ANC | ACOUSTICS & NOISE CONSULTANTS

ANC GOOD PRACTICE GUIDE

Acoustic Testing of Schools

This document sets out the technical guidance for acoustic measurements in accordance with Building Bulletin 93 (BB93). There is an ANC scheme in place to assess testers for compliance with these guidelines.

The purpose of these guidelines is to enable consistency in interpretation of the methods described in BB93, Approved Document E (ADE), and relevant ISO standards so that acoustic measurements in school buildings may be made consistently between organisations.

This guidance is not intended to be more restrictive than the standards, but to provide guidance for the application of those standards for testing in schools.

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1. Foreword

1.1. Introduction

This document sets out the technical guidance for acoustic measurements in accordance with Building Bulletin 93 (BB93). There is an ANC scheme to assess testers for compliance with these guidelines.

The purpose of these guidelines is to enable consistency in interpretation of the methods described in BB93, Approved Document E (ADE), and relevant ISO standards so that acoustic measurements in school buildings may be made consistently between organisations.

This guidance is not intended to be more restrictive than the standards, but to provide guidance for the application of those standards for testing in schools.

1.2. Competence required

The organisation carrying out testing may demonstrate competence by having third party verification of its procedures. A suitable scope of accreditation by UKAS is an appropriate demonstration of competence. Membership of the Association of Noise Consultants' Registration Scheme for the Acoustic Testing of Schools is also suitable.

Competence to carry out sound insulation tests, reverberation time measurements and ambient noise level measurements does not imply competence for speech transmission index (STI) testing, measurement of noise from equipment or window actuators. STI testing is not recommended in any case, but if specifically required the procedure outlined in Section 10 should be followed.

1.3. Schedule of testing

At least one in four rooms intended for teaching and study purposes should be tested for sound insulation, reverberation time and ambient noise levels. It is not recommended that speech intelligibility is measured, but if there is a requirement to do so, at least one in ten student positions in open plan spaces should be tested. At least one in four teaching / study rooms below a separating floor should be tested.

A representative sample of each different construction type and acoustic performance requirement should be tested.

It is suggested that the total number of rooms or spaces for teaching and learning is determined, and divided by four (rounding up) to calculate the number of wall (and floor, where appropriate) airborne sound insulation, reverberation time and ambient noise level tests required.

Breakout areas that are used for teaching / study may also be counted as "rooms", and may be tested if appropriate.

A representative sample of each construction type and acoustic performance requirement would typically include tests of different room

types, i.e. including assembly and sports halls as well as room types that occur with greater frequency.

1.4. Performance standards

The acoustic performance standards are described in section 1 of BB93. The room type should be derived from the descriptions in Table 1, 4a & 4b, and 5 of BB93. In addition, the performance standards for ambient noise in naturally ventilated rooms are modified by Table 2.

Where there are alternative performance standards, specified in accordance with section 0.5 of BB93, these should be should be stated.

1.5. Permitted use of this Guide

This Guide is Copyright of the Association of Noise Consultants Ltd. Its purpose is to advise ANC members, other consultants and other interested parties.

It may be quoted or referenced in other documents but such references do not imply that the ANC endorse those documents. Use of this Guide does not mean that a company is member of the Association.

1.6. Association of Noise Consultants

The ANC (Association of Noise Consultants) is the representative body for consultancy practices providing advice on acoustics, noise and vibration issues. ANC represents over 100 companies who employ approximately 800 professionally qualified acousticians.

For further details of ANC and contact information please go to www.theanc.co.uk or email info@theanc.co.uk

1.7. Format and updating of this Guide

This guide is made available electronically via the ANC website. It is intended to be a dynamic document that will be amended and updated as necessary. Users are invited to send comments, queries and suggestions for changes to the Chairman of the ANC Schools Committee.

2. Abbreviations and references

2.1. Abbreviations

Abbreviations and acronyms used in this guide are explained below.

ANC	Association of Noise Consultants, the UK's professional body for acoustic consultancies.
ADE	Approved Document E of the Building Regulations "Resistance to the passage of sound" which refers to BB93 for acoustic performance standards for school buildings.
UKAS	United Kingdom Accreditation Service.
BB93	Building Bulletin 93 Acoustic Design of Schools: Performance Standards, 2014, DfE

2.2. References

All standards are subject to revision, and parties to agreements should apply the most recent editions of the standards indicated below.

Approved Document E of the Building Regulations "Resistance to the passage of sound" 2003 edition, incorporating 2004, 2010, 2013 and 2015 amendments.

Building Bulletin 93 - Acoustic design of schools: performance standards, 2014.

Building Bulletin 101 – Ventilation of school buildings, 2006.

BS EN ISO 16283-1: 2014 Acoustics – Field measurement of sound insulation in buildings and of building elements. Part 1 – Airborne sound insulation.

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.

BS EN ISO 140-14: 2004 Acoustics – Measurement of sound insulation in buildings and of building elements. Part 14 – Guidelines for special situations in the field.

BS EN ISO 717-1: 2013 Acoustics – Rating of sound insulation in buildings and of building elements. Part 1: Airborne sound insulation.

BS EN ISO 717-2: 2013 Acoustics – Rating of sound insulation in buildings and of building elements. Part 2: Impact sound insulation.

BS EN ISO 3382-2: 2008 Acoustics - Measurement of room acoustic parameters –- Part 2: Reverberation time in ordinary rooms.

BS EN 60268-16: 2011 Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index.

BS EN ISO 16032: 2004 Acoustics – Measurement of sound pressure level from service equipment in buildings – Engineering method.

ANC Guidelines – Noise Measurement in Buildings, Part 1: Noise from Building Services, Association of Noise Consultants, September 2011.

ANC Guidelines – Noise Measurement in Buildings, Part 2: Noise from External Sources, Association of Noise Consultants, February 2013.

3. General Principles, standards and references

Sound insulation should be tested in accordance with ISO 16283-1 and ISO 140-7, and rated in accordance with ISO 717-1 and ISO 717-2 with the additional requirements and clarifications as set out in Building Bulletin 93.

Attention is also drawn to Annexes C, D, and E of ISO 16283-1. These supplement the guidance in the main body of the Standard. These appendices are described as informative rather than normative but offer valuable clarification, which is taken into account in this Guide.

T_{mf} should be derived from reverberation time testing carried out in accordance with ISO 3382-2 in octave bands or one-third octave bands.

Indoor ambient noise measurements should be made in accordance with this Guide. Additional information on noise measurements in buildings is available in the Association of Noise Consultants' Guidelines on Noise Measurement in Buildings, Part 1: Noise from Building Services and Part 2: Noise from External Sources.

Where necessary, speech intelligibility measurements should be made in accordance with BS EN 60268-16, as modified by the additional guidance set out in this Guide.

All testers should have access to, and be familiar with, all of the above standards and documents as relevant to the testing required to be undertaken.

Where the standards allow several methodologies, this guidance does not seek to impose one of these methodologies at the expense of others. Neither does this guidance make requirements that exceed those of the ISO Standards.

4. Requirements for equipment

4.1. Sound level meters, pre-amps and calibrators

In this section the terms “instrument” and “instrumentation” shall be taken to include the sound level meter, pre-amplifier and microphone. The sound level meter should be used with the microphone and pre-amplifier with which the relevant calibration and / or conformance checks were applied. If it is necessary to use a different microphone or pre-amplifier (e.g. due to a failed or damaged microphone), the tester should ensure that these are compatible with the meter and, if necessary, should have the meter re-calibrated with the replacement microphone and/or preamplifier.

The measurement instrumentation and calibrator used on site should comply with the requirements set out in ISO 16283-1, ISO 140-7, and ISO 3382-2, as relevant to the scope of testing undertaken. ISO 16283-1 requires sound level meters or real-time analysers to comply with accuracy Class 0 or 1, as defined in IEC 61672-1 for random incidence application. Filters should meet the requirements for a class 0 or 1 instrument according to IEC 61260. On-site calibrators shall comply with accuracy class 0 or 1, as defined in IEC 60942. It is the responsibility of the tester to ensure that the equipment used complies with this requirement and testers should make reasonable efforts to verify claims made by the manufacturers and suppliers of their equipment.

ISO 16283-1 describes the minimum verification regime for the sound level meter and sound calibrator. It indicates in section 4.3 that:

All compliance testing shall be conducted by a laboratory being accredited or otherwise nationally authorized to perform the relevant tests and calibrations and ensuring metrological traceability to the appropriate measurement standards.

This means that UK laboratories undertaking the calibrations should be UKAS accredited for doing so, but that the calibration performed does not necessarily need to be according to a UKAS accredited procedure, depending on the testing organisation’s own requirements.

After any event such as heavy handling which the tester believes could affect the performance of the instrument, the instrument (and, if appropriate, the calibrator) should be sent for re-calibration in the event of variance or drift outside the limits permitted in the Standards.

The requirements for the calibration regime with the sound calibrator are described in ISO 16283-1.

4.2. Loudspeakers

The directivity requirements for loudspeakers for airborne sound insulation testing are described in ISO 16283-1 Annexe A. Hemisphere polyhedron loudspeakers are explicitly allowed according to the note beneath para A.1 in Annexe A of ISO 16283-1. Loudspeakers for reverberation time testing should comply with the directivity requirements of ISO 3382-2 for Engineering level accuracy.

The loudspeaker should be capable of generating the source noise steadily and continuously at a sufficiently high level to be clearly measurable in the receiving room for the test. Typically this will require a free-field sound pressure level in excess of 90 dB L_{eq} at 1 metre from the loudspeaker in all one-third octave bands from 100 Hz to 3150 Hz. Where high levels of sound insulation are measured, or in situations where the background is not very low, higher sound source levels may be required.

4.3. Noise source

The noise source should be non-time varying random noise at a constant level over the frequency range being measured. Although it is permitted to test separate one-third octave bands sequentially, in practice tests are normally carried out using broadband noise and measuring all one-third octave bands simultaneously. If broad-band noise is used, the spectrum may be shaped to ensure an adequate signal-to-noise ratio in the receiving room.

ISO 16283-1 requires that if the 8 dB rule cannot be achieved, testing is undertaken in one-third octave bands with band limited noise. Therefore the testing laboratory should have a method to carry out this procedure if required.

If two loudspeaker sources are used simultaneously they should be driven by similar, but uncorrelated, signals. In practice this means that they should be driven by separate random noise generators.

The measurement procedure depends on the source room signal being constant. The tester should check periodically under controlled conditions that the source level measured over two 30 second periods does not vary by more than 1 dB in any one-third octave band in the measured frequency range when neither microphone or loudspeaker are moved. If the equipment is found not to comply, the test results which have been taken since the previous check will be thrown into doubt; therefore a suitable period should be chosen to minimise this risk.

If more than one sound source is used simultaneously, the output power of each source should be similar in each relevant frequency band, and checks should be undertaken to demonstrate this.

4.4. Tapping machines

In the absence of any other standard, the requirements for the tapping machine are set out in Annex A of ISO 140-7. It is the responsibility of the tester to ensure that the equipment used complies with this requirement, and testers should make reasonable efforts to verify claims made by the manufacturers and suppliers of their equipment.

As impact sound insulation is measured in terms of level, rather than level difference, any differences between tapping machines and variations in the output of individual tapping machines over time will have a direct effect on the result of the measurement.

Some aspects of a tapping machine are considered vulnerable to change during the life of the machine and ISO 140-7 states that the following parameters should be verified regularly:

- velocity of hammers
- diameter and curvature of hammer heads
- falling direction of hammers
- time between hammer impacts.

Some parameters need only be measured during the conformance checks unless the tapping machine has been modified. These are:

- distance between hammers
- supports of the tapping machine
- diameter of the hammers
- mass of the hammers (unless the hammer heads have been refinished)
- time between impact and lift and maximum possible falling height of the hammers.

In the absence of a national standard for calibration of tapping machines, the Registration Scheme Handbook includes detailed recommendations for conformance checks by the owner.

This guidance also requires a conformance check by a third party (normally a laboratory or the tapping machine manufacturer) at least every two years, to confirm that the tapping machine is within the tolerances set out in Annex A of ISO 140-7. These parameters should be checked by the tapping machine manufacturer; however, testers should make reasonable effort to verify that these parameters meet the values given in Annex A of ISO 140-7 (e.g. a conformance sheet should be included with the tapping machine).

The measurement procedure depends on the tapping machine output being constant. The tester should check periodically under test conditions that the received room level measured over two 30 second periods with no change in the tapping machine position does not vary by more than 1 dB in any ⅓-octave band in the measured frequency range.

Where measurements are carried out on bonded soft floor coverings, such as carpet, the hammer drop height should be set up on a flat hard surface initially.

4.5. Loudspeaker for STI measurements

As described in EN 60268-16, the sound source used for STI measurements of unamplified talkers should either be an artificial mouth or suitable test loudspeaker having similar directivity characteristics to those of the human mouth or head (see ITU-T Recommendation P.51: 1996).

5. Measurement procedures - airborne sound insulation

5.1. General requirements and options

The airborne sound insulation should be measured in accordance with ISO 16283-1. All measurements and calculations should be carried out using one-third octave frequency bands. Performance should be rated in terms of the weighted standardized level difference, $D_{nT,w}$, in accordance with ISO 717-1. The reference reverberation time, T, may be either:

The upper limit for the mid-frequency reverberation time, $T_{mf,max}$ for the receiving room in accordance with Table 6 of BB93, applied to all one-third octave frequency bands;
or:

the measured reverberation time in each one-third octave band, provided that the mid-frequency reverberation time, T_{mf}, complies with the requirements in Table 6 of BB93 and is representative of the reverberation times expected when the room is finished and unfurnished.

In the second case above, the parameter calculated may be described as the in-situ weighted level difference, $D_{w.}$

5.2. Room types, sizes and conditions

Room types

Rooms to be tested will normally be teaching and learning spaces, when seeking to demonstrate compliance with the Building Regulations. Where appropriate, however, tests may be carried out in ancillary spaces, but not usually corridors, stairwells or hallways. Tests should be conducted between completed rooms.

Changes in teaching methods mean that circulation spaces may also be used for teaching purposes. However, there may be no standard method for testing sound insulation to adjacent spaces.

Measurements may be made in furnished or unfurnished rooms.

Room volumes and test direction

The sound insulation requirement may determine the direction of the test, so that the test may be carried out from the smaller to the larger room.

When measuring airborne sound insulation between a pair of rooms and the sound insulation requirement is the same in both directions, the sound source should be in the larger room.

Where the room volumes are significantly unequal (e.g. where one is at least twice as large as the other) and the performance requirement differs in different directions, it may be appropriate to test in both directions.

It is noted that the sound insulation requirement between different rooms changes in steps of 5 dB. The variation in level difference in each direction is a function of the receiving room volume and reference

reverberation time. Under diffuse field assumptions, the level difference measured in each direction may be expected to differ by:

$$10 \log_{10} \left(\frac{V_1 \, T_{\mathrm{mf,max2}}}{V_2 \, T_{\mathrm{mf,max1}}} \right) \mathrm{dB}$$

where V_1 is the volume of room 1, and $T_{\mathrm{mf,max2}}$ the reference reverberation time of room 2, etc. Therefore unless reference reverberation times are significantly different, the room volumes need to be a multiple of one another for the level difference to be significantly different in each direction.

The requirement for measuring in the appropriate direction takes precedence over the practice of using the lower room as the source room. If the source is located in the upper room a loudspeaker stand should be used to comply with the minimum distance requirements.

Use of guidance in Annexes C, D and E of ISO 16283-1

Where rooms are large, highly damped, or contain significant dimensions perpendicular to the separating partition, consideration should be given to the application of the guidance in these Annexes. Typical classrooms are often highly damped, and therefore the accuracy and repeatability of measurements may be improved by using the guidance in these annexes.

Openings

Doors should be closed; ventilators and windows should be open as required to provide adequate ventilation in both the source and receiving rooms. Where there is a natural ventilation strategy using opening windows, the extent to which windows will need to be opened to provide "adequate ventilation" will depend on the physical arrangement, environmental conditions, and the number of room occupants. The mechanical engineers should be able to advise the maximum design requirement for openings to provide "adequate ventilation" for normal conditions, i.e. outside the hottest 200 hours of the year.

Units, cupboards, etc., on all walls should have their doors open and be unfilled.

Room modes and use of diffusers

ISO 16283-1 recommends that diffusers should not be used to temporarily modify the sound field.

5.3. Loudspeaker positions, source noise spectrum, sound level measurements, background noise measurements

A test procedure in compliance with the requirements of ISO 16283-1 should be followed.

5.4. Measurement of reverberation time

Reverberation time in the receiving room may be measured using either an interrupted noise method or integrated impulsive response method according to BS EN ISO 3382-2.

The standards allow the use of either T_{20} or T_{30}, but ISO 3382-2 recommends the use of T_{20}, for the reasons described in ISO 3382-2.

6. Measurement procedures - impact sound transmission

6.1. General requirements and options

The impact sound transmission of a separating floor should be measured in accordance with ISO 140-7, using one-third octave frequency bands. It is noted that ISO 16283-2, field measurement of impact sound insulation is currently in draft form, and will supersede ISO 140-7 when published.

The performance should be rated in terms of the weighted standardised impact sound pressure level, $L'_{nT,w}$, or the *in situ* weighted level difference, L'_{w} in accordance with BB93 and ISO 717-2.

6.2. Tests between rooms

The test should be conducted from an upper room or circulation zone to a room below. Tests should not normally be conducted into circulation zones such as corridors or stairwells.

6.3. Tapping machine hammer height check

The height of the hammer heads above the floor surface should be checked before the test.

6.4. Tapping machine locations and set-up

The minimum number of tapping machine positions according to ISO 140-7 is four. ISO 140-14 describes how the reproducibility of results in larger rooms may be increased with increased numbers of tapping machine positions.

6.5. Measurements using fixed or moving microphones

The measurement requirements are noted in ISO 140-7.

It may be considered acceptable to use moving microphone techniques from ISO 16283-1 for manually scanned moving microphones.

6.6. Floor coverings

The floor covering in schools is generally an integral part of the floor, and testing on the floor finish is generally appropriate.

Where a room has different floor types or finishes on different parts of the floor, ISO 140-14 indicates that measurements should be taken and reported for each floor type separately. In this case the floor covering should be noted in the test report.

6.7. Background noise and reverberation time measurement

The procedures are the same as those for airborne tests and are described in previous sections of this Guide.

7. Sound insulation calculation procedures and precision

7.1. Calculation procedures

If using proprietary software, whether built into sound level meters or for subsequent analysis it is the tester's responsibility to ensure that the software complies with the relevant standards.

Testers using spreadsheets to process the measurements and calculate the results should ensure that these spreadsheets comply with all of the requirements of the Standards.

7.2. Calculation of $D_{nT,w}$ and $L'_{nT,w}$

The reference reverberation time ($T_{mf,max}$) of the receiving room is selected from Table 6 of BB93, depending on the room type description. This value should be used in all one-third-octave bands to calculate the $D_{nT,w}$ and $L'_{nT,w}$ parameters required by BB93.

7.3. Calculation of D_w and L'_w

There should be no adjustment of measured receiving room levels to account for reverberation time. This may be practically achieved in proprietary software by using a dummy value of 0.5 seconds in lieu of the measured reverberation time in each one-third octave band. In this case, the standardised $D_{nT,w}$ and $L'_{nT,w}$ parameters will be the *in-situ* level differences D_w and L'_w.

8. Indoor ambient noise level measurements

8.1. General requirements

Rooms should be finished and unoccupied, but may be either furnished or unfurnished, although it is noted that the performance standards refer to rooms in their normally furnished state. There should be no more than one person present in the room.

Measurements should be made when external noise levels are representative of conditions during normal school operation.

Where there is negligible change in noise level over a teaching period, measurements of $L_{Aeq,t}$ over a time period much shorter than 30 minutes – e.g. five minutes - can give a good indication of whether the performance standard in terms of $L_{Aeq,30\ min}$ is likely to be met. A five minute period may consist of more than one measurement position, but measurements at any one position should not be shorter than two minutes. 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 representative 30 minute period in the school day.

In general each room will have a ventilations strategy for "normal" conditions as described in Table 2 of BB93, and a ventilation strategy to control summertime overheating. Both conditions should be measured, and the results compared against the relevant performance requirement.

Some rooms may have different ventilation systems for use at different times of the year. In this case, each mode of operation should be measured separately for the most onerous conditions to provide "normal" ventilation as described in Table 2 of BB93. The different modes may be normal, mechanical, or hybrid at different times of the year.

Some rooms may also have intermittent boost ventilation, as described in Table 2 of BB93; in this case a further set of measurements should be made under these conditions.

Where there is process extract as described in Table 2 of BB93, compliance with the performance standards described in Acoustics of Schools: a Design Guide is required to meet the requirements of the Schools Premises Regulations or Independent Schools Standards, but not the Building Regulations. Where measurements are required, they should be made in the same format as for intermittent boost ventilation.

Measurements may be made of the broadband A-weighted levels only; however, it may be advantageous when measuring noise from mechanical services to include measurements in octave bands, in case any remedial advice is required. Measurements should be made for an equal time period at each position, and the energy-averaged result from all three positions should be calculated to compare with the requirement from Table 1 and Table 2 of BB93. There is additional guidance on the measurement of noise in rooms in ISO 16032, with methods for correcting for background noise where appropriate.

8.2. Rooms with a natural ventilation system

Measurements should be made in three positions that are normally occupied during teaching or study periods, including those closest to the most significant sources of noise, for each ventilation state. The microphone should be located between 1.2 and 1.5 metres above floor level, and at least 1 metre from any other room surface.

The windows or vents should be open as required to provide adequate ventilation outside the hottest 200 hours of the year. The mechanical engineers will need to identify the extent of window or vent opening to achieve the design conditions. If this information is not available, it is suggested that all the opening lights are opened to half their full extent, and this is noted in the test report.

If there is a natural ventilation strategy to control thermal comfort during the hottest 200 hours of the year, the indoor ambient noise level should also be measured with representative external conditions and façade openings required, at a minimum of three positions. If the extent of opening lights required to meet the design condition cannot be determined because the information is not available at the time of testing, it is suggested that all opening lights are fully opened, and this is noted in the test report.

8.3. Rooms with a mechanical ventilation system

Where there is a mechanical ventilation system, any opening lights or vents that are not part of the system should be closed during the measurements of noise from the mechanical system. If there is more than one mode of operation of the mechanical system then each mode should be measured and reported separately. The contractor or mechanical engineer will need to advise on the potential modes of operation.

The microphone should be located between 1.2 and 1.5 metres above floor level, and at least 1 metre from any other room surface. Measurements should be made in three positions that are normally occupied during teaching or study periods, and include those positions closest to the most significant sources of noise. Measurements should be made for an equal time period at each position, and the energy-averaged result from all positions should be calculated to compare with the requirement from Table 1 of BB93.

To assess the “normal” ventilation condition described in Table 2 of BB93, the mechanical systems should be controlled to operate at the design duty for the maximum occupancy of the room. It is likely that a mechanical engineer will be required to control this state of operation if the ventilation system is normally automatically controlled by room sensors. At very low occupancy under automatic control, the system may be automatically controlled to operate at a much lower level than the design limit. The method of controlling the ventilation system for the purposes of the test should be described in the test report.

The minimum record length for continuous steady noise from building services should be 30 seconds. A longer sample period may be required if external noise sources are significant in contributing to the overall internal ambient noise level, as this noise is included with mechanical services noise in the limit from Table 1 of BB93.

Rooms that have a mechanical system for normal ventilation may have a different type of system to control summertime overheating. The ventilation system to control summertime overheating should also be measured separately.

8.4. Rooms with a hybrid ventilation system

A hybrid ventilation system typically involves some provision of façade openings working in combination with a mechanical system; the classification of the system should be undertaken by the system designers rather than by the organisation carrying out the testing, as it determines which performance requirements apply.

Table 2 of BB93 indicates which performance requirements apply to the mechanical and natural parts of a hybrid system. If possible, the mechanical system should be measured in the absence of façade openings, unless this would change the operation of the mechanical system so that it would not be representative of normal conditions. This enables a greater opportunity of demonstrating that the limit for the mechanical services element of the overall noise limit is achieved.

When measuring the total noise level, the same considerations as those for measuring natural ventilation systems apply. Measurement positions should include normally occupied positions closest to the most significant noise sources, and be carried out for a representative time period at each position. The minimum period at each of three positions is two minutes, but longer measurements may be required if there is significant variation of the levels measured.

8.5. Precision

Measured and calculated noise levels should be recorded to one decimal place.

The value of $L_{Aeq,t}$ should be reported to the nearest integer.

9. Mid-frequency reverberation time measurements

9.1. General requirements

There should be no more than one person present in the room during the measurements.

The performance standards for mid-frequency reverberation times relate to finished, unoccupied, and normally furnished rooms. Any deviation from these room conditions during the testing should be recorded in the test report.

Assembly halls, multi-purpose halls, lecture rooms and music performance/recital rooms may be considered as normally furnished when they contain permanent fixed seating. Where retractable (bleacher) seating is fitted, measurements should be made with the seating retracted.

The measurement method is according to ISO 3382-2, with Engineering level accuracy as a minimum.

9.2. Measurement method:

For interrupted noise measurements, a minimum of 12 measurements is required; for integrated impulse response measurements, a minimum of six measurements is required.

In rooms with a complicated geometry, more measurement positions should be used. A distribution of microphone positions shall be chosen which anticipates the major influences likely to cause differences in reverberation time throughout the room.

It may be possible to use measurements of reverberation time made for the purposes of sound insulation tests to evaluate the mid-frequency reverberation time. However, it should be noted that more measurements are necessary to determine the reverberation time itself compared to when using the reverberation time to correct other Engineering-level measurements, such as sound insulation.

9.1. Parameters recorded

BB93 notes that the reverberation time in Table 6 is quoted in terms of the mid-frequency reverberation time, T_{mf} which is the arithmetic average of the reverberation times in the 500 Hz, 1 kHz and 2 kHz octave bands, or the arithmetic average of the reverberation times in the one-third octave bands from 400 Hz to 2.5 kHz. Although these are not mathematically equivalent, BB93 allows either method.

The parameters measured should be reported.

9.2. Precision

Reverberation times should be measured to two decimal places. The mid-frequency reverberation time should be reported to one decimal place, in the same manner as the performance requirement.

10. Speech Transmission Index in open plan spaces

The measurement of Speech Transmission Index (STI) is complicated, requires very specialist equipment and knowledge, and is unlikely to practically represent the acoustic model that was used to assess the design. For these reasons, measurement of STI is not recommended, but if required the following procedure should be used to assess the in-situ STI.

In the normal STI measurement set-up for room acoustic assessments, a sound source is used to generate the STI test signal. The test signal is calibrated and corresponds to the nominal speech level. A situation dependant, representative talking distance should be employed. A calibrated STI measuring device is used at the receiver location to determine the STI of the transmission channel.

Measurements should be made in accordance with the general requirements of BS EN 60268-16. This requires measurements to be made several times and an estimate of the standard deviation to be included.

Measurements of the STI should be taken in at least one in ten typical student listening positions in the open-plan spaces.

STIPA (Speech Transmission Index for Public Address Systems) is a simplified form of STI which may be appropriate for assessing the suitability of room acoustics for speech communication in lieu of the full STI method. However, if performance is to be measured in terms of STIPA rather than STI, this should be considered as an alternative performance standard and subject to the normal procedures of section 0.5 of BB93. Measurements using the STIPA method are not directly comparable with measurements of STI.

The RASTI method is now considered obsolete due to serious limitations of the method.

Set the source (artificial mouth or suitable test loudspeaker) on the axis of the appropriate microphone at the normal speaking position and direct it in the normal speaking direction.

Measurements should be made using the heights noted in the acoustic model for listening and speaking, depending on the age of the students.

Set the test signal level at the microphone position to equal that of the speech level under normal operating conditions. The sound pressure level should be set using A-weighting. For source positions representing the teacher's speaking position, the level should be 66.5 dB at 1 m (ie 'raised' vocal effort) in front of the artificial mouth or test loudspeaker. For source positions representing the student's speaking position, the level should be 60 dB at 1 m (i.e. normal vocal effort) in front of the artificial mouth or test loudspeaker.

If it is not possible to obtain a sufficiently clean speech-to-noise ratio, when using maximum length sequence (MLS) analysis equipment, it may be possible to use a higher test signal level, and adjust for the actual speech signal spectrum at the microphone position by manually entering speech level data into the speech data table used by the measuring equipment.

Check that the test signal spectrum at the input microphone position is correct to within ±1 dB over the range 88 Hz to 11.3 kHz (the limits of the 125 Hz and 8 kHz octave bands) – refer to BB93 for test signal spectra for 'raised' and 'normal' vocal effort as appropriate. Adjust the equalisation (if any) of the artificial mouth or test loudspeaker, as necessary, to satisfy this requirement, or alternatively adjust by manually entering into the speech data table used by the measuring equipment.

Simulation of the estimated occupancy noise may be carried out in the STI measurement, or by manually entering noise data into the noise data table used by the measuring equipment. This noise level will have been established at the design stage (see BB93 Appendix 6) 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.

11. Noise from window actuators and equipment

BB93 indicates that noise from window actuators should be measured according to ISO 16032. There is guidance in Acoustics of Schools: A Design Guide for carrying out these measurements. Noise from window actuators is covered under the Building Regulations.

Noise from equipment is not covered under the Building Regulations, but is covered under the Schools Premises Regulations and Independent Schools Standards. There is guidance in Acoustics of Schools: A Design Guide for carrying out these measurements.

12. Reporting

12.1. Administrative information required

The report should include the following information:

- address of building
- dates of testing
- the name and address of the organisation carrying out the testing
- the report number
- the name of the person in charge of the test
- the name and signature of the person who has checked the report
- the name and address of the client
- a description of the test methodology and equipment used
- a statement that the test procedures in this document have been followed. Where the procedure could not be followed exactly then the exceptions should be described and reasons given

12.2. Signature and verification

The report should be checked by the member of staff who carried out the tests where this is not the report author. It should also be checked and signed by another competent person. Where an organisation comprises only one individual both signatures may be by that person. That person should sign that they have checked the report.

12.3. Information required for each test

For each test covered by the report, the following information should be reported:

- identification of the rooms used for each test within the set of tests
- room types interpreted from BB93 Tables 1, 5 and 6
- the acoustic performance requirement as stated in BB93, or as amended by BB93 Table 2.
- any amended acoustic performance requirement accepted as an alternative performance standard
- the measured single-number quantities for each test
- pass or fail for each BB93 compliance test
- description and identification of the construction of the separating element for sound insulation tests
- room volumes, including a statement on which rooms were used as source and which as receiving rooms

12.4. Graphical reporting of sound insulation results

The results of each test should be shown in accordance with the reporting requirements of the appropriate Standard, along with the reference reverberation time used.

12.5. Reverberation time test results

The measurement method used should be reported.

For each reverberation time test the reverberation time in each frequency band should be shown in tabular form, with the calculated T_{mf}.

12.6. Indoor ambient noise level test results

The ventilation system in the rooms tested should be reported, with the ventilating conditions at the time of each test. The method used to over-ride any automatic control systems to achieve maximum design conditions for mechanical systems should be described.

If corrections for background noise are made, all measurements used in the correction should be reported. Optionally, the value in each octave band may be shown in tabular form for each indoor ambient noise level test.

12.7. STI test results

For each STI test, the result should be reported with the simulated occupancy noise level used in the measurements or calculations. The location of the source and receiving position for each test should be indicated on a plan, and their respective heights noted.

12.8. Optional Reporting

Although not required, it may be useful to have a description of the building including:-

- sketches showing the layout and dimensions of rooms tested;
- description of separating walls, external walls, separating floors, and internal walls and floors including details of material used for their construction, and finishes;
- mass per unit area in kg/m² of separating walls, external walls, separating floors, and internal walls and floors;
- dimensions of any step and/or stagger between rooms tested;
- dimensions and position of any windows or doors in external walls;
- details of penetrating elements and sealing (e.g. services passing through a separating floor).

Acoustic Testing of Schools

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