Aims

The acoustic performance for Defence building can have a critical effect on levels of performance and occupier satisfaction. The aim of this Guide is to collate and summarise statutory and MoD best practice standards for acoustic performance of buildings – with the intention of making it easier to consistently apply these standards for buildings on the Defence estate.

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Introduction

This Practitioner Guide addresses standards affecting the acoustic performance of Defence accommodation. This document does not address the nuisance caused by noise emanating from Defence activities on the wider non-operational environment.

Designing for Noisy Environments

Defence establishments have the potential to be noisy for occupants of buildings. This is particularly so for operational airfields – though other Defence establishments can also be noisy – dockyards and training establishments for example. Firing ranges also create a sharp and intrusive noise nuisance.

The suggested acceptable internal noise limits are: for new build, 65 dB (the decibel (dB) is used to measure sound level) and for refurbished accommodation, 69 dB. Noise can cause disturbance for occupiers of sleeping accommodation and can present operational risks if military personnel are kept awake as a consequence of noisy environment.

The sound resisting capability of roof structure is important and should exceed 45 dB. In assessing the potential impact of a noisy environment the following factors should be taken into account:

The recommended noise level with external ventilated window should be no more that 10-13dB greater than internal noise limit. To avoid having to open windows to buildings that require a particularly quiet internal environment in order to function (for example for teaching) there may be an additional requirement for mechanical ventilation.

Designing for acoustic comfort can be a highly specialist requirement. The following list identifies specialist areas that will require scoping:

- Indoor ambient noise levels (defined as the sound pressure at a particular location) from external sources and building services defined on a room classification basis
- Airborne sound insulation between spaces
- Impact sound insulation of floors
- Reverberation within teaching and study spaces
- Sound absorption requirements for corridors, stairwells and entrance halls
- Speech intelligibility requirements in open plan spaces – this is particularly relevant in new open plan offices – especially with senior staff
- Design of internal sound resisting separating structures
- Noise caused by Mechanical and Electrical (M&E) equipment – for example dry coolers, chillers etc
- Mitigating noise emitted by firing ranges
- Noise from aircraft – flying, manoeuvring, maintenance and engine testing
- Partition sound privacy in open plan offices – particularly important where sensitive or matters related to discipline are involved
- Vibration of equipment – for example generators
- Construction noise – in all its forms

Use of Acoustic Panels

Absorptive acoustic panels contain acoustically absorbent materials such as densely packed fibreglass and are covered in an open weave fabric that allows sound waves to travel through so as not to impede the panel’s absorptive properties. The thicker the panel, the higher its absorptive coefficient – the extent to which the panel absorbs sound waves – will tend to be. Acoustic panels control the reverberation – defined as the time taken for noise to dissipate – once the source of the sound itself has become silent. Areas where noise can be a problem include atria, large corridors, entrance halls and specialist accommodation such as music rooms. The level of specification of hard materials – such as stone and glass – and also the introduction of new materials such as ETFE –
affect the acoustic properties of the space. The shape and size of interior spaces also have an effect – for example cylindrical and domed spaces will exhibit quite different sound qualities to rectilinear spaces.

**Use of Specialists**

Acoustic Design Consultants can offer an extensive range of services in relation to the assessment, measurement, prediction and analysis of noise and vibration within the building and architectural acoustics sector. Expertise covers the full range of building types and projects and to provide clients with relevant, high quality, cost-effective advice. Acoustic engineers can calculate the reverberation times at different frequencies – for example human speech is mid-range, drums low frequency, and electric motors high frequency. In this way a design can be ‘tuned’ to satisfy a desired acoustic performance specification.

**Health and Safety aspects**

The health and safety aspects of noise – for example providing acoustic protection to those working in excessively noisy environments is governed by the Control of Noise at Work Regulations 2005. The Control of Noise at Work Regulations 2005 (the Noise Regulations) came into force for all industry sectors in Great Britain on 6 April 2006 (except for the music and entertainment sectors where they come into force on 6 April 2008).

The aim of the Noise Regulations is to ensure that workers’ hearing is protected from excessive noise at their place of work, which could cause them to lose their hearing and/or to suffer from tinnitus (permanent ringing in the ears).

Excessive levels of noise can be caused by:

- Noisy powered tools or machinery – and aircraft (dealt separately in this Guide)
- Explosive sources such as cartridge operated tools or detonators, or guns
- Noise from impacts such as hammering, drop forging, pneumatic impact tools etc

**Planning Policy**

Planning Policy Guidance 24 (PPG24) guides local authorities in England on the use of their planning powers to minimise the adverse impact of noise. It outlines the considerations to be taken into account in determining planning applications both for noise-sensitive developments and for those activities which generate noise.

It explains the concept of noise exposure categories for residential development and recommends appropriate levels for exposure to different sources of noise.

It also advises on the use of conditions to minimise the impact of noise. Six annexes contain noise exposure categories for dwellings, explain noise levels, give detailed guidance on the assessment of noise from different sources, gives examples of planning conditions, specify noise limits, and advise on insulation of buildings against external noise.

**Aircraft Noise**

Aircraft generate considerable amounts of noise pollution and air pollution emissions. Noise emanating for aircraft on operational Defence establishments has the potential to be both a nuisance, as well as in extreme cases having a detrimental operational effect. Sensible planning of the location of functions on airfields will mitigate the impacts. Care is required in terms of compatibility – for example training facilities and libraries are clearly incompatible with engine test facilities.

In assessing the likely impacts consider:
• The frequency of night operations for aircraft
• Ground engine tests for aircraft and whether or how they are shielded (for example by hangars).

The term "Forecast Irregularity" is used in assessing the impact and potential nuisance of aircraft noise. Forecast Irregularity refers to the duration of excessive noise, as occupants may close windows for brief periods of high noise, and there is a learned tolerance for relatively short duration aircraft noise at RAF stations. Also helicopter noise creates its own disturbance. The use of 'sound-cells' to create a 'quiet zone' in Air Traffic Control towers reduces the impact of noise on operationally critical areas.

Acoustic Design Standards for Defence Buildings

Officers Messes

Acoustics/Sound Control

Public Rooms

The public rooms for Officers Mess buildings should provide a good acoustic environment appropriate to the room uses. The dining room needs to present an environment suitable for music accompaniment to dining, public speaking at functions, and general dining catering for small and large numbers. The acoustics of the ante room, bar and lounge should be suitably designed to allow for conversation between small groups of people, as well as larger numbers gathering for receptions etc.

The location of the kitchen relative to the dining room and service corridors should ensure that adequate sound reduction will screen guests from disturbance from kitchen equipment and working catering staff.

SNCO Messes

Acoustics/Sound Control

Public Rooms

The public rooms should provide a good acoustic environment appropriate to the room uses. The dining room needs to be a suitably designed environment for live music, public speaking at functions and general dining for both small and large numbers of people. The acoustics of the ante room, bar and lounge should be suitable for talking among small separate groups as well as larger numbers of people gathering together for receptions etc.

The location of the kitchen relative to the dining room and service corridors should ensure that adequate sound reduction will screen guests from disturbance from kitchen equipment and working catering staff.

Sleeping Quarters (affects both Officers and SNCO Messes)

The habitable rooms within the Mess need to be protected against external noise sources, as well as from adjacent rooms within the building. Measures can be taken to achieve this partly through good internal planning, especially within the sleeping quarters. Noise sensitive rooms such as these should be separated from communal facilities which generate noise, i.e. public rooms, utility rooms, busy circulation cores etc. Where the space planning does not allow this, the construction of separating walls must provide adequate sound insulation.
Most residents will have their own music systems and televisions, and the construction of partitions within the quarters needs to be equivalent to hotel design to provide good sound insulation between rooms. Partitions and floors between bed sitting rooms, and between bed sitting rooms and corridors, should have an average sound insulation of not less than 48 dB(A). Although these buildings do not have to comply with part E of the Building Regulations the design of walls, floor and structure generally should meet the performance standards given in the approved documents to part E of the Building Regulations.

Corridors are spaces where the generation of noise disturbance is most common. Doors across circulation spaces should not be sited adjacent to bedroom partitions, as banging of doors will disturb any sleeping occupants. Corridors should be separated from circulation cores by self-closing doors.

**Combined Messes**

Recent projects feature combined messes intended to share core facilities such as kitchens, which can be more efficiently shared by units – particularly when one operational unit is on tour. These types of design place greater emphasis on solutions to be acoustically effective – especially where different types of accommodation function are separated vertically.

**Junior Ranks Senior Living Accommodation (JRSLA)**

**Noise/Disturbance**

JRSLA should be sited away from facilities or functions which produce loud noise. Where this cannot be achieved, the siting and orientation of the building can reduce the level of disturbance caused within the accommodation. The JRSLA should be orientated to shield as much of the private sleeping quarters as possible from the prevailing sound source. Elevations facing the source of the noise should have a minimum number, and size, of openings in the building envelope, as these will allow sound to enter the building, with double glazed windows for added sound insulation.

External noise disturbance can be reduced by: quietening the source of the noise (although this is generally outside the scope of the JRSLA design); by dissipating the sound on its path between the source and the receiver; or by obstructing the sound path.

Dissipation of the sound is best achieved over distance, as the sound will be weakened and spread out as it travels through the air. Areas of soft landscaping and ground cover, along the sound path, can offer a degree of sound attenuation. Trees can provide noticeable sound reduction only if planted in very deep belts.

Obstructions on the sound path can take the form of screening or fencing, located close to the sound source or to the JRSLA, or by the sound insulation properties of the construction materials of the building itself.

**Acoustics /Sound Control**

The habitable rooms within the JRSLA need to be protected against noise generated outside, as well as from adjacent rooms within the building. This can be achieved partly through the internal planning of the JRSLA. Noise sensitive rooms, such as sleeping quarters, should be separated from communal facilities which generate noise, i.e. utility rooms, busy circulation cores etc. Where the space planning does not allow this, the construction of separating walls must provide adequate sound insulation.

Most servicemen and women have their own stereos and televisions, and the construction of partitions within the JRSLA needs to provide good sound insulation between rooms, equivalent to hotel design. Partitions and floors between bed sitting rooms, and between bed sitting rooms and
corridors, should have an average sound insulation of not less than 48 dB. The effect of this noise reduction is to make loud speech only faintly audible within an adjoining room.

Corridors are spaces where the generation of noise disturbance is most common. Doors across circulation spaces should not be sited adjacent to bedroom partitions, as banging of doors will disturb sleepers, and corridors should be separated from circulation cores by self-closing doors. Where possible, bedroom doors should be staggered so that the opening of one bedroom door will not disturb the occupant opposite. Floor and wall finishes along busy circulation routes should be chosen to minimise noise.

External Noise Control (affects Officers, NCO Messes and JRSLA accommodation)

Control of external noise can be achieved through the sound insulation of the building envelope. The density/mass of the construction will determine its sound insulating properties, with components such as doors and windows, creating local penetrations in the building envelope. For the sound attenuating qualities of the building envelope to be maintained, the penetrations within it should be kept to a minimum, particularly on the elevation exposed to most noise. Take care for example were using prefabricated and offsite methods of construction that they will exhibit an equivalent acoustic performance to traditional masonry construction.

Windows should be double glazed to provide both thermal and sound insulation. In extreme cases, the use of secondary glazing will provide additional sound insulation by creating a larger air gap than can be achieved with a double glazed unit alone. To be effective, the secondary pane must be securely closed.

The design of the building fabric for sound insulation must include protection of the top storey, possibly with a concrete over-slab, where noise levels on the site dictate. For example, the sound insulating properties of a traditional timber and tiled pitched roof will not be good enough to control noise levels from low flying aircraft. Buildings on airfields will generally be subject to greater levels of external noise than on other sites, and the detailed design of the quarters should take this into account.

Acoustic insulation measures should not conflict with the ventilation, fire and health and safety requirements of the design.

Soundproofing for Band Accommodation

One of the main goals of architectural acoustics is to provide optimum speech intelligibility and sound quality in auditoriums of public buildings. Acoustical conditions are also important in halls where sound amplification systems are used.

Generally acoustical performance has been measured in terms of the optimum reverberation time (defined simply as the time for the sound to die away) – as the reverberation time affects intelligibility of sound inside buildings.

The Scale for Band Accommodation states that rehearsal and instruction rooms are to include an economical form of soundproofing. In addition, easily adjusted acoustic material, e.g. heavy drapes, may be provided to facilitate rapid changes in acoustic conditions. The acoustic design is to comply with Noise in the Workplace regulations. In designing the building, consideration should be given to using non-practice rooms, e.g. library, to form noise barriers between practice rooms.

Resistance to the Passage of Sound:
Building Regulations Approved Document E
(Outside England/Wales Home Country equivalents will apply)

This edition of Approved Document E - Resistance to the passage of sound, replaces the previous edition incorporating 2004 amendments and came into force on July 1 2003. Various forms of construction are indicated for providing reasonable sound resistance to walls and floors in new
dwellings or conversions. The updated Approved Document includes requirements for sound testing, and robust details for new housing. It is designed to meet demands for improved acoustic insulation and to combat the problems of noise pollution from neighbours.

The Regulations apply to both new build and conversion or refurbishment work and set out standards for; the sound insulation of party walls and floors between dwellings (or rooms used for residential purposes), the sound insulation of internal walls and floors, the control of reverberation within communal areas and the acoustics of schools (See Building Bulletin 93).

The Regulations require the builder to undertake pre-completion sound insulation testing of a sample of party walls and party floors to demonstrate to Building Control that compliance with Part E has been achieved.

A series of Robust Standard Details (RSDs), constructions that will provide the required level of sound insulation with a suitable tolerance for workmanship have been developed and adopted as an alternative to pre-completion testing.

Robust details are construction solutions which provide an alternative to pre-completion sound testing as a method of complying with the Building Regulations Part E (resistance to the passage of sound). A robust detail, for Part E of the Building Regulations, is a separating wall or floor construction which has been assessed and approved by Robust Details Limited. In order to be approved, each robust detail must:

- Be capable of consistently exceeding the performance standards given in The Building Regulations Approved Document E.
- Be practical to construct on site.
- Be reasonably tolerant to workmanship.

In using robust details, there is not a requirement to carry out pre-completion sound testing but a builder will need to obtain permission from Robust Details Ltd and pay the fee for each dwelling. If the robust details are built correctly then they will be accepted by all building control bodies as evidence that the dwellings are exempt from pre-completion testing. On completion of each separating floor or wall the builder is required to complete a compliance certificate and pass it to the building control officer. Without this certificate the building control will not approve the construction.

**Lightweight Construction**

The Building Research Establishment's (BRE's) Acoustics Centre, funded by the Department for Children Schools and Families, has developed an Excel spreadsheet to help designers carry out calculations of façade insulation and reverberation times in rooms. The spreadsheet is available for use from this site. Although intended for schools this research is relevant and transferable to other lightweight buildings.

Acoustic performance has historically been low on the list of design priorities, however, Building Bulletin 93; Acoustic design of schools places a higher priority on acoustics and ‘recommends a structured approach to acoustic design at each stage of the planning and design process’. Compliance of BB93 requires that “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.”

In recent years, buildings which have lightweight metal roof constructions have been the most susceptible to problems caused by external ambient noise, and in particular rain noise. In some cases rain noise in excess of 70dB – similar to typical street traffic – has been recorded.

The need to address the problem of rain noise has helped to drive new building standards. While upper limits are given for the indoor ambient noise levels in specified room types, there is currently no provision for impact noise created by rain. Section 3 of BB93; Insulation from external noise recognises that rain noise is a potentially important noise source which must be considered early in
the early initial stages of roof design and planning and promises that in future amendments 'consideration will be given to including a performance standard for rain noise in BB93. Until this time, it is appropriate for design teams to provide evidence to the Building Control Body that the roof has been designed to minimise rain noise'.

Section 3 also highlights the need for acoustic absorption and dampening and gives detailed guidance on construction, including the use of additional mass and independent acoustic ceilings to improve external noise reduction and internal ambient noise levels.

Clearly, laboratory measured data regarding the performance of lightweight metal is required to aid specifiers in the design of lightweight metal roof systems. BB93 recommends that future roof constructions are compared for rain noise performance using a new acoustic measurement standard: ISO/CD 140-80, which will allow the comparison of the acoustic insulation provided by different roof constructions and materials.

ISO/CD 140-18 specifies two types of artificial rainfall, ‘intense’ and ‘heavy’ rain, with the latter having a higher rainfall rate, larger raindrop diameter and greater fall velocity. For comparison purposes, ‘heavy’ rain was chosen, which is understood to be the preferred type of artificial rainfall for the comparison of products in Europe. Individual sound intensity measures were taken below the roof construction at each frequency between 50 – 5000 Hz. The BRE then calculated the Reverberant Sound Pressure Level for a typical school classroom and gymnasium using the measured sound intensity data for each construction.

Further Reading and Information

General:
Building Regulations Approved Document E Resistance to the Passage of Sound
Building Research Establishment (BRE) Digests
Building Bulletin 93; Acoustic Design of Schools
Chartered Institute of Building Services Engineers (CIBSE)
Weblink: www.cibse.org
Institute of Acoustics
Weblink: www.ioa.org.uk
Association of Noise Consultants (ANC)
Planning Policy Guidance 24 - Noise” (PPG24)
Weblink: http://www.odpm.gov.uk/index.asp?id=1144097
British Standard (BS) EN ISO 140-1:1998 Acoustics Parts 1-12
BS EN ISO 3382:2000 Acoustics Measurement of Reverberation Time in Rooms
BCO Best practice in the specification for offices, 2005.

MoD:
MOD Position and Policy on Aircraft Environmental Noise
Noise & Vibration Division RAF Henlow
JSP 418 Volume 2 Leaflets 15: Environmental Noise and Other Forms of Nuisance
JSP 434 Defence Construction in the Built Environment
JSP 315 Defence Scales of Accommodation