SPRA
Single Ply Roofing Association

TECHNICAL GUIDANCE

ACOUSTIC
CONTROL WITHIN BUILDINGS

ENSURING THAT CLIENTS OBTAIN HIGH QUALITY POLYMER-BASED SINGLE PLY ROOFING, THROUGH A PARTNERSHIP OF QUALITY ASSURED MANUFACTURERS AND CONTRACTORS

S9/10

GUIDANCE DOCUMENT

ACOUSTIC CONTROL WITHIN BUILDINGS

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1.0 INTRODUCTION

Noise is defined as unwanted sound & it is therefore essential that the control of noise pollution is addressed from the earliest stage in the design process.

The external roof represents a large proportion of a building's surface area, and therefore it's acoustic performance plays a significant role in establishing an acceptable environment within the rooms below. It is unfortunate that the acoustic performance of a roof often gets overlooked or is addressed too late in the design process to be effective and as a consequence the solution provided thereby is possibly inadequate.

Tendering contractors should establish whether there is an acoustic report for the project and whether the designer has consulted an acoustic engineer. (See check list for Acoustic Specification, Appendix C).

Acoustic reports are typically constructed from noise surveys on a specific project and hold some early key information on design parameters. Unless an acoustic engineer is consulted throughout the design process, the design teams could be relying on data, which may not meet the relevant standards and could fall short of the client's requirements.

Education and Healthcare premises particularly have seen an increase in acoustic performance requirements. It is important that all parties involved in the construction process have a basic understanding of the key issues relating to acoustic performance. It is critical that products and systems are fit-for-purpose and conform to the appropriate standard and will deliver the solutions required.

Retro fit solutions add cost to the construction process and will never be a suitable alternative to good planning and consultation during the design stage of a project.

2.0 SOUND CONTROL WITHIN BUILDINGS

2.1 AIRBORNE SOUND REDUCTION FOR ROOFS

The acoustic performance requirements of an external roof will be specifically influenced by the buildings location together with its layout and overall design. Performance is therefore project specific and not addressed by Approved Document E of the Building Regulations per se. Sound break-in should be considered for instance where a building's location is adjacent to busy roads or railways, under air traffic paths or near noisy commercial or industrial operations. Design should provide for control and reduction of noise break-out for building types such as nightclubs, concert halls and similar environments.

Should the roof structure be required to provide sound reduction from external sources, then the mass of the structural deck and individual roof layers is of importance in the determination of acoustic performance.

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Should the roof structure be required to provide sound reduction from external sources, then the mass of the structural deck and individual roof layers is of importance in the determination of acoustic performance.

Concrete decks due to their high mass will generally exhibit good acoustic performance with respect to airborne sound reduction through the roof construction.

Lightweight metal decks incorporating single ply membrane can provide good levels of sound reduction. This can be enhanced further as required by the individual project performance specification through use of additional unit mass using insulation boards in combination with additional mass layers. Specifications are often achieved by the use of ceiling voids and standard / acoustic ceilings to offer improved sound attenuation and thereby assist in minimising disturbance.

Although proposed, ceilings are often not identified, for example in specifications or on tender drawings. Whether or not a ceiling is proposed should be verified. This should be verified so that the complete roof construction is understood when the acoustic performance is being assessed. The installation of an absorptive acoustic ceiling may reduce the overall mass required for the roof. The use of a solid plasterboard suspended ceiling could improve the sound insulation even more, but, being reflective, might result in poor acoustic conditions inside the room.

Consideration should also be given to the acoustic performance of other components such as roof lights, the external wall construction, and external windows and doors, which may influence internal noise levels. All likely sources of external and internal noise should be identified in order to establish the degree of attenuation required to suit the building function.

It is generally not advisable to place external air handling plant directly on the roof surface for reasons of satisfactory weatherproofing. In lightweight construction this may also contribute to sound transmission. Where it is necessary to place such plant on the flat roof area, vibration isolator mountings should be used. Single ply membrane should be detailed around the vibration isolator mountings to ensure effective weatherproofing.

The most common specification for airborne sound reduction will state the required decibel (dB) sound reduction asa weighted sound reduction Index (R_w). This is a single figure quantity, measured in a laboratory, which characterises the sound insulating properties of a material or building element across a stated frequency range. The higher the figure the better the performance.

Where a performance specification is determined by an acoustic consultant, this will require minimum sound reduction indices (R), measured in decibels (dB), for each frequency band, the particular values specified relating to individual project requirements. It is important to ensure that these requirements are achievable by reference to either an acoustic test report or assessment for the proposed roof construction from a UKAS accredited acoustic testing laboratory or acoustic consultant.

For specific project testing, tests shall be conducted in accordance with BS EN ISO 140-3:1995. If a roof forms part of a façade, then on-site commissioning tests may be done in accordance with BS EN ISO 140-5:1998.

2.2 RAIN NOISE

Impact noise from rain must be considered at an early part in the roof design, due to the fact that this may significantly increase the indoor noise levels. The inherent flexibility of single ply membranes combined with appropriate insulation and fastening systems can offer a significantly improved acoustic performance when compared with rigid metal composite roofing systems.

The method of testing to determine for rain noise for a specific roof construction is detailed within British Standard BS EN ISO 140-18: 2006.

Where a specific rain noise performance is specified for a roof construction, it is recommended that an acoustic expert is employed to assess the proposed roof construction. Determining the existing external noise levels is not relevant to rain noise prediction. (This would have been done by the acoustic consultant to calculate the required sound reduction indices discussed in section 2.1). The performance targets for different room types are expressed as an A-weighted equivalent continuous sound pressure level (L_{Aeq}). For sounds that do not vary in level, this is simply equal to the A- weighted sound pressure level. The rainfall conditions under which the targets are to be met must be specified. Types of rainfall are defined in the Standard, with ''heavy'' being the type usually specified. Test data, usually given in terms of sound intensity levels (LI) in frequency bands and A-weighted sound intensity level (LAI), should allow for these values to be calculated by an acoustic consultant (see checklist for guidance). Note the lower the L_{Aeq} figure the better the performance.

Should the roof construction not achieve the ambient noise levels proposed, then it is typical to treat the ceiling. Where the ceiling is also the soffit of the roof then additional lining and sound absorption materials may be required. The solution may involve the use of an acoustic suspended ceiling, or alternatively a perforated metal lining tray solution and is specific to the room design and usage.

Where no test data is available, an acoustic assessment should be made for the proposed roof and roof light constructions to demonstrate that rain noise conditions will be acceptable.

Currently there are two specific categories of building where rain noise calculations / assessments are required namely Educational buildings (See 2.2.1) and Healthcare buildings (See 2.2.2).

2.2.1 EDUCATION

Guidance to designers with respect to rain noise is currently given within Approved Document E of the Building Regulations – via Building Bulletin 93 for schools and educational establishments. This is specifically for teaching and learning spaces. Building Bulletin 93 advises designers to consider the effect of impact noise from rain at an early stage of the roof design in order to minimise disturbance within the building. Whilst no limit is set, methods of control must be included and justified to building control.

Within BREEAM (Building Research Establishment Environment Assessment Method) Education 2008, rain noise is assessed under Health and Well-being, which details the requirements for acoustic performance. For new build and refurbishment of existing buildings, one credit is awarded should the increase in indoor ambient noise level during 'heavy rainfall' not exceed the levels defined in Table 1.1 of Building Bulletin by more than 20dB. (See Appendix A).

2.2.2 HEALTHCARE

Healthcare Technical Memorandum 08-01: Acoustics is the main acoustic design document used by designers for healthcare buildings.

This document states that rain noise should not result in undue disturbance in internal spaces. Also that some noise from rain is acceptable in most types of room, and indeed can be comforting to occupants. It requires that Indoor ambient-noise levels during "heavy" 1 rainfall should not exceed the intrusive noise criteria in Table 1 (see Appendix B) by more than 20dB(A) or should not be more than 65 dB(A), whichever is lower.

Furthermore, Healthcare Technical Memorandum 08-01 states that suitable lightweight roof constructions that provide sufficient attenuation will probably consist of many layers. It stipulates a requirement for laboratory measured data to assess the noise level that will result inside the building.

Table 1 of Healthcare Technical Memorandum 08-01 sets out recommended criteria for noise intrusion for the completed building (including normal furniture) and is reproduced as Appendix B.

[1] "Moderate" and "heavy" rainfall is as described in BS EN ISO 140-18:2006

2.3 SOUND ABSORPTION

Sound absorption within buildings is important for building categories including manufacturing plants, offices, convention and sports halls where sound reflection may become a problem following occupancy. This may be achieved using a combination of insulation boards in conjunction with perforated decking, acoustic ceilings or other sound reduction measures.

Acoustic testing for sound absorption of a roof structure should be in accordance with BS EN ISO 354:2003. Absorption coefficients are then attained for individual frequency ranges. In order to achieve the desired acoustic performance it is essential that the construction used is the same as that tested. For example, should perforated metal roof liners be used, the percentage of the free area of the perforated element is an important consideration for absorption and therefore should be of the same type as tested.

There are five defined sound absorption class categories and these range from type A to E. They are based upon the weighted sound absorption coefficient, calculated in accordance with BS EN ISO 11654:1997. Class A absorption is the best and E is the worst.

Within Approved Document E of the building regulations (England & Wales) are defined sound absorption requirements. Section 7 of E3 covers entrance halls, corridors, hallways and stairwells. Method A compliance is referred to in E3 & E4 and also Building Bulletin 93 for Schools, and this method can generally be satisfied using ceilings with Class C sound absorption.

2.4 FLANKING SOUND TRANSMISSION

In order for the construction to be effective, care should be taken to correctly detail the junctions between the various elements. Any penetrations or abutting elements should be isolated and appropriately insulated to control flanking transmission.

Approved Document E (England & Wales) provides advice on how to isolate at junctions of walls and floors and around penetrations.

3.0 ACKNOWLEDGEMENTS AND USEFUL REFERENCES

SPRA wishes to thank Trevor Hickman of Sound Research Laboratories Limited for his input to this acoustic guidance document.

Further references include:

3.5.1 BS 6229: 2003 Flat roofs with continuously supported coverings - Code of Practice details some flat roofing acoustic basics and BS 8233: 1999 Sound insulation and noise reduction for buildings

3.5.2 Shaping the future of Education: Standardised specifications, Layouts and Dimensions, Performance Specifications and Design Solutions for Roof Coverings in Secondary Schools. DfES.

3.5.3 Healthcare Technical Memorandum 08-01: Acoustics. Department of Health.

3.5.4 Acoustic Design Of Schools - DFES (ISBN 0 11 271105 7)

3.5.5 BREEAM Schools 2008. Assessor Manual. Health and Wellbeing. Acoustic Performance.

3.5.6 Building Bulletin 93. Acoustic Design Of Schools. A Design Guide. DfES

3.5.7 Building Regulations Approved Document E - Acoustics.

3.5.8 BREEAM Healthcare: http://www.breeam.org/page.jsp?id=105

3.5.9 Measurement of sound insulation in buildings – Laboratory Measurement of sound generated by rainfall on building elements. The BRE Information Paper IP 2 / 06 "Rain noise on glazed and lightweight roofing"

APPENDIX A: TABLE 1.1 FROM BB93 ACOUSTIC DOCUMENT FOR SCHOOLS

SPECIFICATION OF ACOUSTIC PERFORMANCE

Type of room	Room classification for the purpose of airborne sound insulation in Table 1.2		Upper limit for the indoor ambient noise level $L_{Aeq30min}$(dB)
	Activity noise (Source room)	Noise tolerance (Receiving room)	
Nursery school playrooms Nursery school quiet rooms	High Low	Low Low	351 351
Primary school: classrooms, class bases, general teaching areas, small group rooms	Average	Low	351
Secondary school: classrooms, general teaching areas, seminar rooms, tutorial rooms, language laboratories	Average	Low	351
Openplan2 Teaching areas Resource areas	 Average Average	 Medium Medium	 401 401
Music Music classroom Small practice/group room Ensemble room Performance/recital room Recording studio3 Control room for recording	 Very High Very High Very High Very High Very High High	 Low Low Very Low Very Low Very Low Low	 351 351 301 301 301 301
Lecture rooms Small (fewer than 50 people) Large (more than 50 people)	 Average Average	 Low Very Low	 351 301
Classrooms designed specifically for use by hearing impaired students (including speech therapy rooms)	Average	Very Low	301
Study room: Individual study, withdrawal, remedial work, teacher preparation	Low	Low	351
Libraries Quiet study areas Resource areas	 Low Average	 Low Medium	 351 40
Science laboratories	Average	Medium	40
Drama studios	High	Very Low	301
Design and Technology • Resistant materials, CADCAM areas • Electronics/control, textiles, food,graphics, design\resources areas	 High Average	 High Medium	 40 40
Art rooms	Average	Medium	40
Assembly halls4, multi-purpose halls4, (drama, PE, audio-visual presentations, assembly, occasional music)	High	Low	351
Audio-visual, video-conferencing rooms	Average	Low	351
Atria, circulation spaces used by students	Average	Medium	45
Indoor sports hall	High	Medium	40
Dance studio	High	Medium	40
Gymnasium	High	Medium	40
Swimming pool	High	High	50
Interview/counselling rooms, medical rooms		Low	351
Dining rooms	High	High	45
Ancilary spaces: Kitchens* Offices, staff rooms* Corridors, stairwells* Coats and changing areas* Toilets*	High Average Average - High High Average	High Medium High High High	50 40 45 15 50

TABLE 1.1: PERFORMANCE STANDARDS FOR INDOORAMBIENT NOISE LEVELS - UPPER LIMITS FOR THE INDOOR AMBIENT NOISE LEVEL, $L_{awq30min}$

*Part E of Schedule 1 to the Building Regulations 2000 (as amended by S1 2002/2871) applies to teaching and learning spaces and is not intended to cover administration and anciallry spaces (see under Scope in the introduction). For these areas the performance standards are for guidance only.

APPENDIX B: TABLE OF HEALTHCARE TECHNICAL MEMORANDUM 08-01

Room type	Example	Criteria for noise intrusion to be met inside the spaces from external sources (dB)
Ward - single person	Single bed ward, single bed recovery areas and on-call room, relatives' overnight stay	40 $L_{Aeq, 1hr}$ daytime 35 $L_{Aeq, 1hr}$ night 45 $L_{Amax, f}$ night
Ward - multi bed	Multi-bed wards, recovery areas	40 $L_{Aeq, 1hr}$ daytime 35 $L_{Aeq, 1hr}$ night 45 $L_{Amax, f}$ night
Small office-type spaces	Private offices, small treatment rooms, intreview rooms, consulting rooms	40 $L_{Aeq, 1hr}$
Open clinical areas	A&E	45 $L_{Aeq, 1hr}$
Circulation spaces	Corridors, hospital street, atria	55 $L_{Aeq, 1hr}$
Public areas	Dining areas, waiting areas, playrooms	50 $L_{Aeq, 1hr}$
Personal hygiene (en-suite)	Toilets, showers	45 $L_{Aeq, 1hr}$
Personal hygiene (public and staff)	Toilets, showers	55 $L_{Aeq, 1hr}$
Small food-preparation areas	Wards, kitchens	50 $L_{Aeq, 1hr}$
Large food-preparation areas	Main kitchens	55 $L_{Aeq, 1hr}$
Large meeting rooms (>35m2 floor area)	Lecture theatres, meeting rooms, board rooms, seminar rooms, classrooms	35 $L_{Aeq, 1hr}$
Small meeting rooms (≤35m2 floor area)	Average	40 $L_{Aeq, 1hr}$
Operating theatres	Operating theatres	40 $L_{Aeq, 1hr}$ 50 $L_{Amax, f}$
Laboratories	Laboratories	45 $L_{Aeq, 1hr}$

APPENDIX C: CHECKLIST FOR ACOUSTIC SPECIFICATION

Record the roof build-up of proposed construction:	Outside: (including e.g. green roof, ballast etc) 1. 2. 3. 5. 6. 7. 8. 9. Inside: (Including Ceiling build-up)
Is there an acoustic engineer's report for the project?	Yes / No
Has the system been tested in accordance with required standards?	Yes / No* * If no, additional acoustic assessment/ confirmation required
Are the stated performance figures in accordance with the specification? e.g. • Airborne Sound Reduction = Rw dB • Rain Noise = LAeq • Absorption = NRC or	Yes / No
Do the test results meet the performance figures in the specification?	Yes / No
Is there a ceiling? If yes then is it an acoustic ceiling?	Yes* / No Yes* / No * Material description required
How is the system fixed?	Full details required including which layers bonded/mechanically fixed.
Is the method of fixing compatible with the membrane manufacturer's guidance?	Yes / No
Has a condensation risk analysis been performed?	Yes / No* * Should be verified to avoid risk
Is the weight of the system within the structural design limits?	Yes / No