Proceedings of The Institute of Acoustics

ACOUSTIC DESIGN OF BBC STUDIOS

D.J. Meares

BBC Research Department, Kingswood Warren, Tadworth, Surrey.

INTRODUCTION

Since its conception, the BBC has designed, built and tested many hundreds of studios and other technical areas. The design criteria and practical details presented in this paper are based on the experience gained during that period.

ACOUSTIC CRITERIA

The derivation of the BBC's criteria for ventilation noise and for airborne sound insulation has been presented previously, References [1], [2] and [3]. For completeness however the criteria are presented here as Figs. 1 and 2 respectively. Fig. 1 shows the three criteria for noise in studios separated into appropriate classes of sensitivity according to the programme type. The most critical application, namely Drama, has a criterion of its own, criterion (iii), whilst radio studios for talks, continuity and music recitals, and television studios are grouped together under criterion (ii). Remaining classifications of radio studios, such as those including a live audience, are covered by the remaining criterion (i). Fig. 2 shows an example of part of the sound insulation criteria chart for a selection of radio facilities. The nomenclature used is described in detail in References [2] and [3], but taking as an example the insulation between two Talks studios, the criterion starts at a level of 34 dB at 63 Hz, rises at a rate of 15 dB per octave to a level of 52 dB, at a rate of 10 dB per octave from there up to 60 dB, continues at a rate of 8 dB per octave to 62 dB, and finally at a rate of 5 dB per octave to a level of 68 dB, which should coincide with a frequency of 700 Hz. As can be seen from Fig. 2, certain combinations of areas should be avoided in laying out the overall plan of a studio complex. For instance, if one is unwise enough to locate a Pop studio adjacent to a Drama studio, then the insulation criterion starts at 77 dB at a frequency of 63 Hz, rising to 107 dB at 1 kHz.

The only aspect of the criteria not previously published is the tolerances which are applied to them. In prescribing the tolerances it has to be borne in mind that the noise and insulation criteria are intrinsically linked one with another. In the subjective appraisal of the achieved sound insulation, an operator's awareness of breakthrough into his studio from another area is directly affected by the ambient noise level in his studio normally resulting from the ventilation system. The normal laws of masking apply even at the relatively low levels of studio ventilation noise. Thus, if the achieved ventilation noise were a long way below its criterion, it would not provide the desired amount of masking required to ensure that extraneous noises were at a subjectively unimportant level. It is therefore necessary with the noise criterion to specify both an upper and a lower limit to the allowable levels. The allowable tolerances for ventilation noise are that the average deviation, irrespective of sign, between the achieved noise curve and the criterion curve across the band 50 Hz to 4 kHz should be less than 2½ dB per third octave band. Furthermore, no individual third octave level should exceed the criterion by more than 5 dB, nor should individual third octave levels exceed their immediate neighbours by more than 5 dB.

The tolerances applicable to sound insulation are somewhat more relaxed. Apart from possible building cost penalties, there is no operational reason why the level of extraneous noise should not be attenuated beyond that level specified by the criterion. However, it is still necessary to specify any shortfall in achieving the criterion. It is also recognised in the specification of these tolerances that it is extremely difficult accurately to prescribe sound insulation at the design stage at low frequencies and thus the sound insulation tolerances are split into two bands. Between the limits 63 Hz to 200 Hz the average adverse difference should be less than 6 dB per third octave, whilst the largest adverse difference in any individual band should be less than 10 dB. Between the limits 250 Hz to 10 kHz these parameters are 2 dB and 5 dB respectively.

The specification of the internal acoustics of a studio is somewhat more difficult to prescribe. Obviously the parameter of reverberation time is both specified and measured but it is known that this is not the only parameter of importance when designing a studio. Other factors such as control of room modes, distribution of absorption etc. are dealt with separately. Thus the reverberation criterion for Talks studios and all Control Rooms is shown in Fig. 3. This allows an average reverberation time in the range 250 Hz to 3.15 kHz to be in the range .2 secs to .3 secs. Individual third octave band results should be within 10% of this average value. In addition the reverberation time at lower frequencies is allowed to rise by a fixed percentage of the achieved average reverberation time in the higher frequency band. This is illustrated by the shape of the upper limit shown in Fig. 3. Reverberation times allowable in other studios depend very much on the type of programme being generated in that area and the volume of the individual rooms. Table 1 shows a range of reverberation times and volumes for different programmes. In these particular cases, the average reverberation time will be allowed to vary by up to $\pm$ 10% of the designed average reverberation time, but normally a relaxation at bass frequencies is not allowable.

Table 1 : Average Reverberation Times

Radio:	talks	60m^3	0.25 seconds
Radio:	music, small	600m^3	0.9 seconds
	large	10,000m^3	2.0 seconds
Radio:	drama	400m^3	0.4 seconds
Television:	general purpose	7,000m^3	0.7 seconds

ACHIEVING THE CRITERIA

The BBC's shape of noise criterion is rather different from the more commonly prescribed Noise Rating Curves [4]. A comparison of BBC criterion (ii) against NR15 shows that, whilst above 250 Hz the curves are quite close, at lower frequencies they diverge significantly, amounting to up to 8 dB at 50 Hz. The shape of the noise rating curves was derived from human perception of the loudness of a sound in the room in which it is generated. In the BBC's case, what matters more is the perception of a studio's acoustic noise after the sound has been recorded via a microphone and reproduced, at the end of the broadcasting chain, in the listener's home. Both the variation of directivity of microphones with frequency and the reverberation time characteristic of typical domestic environments (see for instance reference 5) conspire to increase the relative levels of reproduced low frequency noise. Thus, experience has generated a unique shape to the BBC criterion curves.

This particular shape however gives rise to problems in the design of ventilation systems. It is well known that the vast majority of duct attenuators are extremely efficient at absorbing mid and high frequency noise, whilst they are less efficient at the lower frequency end of the spectrum. It has been the BBC's experience of late that a simple design of ventilation system capable of achieving the appropriate criterion at low frequencies, very seriously over-absorbs the mid and high frequency noise coming down the duct. If no remedial action were to be taken in the studio then this would result in excessively quiet ventilation noise at mid and high frequencies and, as has already been pointed out, the possibility would then exist of increased awareness on the part of operators to other sources of noise. It is necessary therefore to regenerate some of this mid and high frequency noise within the studio itself. A relatively uncontrolled technique of achieving this is to generate turbulence in the diffusing grilles at the ventilation outlets, but under this arrangement a compromise would have to be sought between regenerated noise and the ability to control the direction of airflow to optimise the ventilating action in its own right. Electro-acoustic methods have also been examined, but these are both expensive and give rise to operational problems.

An alternative approach is to generate turbulence, and thus noise, in the duct between the final silencer and the studio diffuser. The BBC has recently been conducting experiments in one of its local radio installations to study this approach in detail. A selection of perforated plates has been designed which, whilst generating a constant back-pressure to the flow of air, are capable also of generating a range of regenerated noise levels depending on the details of the perforations. Thus the airflow aspects of a system would be adjusted with any one of the plates installed and then as a separate process the plate itself can be selected to give the required noise level in the studio. Preliminary tests indicate that this approach shows great promise.

Examination of the full insulation criterion chart (of which Fig. 2 is just a very small part) shows that many of the specified levels of sound insulation are very high. By careful planning of the site however many of the problems can be avoided. Thus the judicious placement of offices and corridors as intermediate zones between sensitive studio areas can significantly reduce the sound insulation required of any individual partition. Because the BBC is involved in converting many existing buildings to studio usage, a great number of these conversions have to make use of lightweight stud partitions. The particular design used widely in the BBC, known as a Camden partition, is a combination of 12.5mm plasterboard and 12.5mm softboard on both sides of 75mm softwood studs. This format, as a single skin, does not have a very good sound insulation performance, but multiple layers are able to give extremely high values. Fig. 4 shows the spread of results for 11 partitions comprising a double Camden as the perimeter of a studio, a corridor for general personnel access, and a second double Camden into the adjacent studio area. The characteristic shows a low frequency insulation averaging 40 dB, rising to 70 dB at 500 Hz and 83 dB at 1.8 kHz. Comparison of this characteristic with the specifications shown in Fig. 2 indicates that this form of partition is entirely adequate for any combination of Talks studios and Drama studios.

It is obviously not possible under all circumstances to have total freedom where studios and other facilities are located. On very constricted sites there are many occasions where studios have to be placed adjacent to one another and indeed on one such site, the BBC's Maida Vale Studios, a Drama studio has been located next to a Pop Music studio. The form of construction for these two areas is shown in Fig. 5. Both the Drama studio, Studio 7, and the Pop studio, Studio 6, were independently floated from the foundations. In addition two intermediate masonry walls were positioned between the two studio walls. The sound insulation achieved with this form of construction is shown in Fig. 6. In point of fact this is an estimate of the minimum likely achieved insulation. The measurement was made by exploding a theatrical maroon in Studio 7 and measuring the maximum sound level in both environments at the instant of detonation. Subjectively the maroon was only just audible in Studio 6 and only then at low frequencies. It is likely therefore that the measurement of received sound level in Studio 6 above 315Hz is general ambient noise as opposed to noise due to the maroon.

Regardless of the form of partition, whether it be a lightweight Camden partition, or multiple-leaf, heavy masonry, attention to details is essential if flanking paths are to be avoided. Within broadcasting centres there are many possible apertures in studio walls, all of which have to receive detailed attention. Operations require the provision of large windows and access doors, together with cable ducts and ventilation. Flanking paths resulting from the latter two can be controlled relatively easily by specifying indirect routes, but with the former this degree of flexibility is not possible. Thus multiple pane windows with attention to details in the soffit and where the window crosses the cavity are essential. Additional routes which have to be guarded against are above the ceilings and below the floors, particularly where floated structures are being designed. The floated structure itself has also to be very carefully prescribed to ensure adequate isolation at all likely source frequencies. (This matter has been the subject of a very detailed study and is reported in a separate paper at this Convention.)

For many years the BBC has based the majority of its radio studio designs on the use of modular acoustic absorbers. The format of the absorber is shown in Fig. 7. By careful choice of the percentage perforation of the front panel, the density of the mineral wool, and the depth of the airspace, different absorbing characteristics have been designed which allow a balanced acoustic to be achieved within the studios. In the main, acoustic absorption is provided by such modular absorbers from 80 Hz up to about 4 kHz. Above that upper limit, both air absorption and absorption from thin fabrics tends to control the reverberation time adequately without specific measures being taken. Below the lower limit, additional measures are sometimes necessary. The use of Camden partitioning in smaller Talks studios provides much of the necessary lower frequency absorption as a result of small controlled structural resonances. In larger studios however, where masonry walls are more common, additional very deep acoustic absorbers are frequently used.

In designing studios it is very difficult to achieve both controlled acoustics and a naturally pleasing visual appearance to the studio. The current trend with architects is to make great use of fabric to provide both the appropriate finishing colour and texture to the walls of a studio. In addition, users naturally require carpet on the floor and if at all possible a visually flat ceiling: thus ceiling tiles frequently creep into the design. All of these finishes provide very efficient absorption above 1 kHz and thus it can be difficult to maintain the balanced acoustic. The BBC's current approach is to try to eliminate ceiling tiles and provide a visual ceiling which is acoustically transparent, with conventional modular absorbers on a structural ceiling above. The acoustic absorption of fabric finishes is minimised by keeping the airspace between the fabric and the acoustic treatment as small as possible. Suitable choice of the weave of a carpet can also significantly reduce the high frequency absorption.

Having specified the amount of absorption and therefore the number of absorbing modules that go into a studio, the position of the absorbers has to be selected with care. Within a studio one may have several windows to adjacent rooms and within control rooms the additional problems of apparatus bays, tape recorders etc. All of these can give rise to specular reflections and, if the wrong location is chosen for the absorbers, flutter echoes can occur. Non-parallel surfaces obviously help in this context, but particularly when converting existing premises this element of flexibility is not always available.

In Television studios the main aim is to provide as much absorption as possible. Being general purpose, a Television studio is often required to represent an outdoor scene in a drama and thus as low a reverberation time as possible is desired. Under these circumstances, all available wall and ceiling surfaces are treated in the manner shown in Fig. 8. Even so, with the concentration of lighting and scenery hoists on the ceiling lighting grid and control panels, observation windows, and scene dock doors on the walls it can be difficult to find sufficient wall space for the acoustic treatment. In Television control rooms where normally modular absorbers would be perfectly acceptable, and indeed they have been used in the past, a slightly harder wearing finish has been favoured of late. For these areas a wood slat treatment is prescribed to give this hard finish and acoustic treatment has been designed to work behind this.

CONCLUSIONS

This paper has presented the acoustic criteria currently used by the BBC when designing its studios and other technical areas. These now include a tolerance zone to reflect the difficulty of prescribing acoustics at the design stage and even of measuring them accurately once the work has been completed. Guidance has also been given on the way the BBC has achieved these criteria.

REFERENCES

1. Meares, D.J. & Lansdowne, K.F.L. 1980. Revised background noise criteria for broadcasting studios. BBC Research Department Report No. 1980/8.

2. Walker, R. 1981. Revision of the sound insulation requirements in broadcasting studio centres. BBC Research Department Report No. 1981/1.

3. Meares, D.J. & Walker, R. 1982. New standards for the acoustic design of BBC studios. Proceedings of the Institute of Acoustics Spring Conference 1982. Paper A.3.3.

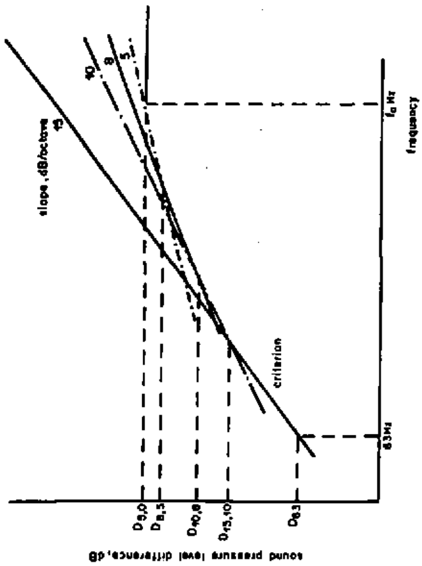
4. Acoustics: Assessment of noise with respect to community response. ISO Recommendation 1996.

5. Burgess, M.A. and Utley, W.A. 1985. Reverberation times in British living rooms. Applied Acoustics 18 (1985) pp. 369 - 380.

ACKNOWLEDGEMENT

The Author wishes to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this paper.

ACOUSTIC DESIGN OF BBC STUDIOS



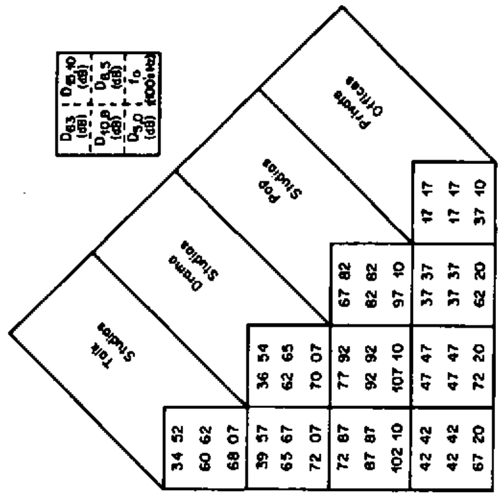
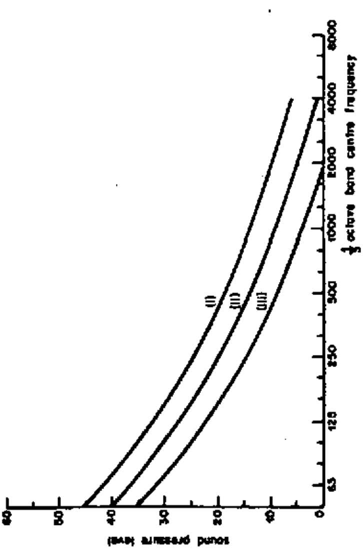


Fig.2 AIRBORNE SOUND INSULATION CRITERIA



(i) Radio - other than classes (ii) and (iii)
(ii) Radio - talks, continuity, recital. Television all categories
(iii) Radio - drama

Fig.1 NOISE CRITERIA

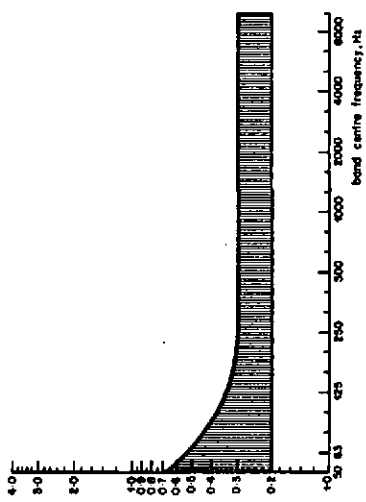


Fig.3 REVERBERATION TIME FOR TALKS STUDIOS: OVERALL TOLERANCE

ACOUSTIC DESIGN OF BBC STUDIOS

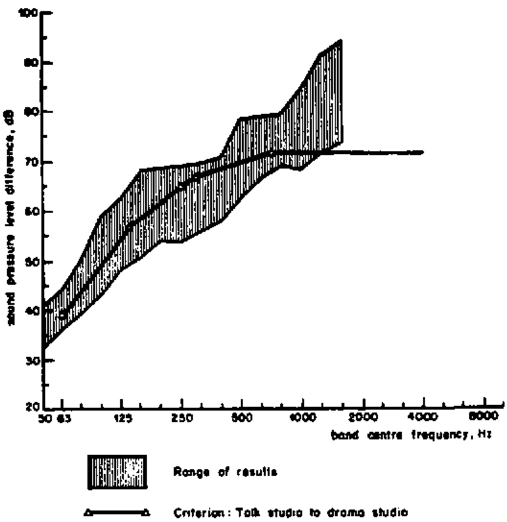
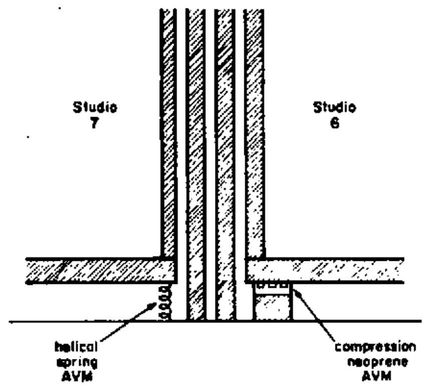


Fig 4 INSULATION OF DOUBLE CAMDEN/CORRIDOR/DOUBLE CAMDEN PARTITION



Wall details: Studio 7

225mm brick
225mm cavity
325mm brick
225mm cavity
340mm brick
225mm cavity
340mm brick

Studio 6

Fig.5 CONSTRUCTIONAL DETAILS MV7 TO MV6

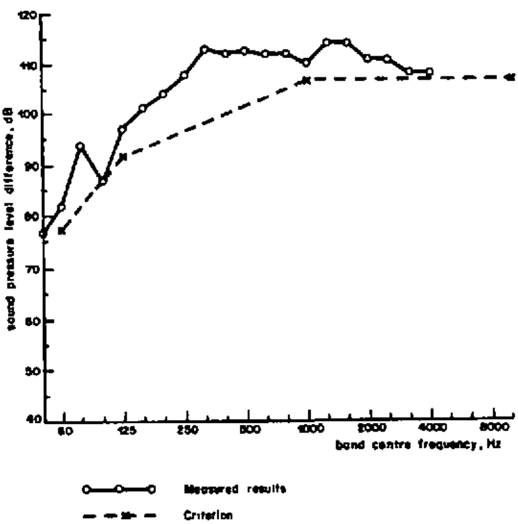


Fig.6 SOUND LEVEL DIFFERENCE MV7 TO MV6

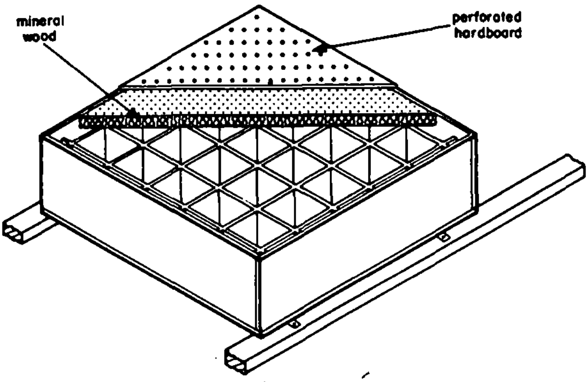


Fig.7 CONSTRUCTIONAL DETAILS OF A MODULAR ABSORBER

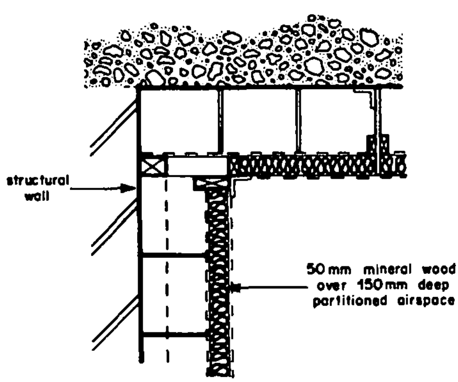


Fig.8 ACOUSTIC TREATMENT IN TELEVISION STUDIOS