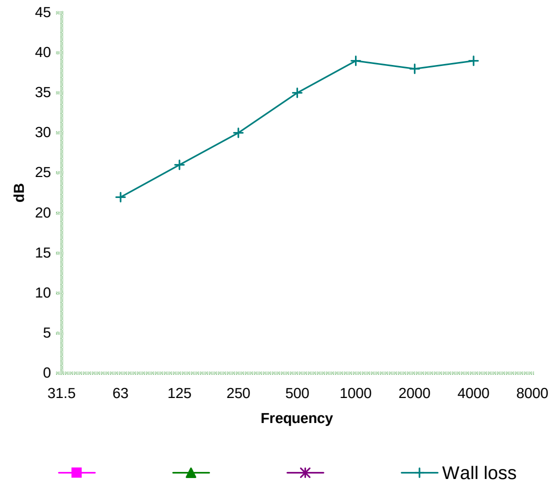
Fixed element: None

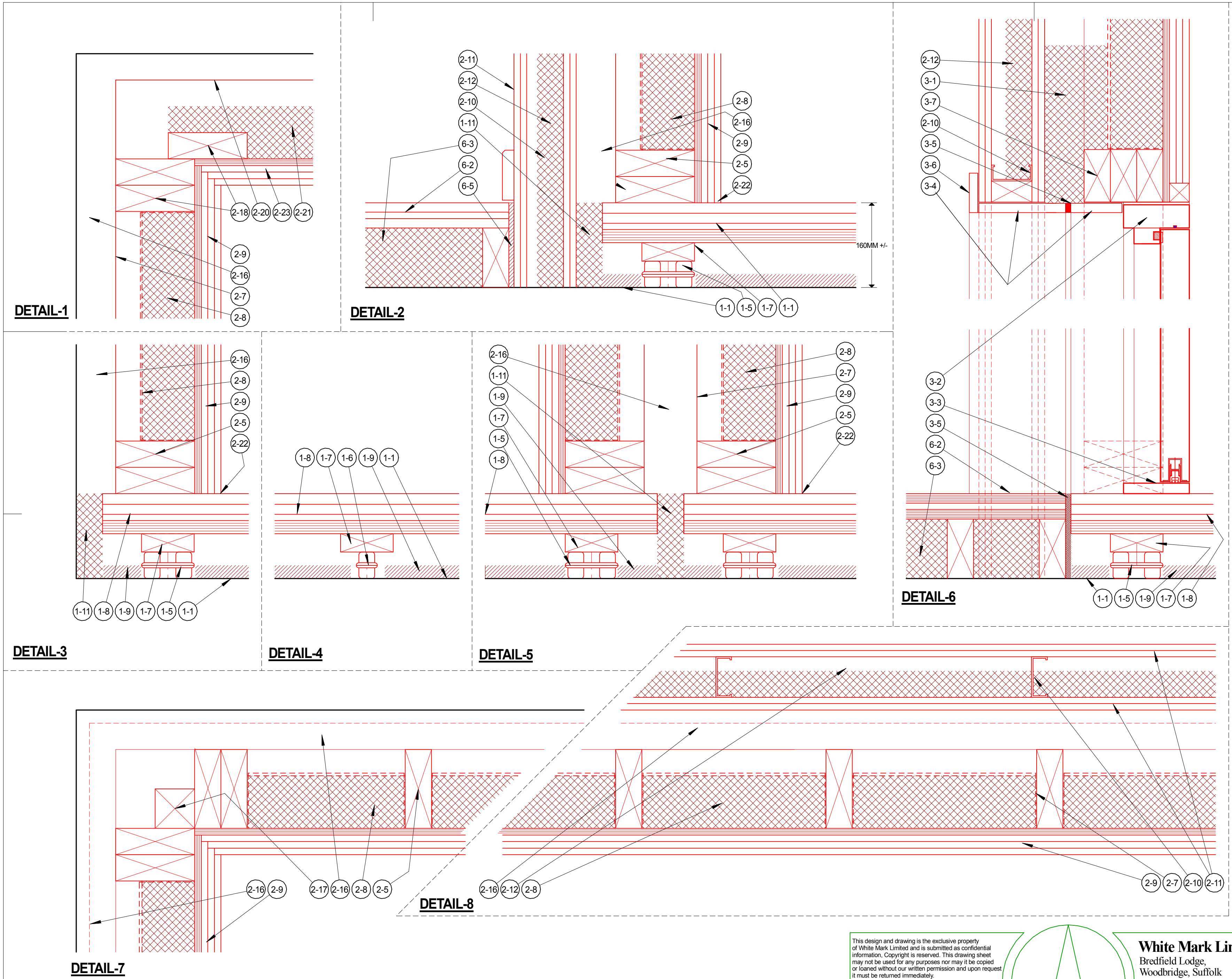
Studio Isolation Cap: One layer sheathing ply and three layers of plasterboard

Rw: 38

M-A-M resonance: NA

Frequency	Wall loss
31.5	
63	22
125	26
250	30
500	35
1000	39
2000	38
4000	39
8000	





Please note this drawing must be read in accordance with the specification and any other related drawings.

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Project:
Fryderyk Chopin University of Music, Warsaw

Title:
Isolation Shell Details
150mm stud wall with laminated board floor

Project No:	2755
Drawing No:	202
Revision:	-
Scale:	1:5 @ A2
Date:	Nov 2013

6.1.3 Soundproofing parameters of technical holes and cable grommets

The following pages offer illustrations of the proposed treatment of air-conditioning duct penetrations and cable duct ingresses.

Air-conditioning duct penetrations are specified thus:

All penetrations of any isolation shell should be to a detail approved by White Mark Limited. There should be a decoupling of the plant from any section of ductwork that is connected to a floating isolation shell. This should be achieved by using a section of flexible duct or other approved method. No ductwork, plant or support bracket should be allowed to bridge the gaps between any isolation shells or between any isolation shell and the main fabric of the building.

All plant, where fixed to the fabric of the building, should be decoupled from it by using a suitable anti-vibration mount system. This is to ensure that disturbance to the non-technical areas of the building by cycling of the air-conditioning in the studios is minimised.

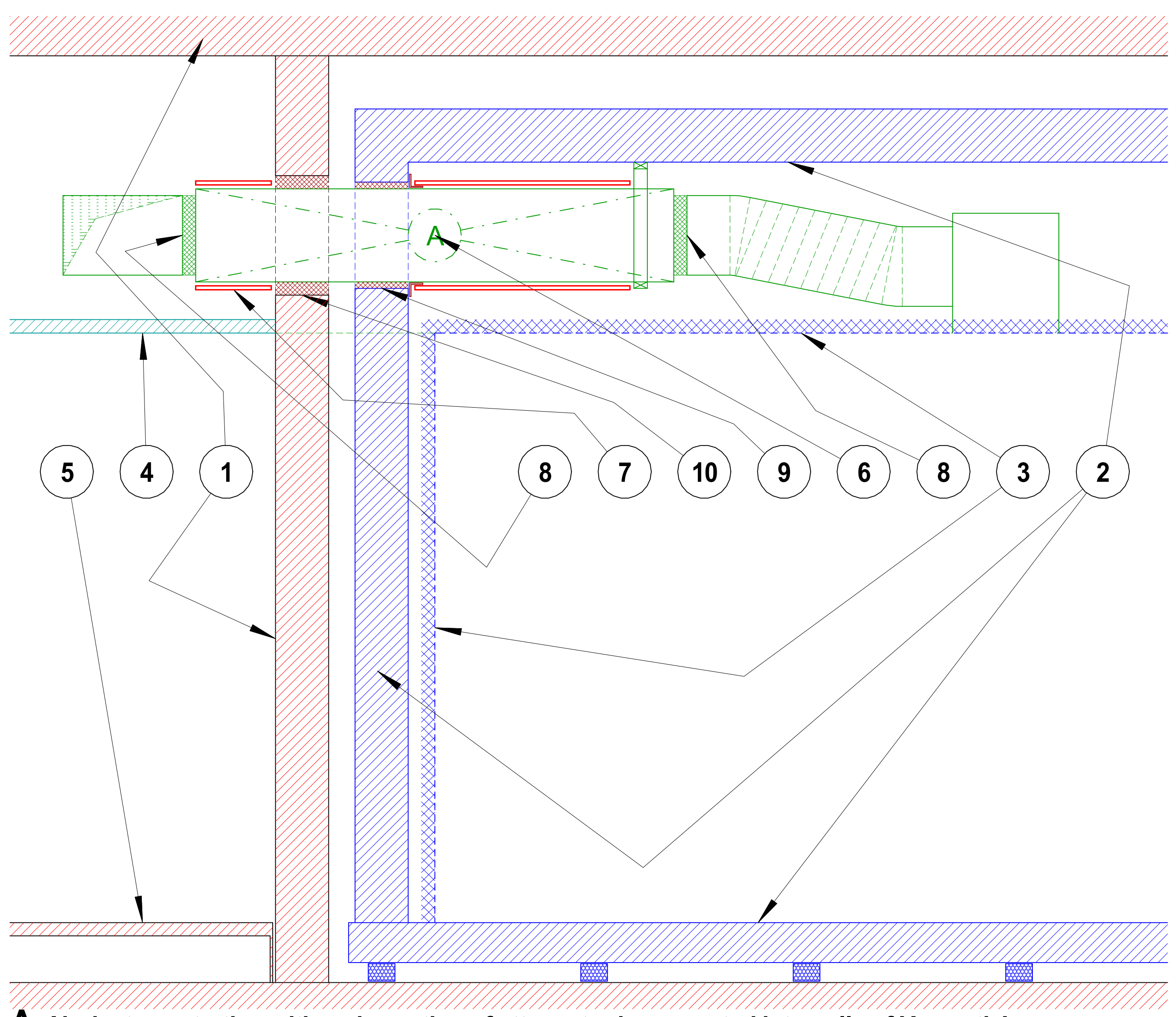
Silencers should be used in all supply and extract ducting where they are needed to attenuate duct born noise from air handling machinery. Their use will also be specified at the point of all duct penetrations of isolation walls and they should be installed so as to maintain the performance of the penetrated wall in its role as a barrier to sound transmission in the prevention of unwanted inter-area cross-talk. All ducts within technical spaces should be internally lined with Barafoam or similar to minimise both resonance of the cavity formed by the enclosure and duct born transmission of sound along its length. Duct lining materials should be presented to White Mark Limited for approval and should comply with any relevant local code or building regulation requirements.

Cross-talk between all areas will be minimised by the use of silencers designed to match the performance of the walls/ceilings through which they penetrate, by suitable cladding of the silencers and by the placement and routing of ducts, which should always maximise their spatial separation. Where specified, duct runs should be clad using one layer of ply and two layers of plasterboard with all joints sealed and all boards screwed through to the ply layer. Suitable frame work will be needed to support the cladding. Details will be issued upon request where ducts are run in corners and the existing wall or ceiling structure can be used as part of the cladding. Silencers should similarly be clad where specified except where the unit to be installed already has mass enhanced walls to provide the required flanking path attenuation. This should be clearly stated by the mechanical systems designer and be approved by White Mark Limited before the cladding can be omitted.

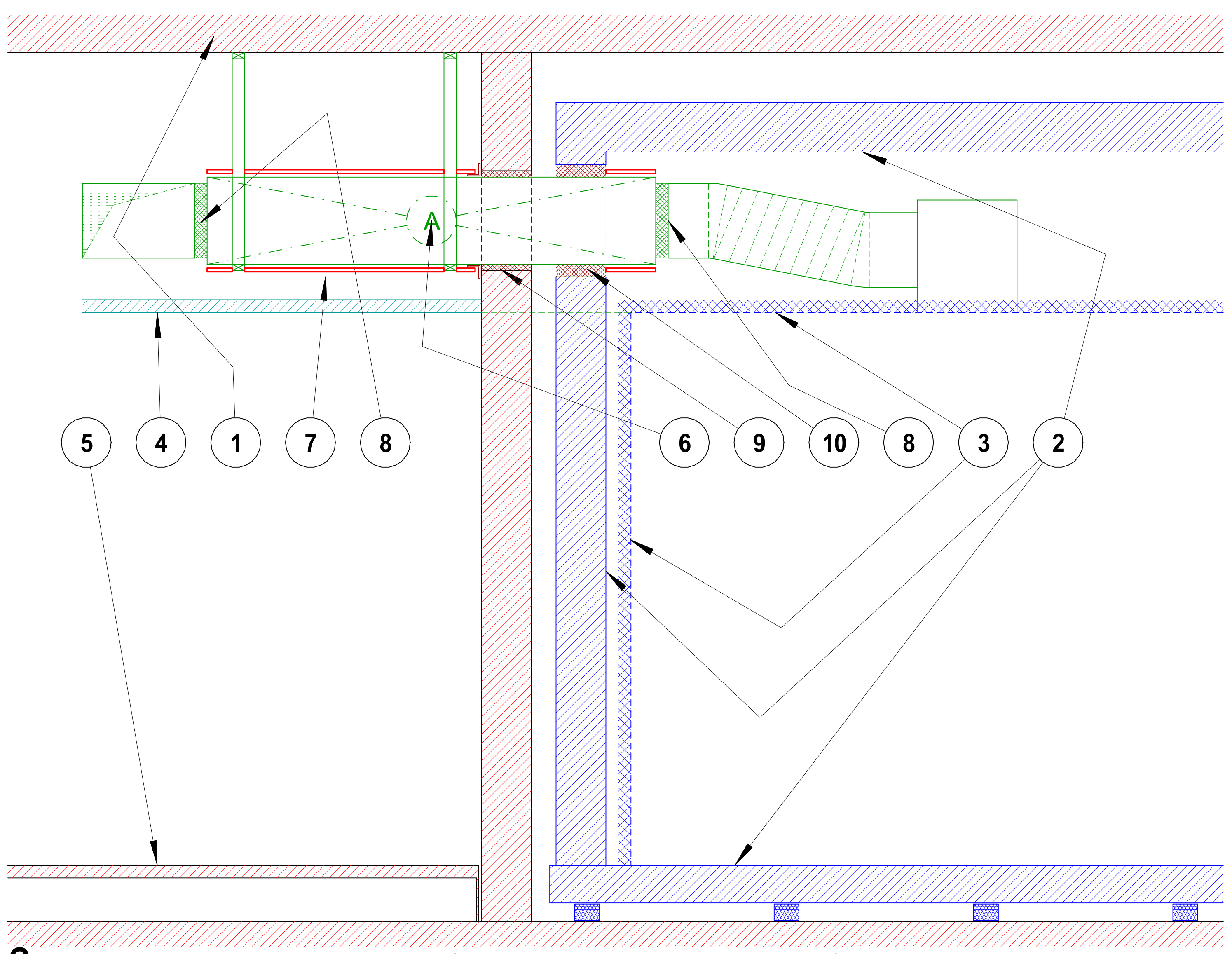
Cable entries that are of fixed capacity, not requiring subsequent addition, are specified thus:

Penetrations into the isolation shells are to be kept to a minimum, and sealed after all cables are drawn. Flexible conduit is to be used across all air cavities between Lobby and Isolation shells. If transformers for low voltage fittings are required, then these should be located in the adjacent lobby ceiling voids where they can be accessed.

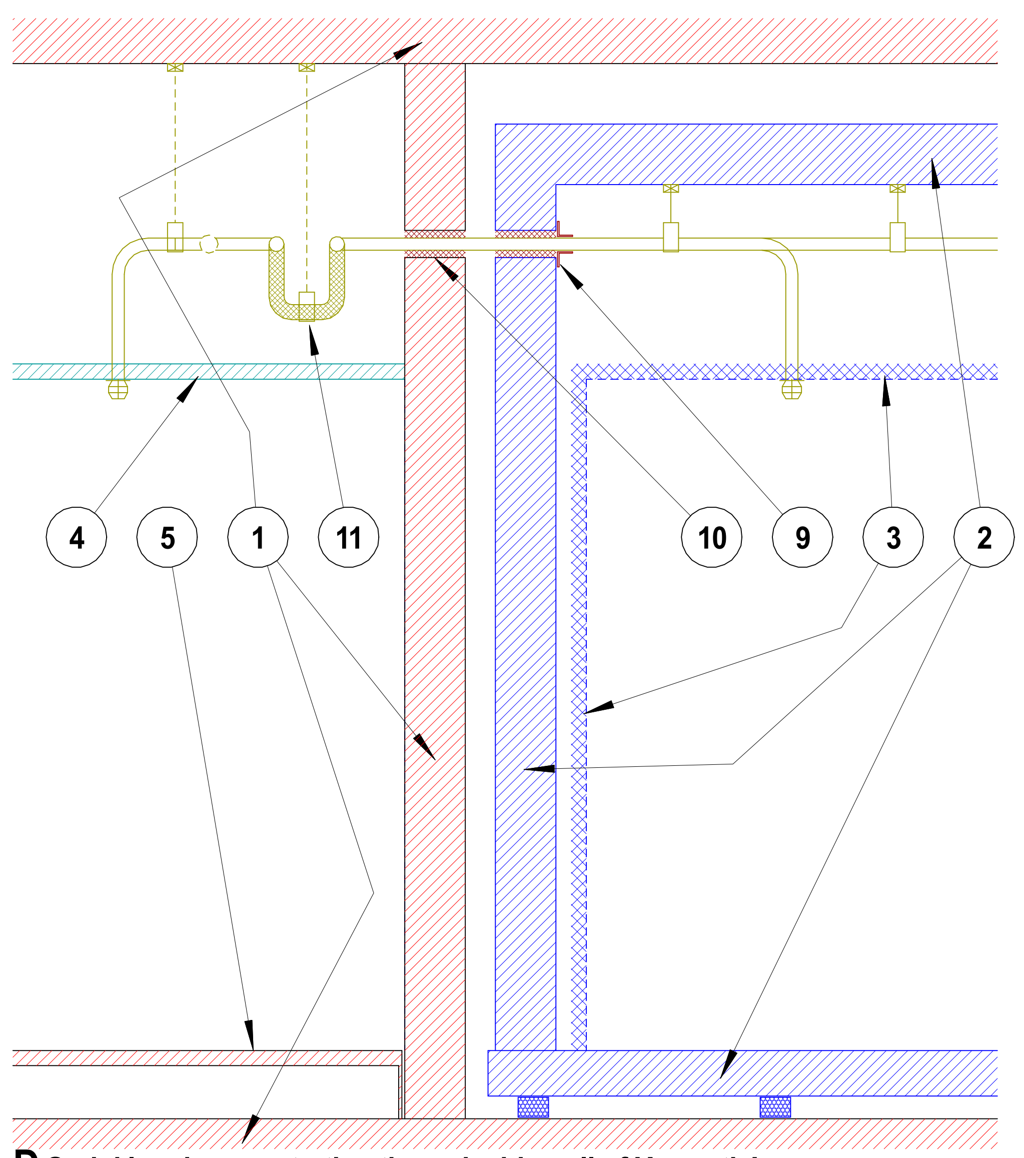
In all cases of technical penetration, the construction method used should ensure that the performance of the boundary, through which any such penetration is made, does not compromise the performance of that boundary.



A Air duct penetration with main section of attenuator is supported internally of 'Acoustic' space

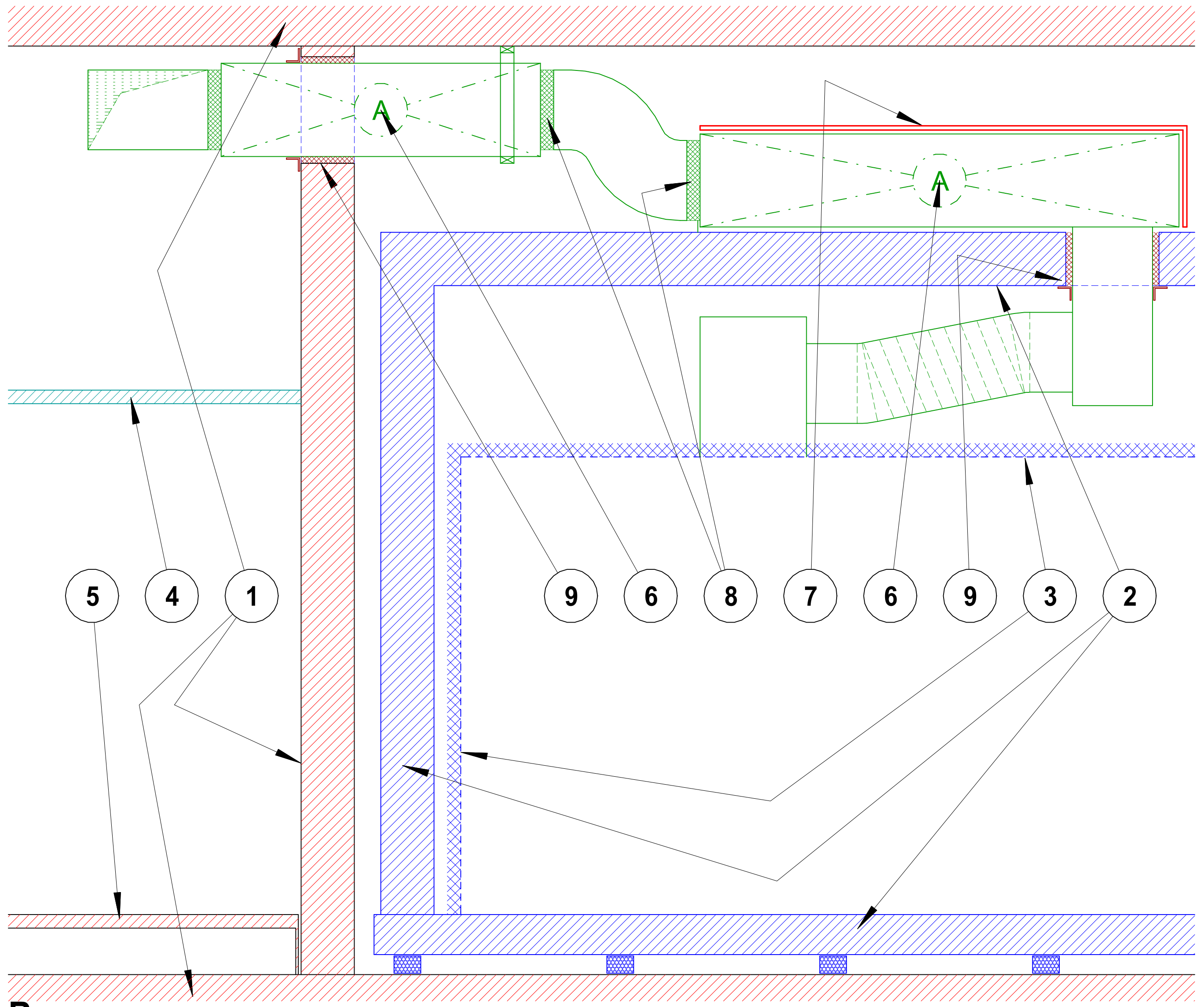


C Air duct penetration with mainsection of attenuator is supported externally of 'Acoustic' space

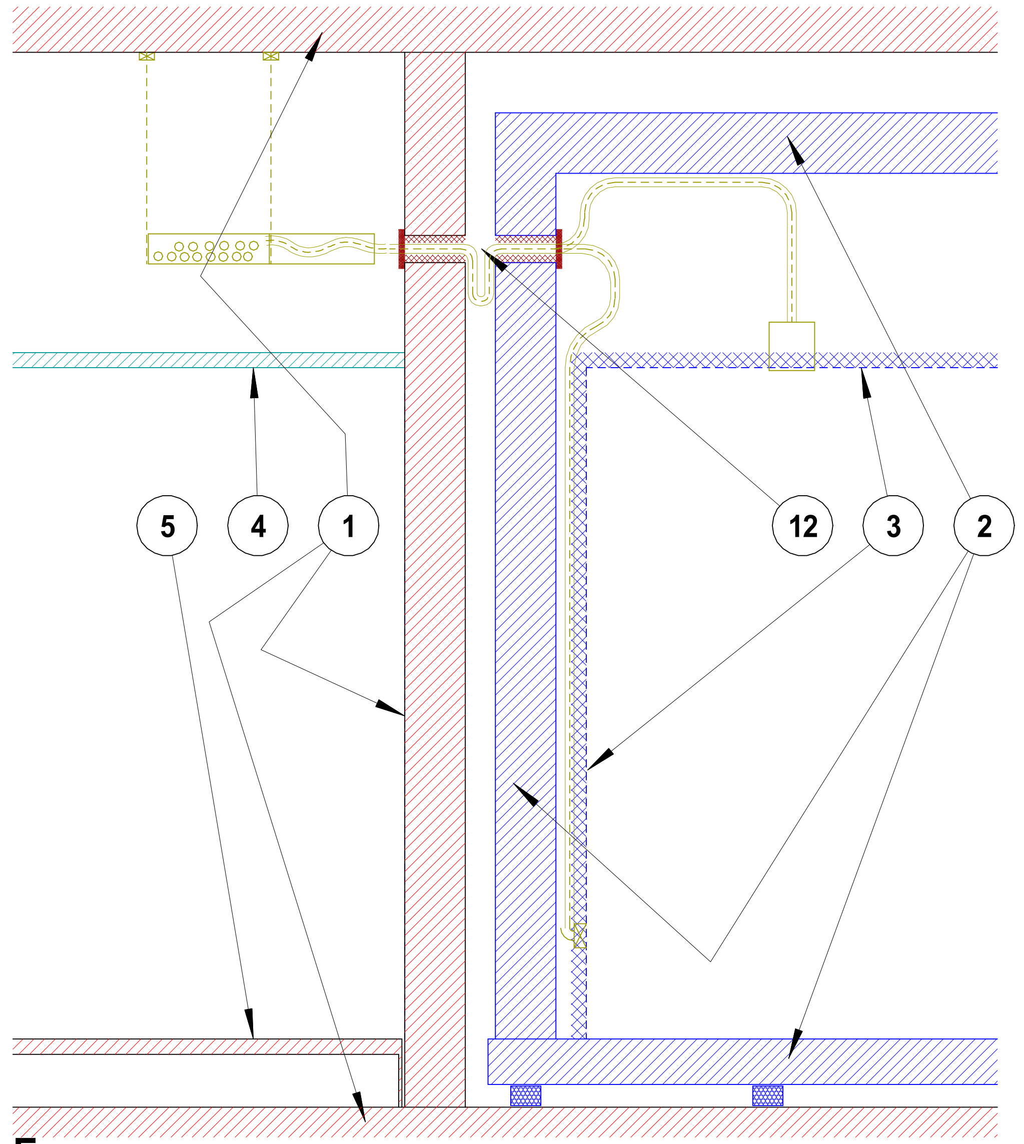


D Sprinkler pipe penetration through side wall of 'Acoustic' space

	1	The main building fabric and structure that is not directly connected to the studio isolation shells
	2	The acoustic isolation shell forming the high performance sound isolated 'box' room space. Likely to have a raised floating floor with seperate walls and a ceiling cap forming the 'box'
	3	Acoustic treaments within the 'box' room space, the surface where the grilles and outlets will be mounted
	4	Suspended ceiling in space adjacent to the Acoustic spaces The ceiling may require maintenance access to plant and control devices placed within the ceiling void
	5	Raised access floor in the space adjacent to the acoustic space This provides an accessible space for services and must abutt all acoustic boundary wall elements with the agreed WML detail.
A	6	Sound attenuator/silencer to the supply and return air ducts . These are required to ensure that the performance of the wall or ceiling through which the air ducts have to pass to serve the 'acoustic' space is maintained at the point of penetration.
	7	Additional protection to the silencer/attenuater should be provided at the point of penetration by encasing the exposed surfaces of the unit with a gypsum plasterboard (US sheetrock) casing or agreed substitute. This adds mass to the walls and ensures that the attenuation performance of the attenuator is not bypassed.
FC	8	FC-flexible collar to the air ducts. This is to be located where support of the system is transferred between the fixed building fabric (item 1) and the acoustic isolated 'box' room (item 2).
	9	Air tight rigid seal. When a duct component passes the wall or ceiling and where it is mechanically fixed to that structure, the gap should be no larger than to allow the component to be site installed. The gap should be a maximum of 25mm all round the duct. At the wall surface, the component should be mechanically fixed and sealed to the wall/ceiling element through which it is passing, providing an airtight seal and support.
	10	Air tight 'soft' seal. When a duct component passes through the wall or ceiling and where it is **NOT** mechanically fixed to that structure, the gap should be 30 to 40mm all around it. This allows the component to be site installed and permit an even mineral wool pack of 60kg/m3 material density material to be evenly fitted around it to form a seal with all walls through which it penetrates.
	11	Where a fire sprinkler systems is required, a 'Fireloop' isolator will be installed at the point where the pipework passes into the acoustic 'box' room. This loop ensures the system can handle flexible movement in all directions, and acoustically decouples the system entering the room. On one side of the loop the pipe will be mechanically fixed to the main building fabric/structure (item 1), on the other side of the loop will be mechanically fixed to the acoustic 'box' room (item 2)
	12	Any cables (electric, fire alarm system, data, security etc) will need to be of a flexible specification at the point where they pass through the double wall construction noted above. The hole should be kept to the minimum size that allows the cables to be installed and then be packed with mineral wool and sealed with an acoustic caulking. The cables should form a swan neck to absolutely decouple the run to the penetration from the run away from it.



B Air duct penetration with main section of attenuator set on ceiling cap of 'Acoustic' space



E Typical cable penetration from support tray through side wall of 'Acoustic' space

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Title:
Technical standards for detailing service penetrations of 'Acoustic' room spaces

Project No: 2004
Drawing No: 114
Revision: -
Scale: 1:25 at A2
Date: March 2012

6.1.4 Soundproofing parameters of windows and doors

The following pages offer illustrations of the proposed construction detailing of window and door openings. The data given here is based on the predicted performance of the proposed window structure as an isolation boundary. The size of the windows specified will affect the extent to which they reduce the performance of the wall structure into which they are placed, reducing it by an amount related to the relative dimensions and make up of each element. Generally reducing window openings has beneficial effects on the acoustic separation achievable but compromises visual communication. Once this aspect of the design is fixed, more detailed estimates of the achievable performance will be made.

It is anticipated, and illustrated in the layouts produced to date, that in all possible instances of door access to acoustically sensitive areas, lobbies will be provided with the inter-door spacing maximised. This allows the doors to sum most efficiently in their performance and also creates the situation that, in most cases of entry or egress to a room, only one door will be open of the lobbied pair at any given moment. This effect is also enhanced by increasing the physical door separation and contributes to minimising "spill" of working studio noise into the circulation spaces.

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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Generic Control Room to Booth

Fixed Pane: 16.8mm laminate glass (Pilkington Optiphon)

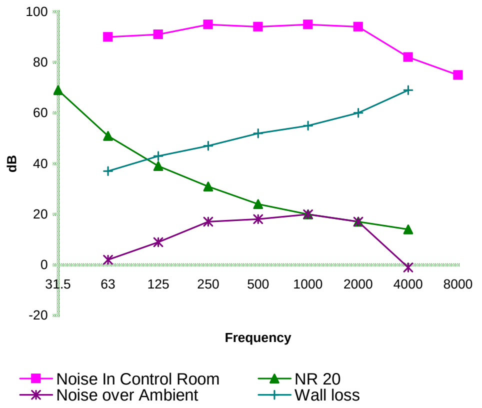
Floating Wall Pane: 13.5mm laminate glass (Pilkington Optiphon) 300mm air gap

Rw: 55

M-A-M resonance: 22Hz

	Frequency	Noise In Control Room	Wall loss	NR 20	Noise over Ambient
0	31.5			69	
1	63	90	37	51	**2**
2	125	91	43	39	**9**
3	250	95	47	31	**17**
4	500	94	52	24	**18**
5	1000	95	55	20	**20**
6	2000	94	60	17	**17**
7	4000	82	69	14	-1
8	8000	75			

NB Exceedance



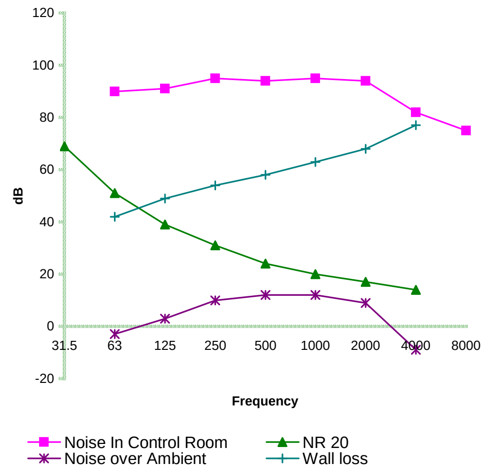
2nd Floating Wall Pane: 13.5mm laminate glass (Pilkington Optiphon) 300mm air gap

Rw: 63

M-A-M resonance: 17Hz

Frequency	Noise In Control Room	Wall loss	NR 20	Noise over Ambient
31.5			69	
63	90	42	51	-3
125	91	49	39	**3**
250	95	54	31	**10**
500	94	58	24	**12**
1000	95	63	20	**12**
2000	94	68	17	**9**
4000	82	77	14	-9
8000	75			

NB Exceedance



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Single Door to IAC design

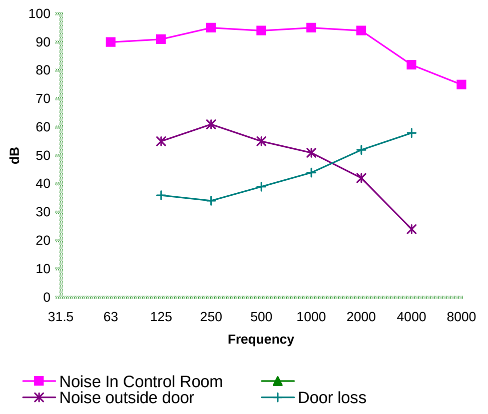
Fixed Pane: 16.8mm laminate glass (Pilkington Optiphon)

IAC STC 48 Door type

R'w: 47

M-A-M resonance: NA

	Frequency	Noise In Control Room	Door loss	Noise outside door
0	31.5			
1	63	90		
2	125	91	36	55
3	250	95	34	61
4	500	94	39	55
5	1000	95	44	51
6	2000	94	52	42
7	4000	82	58	24
8	8000	75		



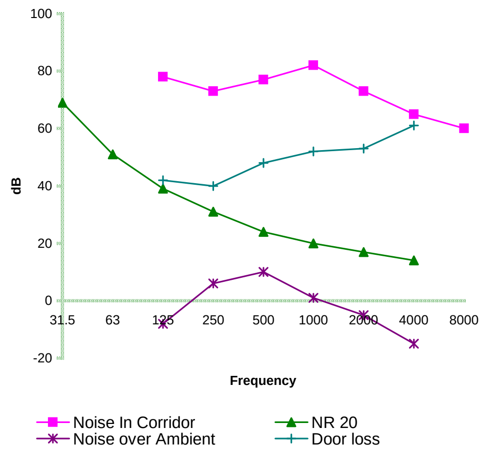
IAC STC 54 Door type

R'w: 48

M-A-M resonance: NA

Frequency	Noise In Corridor	Door loss	NR 20	Noise over Ambient
31.5			69	
63			51	
125	78	42	39	-8
250	73	40	31	**6**
500	77	48	24	**10**
1000	82	52	20	**1**
2000	73	53	17	-5
4000	65	61	14	-15
8000	60			

NB Exceedance



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Single Door to BBC design

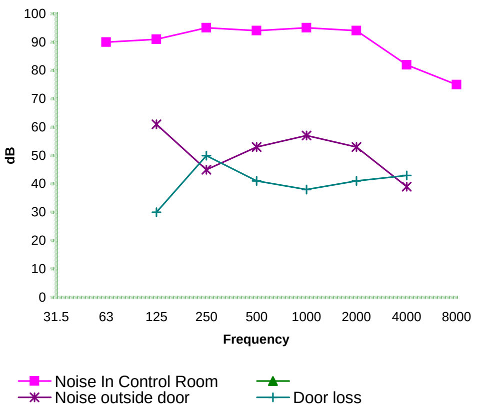
Fixed Pane: 16.8mm laminate glass (Pilkington Optiphon)

Wooden door to BBC design, magnetic seals:

Rw:

M-A-M resonance: NA

	Frequency	Noise In Control Room	Door loss	Noise outside door
0	31.5			
1	63	90		
2	125	91	30	61
3	250	95	50	45
4	500	94	41	53
5	1000	95	38	57
6	2000	94	41	53
7	4000	82	43	39
8	8000	75		



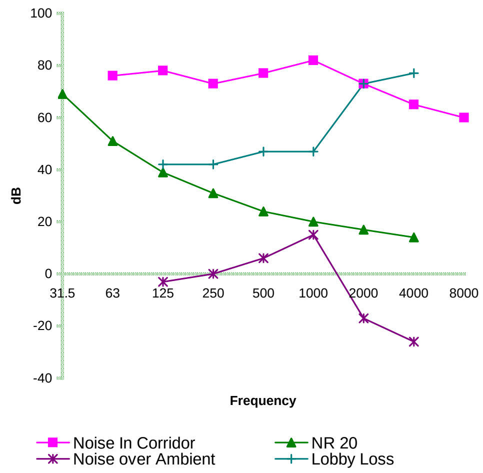
2 door lobby, on site measurement:

Rw: 53

M-A-M resonance: NA

Frequency	Noise In Corridor	Lobby Loss	NR 20	Noise over Ambient
31.5			69	
63	76		51	
125	78	42	39	-3
250	73	42	31	0
500	77	47	24	**6**
1000	82	47	20	**15**
2000	73	73	17	-17
4000	65	77	14	-26
8000	60			

NB Exceedance



6.2 Interior Acoustics

6.2.1 Frequency-time parameters of electrical signals in the facilities

The acoustic parameters considered in this section are the reverberation time within each space versus frequency. The design targets in case of Control Rooms and Live recording spaces are different and their achievement will be approached in different ways.

Firstly, Live areas are addressed:

There are only three "live" performance areas in the project and these are the large orchestral/multifunction room (004), the booth space (007A) and the Foley Studio (008A).

Foley Studio Room 008A

This space must allow live performed sound effect recording, the subsequent necessary manipulation of the raw sounds captured and the integration of these effects with the music, dialogue and any live action sound that exists as far as is necessary to check their quality whilst the opportunity to re-record them is available.

Developments in recording technology have resulted in an accepted method of recording the ambient reverberation characteristics of locations such that reverberation fields can be recreated as ProTools plug-ins. This means that either actual data logged at the site of filming, or representative data maintained based on a range of standard architectural and environmental situations, can be used to add realistic ambience characteristics to recordings made either in the studio or by close or directional miking techniques on location. One favoured system for doing this is currently the Altiverb system and others also are used.

This approach takes care of the environmental ambience in generality but the proximity of sounds, as presented on film, requires careful management so that the reality of sounds as applied to the visual action is maximised. The fundamental features that individualise each recording are the early reflections that colour the sound and the dynamic changes that affect it as the perspective is shifted by character action or as the camera viewpoint changes during a scene. The above description of the use of reverberation generation can take care of the generality of acoustic environment. However, the colouration or character of the sound caused by proximity to hard or soft surfaces, narrow corridors or open fields must be generated by the characteristics of the studio and the Foley artist's use of his position within the studio for their creation.

The internal acoustics have a dual function, therefore. Firstly, they must allow the recording engineer to easily manipulate the reverberant field in the room and, secondly, they must allow the range of necessary finishes to offer recording in proximity to surfaces with the appropriate early reflection characteristics to generate the early strong specular colourations required. The overall reverberation time of the space should be variable from dry and reflective to relatively dead and this must be effective over as wide a range of frequencies as possible. It is necessary, therefore to provide an acoustic environment that is variable from an absorptive colouration free "outside" and "dead"feel to one that offers brighter short reverberation times. The ability to position early reflection surfaces as necessary should also be offered.

It is the intention, therefore, to provide a choice of "wooden" and diffuse stone surfaces in the studio that can be masked off using two types of absorbent treatment. Firstly, areas of hard wood will be interspersed with areas of diffuse stone finish along the walls of the studio. A medium weight "scrim" type blind will be provided in front of these hard surface elements to offer a "softening" option to provide a more distant or "softer focus" early reflection. This can also be used to reduce the general ambience of the studio space by degrees as more panels are covered or left exposed. A second heavy curtain system will also be supplied which will be set forward of the zone occupied by the lighter blind type treatment. This will be a 100%–200% fullness curtain offering significant broadband absorption and will be usable in zones to treat both the near field response of the local wall and the general ambient field characteristic of the space as a whole. The main function of this absorption will be to lower the reverberation time of the whole area and remove the further reflections that tend to give a room a feeling of size and, therefore, to help in the creation of the outdoor acoustic.

A variable ceiling treatment system could be proposed that allows this element of the room boundary to be hard, gently soft or broadband absorbent. This could be set into the roof of the higher section of the Foley Studio to offer a wider range of acoustic possibilities for the recording engineer to select.

It is further suggested that a limited number (say two or three) 1200mm wide floor standing baffles are made that can be used to create right angled or corridor like spaces for effects recording. These baffles would resemble the baffles or gobos used in music recording studios and would be soft on one side and hard on the other. These would be movable within the space to offer parallel surfaces separated by, for example, 1800mm to simulate corridor acoustics. When set at right angles they could create small space colouration whilst used in an otherwise dead space they could simulate external acoustics in proximity to isolated structures.

A small number of doors could be offered with a wider variety of door furniture. Recent developments have seen a wider availability of realistic location door recordings in libraries or the increasing practice of recordings being made on a project by project basis on location. The repeated use of the same door for multiple effects has ceased to be the standard practice. The lingering use of door furniture for scenes where departure can be delayed or stopped at the point of leaving a room could be catered for though, if this is thought important, with the doors installed as permanent features in the room being fundamental for this purpose.

Thus, the acoustic treatment for the Foley Studio will offer bass absorption in bulkhead and ceiling zones with variable acoustics offered as described above.

Assignable voice-over booth, Room 007A

This space should offer a short reverberation time un-coloured response for the neutral capture of voice-over performances and the possibility of small scale Foley performance. High levels of bass absorption will be used and an overall reverberation time of 0.1 seconds anticipated.

Acoustic recording space, Room 004

The base acoustic design target for this space is to render it suitable for music recording with a diffuse sound field and a reverberation time of around 1.4s. Variable acoustics are requested for this room and it is proposed that these be achieved using heavy curtain systems mounted on three walls, set away from the boundaries to create broadband absorption. The design of the base conditions will make use of widespread diffusion, both from quadratic residue elements and from poly-cylinders, which will also offer a measure of lower mid frequency absorption. Broadband absorptive elements will be used to control the overall RT and all surfaces will be universally distributed on the walls and ceilings. 80% of the proposed treatment area will be diffuse in nature to create an even response across the space available. Investigation of the design process and room characterisation is set out as follows:

Room modal response: The basic modal response of the room is intrinsically set by its shape and geometry. Basing an assessment of the character of the room on the Bonello criteria, an assessment of the modal density of the volume against frequency should see an equal or increased number of modes within each third octave as the frequency increases. As illustrated, this is found to be the case:

Axial modes of room

N,0,0	0,N,0	0,0,N
11.1	14.7	27.6
22.1	29.3	55.3
33.2	44.0	82.9
44.2	58.7	110.5
55.3	73.4	138.2
66.3	88.0	165.8
77.4	102.7	193.4
88.4	117.4	
99.5	132.1	
110.5	146.7	
121.6	161.4	
132.6	176.1	
143.7	190.7	
154.7	205.4	
165.8		
176.9		
187.9		
199.0		
210.0		

Tangential modes of room

N,N,0	N,0,N	0,N,N
18.4	29.8	31.3
36.7	59.5	62.6
55.1	89.3	93.9
73.5	119.0	125.1
91.9		156.4
110.2		187.7
128.6		
147.0		
165.3		
183.7		
202.1		

N+1,N,0	N+1,0,N	0,N+1,N
26.5	35.4	40.3
44.3	64.5	70.7
62.4	94.0	101.6
80.6	123.6	132.7
98.9	153.3	163.8
117.2	183.0	195.0
135.5	212.7	
153.9		
172.2		
190.6		
208.9		

N,N+1,0	N,0,N+1	0,N,N+1
31.4	56.4	57.2
49.3	85.8	87.9
67.4	115.4	119.0
85.7	145.1	150.1
103.9	174.8	181.3
122.3	204.5	212.5
140.6		
158.9		
177.3		
195.6		

Oblique modes of room

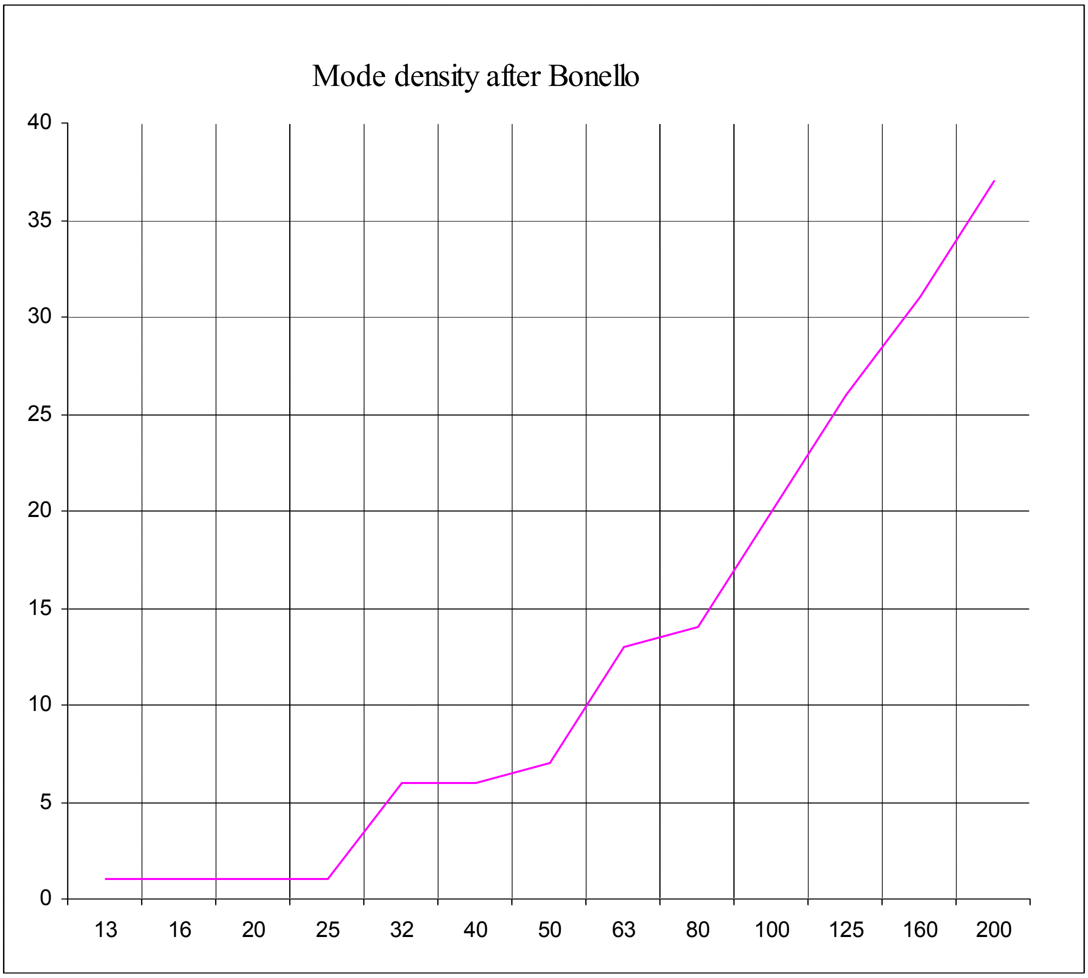
N,N,N	N+1,N,N	N.N+1,N	N,N,N+1
33.2	38.3	41.8	58.2
66.4	70.8	74.0	90.7
99.5	103.8	106.8	123.5
132.7	136.8	139.8	156.5
165.9	169.9	172.9	189.5
199.1	203.0	206.0	

N+2,N+1,N	N+2,N,N	N.N+2,N	N,N,N+2
52.2	45.6	53.1	84.9
83.3	76.6	83.6	116.5
115.6	108.9	115.6	148.8
148.3	141.6	148.1	181.4
181.2	174.5	180.8	
	207.5		

N+2,N,N+1	N+1,N+2,N	N.N+2,N+1	N+1,N,N+2
36.3	56.5	71.5	87.0
94.0	87.2	104.0	119.1
126.9	119.2	136.7	151.6
160.0	151.7	169.7	184.4
193.1	184.5	202.7	

N,N+1,N+2
88.6
121.0
153.7
186.6

This can be illustrated as follows, showing the number of modes against frequency in third octave bands:



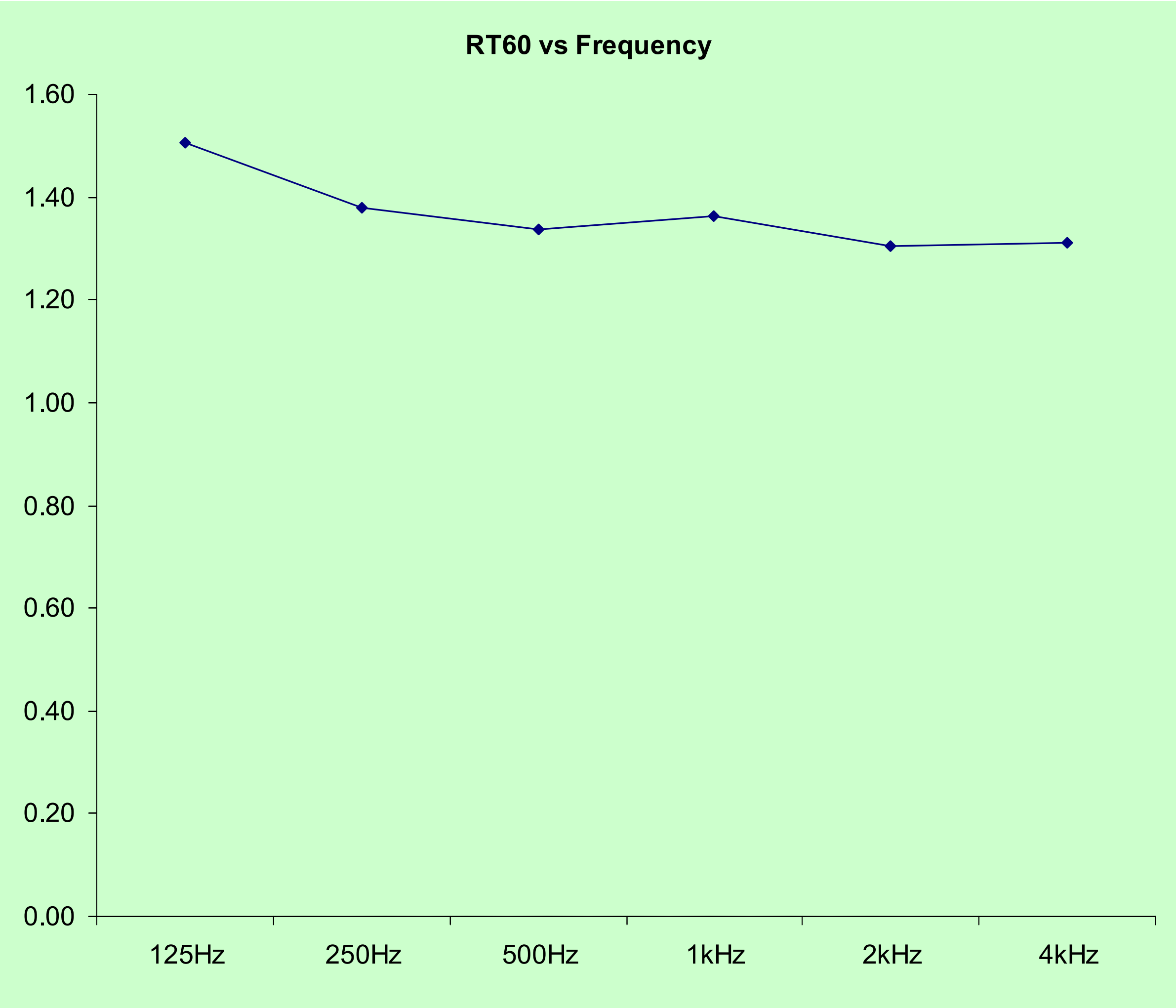
Room reverberation time response: Having ascertained the basic modal response of the room to be satisfactory, it is proposed to offer a reverberation time set at approximately 1.4seconds. In deriving this figure, assumptions have been made as to the base construction of the room. It is possible that the floor is a concrete base with vinyl tiles set directly upon it and this is to be checked. Should this be the case a wooden floor is proposed based on a fixed floor board or block parquet system, finished in varnished gloss.

The illustrated diffuser array, interspersed with absorptive areas, into which lighting can easily be fitted, and poly-cylindrical elements after Mankovsky. Corner bass absorption will be offered with heavy curtain elements drawn back for live use and able to be set against wide areas of the wall to offer drier acoustic for other functions.

The exact layout and position of these elements needs to be fixed once the range of uses to which the room is to be put has been agreed.

The Sabine calculation of the space is set out as follows:

Graphically expressed, this results in a response forecast to be thus:



Further development of the design is required once fire exits are agreed, make up of the floor and ceiling are confirmed and the nature of the wall surface construction is fully understood.

The creation of an excellent acoustic environment for the live room requires that measurements are taken at various stages of the construction of the space to allow review of the acoustic conditions as they are affected by the treatments during their installation. Care should be taken that this work is budgeted for during the construction phase, both in cost and in time during the construction programme, so that the best results for the space are achieved and the design is given a chance for verification whilst adjustments can efficiently be made.

Secondly, Control Room areas are addressed:

The design aim with all mixing spaces is to create a monitoring environment that offers uncoloured monitoring over as wide a proportion of the working area as possible. White Mark design philosophy has always been to suppress early reflections as far as possible such that the early direct sound from the main monitors is unaffected by reflected sound from the room for as long as is possible. Once the inevitable reflections begin to arrive at the main monitoring position, a quickly developing dense reverberant field should be created which tails off uniformly against frequency at a controlled rate. The size of the rooms renders them non-statistical in respect of Sabine calculation and so a mixture of absorption coefficient calculation and spatial distribution of the absorptive elements within the room, in concert with specular and diffuse reflective sections of treatment, are used to achieve the above aims.

This results in heavy broadband absorption being placed in the front section of the rooms. Specularly reflective side wall and ceiling zones, towards the rear of each space and angled to feed the diffuse rear wall, feed non-destructive energy back into the monitoring area to create the desired reverberant dense field to give the room "context" and make it a neutral, comfortable working environment. Care is taken to assess spaces at an early stage for modal problems as above, particularly as the smaller size of most of the spaces causes the region of the room response that is dominated in this way to rise in the audio spectrum and, potentially, become damaging to the important lower mid range of the audio spectrum.

The placement of absorption within the space to mitigate modal effects and suppress early reflections across a wide frequency range, predicates the placement of the absorptive elements of treatment. Additional corner bass absorption is placed using bulkheads and broadband diffusion is mounted towards the rear of the rooms to balance the absorption required to achieve the above. This is all balanced to produce a reverberation time within the space as specified by Dolby for all of their licensed monitoring environments. The reasons for adopting their guidelines extensively are twofold; firstly, the responses suggested offer excellent monitoring conditions in themselves and, secondly, consistency across the monitoring environments offered by the range of control rooms is strongly desirable to ensure successful transfer of work between them.

Thus, taking the Atmos/Film Dubbing suite (005) as a benchmark, Dolby offers the following guidance for a room of this size:

5. Reverberation

Production Services

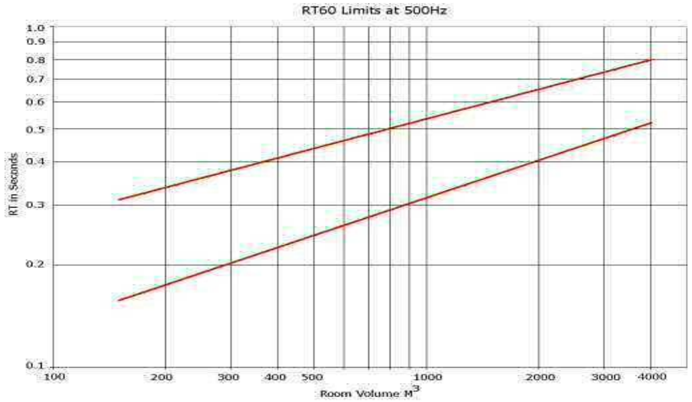
Studio Name **FCUM**

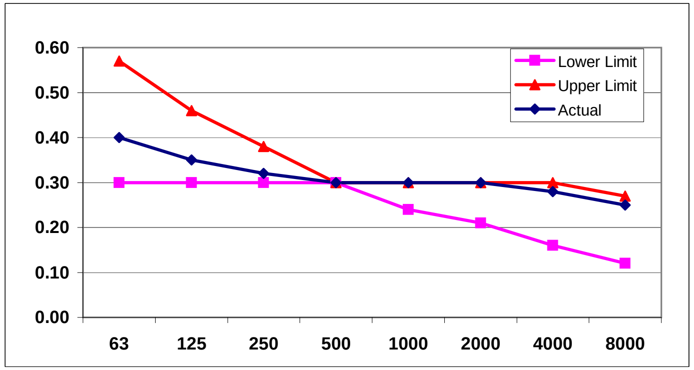
Date **28/11/2013**

Ident Room 005

Dolby Measurements		INPUT CELLS			NOTES
Room volume		366	m³		
Measured RT60 at 500Hz		0.30	*s*		*OK*
Enter Noise Criteria value		25	*NC*		*OK*
Frequency Variation		Lower	Upper	Actual	
RT60 at 63Hz	63	0.300	0.570	0.40	*OK*
RT60 at 125 Hz	125	0.300	0.460	0.35	*OK*
RT60 at 250Hz	250	0.300	0.380	0.32	*OK*
RT60 at 500	500	0.300	0.300	0.30	
RT60 at 1kHz	1000	0.240	0.300	0.30	*OK*
RT60 at 2kHz	2000	0.210	0.300	0.30	*OK*
RT60 at 4kHz	4000	0.160	0.300	0.28	*OK*
RT60 at 8kHz	8000	0.120	0.270	0.25	*OK*

Version Ver 1.2 19-11-09





It can be seen that a level response with frequency is specified, rising as is inevitable, in the low frequency region and gently tailing off in the high frequency area. This form of response is designed for in all of the Control Rooms with the 1kHz value being varied based on the size of the suite in question. The target area for this figure is specified below, together with an estimate of variance, for each space in turn.

Room identifier	**1kHz RT**	**Variance**
Control Room 004A	0.18	+/-0.05
Atmos Room 005	0.3	+/-0.05
Control Room 007	0.16	+/-0.04
Control Room 003	0.18	+/-0.05
Control Room 008	0.12	+/-0.03

7.0 Calculations

This section offers a list of acoustic performance characteristics of each space with reference to separation from the surrounding areas for each room in turn. These anticipated performance figures are set out in table form with illustrative graphical representation also offered. The operating levels chosen are representative of the uses to which the rooms will be put and the anticipated noise floors that are to be specified from the mechanical systems to be installed. These figures are as described in section 6.1.1

It will be noted that all spaces perform well in all cases but that there is a limitation on the performance achievable between the old Control Room (007) and the Live Room (004). The performance of the wall element is limited by the absence of cavity damping between the substantial isolation walls. Investigation will be needed as to whether this can be rectified by the correct placement of mineral wool batts to improve this boundary separation. Further, the performance of any window in this wall will reduce the isolation performance but this can only be quantified once the wall structure, the sight lines and the window element separation are all finalised. At that stage an anticipated performance figure can be derived and a workable sound level maximum set for the operation of the room. It is anticipated that this will not be too limiting in the performance anticipated for the space.

The newly constructed Control Room (004A) will also be limited by its isolation performance if it is to work on unrelated projects whilst the Live Room is being used at low noise floor recording or performance. The predicted performance of this boundary is significantly better than that discussed above for Room 007A, limited by the performance of the window primarily, but management of the potentially conflicting uses to which the three rooms can be put concurrently must take account of the realistically achievable acoustic separation that exists, each from the others.

It should be noted that the figures are based on predictions of the boundary performances in ideal conditions and some diminution of the actual achieved separation is to be expected once constructed. This is common in all design projects but it is anticipated, as far as is possible, that the forecast margins of safety are sufficient. Once the studio complex is completed, actual separation figures should be obtained by measurement and maxima set for operating levels in all areas where the performance calls for this.

The data called for in for sections 7.1 and 7.2 are presented together in each case on the following pages.

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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Room 005 to Room 004 and to exterior space above

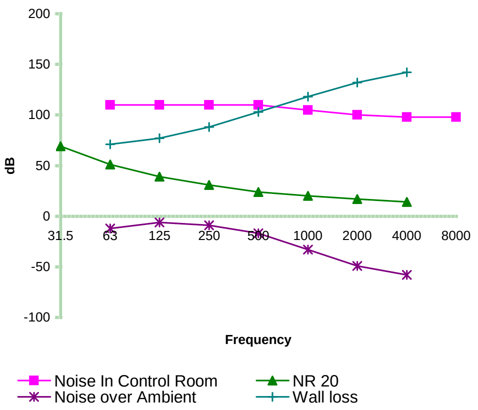
Existing wall: 250mm solid brick rendered (400kg/m2)

Studio wall: 140mm concrete block, 150mm air gap, 100mm mineral wool void damping.

Rw: 101

M-A-M resonance: 10Hz

	Frequency	Noise In Control Room	Wall loss	NR 20	Noise over Ambient
0	31.5			69	
1	63	110	71	51	-12
2	125	110	77	39	-6
3	250	110	88	31	-9
4	500	110	103	24	-17
5	1000	105	118	20	-33
6	2000	100	132	17	-49
7	4000	98	142	14	-58
8	8000	98			



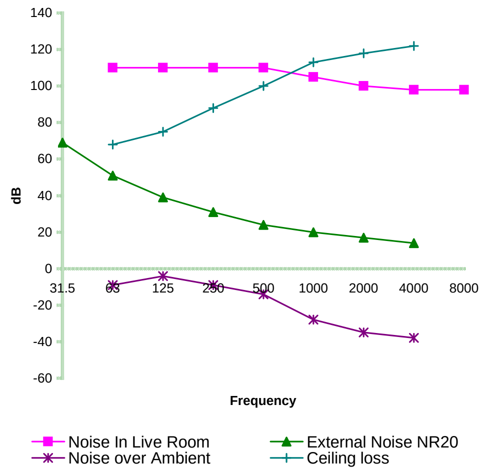
Existing roof: 300mm concrete cast floor with masonary above and support beams

Studio Isolation Cap: 15mm marine ply and three layers of 12.5mm plasterboard with studs on 600mm centres, 200mm Air Gap, 100mm mineral wool void damping.

Rw: 99

M-A-M resonance: 10Hz

Frequency	Noise In Live Room	Ceiling loss	External Noise NR20	Noise over Ambient
31.5			69	
63	110	68	51	-9
125	110	75	39	-4
250	110	88	31	-9
500	110	100	24	-14
1000	105	113	20	-28
2000	100	118	17	-35
4000	98	122	14	-38
8000	98			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Room 005 to Adjacent Booth 007A

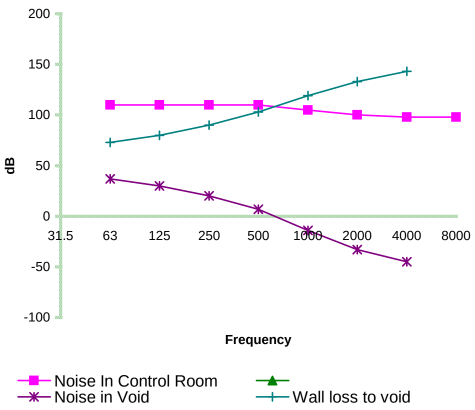
Existing wall: 250mm solid brick rendered (400kg/m2)

Control Room wall: 140mm concrete block, 150mm air gap, 100mm mineral wool void damping.

Rw: 102

M-A-M resonance: 9Hz

	Frequency	Noise In Control Room	Wall loss to void	Noise in Void
0	31.5			
1	63	110	73	37
2	125	110	80	30
3	250	110	90	20
4	500	110	103	7
5	1000	105	119	-14
6	2000	100	133	-33
7	4000	98	143	-45
8	8000	98		

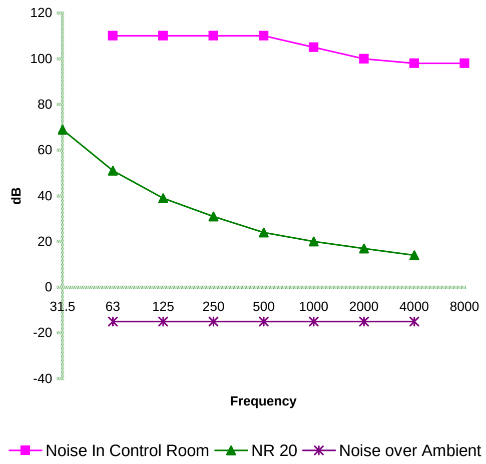


Additional Floated Booth Wall 140mm concrete block, 100mm air gap, 75mm mineral wool void damping.

Rw: 110

M-A-M resonance: 10Hz

Frequency	Noise In Control Room	Wall loss to Booth	NR 20	Noise over Ambient
31.5			69	
63	110	102	51	*-15*
125	110	115	39	*-15*
250	110	*>120*	31	*-15*
500	110	*>120*	24	*-15*
1000	105	*>120*	20	*-15*
2000	100	*>120*	17	*-15*
4000	98	*>120*	14	*-15*
8000	98			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Control Room 007 to Live Room 004 Note: Isolation limited by window design, reviewed elsewhere

Fixed wall: 250mm brick with 100mm Air gap

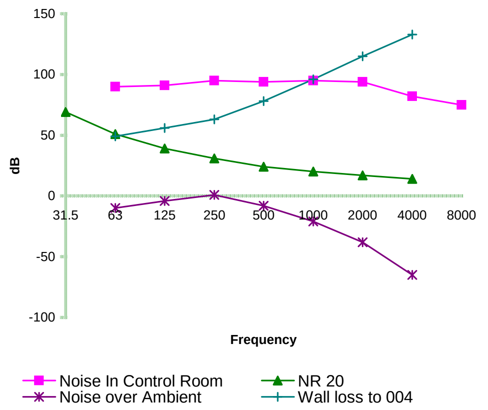
Control Room wall: 250mm brick with 100mm Air gap

Rw: 76

M-A-M resonance: 17Hz

	Frequency	Noise In Control Room	Wall loss to 004	NR 20	Noise over Ambient
0	31.5			69	
1	63	90	49	51	-10
2	125	91	56	39	-4
3	250	95	63	31	**1**
4	500	94	78	24	-8
5	1000	95	96	20	-21
6	2000	94	115	17	-38
7	4000	82	133	14	-65
8	8000	75			

NB Reduced levels **NB** Exceedance

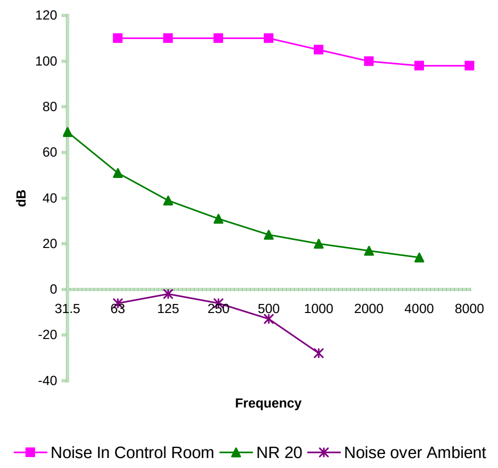


If cavity was infilled: 250mm brick with 100mm Air gap, 75mm mineral wool void damping.

Rw: 96

M-A-M resonance: 14Hz

Frequency	Noise In Control Room	Wall loss to 004	NR 20	Noise over Ambient
31.5			69	
63	110	65	51	-6
125	110	73	39	-2
250	110	*85*	31	-6
500	110	*99*	24	-13
1000	105	*113*	20	-28
2000	100	*>120*	17	
4000	98	*>120*	14	
8000	98			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Room 008 to Foley Control Room

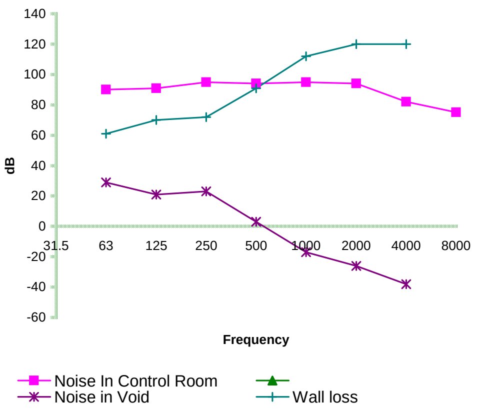
Fixed wall: 140mm Concrete block

Studio wall to void: 140mm concrete block, 50mm air gap, 50mm mineral wool void damping.

Rw: 88

M-A-M resonance: 20Hz

	Frequency	Noise In Control Room	Wall loss	Noise in Void
0	31.5			
1	63	90	61	29
2	125	91	70	21
3	250	95	72	23
4	500	94	91	3
5	1000	95	112	-17
6	2000	94	120	-26
7	4000	82	120	-38
8	8000	75		



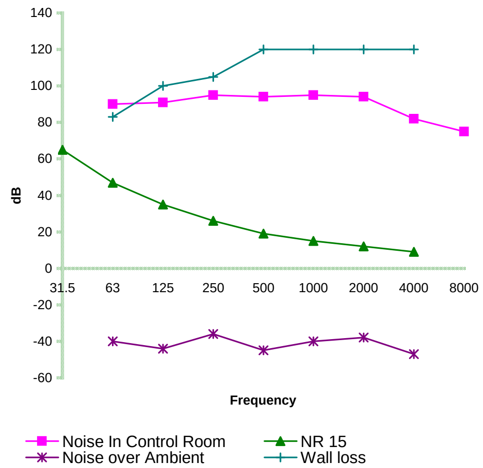
Secondary Wall to Control Room: 140mm concrete block, 90mm air gap, 50mm mineral wool void damping.

Studio to Control Room: 140mm concrete block, 50mm air gap, 50mm mineral wool void damping.

Rw: 105

M-A-M resonance: 20Hz

Frequency	Noise In Control Room	Wall loss	NR 15	Noise over Ambient
31.5			65	
63	90	83	47	-40
125	91	100	35	-44
250	95	105	26	-36
500	94	120	19	-45
1000	95	120	15	-40
2000	94	120	12	-38
4000	82	120	9	-47
8000	75			



White Mark Limited

Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Room 008 to Circulation spaces

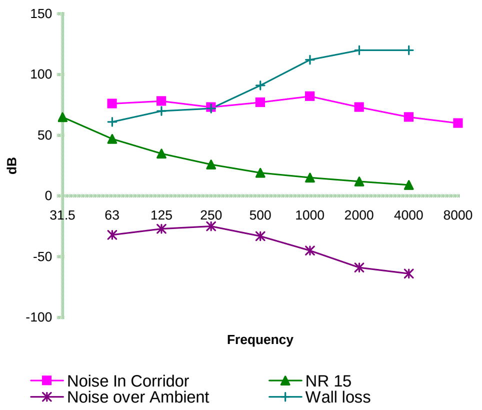
Studio wall: 140mm Concrete block

Corridor wall: 140mm concrete block, 50mm air gap, 50mm mineral wool void damping.

Rw: 88

M-A-M resonance: 20Hz

	Frequency	Noise In Corridor	Wall loss	NR 15	Noise over Ambient
0	31.5			65	
1	63	76	61	47	-32
2	125	78	70	35	-27
3	250	73	72	26	-25
4	500	77	91	19	-33
5	1000	82	112	15	-45
6	2000	73	120	12	-59
7	4000	65	120	9	-64
8	8000	60			



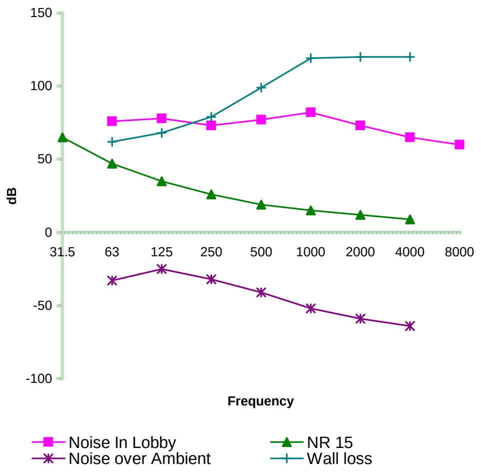
Secondary Wall to Control Room: 140mm concrete block, 90mm air gap, 50mm mineral wool void damping.

Lobby wall 250mm brick block, 50mm air gap, 50mm mineral wool void damping.

Rw: 91

M-A-M resonance: 18Hz

Frequency	Noise In Lobby	Wall loss	NR 15	Noise over Ambient
31.5			65	
63	76	62	47	-33
125	78	68	35	-25
250	73	79	26	-32
500	77	99	19	-41
1000	82	119	15	-52
2000	73	120	12	-59
4000	65	120	9	-64
8000	60			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Room 007 to Adjacent Booth, Room 007A

Note: Boundary calculations only, wall/floor excitation ignored

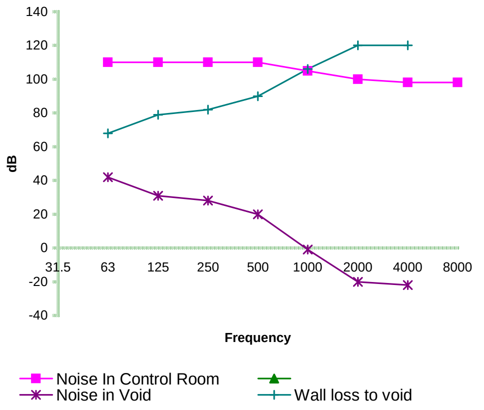
Fixed wall: 100mm concrete block rendered with 155mm Air gap to Control Room 75mm to Booth

Control Room wall: 140mm concrete block, 155mm air gap, 100mm mineral wool void damping.

Rw: 95

M-A-M resonance: 9Hz

	Frequency	Noise In Control Room	Wall loss to void	Noise in Void
0	31.5			
1	63	110	68	42
2	125	110	79	31
3	250	110	82	28
4	500	110	90	20
5	1000	105	106	-1
6	2000	100	120	-20
7	4000	98	120	-22
8	8000	98		

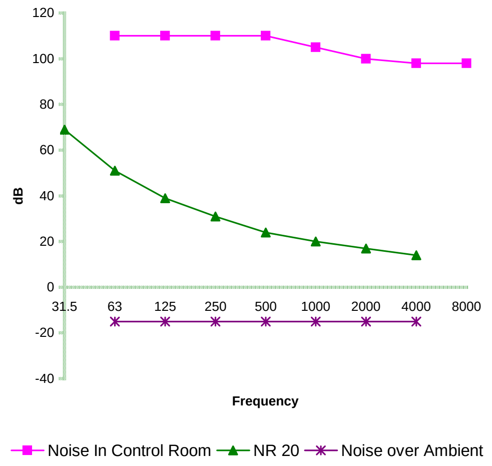


Additional Floated Booth Wall 140mm concrete block, 75mm air gap, 75mm mineral wool void damping.

Rw: 110

M-A-M resonance: 10Hz

Frequency	Noise In Control Room	Wall loss to Booth	NR 20	Noise over Ambient
31.5			69	
63	110	99	51	*-15*
125	110	117	39	*-15*
250	110	*>120*	31	*-15*
500	110	*>120*	24	*-15*
1000	105	*>120*	20	*-15*
2000	100	*>120*	17	*-15*
4000	98	*>120*	14	*-15*
8000	98			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Room 003 to Foley Room 008 Adjacent on Level -1

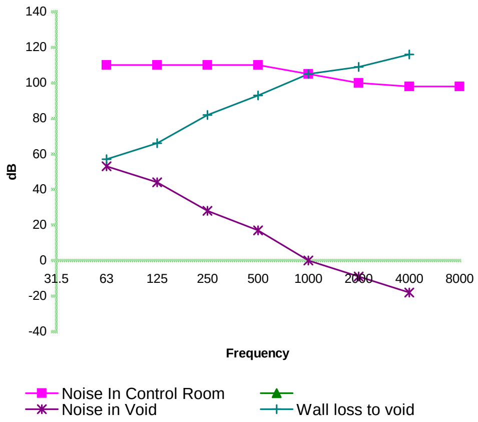
Fixed wall: 250mm brick with 100mm Air gap

Control Room wall to cavity: 15mm marine ply and three layers of 12.5mm plasterboard with studs on 600mm centres, 200mm Air Gap, 100mm mineral wool void damping.

Rw: 76

M-A-M resonance: 19Hz

	Frequency	Noise In Control Room	Wall loss to void	Noise in Void
0	31.5			
1	63	110	57	53
2	125	110	66	44
3	250	110	82	28
4	500	110	93	17
5	1000	105	105	0
6	2000	100	109	-9
7	4000	98	116	-18
8	8000	98		

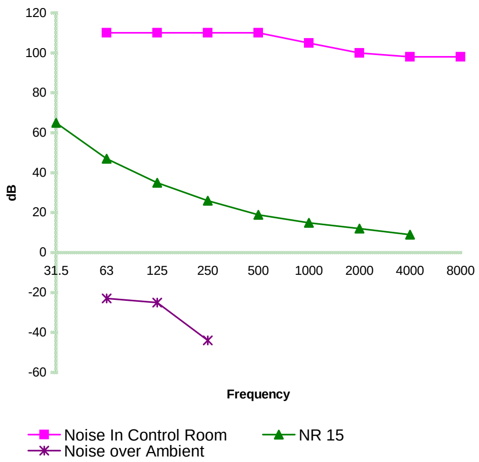


To Foley Suite upper zone: 140mm block with 100mm Air gap, 75mm mineral wool void damping.

Rw:

M-A-M resonance: 13Hz

Frequency	Noise In Control Room	Wall loss to 008	NR 15	Noise over Ambient
31.5			65	
63	110	86	47	-23
125	110	100	35	-25
250	110	*128*	26	-44
500	110	*>120*	19	
1000	105	*>120*	15	
2000	100	*>120*	12	
4000	98	*>120*	9	
8000	98			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

Control Room 003 to Foley Room 008

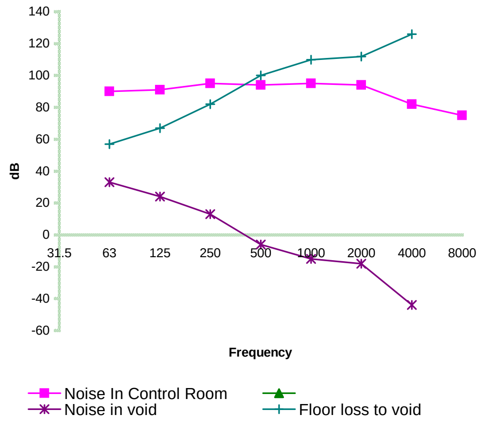
Existing Floor 200mm Concrete with 85mm Air gap

Control Room floor to cavity: 15mm marine ply and three layers of 12.5mm plasterboard with studs on 600mm centres, 200mm Air Gap, 100mm mineral wool void damping.

Rw: 92

M-A-M resonance: 24Hz

	Frequency	Noise In Control Room	Floor loss to void	Noise in void
0	31.5			
1	63	90	57	33
2	125	91	67	24
3	250	95	82	13
4	500	94	100	-6
5	1000	95	110	-15
6	2000	94	112	-18
7	4000	82	126	-44
8	8000	75		

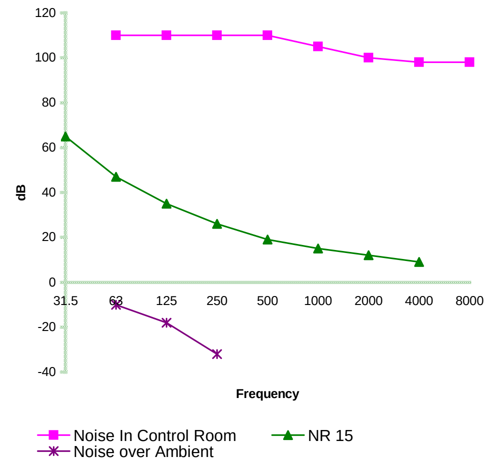


To Foley Suite ceiling cap: 15mm marine ply and three layers of 12.5mm plasterboard with studs on 600mm centres, 200mm Air Gap, 100mm mineral wool void damping.

Rw:

M-A-M resonance: 21Hz

Frequency	Noise In Control Room	Wall loss to 008	NR 15	Noise over Ambient
31.5			65	
63	110	73	47	-10
125	110	93	35	-18
250	110	*116*	26	-32
500	110	*>120*	19	
1000	105	*>120*	15	
2000	100	*>120*	12	
4000	98	*>120*	9	
8000	98			



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Isolation assessment chart (values calculation by Insul v 6.30 by Marshall Day Acoustics) **26/11/2013**

ContoRoom 004A to Live Room 004 — Note: Isolation limited by window design, reviewed elsewhere

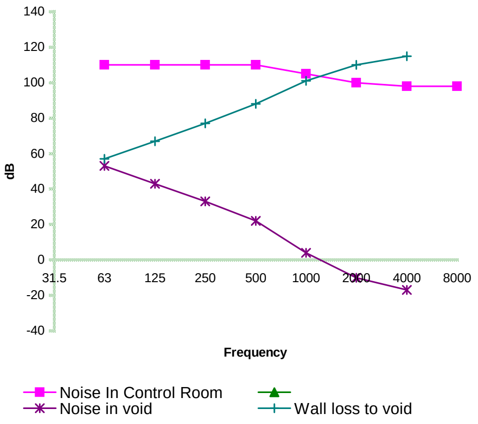
Fixed wall: 150mm Concrete block with 200mm air gap, 100mm mineral wool void damping

Control Room wall to cavity: 15mm marine ply and three layers of 12.5mm plasterboard with studs on 600mm centres, 200mm Air Gap, 100mm mineral wool void damping.

Rw: 89

M-A-M resonance: 20Hz

	Frequency	Noise In Control Room	Wall loss to void	Noise in void
0	31.5			
1	63	110	57	53
2	125	110	67	43
3	250	110	77	33
4	500	110	88	22
5	1000	105	101	4
6	2000	100	110	-10
7	4000	98	115	-17
8	8000	98		

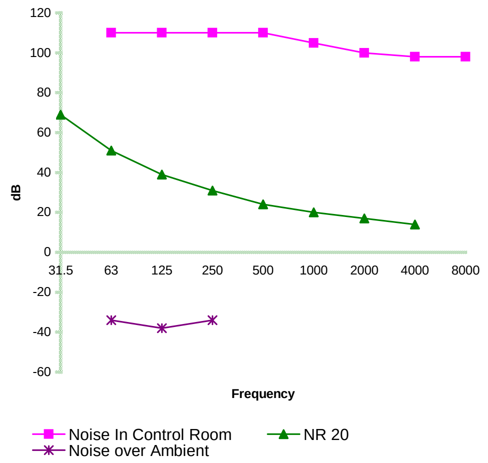


Control Room to Live Room 004: 150mm Concrete block with 200mm air gap, 100mm mineral wool void damping

Rw:

M-A-M resonance: 14Hz

Frequency	Noise In Control Room	Wall loss to 004	NR 20	Noise over Ambient
31.5			69	
63	110	93	51	-34
125	110	109	39	-38
250	110	*113*	31	-34
500	110	*>120*	24	
1000	105	*>120*	20	
2000	100	*>120*	17	
4000	98	*>120*	14	
8000	98			



Anechoic Chamber (Room 009)

The current Anechoic Chamber will be refurbished. It is proposed that the interior treatment be replaced with new on a like-for-like basis as its design is current and performance satisfactory. The door, which has at some time been removed, should be replaced in the manner illustrated in the overall scheme design drawings and investigations as to necessary detailing for this will be undertaken.

The air-conditioning to the space will be replaced with a system compatible with the rest of the facility and specified to meet expected cross-talk and noise performance parameters. It is suggested that the system be called to run at NC15, but this can be agreed upon during discussion prior to the Phase 2 drawing issue.