Building Bulletin 93 aims to:

- provide a regulatory framework for the acoustic design of schools in support of the Building Regulations
- give supporting advice and recommendations for planning and design of schools
- provide a comprehensive guide for architects, acousticians, building control officers, building services engineers, clients, and others involved in the design of new school buildings.

The constructional standards for acoustics for new school buildings, as given in Section 1 of this document, are required to be achieved under the Building Regulations. This represents a significant tightening of the regulation of acoustic design in schools, to reflect a general recognition, supported by research, that teaching and learning are acoustically demanding activities. In particular, there is a consensus that low ambient noise levels are required, particularly in view of the requirements of the Special Educational Needs and Disability Act 2001[1] for integration of children with special needs in mainstream schools.

Unfortunately, a large number of classrooms in the UK currently suffer from poor acoustics. The most serious acoustic problems are due to noise transfer between rooms and/or excessive reverberation in rooms. There are many reasons for the poor acoustics, for example:

- The acoustics of the stock of old Victorian schools are often unsuitable for modern teaching methods.
- Modern constructions do not always provide adequate sound insulation and may need special treatment.
- Open plan, or semi-open plan layouts, designed to accommodate a number of different activities, are areas where background noise and sound intrusion often cause problems.
- The acoustics of multi-purpose rooms, such as halls, have to be suitable for a variety of activities, for example music (which requires a long reverberation time) and speech (which requires shorter reverberation times).
- Many activities, such as music and design technology lessons, can be noisy and will cause problems if there is inadequate sound insulation between areas for these activities and those requiring quieter conditions.

Poor acoustic conditions in the classroom increase the strain on teachers' voices as most teachers find it difficult to cope with high noise levels. This often leads to voice problems due to prolonged use of the voice and the need to shout to keep control. Recent surveys in the UK and elsewhere show that teachers form a disproportionate percentage of voice clinic patients.

Historically, there have been a number of factors preventing good acoustic design and this Building Bulletin addresses these issues.

- Before 2003, Part E of the Building Regulations did not apply to schools. It now includes schools within its scope.
- Although the constructional standards for schools previously quoted Building Bulletin 87[2] as the standard for acoustics in schools, many designers were unaware of the requirements of BB87 and the standards were rarely enforced. These standards have been updated to reflect current research and the relevant requirements of the Disability Discrimination Act, and are included in the compliance section, Section 1, of this bulletin.
- The pressure on finances has meant in the past that acoustics came low on the list of design priorities. The acoustic design will now have a higher priority as it will be subject to building control

1. Now incorporated as Section IV of the Disability Discrimination Act[1] approval procedures.

• There has been little guidance available in the past on how to achieve the right balance of acoustics in the complex and dynamic environment of a school. Architects and designers have had a difficult time finding information to make design easy and, in particular, to help them choose the correct target values of appropriate parameters.

Overall, Building Bulletin 93 recommends a structured approach to acoustic design at each stage of the planning and design process, as shown in the table below.

A structured approach to acoustic design at each stage of the planning and design process	
Feasibility/Sketch Design	■ Selection of the site ■ Noise survey to establish external noise levels ■ Orientation of buildings ■ Massing and form of the buildings ■ Consideration of need for external noise barriers using the buildings, fences and screens and landscape features ■ Preliminary calculation of sound insulation provided by building envelope including the effect of ventilation openings
Detailed Design	■ Determine appropriate noise levels and reverberation times for the various activities and room types ■ Consider the special educational needs of the pupils ■ Consider the design of music, drama and other specialist spaces separately from that of normal classrooms as the design criteria are very different. ■ Provide the necessary façade sound insulation whilst providing adequate ventilation, particularly in the case of spaces such as classrooms and science laboratories which require high ventilation rates ■ Architectural/acoustic zoning: plan the disposition of 'quiet' and 'noisy' spaces, separating them wherever possible by distance, external areas or neutral 'buffer' spaces such as storerooms or corridors ■ Consider sound insulation separately from other aspects of room acoustics using walls, floors and partitions to provide adequate sound insulation ■ Design the acoustics of the rooms by considering their volume and shape, and the acoustic properties of their surfaces ■ Specify the acoustic performance of doors, windows and ventilation openings ■ Specify any amplification systems
Building Control Approval	■ Submit plans, including specific details of the acoustic design, for approval by Building Control Body

SCOPE of Building Bulletin 93

Section 1 of Building Bulletin 93 supersedes Section A of Building Bulletin 87[2] as the constructional standard for acoustics for new school buildings.

In addition, Part E of the Building Regulations includes schools within its scope and Approved Document E[3] gives the following guidance: *"In the Secretary of State's view the normal way of satisfying Requirement E4 will be to meet the values for sound insulation, reverberation time and internal ambient noise which are given in Section 1 of Building Bulletin 93 'The Acoustic Design of Schools', produced by DfES."*

The requirements of Section 1 came into force on 1st July 2003, at the same time as those contained in the new Approved Document Part E[3], in support of the Building Regulations.

Requirement E4 from Part E of Schedule 1 to The Building Regulations 2000 (as amended) states that:

"Each room or other space in a school building shall be designed and constructed in such a way that it has the acoustic conditions and the insulation against disturbance by noise appropriate to its intended use."

The Education (School Premises) Regulations 1999, SI 1999 No.2 which applies to both new and existing school buildings, contains a similar statement: *"Each room or other space in a school building shall have the acoustic conditions and the insulation against disturbance by noise appropriate to its normal use."*

Compliance with the acoustic performance standards specified in Section 1 will satisfy both regulations for new schools.

Although Building Regulations do not apply to all alteration and refurbishment work, it is desirable that such work should consider acoustics and incorporate upgrading of the acoustics as appropriate. (In the case of existing buildings, the Building Regulations apply only to 'material alterations' as defined in Regulations 3 and 4.) Although it would be uneconomic to upgrade all existing school buildings to the same standards as new school buildings, where there is a need for upgrading the acoustic performance of an existing building or when refurbishment is happening for other reasons, then the designer should aim to meet the acoustic performance given in Section 1 of BB93 to satisfy the School Premises Regulations and the Disability Discrimination Act.

The exemption of Local Education Authority (LEA) maintained schools from the Building Regulations has ended. New school buildings, including extensions to existing school buildings and new schools formed by change of use of other buildings, are now included in the Building Regulations and may be subject to detailed design checks and on-site inspections by Building Control Bodies.

The Building Regulations and hence the requirements of BB93 only apply in England and Wales. They apply to both LEA maintained schools and independent schools.

Temporary buildings are exempt from the Building Regulations. Temporary buildings are defined in Schedule 2 to the Building Regulations as those which are not intended to remain in place for longer than 28 days. What are commonly called temporary buildings in schools are classed as prefabricated buildings and are normally subject to the same Building Regulations requirements as other types of building. Additional guidance is given in Clause 0.6 of Approved Document E[3]. A building that is created by dismantling, transporting and re-erecting the sub-assemblies on the same premises, or is constructed from sub-assemblies obtained from other premises or from stock manufactured before 1st July 2003, would normally be considered to meet the requirements for schools if it satisfies the relevant provisions relating to acoustic standards set out in the 1997 edition of Building Bulletin 87[2].

The extension of Part E of Schedule 1 to the Building Regulations 2000 (as amended by SI 2002/2871) to schools applies to teaching and learning spaces. Therefore the performance standards in the tables in Section 1 are required for compliance with Part E for all teaching and learning spaces. Part E of the Building Regulations is not intended to cover the acoustic conditions in administration and ancillary spaces not used for teaching and learning except in as far as they affect conditions in neighbouring teaching and learning spaces. Therefore consideration needs to be given to adjoining areas, such as corridors, which might have doors, ventilators, or glazing separating them from a teaching or learning space. The performance standards given in the tables for administration and ancillary spaces are for guidance only.

Rooms used for nursery and adult/community education within school complexes are also covered by Part E. Part E does not apply to nursery schools which are not part of a school, sixth form colleges which have not been established as schools, and Universities or Colleges of Further and Higher Education[2]. However, many of the acoustic specifications are desirable and can be used as a guide to the design of these buildings. The standards are particularly appropriate for nursery schools as figures are quoted for nursery spaces within primary schools.

The Disability Discrimination Act 1995[1], as amended by the Special Educational Needs and Disability Act 2001, places a duty on all schools and LEAs to plan to increase over time the accessibility of schools for disabled pupils and to implement their plans. Schools and LEAs are required to provide:

- increased access for disabled pupils to the school curriculum. This covers teaching and learning and the wider curriculum of the school such as after-school clubs, leisure and cultural activities.
- improved access to the physical environment of schools, including physical aids to assist education. This includes acoustic improvements and aids for hearing impaired pupils.

When alterations affect the acoustics of a space then improvement of the acoustics to promote better access for children with special needs, including hearing impairments, should be considered. Approved Document M: 1999 – Access and facilities for disabled people, in support of the Building Regulations[4] includes requirements for access for children with special needs. See also BS 8300: 2001 Design of buildings and their approaches to meet the needs of disabled people[5].

2. Part E of the Building Regulations quotes the definition of school given in Section 4 of the 1996 Education Act. In the case of sixth form colleges Section 4 of the 1996 Act should be read in conjunction with Section 2 of the same Act, in particular subsections (2), (2A) and (4) which deal with the definition of secondary education.

If a sixth form college is established as a school under the 1998 School Standards and Framework Act then it will be classed as a school under Section 4 of the 1996 Education Act and Part E of the Building Regulations on acoustics will apply. Only one sixth form college has been established in this way up until now.

Therefore, most sixth form colleges are institutions in the Further Education sector and not schools, and Part E of the Building Regulations will not apply.

In the case of a new sixth form college it will be necessary to contact the LEA to enquire if the sixth form college has been established as a school or as an Institute of Further Education.

Overview of contents of Building Bulletin 93

Section 1: Specification of Acoustic Performance consists of three parts.

Section 1.1 gives the performance standards for new school buildings to comply with the Building Regulations. These provide a good minimum standard for school design. However, on occasion higher standards will be necessary.

Section 1.2 sets out the preferred means of demonstrating compliance to the Building Control Body.

Section 1.3 gives the tests recommended to be conducted as part of the building contract.

Section 2: Noise Control describes how to conduct a site survey and to plan the school to control noise. It also includes recommendations on maximum external noise levels applying to playing fields, recreational areas and areas used for formal and informal outdoor teaching. External levels are not covered by Building Regulations but are taken into consideration in planning decisions by local authorities[6].

Section 3: Sound Insulation gives detailed guidance on constructions to meet the performance standards for sound insulation specified in Section 1.1.

Section 4: The Design of Rooms for Speech and Section 5: The Design of Rooms for Music give guidance on various aspects of acoustic design relevant to schools.

Section 6: Acoustic Design and Equipment for Pupils with Special Hearing Requirements discusses design appropriate for pupils with hearing impairments and special hearing requirements. It discusses the necessary acoustic performance of spaces and describes the range of aids available to help these pupils.

Section 7 contains 10 case studies illustrating some of the most important aspects of acoustic design of schools.

Appendix 1 defines the basic concepts and technical terms used in the Bulletin.

Appendices 2 and 3 describe the basic principles of room acoustics and sound insulation.

Appendices 4 to 7 give examples of calculations of sound insulation, reverberation time and absorption.

Appendix 8 gives equipment specifications for sound field systems to guide those who need to specify this type of equipment.

Appendix 9 gives an overview of the Noise at Work Regulations as they relate to teachers.

Appendix 10 gives an example of a submission for approval by a Building Control Body.

The DfES acoustics website www.teachernet.gov.uk/acoustics contains further reference material which expands on the source material for acousticians and designers. For example, it links to a spreadsheet which can be used to calculate the sound insulation of the building envelope and the reverberation time of internal rooms. The website will be regularly updated with new information, discussion papers and case studies. The website also contains complete downloads of BB93.

References

[1] Disability Discrimination Act (1995) Part IV www.hmso.gov.uk

[2] Building Bulletin 87, Guidelines for Environmental Design in Schools (Revision of Design Note 17), The Stationery Office, 1997. ISBN 011 271013 1. (Now superseded by 2003 version of BB87, which excludes acoustics, and is available on www.teachernet.gov.uk/energy)

[3] Approved Document E – Resistance to the passage of sound. Stationery Office, 2003. ISBN 0 11 753 642 3. www.odpm.gov.uk

[4] Approved Document M:1999 Access and facilities for disabled people, in support of the Building Regulations, Stationery Office, 1999 ISBN 0 11 753469. To be replaced shortly by Approved Document M, Access to and use of buildings. www.odpm.gov.uk

[5] BS 8300: 2001 Design of buildings and their approaches to meet the needs of disabled people, Code of Practice.

[6] PPG 24, Planning Policy Guidance: Planning and Noise, Department of the Environment, The Stationery Office, September 1994. To be replaced by revised Planning Policy documents.

Specification of acoustic performance

SECTION 1

Section 1 of Building Bulletin 93 sets the performance standards for the acoustics of new buildings, and describes the normal means of demonstrating compliance with The Building Regulations.

Contents

The normal way of satisfying Requirement E4 of The Building Regulations is to demonstrate that all the performance standards in Section 1.1, as appropriate, have been met.

Section 1.2 sets out the preferred means for demonstrating compliance of the design to the Building Control Body.

Section 1.3 describes acoustic tests that can be used to demonstrate compliance with the performance standards in Section 1.1. It is strongly recommended that the client require acoustic testing to be carried out as part of the building contract, because testing of the completed construction is the best practical means of ensuring that it achieves the design intent.

In all but the simplest of projects it is advisable to appoint a suitably qualified acoustic consultant[1] at an early stage of the project, before the outline design has been decided. This will prevent simple mistakes which can be costly to design out at a later stage. An acoustic consultant will normally be needed to check the design details and on-site construction, and to carry out acoustic tests to confirm that the building achieves the required acoustic performance.

1 The primary professional body for acoustics in the UK is the Institute of Acoustics. An experienced professional acoustician who is competent to be responsible for the acoustic design of school buildings would normally be a corporate member of the Institute of Acoustics.

1.1 Performance standards

The overall objective of the performance standards in Section 1.1 is to provide acoustic conditions in schools that (a) facilitate clear communication of speech between teacher and student, and between students, and (b) do not interfere with study activities.

Performance standards on the following topics are specified in this section to achieve this objective:

- indoor ambient noise levels
- airborne sound insulation between spaces
- airborne sound insulation between corridors or stairwells and other spaces
- impact sound insulation of floors
- reverberation in teaching and study spaces
- sound absorption in corridors, entrance halls and stairwells
- speech intelligibility in open-plan spaces.

All spaces should meet the performance standards defined in Tables 1.1, 1.2, 1.3, 1.4 and 1.5 for indoor ambient noise level, airborne and impact sound insulation, and reverberation time. Open-plan spaces should additionally meet the performance standard for speech intelligibility in Table 1.6.

The notes accompanying Tables 1.1, 1.2, 1.3 and 1.5 contain additional guidance that should be considered when designing the spaces to meet the performance standards in these tables. Although good practice, this guidance will not be enforced under the Building Regulations.

1.1.1. Indoor ambient noise levels in unoccupied spaces

The objective is to provide suitable indoor ambient noise levels (a) for clear communication of speech between teacher and student, and between students and (b) for study activities.

The indoor ambient noise level includes noise contributions from:

- external sources outside the school premises (including, but not limited to, noise from road, rail and air traffic, industrial and commercial premises)
- building services (eg ventilation system, plant, etc). If a room is naturally ventilated, the ventilators or windows should be assumed to be open as required to provide adequate ventilation. If a room is mechanically ventilated, the plant should be assumed to be running at its maximum operating duty.

The indoor ambient noise level excludes noise contributions from:

- teaching activities within the school premises, including noise from staff, students and equipment within the building or in the playground. Noise transmitted from adjacent spaces is addressed by the airborne and impact sound insulation requirements.
- equipment used in the space (eg machine tools, CNC machines, dust and fume extract equipment, compressors, computers, overhead projectors, fume cupboards). However, these noise sources should be considered in the design process.
- rain noise. However, it is essential that

NOTES ON TABLE 1.1

1 Research indicates that teaching can be disrupted by individual noisy events such as aircraft flyovers, even where the noise level is below the limits in Table 1.1. For rooms identified in Table 1.1 having limits of 35 dB or less the noise level should not regularly exceed 55 dB $L_{A1,30min}$.

2 Acoustic considerations of open-plan areas are complex and are discussed in Section 1.1.7 and Section 4.

3 Studios require specialised acoustic environments and the noise limits for these will vary with the size, intended use and type of room. In some cases noise limits below 30 dB L_{Aeq} may be required, and separate limits for different types of noise may be appropriate; specialist advice should be sought.

4 Halls are often multi-functional spaces (especially in primary schools) used for activities such as dining, PE, drama, music, assembly, and performing plays and concerts. In such multi-functional spaces the designer should design to the lowest indoor ambient noise level for which the space is likely to be used. For large halls used for formal drama and music performance lower noise levels than those in Table 1.1 are preferable, and levels of 25 dB $L_{Aeq,30min}$ may be appropriate. In these cases specialist advice should be sought.

Type of room	Room classification for the purpose of airborne sound insulation in Table 1.2		Upper limit for the indoor ambient noise level $L_{Aeq,30min}$ (dB)
	Activity noise (Source room)	Noise tolerance (Receiving room)	
Nursery school playrooms	High	Low	35[1]
Nursery school quiet rooms	Low	Low	35[1]
Primary school: classrooms, class bases, general teaching areas, small group rooms	Average	Low	35[1]
Secondary school: classrooms, general teaching areas, seminar rooms, tutorial rooms, language laboratories	Average	Low	35[1]
Open-plan[2]			
Teaching areas	Average	Medium	40[1]
Resource areas	Average	Medium	40[1]
Music			
Music classroom	Very high	Low	35[1]
Small practice/group room	Very high	Low	35[1]
Ensemble room	Very high	Very low	30[1]
Performance/recital room	Very high	Very low	30[1]
Recording studio[3]	Very high	Very low	30[1]
Control room for recording	High	Low	35[1]
Lecture rooms			
Small (fewer than 50 people)	Average	Low	35[1]
Large (more than 50 people)	Average	Very low	30[1]
Classrooms designed specifically for use by hearing impaired students (including speech therapy rooms)	Average	Very low	30[1]
Study room (individual study, withdrawal, remedial work, teacher preparation)	Low	Low	35[1]
Libraries			
Quiet study areas	Low	Low	35[1]
Resource areas	Average	Medium	40
Science laboratories	Average	Medium	40
Drama studios	High	Very low	30[1]
Design and Technology			
• Resistant materials, CADCAM areas	High	High	40
• Electronics/control, textiles, food, graphics, design/resource areas	Average	Medium	40
Art rooms	Average	Medium	40
Assembly halls[4], multi-purpose halls[4] (drama, PE, audio/visual presentations, assembly, occasional music)	High	Low	35[1]
Audio-visual, video conference rooms	Average	Low	35[1]
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
Interviewing/counselling rooms, medical rooms	Low	Low	35[1]
Dining rooms	High	High	45
Ancillary spaces Kitchens*	High	High	50
Offices*, staff rooms*	Average	Medium	40
Corridors*, stairwells*	Average - High	High	45
Coats and changing areas*	High	High	45
Toilets*	Average	High	50

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

Table 1.1: Performance standards for indoor ambient noise levels - upper limits for the indoor ambient noise level, $L_{Aeq,30min}$

Table 1.2: Performance standards for airborne sound insulation between spaces - minimum weighted BB93 standardized level difference, $D_{nT\,(T_{mf,max}),w}$

Minimum $D_{nT\,(T_{mf,max}),w}$ (dB)		**Activity noise in source room** *(see Table 1.1)*			
		Low	Average	High	Very high
Noise tolerance in receiving room *(see Table 1.1)*	High	30	35	45	55
	Medium	35	40	50	55
	Low	40	45	55	55
	Very low	45	50	55	60

NOTES ON TABLE 1.2

1 Each value in the table is the minimum required to comply with the Building Regulations. A value of 55 dB $D_{nT\,(T_{mf,max}),w}$ between two music practice rooms will not mean that the music will be inaudible between the rooms; in many cases, particularly if brass or percussion instruments are played, a higher value is desirable.

2 Where values greater than 55 dB $D_{nT\,(T_{mf,max}),w}$ are required it is advisable to separate the rooms using acoustically less sensitive areas such as corridors and storerooms. Where this is not possible, high performance constructions are likely to be required and specialist advice should be sought.

3 It is recommended that music rooms should not be placed adjacent to design and technology spaces or art rooms.

4 These values of $D_{nT\,(T_{mf,max}),w}$ include the effect of glazing, doors and other weaknesses in the partition. In general, normal (non-acoustic) doors provide much less sound insulation than the surrounding walls and reduce the overall $D_{nT\,(T_{mf,max}),w}$ of the wall considerably, particularly for values above 35 dB $D_{nT\,(T_{mf,max}),w}$. Therefore, doors should not generally be installed in partitions between rooms requiring values above 35 dB $D_{nT\,(T_{mf,max}),w}$ unless acoustic doors, door lobbies, or double doors with an airspace are used. This is not normally a problem as rooms are usually accessed via corridors or circulation spaces so that there are at least two doors between noise-sensitive rooms. For more guidance see Section 3.

this noise is considered in the design of lightweight roofs and roof lights as it can significantly increase the indoor ambient noise level (see the design guidance in Section 3.1.1). It is intended that a performance standard for rain noise will be introduced in a future edition of BB93. To satisfy this edition of BB93 it should be demonstrated to the Building Control Body that the roof has been designed to minimise rain noise (see Section 1.2).

Table 1.1 contains the required upper limits for the indoor ambient noise levels for each type of unoccupied space. The noise levels in Table 1.1 are specified in terms of $L_{Aeq,30min}$. This is an average noise level over 30 minutes, as explained in Appendix 1. The specified levels refer to the highest equivalent continuous A-weighted sound pressure level, $L_{Aeq,30min}$, likely to occur during normal teaching hours. The levels due to external sources will depend on weather conditions (eg wind direction) and local activities. High noise levels due to exceptional events may be disregarded.

The indoor ambient noise levels in Table 1.1 apply to finished but unoccupied and unfurnished spaces.

Tonal and intermittent noises are generally more disruptive than other types of noise at the same level. Noise from plant, machinery and equipment in noise–sensitive rooms should therefore be constant in nature and should not contain any significant tonal or intermittent characteristics. Noise from building services which is discontinuous, tonal, or impulsive (ie noise which can be distracting) should be reduced to a level at least 5 dB below the specified maximum.

In rooms with very low noise tolerance, including music rooms, studios and rooms used for formal music and drama performance, any audible intermittent noise source of this type is likely to cause problems and specialist advice should be sought.

1.1.2. Airborne sound insulation between spaces

The objective is to attenuate airborne sound transmitted between spaces through walls and floors.

Table 1.2 contains the required minimum airborne sound insulation values between rooms. These values are defined by the activity noise in the source room and the noise tolerance in the receiving room. The activity noise and noise tolerance for each type of room are given in Table 1.1. The airborne sound insulation is quoted in terms of the weighted BB93 standardized level difference, $D_{nT\,(T_{mf,max}),w}$, between two rooms.

The BB93 standardized level difference, $D_{nT\,(T_{mf,max})}$, is the level difference, in decibels, corresponding to a BB93 reference value of the reverberation time in the receiving room:

$$D_{nT(T_{mf,max})} = D + 10 \lg \frac{T}{T_{mf,max}} \text{ dB}$$

where

D is the level difference (dB)

T is the reverberation time in the receiving room (s)

$T_{mf,max}$ is the reference reverberation time equal to the upper limit of the reverberation time, T_{mf}, given in Table 1.5 for the type of receiving room. This reference reverberation time shall be used for all frequency bands.

The BB93 standardized level difference, $D_{nT\,(T_{mf,max}),w}$, is measured in accordance with BS EN ISO 140-4:1998[1] in octave or one-third octave bands, the results are weighted and expressed as a single-number quantity, $D_{nT\,(T_{mf,max}),w}$, in accordance with BS EN ISO 717-1:1997[2].

The prediction and measurement of $D_{nT\,(T_{mf,max}),w}$ between two rooms must be carried out in both directions as its value depends upon the volume of the receiving room, see the example below.

1.1.3 Airborne sound insulation between circulation spaces and other spaces used by students

The objective is to attenuate airborne sound transmitted between circulation spaces (eg corridors, stairwells) and other spaces used by students.

Table 1.3 contains the required minimum airborne sound insulation for the separating wall construction, any doorset in the wall and any ventilators in the wall. The airborne sound insulation for walls and doorsets is quoted in terms

Example to determine the performance standards for airborne sound insulation between a music classroom and a secondary school general teaching area.

***From* the music classroom (source room) *to* the general teaching area (receiving room):**
Table 1.1 shows that music classrooms have ‘very high’ activity levels and that general teaching areas have ‘low’ tolerance. Table 1.2 shows that at least 55 dB $D_{nT\,(0.8s),w}$ is required.

***From* the general teaching area (source room) *to* the music classroom (receiving room):**
Table 1.1 shows that general teaching areas have ‘average’ activity levels and that music classrooms have ‘low’ tolerance. Table 1.2 shows that at least 45 dB $D_{nT\,(1.0s),w}$ is required.

In this example the requirement to control noise from the music classroom to the general teaching area is more stringent.

The construction should be designed to achieve at least 55 dB $D_{nT\,(0.8s),w}$ from the music classroom (source room) to the general teaching area (receiving room), and at least 45 dB $D_{nT\,(1.0s),w}$ from the general teaching area (source room) to the music classroom (receiving room).

Table 1.3: Performance standards for airborne sound insulation between circulation spaces and other spaces used by students - minimum sound reduction index, R_w and minimum $D_{n,e,w}$ −10lg$N$ (laboratory measurements)

Type of space used by students	Minimum R_w (dB)		Minimum $D_{n,e,w}$ −10lg$N$ (dB)
	Wall including any glazing	Doorset[1]	
All spaces except music rooms	40	30	39
Music rooms[2]	45	35	45[3]

NOTES ON TABLE 1.3
1 The R_w ratings are for the doorset alone. Manufacturers sometimes provide doorset sound insulation data as a combined rating for the wall and doorset where the R_w refers to the performance of an ≈10 m^2 high-performance wall containing the doorset. This is not appropriate as it gives higher figures than the R_w of the doorset itself. However, with knowledge of the wall and doorset areas the R_w of the doorset can be calculated from these test results.
2 Special design advice is recommended.
3 Wherever possible, ventilators should not be installed between music rooms and circulation spaces.

of the weighted sound reduction index, R_w, which is measured in the laboratory. The airborne sound insulation for ventilators is quoted in terms of the weighted element-normalized level difference, $D_{n,e,w}$. The performance standard for ventilators is quoted in terms of $D_{n,e,w}$ −10lg$N$ where N is the number of ventilators with airborne sound insulation $D_{n,e,w}$.

The weighted sound reduction index is measured in accordance with BS EN ISO 140-3:1995[3] and rated in accordance with BS EN ISO 717-1:1997[2].

The weighted element-normalized level difference is measured in accordance with BS EN 20140-10:1992[4] and rated in accordance with BS EN ISO 717-1:1997[2].

Table 1.3 excludes:

- service corridors adjacent to spaces that are not used by students
- lobby corridors leading only to spaces used by students that have a high tolerance to noise as defined in Table 1.1.

The performance standard is set using a laboratory measurement because of the difficulty in accurately measuring the airborne sound insulation between rooms and corridors, or rooms and stairwells in the field. Therefore it is crucial that the airborne sound insulation of the wall and/or doorset is not compromised by flanking sound transmission, eg sound transmission across the junction between the ceiling and the corridor wall (see guidance in Section 3.10.3).

1.1.4. Impact sound insulation of floors

The objective is to attenuate impact sound (eg footsteps) transmitted into spaces via the floor.

Table 1.4 contains the recommended maximum weighted BB93 standardized impact sound pressure level, $L'_{nT(T_{mf,max}),w}$, for receiving rooms of different types and uses.

The BB93 standardized impact sound pressure level, $L'_{nT(T_{mf,max})}$, is the impact sound pressure level in decibels corresponding to a BB93 reference value of the reverberation time in the receiving room:

$$L'_{nT(T_{mf,max})} = L_i - 10 \lg \frac{T}{T_{mf,max}} \text{ dB}$$

where
L_i is the impact sound pressure level (dB)
T is the reverberation time in the receiving room (s)
$T_{mf,max}$ is the reference reverberation time equal to the upper limit of the reverberation time, T_{mf}, given in Table 1.5 for the type of receiving room. This reference reverberation time shall be used for all frequency bands.

The BB93 standardized impact sound pressure level, $L'_{nT(T_{mf,max})}$, is measured in accordance with BS EN ISO 140-7:1998[5] in octave or one-third octave bands, the results are weighted and expressed as a single-number quantity, $L'_{nT}(T_{mf,max}),w$, in accordance with BS EN ISO 717-2:1997[6].

Impact sound insulation should be designed and measured for floors without a soft covering (eg carpet, foam backed vinyl) except in the case of concrete structural floor bases where the soft covering is an integral part of the floor.

1.1.5. Reverberation in teaching and study spaces

The objective is to provide suitable reverberation times for (a) clear communication of speech between teacher and student, and between students, in teaching and study spaces and (b) music teaching and performance.

Table 1.5 contains the required mid-frequency reverberation times for rooms which are finished but unoccupied and unfurnished. The reverberation time is quoted in terms of the mid-frequency reverberation time, T_{mf}, the arithmetic average of the reverberation times in the 500 Hz, 1 kHz and 2 kHz octave bands.

Sound absorption from pinboards and noticeboards can change when they are covered up or painted. Absorption coefficients for pinboards and noticeboards used in design calculations should be for fully covered or painted boards, as appropriate. If these data are not available then the absorption coefficient for the board area used in the design calculation should be the absorption coefficient of the wall to which the board is attached.

Table 1.4: Performance standards for impact sound insulation of floors - maximum weighted BB93 standardized impact sound pressure level $L'_{nT}(T_{mf,max}),w$

Type of room (receiving room)		Maximum weighted BB93 standardized impact sound pressure level $L'_{nT}(T_{mf,max}),w$ (dB)
Nursery school playrooms		65
Nursery school quiet rooms		60
Primary school: classrooms, class bases, general teaching areas, small group rooms		60
Secondary school: classrooms, general teaching areas, seminar rooms, tutorial rooms, language laboratories		60
Open-plan		
Teaching areas		60
Resource areas		60
Music		
Music classroom		55
Small practice/group room		55
Ensemble room		55
Performance/recital room		55
Recording studio		55
Control room for recording		55
Lecture rooms		
Small (fewer than 50 people)		60
Large (more than 50 people)		55
Classrooms designed specifically for use by hearing impaired students (including speech therapy rooms)		55
Study room (individual study, withdrawal, remedial work, teacher preparation)		60
Libraries		60
Science laboratories		65
Drama studios		55
Design and Technology		
• Resistant materials, CADCAM areas		65
• Electronics/control, textiles, food, graphics, design/resource areas		60
Art rooms		60
Assembly halls, multi-purpose halls (drama, PE, audio/visual presentations, assembly, occasional music)		60
Audio-visual, video conference rooms		60
Atria, circulation spaces used by students		65
Indoor sports hall		65
Gymnasium		65
Dance studio		60
Swimming pool		65
Interviewing/counselling rooms, medical rooms		60
Dining rooms		65
Ancillary spaces	Kitchens*	65
	Offices*, staff rooms*	65
	Corridors*, stairwells*	65
	Coats and changing areas*	65
	Toilets*	65

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

1 Specification of acoustic performance

Type of room	T_{mf}[1] (seconds)
Nursery school playrooms	<0.6
Nursery school quiet rooms	<0.6
Primary school: classrooms, class bases, general teaching areas, small group rooms	<0.6
Secondary school: classrooms, general teaching areas, seminar rooms, tutorial rooms, language laboratories	<0.8
Open-plan	
Teaching areas	<0.8
Resource areas	<1.0
Music	
Music classroom	<1.0
Small practice/group room	<0.8
Ensemble room	0.6 - 1.2
Performance/recital room[3]	1.0 - 1.5
Recording studio	0.6 - 1.2
Control room for recording	<0.5
Lecture rooms[3]	
Small (fewer than 50 people)	<0.8
Large (more than 50 people)	<1.0
Classrooms designed specifically for use by hearing impaired students (including speech therapy rooms)	<0.4
Study room (individual study, withdrawal, remedial work, teacher preparation)	<0.8
Libraries	<1.0
Science laboratories	<0.8
Drama studios	<1.0
Design and Technology	
• Resistant materials, CADCAM areas	<0.8
• Electronics/control, textiles, food, graphics, design/resource areas	<0.8
Art rooms	<0.8
Assembly halls, multi-purpose halls (drama, PE, audio/visual presentations, assembly, occasional music)[2,3]	0.8 - 1.2
Audio-visual, video conference rooms	<0.8
Atria, circulation spaces used by students	<1.5
Indoor sports hall	<1.5
Gymnasium	<1.5
Dance studio	<1.2
Swimming pool	<2.0
Interviewing/counselling rooms, medical rooms	<0.8
Dining rooms	<1.0
Ancillary spaces	
Kitchens*	<1.5
Offices*, staff rooms*	<1.0
Corridors, stairwells	See Section 1.1.6
Coats and changing areas*	<1.5
Toilets*	<1.5

Table 1.5: Performance standards for reverberation in teaching and study spaces – mid-frequency reverberation time, T_{mf}, in finished but unoccupied and unfurnished rooms

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

1.1.6. Sound absorption in corridors, entrance halls and stairwells

The objective is to absorb sound in corridors, entrance halls and stairwells so that it does not interfere with teaching and study activities in adjacent rooms.

The requirement is to provide additional sound absorption in corridors, entrance halls and stairwells. The amount of additional absorption should be calculated according to Approved Document E[7], Section 7. This describes two calculation methods, A and B, for controlling reverberation in the common internal parts of domestic buildings. One of these methods should be used to determine the amount of absorption required in corridors, entrance halls and stairwells in schools. (See sample calculations using calculation methods A and B in Appendix 7.)

Sound absorption from pinboards and noticeboards can change when they are covered up or painted. Absorption coefficients for pinboards and noticeboards used in design calculations should be for fully covered or painted boards, as appropriate. If these data are not available then the absorption

NOTES ON TABLE 1.5

1 Common materials often absorb most sound at high frequencies. Therefore reverberation times will tend to be longer at low frequencies than at high frequencies. In rooms used primarily for speech, the reverberation times in the 125 Hz and 250 Hz octave bands may gradually increase with decreasing frequency to values not more than 30% above T_{mf}.

2 For very large halls and auditoria, and for halls designed primarily for unamplified music rather than speech, designing solely in terms of reverberation time may not be appropriate and specialist advice should be sought. In large rooms used primarily for music, it may be appropriate for the reverberation times in the 125 Hz and 250 Hz octave bands to gradually increase with decreasing frequency to values up to 50% above T_{mf}. For more guidance see Section 5.

3 Assembly halls, multi-purpose halls, lecture rooms and music performance/recital rooms may be considered as unfurnished when they contain permanent fixed seating. Where retractable (bleacher) seating is fitted, the performance standards apply to the space with the seating retracted.

coefficient for the board area used in the design calculation should be the absorption coefficient of the wall to which the board is attached.

1.1.7 Speech intelligibility in open-plan spaces

The objective is to provide clear communication of speech between teacher and student, and between students, in open-plan teaching and study spaces.

For enclosed teaching and study spaces it is possible to achieve good speech intelligibility through specification of the indoor ambient noise level, sound insulation and reverberation time. Open-plan spaces require extra specification as they are significantly more complex acoustic spaces. The main issue is that the noise from different groups of people functioning independently in the space significantly increases the background noise level, thus decreasing speech intelligibility.

Open-plan spaces are generally designed for high flexibility in terms of the layout of teaching and study spaces. In addition, the layout is rarely finalised before the school is operational. This increases the complexity of assessing speech intelligibility in the open-plan space. Therefore, at an early stage in the design, the designer should establish the expected open-plan layout and activity plan with the client.

The open-plan layout should include:

- the positions at which the teacher will give oral presentations to groups of students
- the seating plan for the students and teachers in each learning base
- the learning base areas.

The activity plan should include:

- the number of teachers giving oral presentations to groups of students at any one time
- the number of students engaged in discussion at any one time
- the number of people walking through the open-plan space (eg along corridors and walkways) during teaching and study periods
- any machinery (eg engraving machines, CNC machines, dust and fume extract equipment, computers, printers, AVA) operating in the open-plan space.

The expected open-plan layout and activity plan should be agreed as the basis on which compliance with BB93 can be demonstrated to the Building Control Body.

The activity plan should be used to establish the overall noise level due to the combination of the indoor ambient noise level, all activities in the open-plan space (including teaching and study), and transmitted noise from adjacent spaces. A computer prediction model should be used to calculate the Speech Transmission Index (STI)[8] in the open-plan space, using the overall noise level as the background noise level. Other methods of estimating STI may also be applicable.

The performance standard for speech intelligibility in open-plan spaces is described in terms of the Speech Transmission Index in Table 1.6. The calculated value of STI should be between 0.60 and 1.00, which gives an STI rating of either ‘good’ or ‘excellent’. This performance standard applies to speech transmitted from teacher to student, student to teacher and student to student.

The performance standard in Table 1.6 is intended to ensure that open-plan spaces in schools are only built when suited to the activity plan and layout. With some activity plans, room layouts and open-plan designs it will not be possible to achieve this performance standard. At this point in the design process the decision to introduce an open-plan space into the school should be thoroughly re-assessed. If, after re-assessment, there is still a need for the open-plan space, then the inclusion of operable walls between learning bases should be considered. These operable walls will form classrooms and be subject to the airborne sound insulation requirements in Table 1.2. It is not appropriate to simply adjust the activity

Room type	Speech Transmission Index (STI)
Open-plan teaching and study spaces	>0.60

Table 1.6: Performance standard for speech intelligibility in open-plan spaces – Speech Transmission Index (STI)

plan until the performance standard for speech intelligibility is met.

Computer prediction software capable of simulating an impulse response should be used to create a three-dimensional geometric model of the space, comprising surfaces with scattering coefficients and individually assigned absorption coefficients for each frequency band. The model should allow for the location and orientation of single and multiple sources with user-defined sound power levels and directivity. (See guidance on computer prediction models on the DfES acoustics website www.teachernet.gov.uk/acoustics.)

Assumptions to be made in the assessment of speech intelligibility are:

- for students, when seated, the head height (for listening or speaking) is 0.8 m for nursery schools, 1.0 m for primary schools and 1.2 m for secondary schools
- for students, when standing, the head height (for listening or speaking) is 1.0 m for nursery schools, 1.2 m for primary schools and 1.65 m for secondary schools
- for teachers, when seated, the head height (for listening or speaking) is 1.2 m
- for teachers, when standing, the head height (for listening or speaking) is 1.65 m
- the background noise level is the overall noise level due to all activities (including teaching and study) in the open-plan space.

1.2 Demonstrating compliance to the Building Control Body

The preferred means of demonstrating compliance to the Building Control Body is to submit a set of plans, construction details, material specifications, and calculations, as appropriate for each area of the school which is covered by Requirement E4 of the Building Regulations.

The plans should identify:

- the highest estimate for the indoor ambient noise level, $L_{Aeq,30min}$, in each space and the appropriate upper limit from Table 1.1
- the estimated weighted BB93 standardized level difference, $D_{nT(T_{mf,max}),w}$, between spaces and the appropriate minimum value from Table 1.2
- the proposed values of R_w for partition walls and for doors, $D_{n,e,w} - 10\lg N$ for ventilators between circulation spaces and other spaces used by students, and the appropriate minimum values from Table 1.3
- the estimated weighted BB93 standardized impact sound pressure level, $L'_{nT(T_{mf,max}),w}$, of floors above spaces and the appropriate maximum values from Table 1.4
- the estimated value of mid frequency reverberation time T_{mf} in each space and the appropriate range of values from Table 1.5
- the proposed absorption treatments in corridors, entrance halls and stairwells
- for open plan spaces, the estimated range of STI values for speech communication from teacher to student, student to teacher and student to student.

The supporting information should include:

- construction details and material specifications for the external building envelope
- construction details and material specifications for all wall and floor constructions, including all flanking details
- calculations of the sound insulation $D_{nT(T_{mf,max}),w}$ and $L'_{nT(T_{mf,max}),w}$
- calculations of reverberation times in teaching and study spaces
- calculations of the absorption area to be applied in corridors, entrance halls and stairwells
- measurements and/or calculations demonstrating how rain noise has been controlled
- sound insulation test reports (laboratory and/or field)
- sound absorption test reports (laboratory)
- activity plan and layout for open-plan spaces.

An example of a submission to a Building Control Body, with explanatory notes, is contained in Appendix 10.

1.2.1 Alternative performance standards

In some circumstances alternative performance standards may be appropriate for specific areas within individual schools for particular educational, environmental or health and safety reasons. In these cases, the following information should be provided to the Building Control Body:

- a written report by a specialist acoustic consultant, clearly identifying (a) all areas of non-compliance with BB93 performance standards (b) the proposed alternative performance standards and (c) the technical basis upon which these alternative performance standards have been chosen
- written confirmation from the educational provider (eg school or Local Education Authority) of areas of non-compliance, together with the justification for the need and suitability of the alternative performance standards in each space.

1.3 Demonstrating compliance to the client

To ensure that the performance standards are met, it is recommended that the client should include a requirement for acoustic testing in the building contract.

The design calculations submitted to the Building Control Body demonstrate only that the construction has the potential to meet the performance standards in Section 1.1. In practice, the performance of the construction is strongly influenced by workmanship on site. If the design calculations and detailing are correct, the most likely causes of failure to meet the performance standards will be poor workmanship, product substitution and design changes on site. Therefore, acoustic testing is recommended.

The DfES acoustics website (www.teachernet.gov.uk/acoustics) will be used to encourage manufacturers and others to disseminate acoustic test results alongside construction details for constructions that consistently satisfy the performance standards.

1.3.1 Timetabling of acoustic testing

Timetabling of acoustic testing is important because any test that results in a failure to satisfy the performance standards will require remedial work to rectify the failure and potential design changes to other parts of the building. For this reason it is desirable, where possible, to complete a sample set of rooms in the school for advance testing.

1.3.2 Remedial treatments

Where the cause of failure is attributed to the construction, other rooms that have not been tested may also fail to meet the performance standards. Therefore, remedial treatment may be needed in rooms other than those in which the tests were conducted. The efficacy of any remedial treatment should be assessed through additional testing.

1.3.3 Indoor ambient noise levels in unoccupied spaces

To demonstrate compliance with the values in Table 1.1, measurements of indoor ambient noise levels should be taken in at least one in four rooms intended for teaching and/or study purposes, and should include rooms on the noisiest façade. These rooms should be finished and unoccupied but may be either furnished or unfurnished. Measurements should be made when external noise levels are representative of conditions during normal school operation.

During measurements, the following should apply:

- Building services (eg ventilation system, plant) should be in use during the measurement period.
- For mechanically ventilated rooms, the plant should be running at its maximum design duty.
- For naturally ventilated rooms, the ventilators or windows should be open as required to provide adequate ventilation.
- There should be no more than one person present in the room. (The values in Table 1.1 allow for one person to be present in the room during the test)
- There should be dry weather conditions outside.

Measurements of $L_{\mathrm{Aeq},T}$ should be made at least 1 m from any surface of the room and at 1.2 m above floor level in at least three positions that are normally occupied during teaching or study periods. A sound level meter complying with BS EN 60804:2001 (IEC 60804:2001)[9] should be used. Further information on noise measurement techniques is available in the Association of Noise Consultants Guidelines on Noise Measurement in Buildings[10].

Where there is negligible change in noise level over a teaching period, measurements of $L_{\mathrm{Aeq},T}$ over a time period much shorter than 30 minutes (eg $L_{\mathrm{Aeq,5min}}$) can give a good indication of whether the performance standard in terms of $L_{\mathrm{Aeq,30min}}$ is likely to be met. However, if there are significant variations in noise level, for example due to intermittent noise events such as aircraft or railways, measurements should be taken over a typical 30 minute period in the school day.

1.3.4 Airborne sound insulation between spaces

To demonstrate compliance with the values in Table 1.2, measurements of airborne sound insulation should be taken between vertically and horizontally adjacent rooms where the receiving room is intended for teaching and/or study purposes. At least one in four rooms intended for teaching and study purposes should be tested. Measurements should be taken in the direction with the more stringent airborne sound insulation requirement.

During measurements, the ventilators or windows should be open as required to provide adequate ventilation in both the source room and the receiving room.

Measurements should be made in accordance with BS EN ISO 140-4:1998[1] and the additional guidance in Approved Document E[7] Annex B, paragraphs B2.3 – B2.8. Performance should be rated in accordance with BS EN ISO 717-1:1997[2].

1.3.5 Airborne sound insulation between circulation spaces and other spaces used by students

It is not intended that field measurements should be taken between circulation spaces and other spaces used by students. Laboratory data for the wall, doorsets (if any) and ventilators (if any) should be presented as evidence of compliance with the values in Table 1.3.

1.3.6 Impact sound insulation

To demonstrate compliance with the values in Table 1.4, measurements of impact sound insulation should be taken between vertically adjacent rooms, where the receiving room is intended for teaching and study purposes. At least one in four teaching/study rooms below a separating floor should be tested.

Measurements should be made in accordance with BS EN ISO 140-7:1998[5]. Performance should be rated in accordance with BS EN ISO 717-2:1997[6].

Impact sound insulation should be measured on floors without a soft covering (eg carpet, foam backed vinyl), except in the case of concrete structural floor bases where the soft covering is an integral part of the floor.

1.3.7 Reverberation in teaching and study spaces

To demonstrate compliance with the values in Table 1.5, measurements of reverberation time should be taken in at least one in four rooms intended for teaching and study purposes.

One person may be present in the room during the measurement.

Depending upon the completion sequence for spaces within the school, it may be possible to reduce the measurement effort by utilising measurements of reverberation time that are required as part of airborne or impact sound insulation measurements. For this reason, two measurement methods, described below, are proposed for the measurement of reverberation time. For the purpose of demonstrating compliance, either method can be used to assess whether the performance standards have been met. If one method demonstrates compliance with the performance standard and the other demonstrates failure, then the performance standard should be considered to have been met.

Measurement method 1: Measurements should be made in accordance with either low coverage or normal coverage measurements described in BS EN ISO 3382:2000[11].

Measurement method 2: Reverberation time measurements should be made in accordance with BS EN ISO 140-4:1998[1] (airborne sound insulation) or BS EN ISO 140-7:1998[5] (impact sound insulation) in octave bands.

1.3.8 Sound absorption in corridors, entrance halls and stairwells

It is not intended that field measurements of reverberation time should be taken in corridors, entrance halls and stairwells.

1.3.9 Speech intelligibility in open-plan spaces

To demonstrate compliance with the values in Table 1.6, measurements of the Speech Transmission Index (STI) should be taken in at least one in ten student positions in the open-plan spaces.

Measurements should be made in accordance with BS EN 60268-16:1998[8].

Measurements should be made using the following heights for listening or speaking:

- to represent seated students, a head height of 0.8 m for nursery schools, 1.0 m for primary schools and 1.2 m for secondary schools
- to represent standing students, a head height of 1.0 m for nursery schools, 1.2 m for primary schools and 1.65 m for secondary schools
- to represent seated teachers, a head height of 1.2 m
- to represent standing teachers, a head height of 1.65 m.

Simulation of the estimated occupancy noise should be carried out in the STI measurement. This noise level will have been established at the design stage (see Section 1.1.7) and is defined as the noise level due to the combination of the indoor ambient noise level, all activities in the open-plan space (including teaching and study), and transmitted noise from adjacent spaces.

References

[1] BS EN ISO 140-4:1998 Acoustics – Measurement of sound insulation in buildings and of building elements. Part 4. Field measurements of airborne sound insulation between rooms.

[2] BS EN ISO 717-1:1997 Acoustics – Rating of sound insulation in buildings and of building elements. Part 1. Airborne sound insulation.

[3] BS EN ISO 140-3:1995 Acoustics – Measurement of sound insulation in buildings and of building elements. Part 3. Laboratory measurement of airborne sound insulation of building elements.

[4] BS EN 20140-10:1992 Acoustics – Measurement of sound insulation in buildings and of building elements. Part 10. Laboratory measurement of airborne sound insulation of small building elements.

[5] BS EN ISO 140-7:1998 Acoustics – Measurement of sound insulation in buildings and of building elements. Part 7. Field measurements of impact sound insulation of floors.

[6] BS EN ISO 717-2:1997 Acoustics – Rating of sound insulation in buildings and of building elements. Part 2. Impact sound insulation.

[7] Approved Document E – Resistance to the passage of sound. Stationery Office 2003. ISBN 0 11 753 642 3. www.odpm.gov.uk

[8] BS EN 60268-16:1998 Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index.

[9] BS EN 60804:2001 (IEC 60804:2001) Integrating-averaging sound level meters.

[10] Guidelines on Noise Measurement in Buildings, Part 1: Noise from Building Services and Part 2: Noise from External Sources. Association of Noise Consultants.

[11] BS EN ISO 3382:2000 Acoustics – Measurement of the reverberation time of rooms with reference to other acoustical parameters.