Scottish Health Technical Memorandum 2045

(Part 3 of 4)

Validation and verification
and
Operational management

Acoustics

The production of this document was jointly funded by the Scottish Executive Health Department and the NHSScotland Property and Environment Forum.

NHSScotland, P&EFEx, June 2001

Executive summary

Validation and verification procedures form part of the commissioning process. The objective of commissioning is to ensure that all relevant acoustic criteria have been met and that all performance standards have been satisfied.

This part of SHTM 2045; *Acoustics*, outlines the essential elements of a commissioning brief: listing design criteria; the presentation of survey data; and instruments to be used.

Quality inspections and verification of equipment details should be carried out prior to commissioning. Standards of workmanship are very important in relation to acoustic performance.

Commissioning measurement and survey techniques are outlined. The use of noise rating (NR) curves to evaluate mechanical services and intrusive noise is described. Measurement requirements cover type of sound level meter and microphone positions. Measurement of audio system intelligibility and environment noise is discussed and appropriate methods recommended.

A method for evaluating the vibration performance of mechanical plant and intrusive vibration is described. It indicates the position of vibration transducers, calibration requirements and standards.

The relevant British Standards for measuring impact sound insulation, reverberation times and airborne sound insulation are identified.

The 'Operational management' section highlights management's regulatory responsibilities, including the Noise at Work Regulations 1989, the Health and Safety at Work etc Act 1974, the Control of Pollution Act 1974, the Environmental Protection Act 1990 and the Noise and Statutory Nuisance Act 1993.

It also emphasises the need for clear lines of managerial responsibility and competence in those responsible for compliance with statutory requirements. Management attention is also drawn to the need under certain circumstances to carry out regular monitoring of noise levels, particularly where there is a potential risk to employees or problems with environmental noise emissions. Management is also advised of the need to keep adequate records of such surveys.

A glossary of terms is included in the appendix.

Contents

1. Introduction

1.1 Acoustics in healthcare premises requires careful consideration for many reasons. Management have statutory obligations, for example to control noise exposure to workers, along with other responsibilities to provide an environment suitable for the various activities undertaken in hospitals.

1.2 Scottish Health Technical Memorandum (SHTM) 2045; *Acoustics*, is published in four separate parts. It is mainly applicable to new sites, but measures have sometimes been given which could also be applied retrospectively to existing premises. It gives comprehensive advice and guidance to healthcare management, design engineers, estates managers and operations managers on the legal requirements, design implications, maintenance and routine measures which should be adopted.

1.3 Noise becomes a health hazard when people are exposed to it in large quantities and when it becomes intrusive to an extent that patients and staff are put under stress. Staff work more efficiently and patients may recover more quickly if their noise environment is appropriate.

1.4 Noise must be controlled in a number of ways: for example, the interior noise environment must be sufficiently insulated against local exterior noise sources. Conversely, the site must not significantly affect the exterior noise environment.

1.5 Noise from any activity within the premises should not appreciably intrude on other activities. This requires careful positioning of rooms in relation to one another, or provision of sufficient sound insulation for the purpose.

1.6 In rooms where communication is important, or low noise levels are essential, additional factors need to be taken into account. For example, proprietary acoustic materials on walls may be required to ensure that speech is intelligible and noise levels created in the room itself do not build up.

1.7 In general, the term “noise” also encompasses “vibration”.

1.8 This SHTM replaces any acoustic guidance given previously.

Part A: Validation and verification

2. Introduction to commissioning

2.1 The objective of commissioning is to ensure that all relevant acoustic criteria have been met and all appropriate performance standards have been satisfied.

2.2 The commissioning process involves a variety of survey techniques designed to produce results which can then be compared against the relevant criteria.

2.3 It is vital that those responsible for undertaking commissioning are fully conversant with the appropriate acoustic principles and survey techniques. This normally means that commissioning is performed (or overseen) by those responsible for specification of noise control measures and other acoustical treatments.

2.4 Commissioning results should be carefully collated and used to verify compliance with criteria or otherwise. Furthermore, such results can be of use in determining the degree of success achieved by the various measures. This would normally be of use in future work involving similar situations.

2.5 Due to the nature of noise transfer and propagation, it will not be possible to commence commissioning until all elements of the installation (or construction) are complete. However, this does not prevent indicative measurements and inspections being performed prior to starting detailed commissioning surveys.

Commissioning brief

2.6 Those responsible for commissioning will require a detailed brief. The contents of this brief will depend on what knowledge of the project the commissioning personnel already have. Such a brief would typically include:

a. an introduction describing the nature of the project and the purpose of the commissioning survey;
b. a listing of all appropriate design criteria;
c. a listing of all measurements required in order to demonstrate compliance with the design criteria;
d. a statement as to how commissioning survey data is to be presented.

2.7 Guidelines on minimum standards for instrumentation should be issued. This should involve instructions on verifying the accuracy of test instruments, which should be supported by relevant calibration certificates.

2.8 Where necessary, personnel familiar with the operation of noise-generating equipment should be instructed to run it under normal operating conditions.

2.9 Should design criteria fail to be met in any instance, further investigative measurements and inspections will normally be required in order to identify the source of any problems.

2.10 On demonstrating that all design criteria have been met, a full report should be prepared and included with handover documentation.

3. Pre-commissioning checks

3.1 A number of preliminary inspections and tests would normally be required prior to commencement of final commissioning.

Quality inspections

3.2 Standards of workmanship are very important in relation to acoustic performance. This applies equally to builder's work items such as partitions or suspended ceilings and to proprietary acoustical hardware such as enclosures, attenuators or absorptive wall treatments.

3.3 In particular, the following should be verified:

a. that constructions designed to limit transfer of sound (for example partitions, enclosures) are complete in all respects and have no weaknesses such as gaps around the perimeter;

b. that doors and openable windows have been sealed as specified;

c. that all sealing materials (such as non-setting mastic) have been applied as specified;

d. that all proprietary acoustical items have been installed in accordance with manufacturers' instructions;

e. that all noise-generating equipment is operating "normally".

Verification of equipment details

3.4 All installed noise-generating equipment should be checked to ensure that it is commensurate with the details used to assist with the specification of noise control measures. Where this is not the case, any implications on noise generation should be identified prior to commissioning.

3.5 All acoustical hardware should be inspected to ensure that it complies with the project requirements. In particular, performance parameters should be confirmed and included with the commissioning brief.

4. Commissioning measurements

4.1 There are a number of survey techniques covering the variety of design parameters which may be involved in any given project. The survey techniques are outlined in the following sections.

4.2 Depending upon the particulars of a specific project, the commissioning brief should reference the appropriate survey techniques.

Mechanical services noise

4.3 The noise rating (NR) system is the method used to evaluate mechanical services noise. Using this method it is possible to quantify frequency-dependent measurements with a single number.

4.4 The NR system and its use as a noise design parameter is covered in paragraph 3.9 of the 'Design considerations' part of this SHTM.

4.5 Noise-level measurements should be carried out with all plant and machinery operating normally and achieving the design conditions of airflow, temperature and humidity. Furthermore, the mechanical services installation should be fully balanced and operating at its normal design setting, although it would be appropriate to carry out further measurements if the system is expected to operate at different settings.

4.6 Noise-level measurements will be required in all areas served by the mechanical installation for which criteria have been set. The measurements should be performed in unoccupied rooms in the absence of noise from sources other than services plant and machinery. However, it should be recognised that intrusive noise from sources outside the control of those performing the commissioning may affect the noise-level readings. Due account should be taken of this, and a suggestion for doing so is outlined in paragraph 4.24 under "Intrusive noise".

4.7 Having established those areas in which measurements are required, the exact locations should be identified. In doing this, the following should be taken into consideration:

a. anticipated usage of the area;

b. likely locations of area occupants;

c. locations of proprietary items such as grilles, diffusers or perimeter heating units;

d. size of the area.

For guidance, it should normally be acceptable to carry out a single measurement in small rooms (say, less than 75 m^3). In larger rooms, it may be necessary to establish a "grid" of measurement locations.

4.8 The measurements should be performed using a sound level meter complying with the requirements of BS EN 60651. This standard specifies meters having four degrees of precision, designated types 0, 1, 2 and 3. Under normal circumstances, a Type 2 meter should be acceptable. However, for more critical and/or contractual situations a Type 1 meter would be required. Frequency-band filters should comply with the requirements of BS EN 61260.

4.9 The measuring microphone should be located at a height of approximately 1.5 m above floor level, and should be at least 1 m away from any room surfaces or large objects such as filing cabinets.

4.10 Measurements of L_{eq} (equivalent continuous sound pressure level) should be made in each octave band between 63 Hz and 8 kHz. The sample period may be varied depending upon conditions, but 5 to 15 seconds per octave band should generally be sufficient.

4.11 The octave band results for each location should be analysed to give a single NR value using the method given in paragraph 2.13 of the 'Design considerations' part of this SHTM. Further analysis may be required in order to determine the presence or otherwise of unacceptable tonal components. Depending upon the instrumentation being utilised, it may be possible to establish NR values during the commissioning process. However, it is more usual to do this at a later stage.

4.12 In the event of a measurement result indicating failure to meet a design value, further detailed assessment may be required in order to identify the nature of the problem and appropriate remedial noise control measures.

Intrusive noise

4.13 The noise rating (NR) system is the method used to evaluate intrusive noise. Using this method it is possible to quantify frequency-dependent measurements with a single number.

4.14 The NR system and its use as a noise design parameter are covered in paragraph 2.13 of the 'Design considerations' part of this SHTM.

4.15 Under ideal circumstances, intrusive noise measurements should be carried out in the absence of noise from building services plant and machinery. The measurement of noise from the latter is covered in the preceding section. Should it not be possible to do this, the method given in paragraph 4.24 below should be followed.

4.16 Intrusive noise is a blanket term describing the total noise reaching an area from surroundings and nearby noise sources. Examples of intrusive noise would be:

a. traffic on nearby roads;

b. aircraft flying overhead;

c. plant on neighbouring buildings.

4.17 Measurements of intrusive noise will be required in those areas for which criteria were established during the design process. The exact location of measurement positions should be established by considering worst-case scenarios. For example, if an office worker is likely to be sitting next to a window, an appropriate location for measurement of intrusive noise would be at a point 1 m away from the window.

4.18 The measurements should be performed using a sound level meter complying with the requirements of BS EN 60651. This standard specifies meters having four degrees of precision, designated types 0, 1, 2 and 3. Under normal circumstances, a Type 2 meter should be acceptable. However, for more critical and/or contractual situations a Type 1 meter would be required. Frequency-band filters should comply with the requirements of BS EN 61260.

4.19 The measuring microphone should be located at a height of approximately 1.5 m above floor level, and should be at least 1 m away from any room surfaces or large objects such as filing cabinets.

4.20 Measurements of L_{eq} (equivalent continuous sound pressure level) should be made in each octave band between 63 Hz and 4 kHz. The sample period may be varied, but 2 to 5 minutes per octave band should generally be sufficient.

4.21 The octave band results for each location should be analysed to give a single NR value using the method given in paragraph 2.13 of the 'Design considerations' part of this SHTM. Further analysis may be required in order to determine the presence or otherwise of unacceptable tonal components. Depending upon the instrumentation being utilised, it may be possible to establish NR values during the commissioning process. However, it is more usual to do this at a later stage.

4.22 In the event of a measurement result indicating failure to meet a design value, further detailed assessment may be required in order to identify the nature of the problem and appropriate measures to control intrusive noise.

4.23 Note that there is an exception to the general rule that intrusive noise measurements should be carried out in the absence of building services plant and machinery (see paragraph 4.15). This applies to areas which may be affected by noise transfer from nearby plant itself, as opposed to noise from grilles or diffusers. Under these circumstances, the plant in question should be operated normally.

4.24 Where it is not possible, for whatever reason, to measure intrusive noise in the absence of noise from mechanical services, due account of this must be taken. This is achieved by the logarithmic addition of the mechanical services criterion and the intrusive noise criterion:

		NR
Example 1	Mechanical services criterion	35
	Intrusive noise criterion	35
	Resultant overall criterion	38
Example 2	Mechanical services criterion	40
	Intrusive noise criterion	45
	Resultant overall criterion	46

The resultant overall criterion is then used to assess the acceptability of the commissioning measurements.

The subject of logarithmic addition is covered in paragraph 2.15 of the 'Design considerations' part of this SHTM.

Vibration from mechanical plant

4.25 Vibration from mechanical plant is evaluated in terms of frequency-weighted acceleration in the floor. Measurements should be made with all plant and machinery operating normally. Where items of plant are designed to operate at different speeds, it would be appropriate to measure vibration over the normal operating speed range.

4.26 Vibration measurements should be taken in all areas adjacent to equipment and plantrooms in vertical and horizontal axes. The measurements should be taken in unoccupied rooms in the absence of vibration from sources other than services plant and machinery. Vibration from external sources beyond the control of the competent test person (see Chapter 8) may affect readings. However, if such intruding vibration is intermittent, it should be possible to measure services vibration in between the intruding events. If it is continuous at all times of day and the total vibration measured exceeds the criterion, specialist advice should be sought on the acceptability of the vibration levels.

4.27 Measurements should be taken as close as practicable to the centre span of the floor. In large rooms where there are a number of columns (that is, floor spans) within the room, it may be necessary to choose a number of locations.

4.28 Measurements should be carried out using a set of equipment complying with BS 7482 Parts 1 and 3. The weighting networks used should be W_g (z-axis) and W_d (x,y-axis) as defined in BS 7482 Part 3.

4.29 The vibration transducer, typically an accelerometer, should be clamped or bonded to the floor, either directly or via a solid metal block to facilitate the measurement of horizontal vibration.

4.30 Direct readings of the frequency-weighted acceleration level should be taken. Although not recommended, it is possible to measure the weighted acceleration level in one-third octave bands from 1 Hz to 80 Hz and calculate the weighted acceleration level using the weighting values given in BS 6472.

4.31 In the event of a measured result failing to meet the relevant criterion, a more detailed assessment, including the measurement of the frequency spectrum of the vibration, may be required to determine possible remedial measures.

4.32 Before and after each set of measurements the calibration of the measurement chain (that is, microphone, filters, sound level meter) should be checked using a calibration exciter, preferably on-site.

Intrusive vibration

4.33 Vibration dose value (VDV) is used to assess intermittent and continuous vibration from external sources.

4.34 Intrusive vibration should be measured in the absence of vibration from building services plant and machinery.

4.35 Measurements should be taken in unoccupied rooms in those areas for which criteria were established during the design. It may not be necessary to measure in every such location, but choose sample locations at which to monitor intrusive vibration.

4.36 Transducer location and fixing on the floor should be as for the measurement of services vibration (paragraphs 4.27 and 4.29).

4.37 Measurements should be carried out using a set of equipment complying with BS 7482 Parts 1 and 3. The weighting networks used should be W_g (z-axis) and W_d (x,y-axis) as defined in BS 7482 Part 3.

4.38 Direct readings of the VDV should be taken over a period of time long enough to be representative of variations in vibration level over a complete day. For residential or sleeping accommodation there are different criteria for night-time as opposed to daytime. If vibration is due to a discrete number of events, it may be practicable for a specialist to determine the VDV for a sample of events and calculate the daytime and night-time exposures.

4.39 If a measured result fails to meet the relevant criterion, a more detailed assessment, including the measurement of the frequency spectrum of the vibration, may be required to determine the cause. However, it may not be practicable to reduce the intruding vibration once the building has been constructed.

Airborne sound insulation

4.40 The parameter used for the evaluation of airborne sound insulation is weighted apparent sound reduction index (R'_w).

4.41 The method of measuring airborne sound insulation is described in BS EN ISO 140 Parts 4 and 5.

4.42 Those building elements for which airborne sound insulation criteria have been established should be tested in accordance with the relevant part of BS EN 20140 in order to determine the apparent sound reduction index (R') in each one-third octave band between 100 Hz and 3150 Hz. In brief, the standard covers:

a. scope of application;
b. definitions of relevant acoustical parameters;
c. requirements for instrumentation;
d. test arrangement;
e. test procedure and evaluation of results;
f. expression of results.

4.43 The frequency-dependent values of apparent sound reduction index (R') should be rated in accordance with the relevant part of BS EN ISO 717.

4.44 Having followed the guidance given in BS EN ISO 717, the net result is a single number characterising the frequency-dependent performance. This single number is the weighted apparent sound reduction index (R'_w) and may be compared directly against the design values for R'_w.

Impact sound insulation

4.45 The parameter used for the evaluation of impact sound insulation is weighted standardised impact sound pressure level ($L'_{nT,w}$)

4.46 The method of measuring impact sound insulation is described in BS EN ISO 140-7 Part 7.

4.47 Those building elements for which impact sound insulation criteria have been established should be tested in accordance with the relevant part of BS EN ISO 140/BS EN 20140 in order to determine the standardised impact sound pressure level (L'_{nT}) in each one-third octave band between 100 Hz and 3150 Hz. In brief, the standard covers:

a. scope of application;
b. definitions of relevant acoustical parameters;
c. requirements for instrumentation;
d. test arrangement;
e. test procedure and evaluation of results;
f. expression of results.

4.48 The frequency-dependent values of standardised impact sound pressure level (L'_{nT}) should be rated in accordance with BS EN ISO 717-2.

4.49 Having followed the guidance given in BS EN ISO 717, the net result is a single number characterising the frequency-dependent performance. This single number is the weighted standardised impact sound pressure level ($L'_{nT,w}$), and may be compared directly against the design values for $L'_{nT,w}$.

Reverberation times

4.50 Reverberation time (RT) is the parameter most commonly used to quantify the acoustical characteristics of an internal space. It is expressed in seconds.

4.51 RT measurements should be performed in those areas which have been assigned RT design criteria. However, it is often unnecessary to assess every such area. For example, if there are a number of identical offices, it would normally be acceptable to assess the RTs in only one of the offices.

4.52 Reference should be made to BS 5363. Whilst this standard is specific to auditoria, the underlying principles of measurement remain the same whatever the application.

4.53 The resultant measured RTs should be qualified where necessary to account for the following:

a. absorption of furnishings;

b. likely extent of occupation;

c. future changes in layout or surface finishes.

Audio system intelligibility

4.54 The parameter used for the assessment of audio system intelligibility (that is, “clarity”) is speech transmission index (STI).

4.55 Speech intelligibility should be evaluated in all areas served by the audio system.

4.56 There exist a number of methods for the measurement of STI. However, the easiest to use is termed rapid speech transmission index (RASTI). Reference should be made to BS EN 60268-16. Whilst this standard is specific to auditoria, the underlying principles relating to sound systems remain the same whatever the application.

4.57 Other methods of assessment may be used provided that all interested parties agree beforehand.

Environmental noise

4.58 The parameter used to evaluate environmental noise emissions may be stipulated by a local authority or associated body. Where no such guidance has been given, the appropriate parameter is equivalent continuous A-weighted sound pressure level (L_{Aeq}).

4.59 Environmental noise measurements will be required at all locations for which criteria have been established.

4.60 Where criteria have been stipulated by an official body, the associated survey procedure should be followed. In all other cases the measurements should be carried out in accordance with guidance given in BS 7445: ‘Acoustics – description and measurement of environmental noise’. The resultant values for L_{Aeq} should be suitable for direct comparison with the design criteria.

Failure to meet criteria

4.61 Should any of the criteria fail to be met, the responsibility may lie at the feet of one or a number of different parties, depending on individual circumstances.

4.62 An acoustic specialist representing interested parties may decide to allow small failures, but this will again depend on individual circumstances.

5. Handover procedure

Design information

5.1 The following information regarding the acoustic elements of a project should be made available:

a. calculations covering noise emissions from plant and machinery along with details of related noise control measures;

b. details of building elements and proprietary materials intended for the control of noise transfer;

c. audio system details including a listing of all areas provided with audio coverage;

d. a clear statement of all acoustical design criteria:

(i) NR levels for areas served by the building services installation;
(ii) NR levels for areas where intrusive noise is a consideration;
(iii) sound insulation requirements in terms of weighted apparent sound reduction index (R'_w);
(iv) reverberation times;
(v) speech transmission indices for areas served by an audio system;
(vi) environmental noise levels at specified locations.

Commissioning results

5.2 The following measurement results should be presented:

a. mechanical services noise levels (in terms of NR);

b. intrusive noise levels (in terms of NR);

c. sound insulation ratings (in terms of R'_w);

d. reverberation times (in seconds);

e. speech intelligibility ratings (in terms of STI);

f. environmental noise levels (in terms of the appropriate parameter);

g. comparison of all commissioning results with design criteria, statement of acceptability, details of remedial measures and subsequent changes in results.

Part B: Operational management

6. General

Management responsibilities

6.1 The primary management responsibilities may be summarised as follows:

a. the requirements of the Noise at Work Regulations 1989 should be satisfied in all respects;

b. the requirements of the Health and Safety at Work etc Act 1974 should be satisfied in all respects;

c. any notices issued under the Control of Pollution Act 1974 should be actioned immediately;

d. any notices issued under the Environmental Protection Act 1990 should be actioned immediately;

e. care should be taken not to give cause for complaint under the Noise and Statutory Nuisance Act 1993;

f. the acoustic environment in and around the healthcare premises should be appropriate to the various activities undertaken;

g. careful consideration should be given to the strict and unique requirements of audiological facilities. Reference should be made to the 'Audiology' part of this SHTM.

6.2 Clear lines of managerial responsibility should be in place so that no doubt exists as to who is responsible for the various points outlined in paragraph 6.1 above.

6.3 Those responsible for carrying out routine monitoring and/or ensuring compliance with statutory requirements should be competent to do so. This will require knowledge of basic principles and training to an acceptable standard.

Information

6.4 In order that acoustical standards can be monitored and maintained, the following should be provided:

a. details of all design criteria;

b. details of all noise control measures and acoustical treatments (proprietary or otherwise);

c. results of commissioning measurements, presumably in the form of the handover documentation.

6.5 The information held on file should be updated as necessary in order to provide an up-to-date record.

Training

6.6 Those responsible for carrying out noise surveys should be trained in the accurate operation of instrumentation and correct interpretation of results. It is likely that a competent test person would have to be appointed for more involved situations or where other trained personnel are unavailable.

6.7 Employees exposed to high levels of noise should receive training on risks of damage to hearing and methods of hearing protection.

6.8 Where noise control hardware requires regular maintenance (generally in the form of cleaning), the personnel involved should be made aware of what is required in order to ensure correct operation.

7. Routine maintenance and monitoring

7.1 Once items of noise control hardware or acoustical treatments have been successfully installed or applied, very little routine maintenance will be required due to the passive nature of the equipment involved.

Cleaning

7.2 The performance of certain items of acoustic hardware can be detrimentally affected if the equipment is permitted to become “clogged” with dirt or dust. This is of particular importance in air-moving systems with contaminated airflows.

7.3 Items of acoustic hardware at risk of becoming dirty should be identified and a record kept. They should also be subject to regular cleaning in order to maintain performance. The time intervals between cleaning operations should be specified, based on the time taken for accumulation of dirt.

Monitoring

7.4 Under certain circumstances it will be appropriate to carry out regular monitoring of noise levels.

7.5 Where there are potential problems with environmental noise emissions, noise levels at critical locations should be closely monitored.

7.6 Where there is a potential risk to employees’ hearing, regular noise surveys should be performed as per the Noise at Work Regulations 1989.

8. Records

Designated staff functions

8.1 A person intending to fulfil any of the staff functions specified below should be able to prove that they possess sufficient skills, knowledge and experience to properly perform their designated tasks. This requirement also forms part of some of the regulations described in the above sections.

8.2 **Management** – management is defined as the owner, occupier, employer, general manager, chief executive or other person who is ultimately accountable for the safe operation of the premises.

8.3 **Acoustic specialist** – a person appointed or contracted by the general manager to advise on matters concerning acoustics, noise and vibration.

8.4 **Competent test person** – a person appointed or contracted by the general manager to carry out acoustic, noise and vibration tests and surveys. However, this person would normally be the acoustic specialist.

8.5 **Maintenance person** – a member of the maintenance staff, or noise control equipment manufacturer or installer employed by the general manager to carry out maintenance duties on noise control equipment installations. The maintenance of, for example, the attenuators on ventilation ducts would normally be done by the person responsible for maintaining the ventilation system.

8.6 **Contractor** – the person or organisation responsible for the supply of the noise control equipment, its installation, commissioning and validation as appropriate. This person would not normally be a member of the NHS Trust staff.

8.7 A record should be kept of those appointed to carry out the staff functions listed above. The record should clearly state the extent of the postholder's duties and responsibilities and to whom they should report.

8.8 The details of any training given should be clearly recorded.

8.9 Substitute or replacement staff should be designated to cover for sickness, holidays and staff transfers.

Monitoring

8.10 Where appropriate, the results of noise surveys should be kept on record.

8.11 In the case of Noise at Work surveys, such records will enable both hearing risk and effectiveness of noise control measures to be assessed.

8.12 In the case of environmental noise surveys, such records will provide a detailed picture of long-term noise emissions from the healthcare premises.

Appendix 1: Glossary

Absorption coefficient
The proportion of sound lost when incident at a surface.

Absorptive attenuator
Attenuator that incorporates glass-fibre and mineral-wool materials, effective over a wide range of frequencies.

Ambient noise
Encompassing sound (at a given place), being usually a composite of sounds from many sources near and far. Should not be confused with "background noise".

Attenuation
Noise reduction.

Attenuator
Noise-reducing device – often colloquially and incorrectly known as a "silencer".

Background noise
Total of interference from all sources in a system used for the production, transmission, detection, measurement or recording of a signal acoustically quantified using L_{90} .

Breakout
The escape of sound from any source-enclosing structure such as ductwork, metal casings and building envelopes.

Broad-band (or random) sounds
Oscillation due to the aggregate of a large number of elementary disturbances randomly occurring in time.

Crosstalk
The transfer of airborne noise from one area to another via secondary air paths such as ventilation ductwork or ceiling voids.

Decibel (dB)
One-tenth of a bel. A bel is the unit of level of a quantity proportional to power when the base of the logarithm is 10. Also, the unit of level of a field quantity when the base of the logarithm is the square root of 10.

dB(A)
Specific measuring scale achieved by a weighting network fitted in a sound level meter. Gives a single-figure rating to a broad-band sound. dB(A) is approximately equivalent to the human ear frequency response.

Dynamic insertion loss (DIL)
A measure of the acoustic performance of an attenuator when handling the rated flow. Not necessarily the same as Static Insertion Loss, because it may include regeneration.

Equivalent continuous sound pressure level (L_{eq})
Logarithm of the ratio of a given root-mean-square sound pressure, during a stated time interval, to the reference sound pressure. Average sound pressure level in decibels is 20 times the logarithm to the base 10 of that ratio. Unless otherwise specified, the reference sound pressure for airborne sound is 20 µPa (20 micropascal).

Excitation frequency
A frequency at which a machine produces vibration. Often the speed of rotation of the machine.

Flanking transmission
Transmission of sound from a source room to an adjacent receiving room but not via the common partition.

Flutter echo
Rapid but nearly even succession of echoes originating from the same sound source. Often occurs in empty rooms. An echo is defined as a sound wave that has been reflected and arrives with such a magnitude and time interval after the direct sound as to be distinguishable as a repetition of it.

Free sound field
Sound field in a homogeneous isotropic medium where boundaries exert a negligible effect on the sound waves.

Frequency (Hz) – sound
The number of sound waves to pass a point in one second.

Frequency (Hz) – vibration
The number of complete vibrations in one second.

Hertz (Hz)
The unit of frequency equivalent to one cycle per second.

Insertion loss
The reduction of noise level by the introduction of a noise control device; established by the substitution method of test.

Insulation (sound)
The property of a material or partition of opposing sound transfer through its thickness.

Inverse square law
The reduction of noise with distance. In terms of decibels, it means a decrease of 6 dB for each doubling of distance from a point source when no reflective surfaces are present.

Isolation (vibration)
The reduction of vibrational force into a structure.

Isolation efficiency
The amount of vibration force absorbed by an isolator and thus prevented from entering the supporting structure, expressed as a percentage of the total force applied to the isolator.

L_{eq}
See “Equivalent continuous sound pressure level”

$L'_{nT,w}$
See “Weighted standardised impact sound pressure level”

L_{90}
See “Background noise”

Masking noise or sound conditioning
Extra noise introduced into an area to reduce the variability of fluctuating noise levels and improve the intelligibility of speech.

Mass law
Heavy materials stop more noise passing through them than light materials. For any airtight material there will be an increase in its “noise-stopping” ability of approximately 6 dB for every doubling of mass per unit area.

Natural frequency
Frequency of free oscillation of a system. For a multiple-degree- of-freedom system, the natural frequencies are the frequencies of the normal mode of oscillation.

Near sound field
Sound field near a sound source where instantaneous sound pressure and particle velocity are substantially out of phase. The inverse square law does not apply in the near sound field.

Noise
1. Erratic or statistically random oscillation.
2. Disagreeable or undesired sound or other disturbance.

Noise criterion (NC) curves
A set of curves based on the sensitivity of the human ear. They give a single figure for broad-band noise. Used for indoor design criteria. They are similar to NR curves but have different frequency characteristics.

Noise rating (NR) curves
A set of curves based on the sensitivity of the human ear. They are used to give a single-figure rating for a broad band of frequencies. Used for interior design criteria. They are similar to NC curves but have different frequency characteristics.

Noise reduction
Used to define the performance of a noise barrier. Established by measuring the difference in sound pressure levels adjacent to each surface. (See also Sound Reduction Index)

Octave
Unit of logarithmic frequency interval: two sounds, the ratio of whose fundamental frequencies is 2, have a logarithmic frequency interval of 1 octave.

Octave bands
A convenient division of the frequency scale. Identified by their centre frequency, typically 63, 125, 250, 500, 1000, 2000, 4000, 8000 Hz.

Periodic sounds
A signal containing a finite number of pure tones which repeats itself at regular intervals.

Pure tone
Sinusoidal acoustic oscillation.

Reactive attenuator
An attenuator in which the noise reduction is brought about typically by changes in cross-section, chambers and baffle volumes, for example a car exhaust silencer.

Regeneration
The noise generated by airflow turbulence. The noise level usually increases with flow speed.

Resonance
State of a system in forced oscillation such that any changes, however small, in the frequency of excitation result in a decrease in a response of the system.

Resonant frequency (Hz)
Frequency at which resonance exists.

Reverberation
The sound that persists in an enclosed space, as a result of repeated reflection or scattering, after the source of the sound has stopped.

Reverberation time
Of an enclosure, for a sound of a given frequency or frequency band. The time that would be required for the sound pressure level in the enclosure to decrease by 60 dB, after the source has been stopped.

Room constant
The sound-absorbing capacity of a room, usually expressed in m^2.

R'_w
See “Weighted apparent sound reduction index”.

Sabine’s formula
Predicts the reverberation time of a room or enclosure from known room volume and absorption characteristics. Becomes inaccurate when absorption is high.

Silencer
Colloquialism for attenuator.

Solid state (bottoming)
Vibration isolation, that is, when a spring can be compressed no further and the coils are in contact.

Sound insulation
The property of a material or partition to oppose sound transfer through its thickness.

Sound level meter (noise meter)
An instrument for the measurement of sound level, with a standard frequency weighting and standard exponentially-weighted time-averaging.

Sound power
A measure of sound energy in watts. A fixed property of a machine, irrespective of environment.

Sound power level (L_w)
Logarithm of the ratio of a given sound power to the reference sound power. Power level in decibels is ten times the logarithm to the base 10 of the ratio. Unless otherwise specified, the reference sound power is 1pW.

Sound pressure level (L_p)
Logarithm of the ratio of a given sound pressure to the reference sound pressure. Sound pressure level in decibels is 20 times the logarithm to the base 10 of the ratio. Unless otherwise specified, the reference sound pressure is 20 µPa for airborne sound and 1 µPa for a sound in media other than air. Unless otherwise specified, the sound pressures are understood to be expressed in root-mean-square values.

Sound reduction index (SRI)
Of a partition, for a specified frequency band. Difference in decibels between the average sound pressure levels in the reverberant source and receiving rooms, plus ten times the logarithm to the base 10 of the ratio of the area of the common partition to the total sound absorption in the receiving room.

Sound spectrum
Representation of the magnitudes (and sometimes of the phases) of the components of a complex sound as a function of frequency.

Speech transmission index (STI)
A specialised design and measurement parameter used for the quantification of audio systems. A high value STI indicates a high degree of speech intelligibility.

Standing wave
Periodic wave having a fixed distribution in space that is the result of interference of progressive waves of the same frequency and kind. Such waves are characterised by the existence of nodes or partial nodes and antinodes that are fixed in space.

Static deflection
The distance that vibration isolators compress when loaded.

STI
See “Speech transmission index”.

Third-octave bands
A small division of the frequency scale, three to each octave. Enables more accurate noise analysis.

Transmissibility
The amount of vibratory force that is transferred to the structure through an isolator, expressed as a percentage of the total force applied.

Turbulent flow
A confused state of airflow that may cause noise to be generated inside, for example, a ductwork system.

Vibration dose value (VDV)
A parameter used to reflect the disturbance and/or annoyance caused by variable vibration.

Vibration isolation
Any of several means of reducing the transfer of vibrational force from the mounted equipment to the supporting structure, or vice versa.

Wavelength
The distance between two like points on a wave shape, for example distance from crest to crest.

Weighted apparent sound reduction index (R'_w)
A single-number index which characterises the frequency-dependent airborne sound insulation performance of building elements.

Weighted standardised impact sound pressure level ($L'_{nT,w}$)
A single-number index which characterises the frequency-dependent impact sound insulation performance of building elements.

References

NOTE:
Where there is a requirement to address a listed reference, care should be taken to ensure that all amendments following the date of issue are included.

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
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	Clean Air Act	HMSO	1993	
	Control of Pollution Act	HMSO	1974	
	Electricity Act	HMSO	1989	
	Environmental Protection Act	HMSO	1990	
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SI 3140	Construction (Design and Management) Regulations	HMSO	1994	
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SI 635	Electricity at Work Regulations	HMSO	1989	
SI 1057	Electricity Supply Regulations (as amended)	HMSO	1988 (amd 1994)	
SI 2372	Electromagnetic Compatibility Regulations (as amended)	HMSO	1992	
SI 2451	Gas Safety (Installation and Use) Regulations	HMSO	1998	
SI 917	Health & Safety (First Aid) Regulations	HMSO	1981	

Publication ID	Title	Publisher	Date	Notes
SI 682	Health & Safety (Information for Employees) Regulations	HMSO	1989	
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BS 6472	**Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)**	BSI Standards	1992	
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BS EN ISO 140-5	**Acoustics. Measurement of sound insulation in buildings and of building elements. Field measurements of airborne sound insulation of façade elements and façades**	BSI Standards	1998	
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BS EN ISO 717-2	**Acoustics. Rating of sound insulation in buildings and of building elements. Impact sound insulation.**	BSI Standards	1997	
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SHTM 82	Alarm and detection systems	P&EFEx	1999	CD-ROM
SHTM 83	Fire safety in healthcare premises: general fire precautions	P&EFEx	1999	CD-ROM
SHTM 84	Fire safety in NHS residential care properties	P&EFEx	1999	CD-ROM
SHTM 85	Fire precautions in existing hospitals	P&EFEx	1999	CD-ROM
SHTM 86	Fire risk assessment in hospitals	P&EFEx	1999	CD-ROM
SHTM 87	Textiles and furniture	P&EFEx	1999	CD-ROM
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