BACKGROUND NOISE LEVELS IN STUDIOS AND AUDITORIA

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Abstract

The specification of background noise levels for auditoria must strike a balance between the lowest possible noise level from services and the need for some "masking" of extraneous sources. Studios are often designed to provide a suitable level of masking, using either aerodynamic or electronically-generated white noise. Data on noise levels in a large number of auditoria have been examined to determine whether a similar process is applicable to these. A wide range of seemingly arbitrary design criteria has been found.

Introduction

The acoustic consultant who is asked to design a theatre or concert hall has a vast bibliography of papers on reverberation times, early lateral reflection, hall dimensions, tuned absorbers and diffusers and electro-acoustically assisted reverberation. A design for these will involve a great deal of time, expense and research using complex computer and scale modelling. The specification of a background noise level, on the other hand, will probably occupy five minutes and will be based on an arbitrary figure which depends on a combination of previous experience, noise levels quoted for similar projects and research carried out thirty years ago for an entirely different purpose.

The specified background noise level has a very large effect on the overall cost of the building. This is not merely because of the additional cost of attenuating mechanical services, but also due to the increased acoustic isolation necessary in the structure to control noise break-in from external sources. It has long been recognised that for broadcasting studios, a well-balanced spectrum of noise from the air supply system is as important as the overall ambient noise level. This idea does not, however, appear to have gained universal acceptance in concert hall design.

Commonly used noise criteria

The NC curves introduced by Beranek in 1955 were based on an extensive survey of loudness levels and speech interference in open plan offices [1]. In 1960, following complaints that the NC curves were too permissive at the extremes of the spectrum, Schultz [2] suggested that a more balanced spectrum would result from using annoyance rather than loudness levels. Beranek did this and published the PNC curves [3], which are lower at low frequencies than the corresponding NC and NR curves. These have not passed into general use in Europe.

NR curves appeared in ISO publications in 1960. They originated from work by Stephens, Rosenblith and Bolt [4] on industrial noise. It is not clear from the literature how NR or NC curves came to be used for auditoria, particularly as their extrapolation to the lower levels nowadays applied to auditoria must have been largely conjectural.

Other criteria have been suggested but have not passed into general use. Most recently, ASHRAE recommended the use of RC curves (1980) which may be applicable to performance spaces.

Auditoria

It is notable how rarely consultants refer to background noise in papers on auditoria that they have designed. However, a number of recently published books list the designed and measured acoustic parameters for a variety of concert halls, theatres and multi-purpose auditoria [5,6,7] and some of these include background noise. Other data has been made available by individual consultants, among them Dr M Barron who has recently carried out a survey of the acoustic parameters and audience reactions to auditoria [8]. Added to those for which SRL already have measurements, this gives a database of some 50 auditoria, mostly in the United Kingdom and in the USA. All levels quoted are for empty halls with the air supply working as for a capacity audience and assisted resonance systems (where fitted) on.

The variety of design criteria used is remarkable (see figure 1), with substantial differences even between halls of similar capacities and functions. PNC 15 is quoted for the Royal Concert Hall, Nottingham and for the Derngate multi-purpose hall in Northampton (although Dr Barron's measurements at Derngate suggest an achieved level closer to PNC 30) . The Melbourne Concert Hall and a number of large concert halls in the USA have achieved NR15, and while many halls in Japan are designed to NC20, NC15 was reached at the Wakayama Civic Centre, a 1500-seat multi-purpose hall used mostly for classical music.

At the other extreme, in many highly successful auditoria levels of NR25 and NC25 seem to escape criticism, among them the Snape Maltings (NC25) and the Albert Hall, Bolton (NR25). A number of performing arts centres at universities in the USA generate levels around the PNC30 level although here economic factors may have played a part.

Using Services Noise for Masking

The Queen's Hall in Edinburgh was converted from a church to a 1,000 seat concert hall with a background noise criterion of NR25. In the event, the internal noise level turned out to be NR19, resulting in clearly audible noise break-in from traffic. In the Royal Festival Hall, London, background noise levels are well below PNC 15 at low frequencies and low-frequency train noise is clearly audible. It seems likely that higher noise levels from the ventilation systems in both of these halls would be permissible and would result in noise from external sources becoming inaudible.

An example of the successful use of services noise to mask break-in is the International Hall at Brentwood in Essex. This auditorium breaks many of the preconceived rules of auditorium design. It is a genuine multi-purpose hall, used for sport as well as for classical concerts, with a volume of 26000 cubic metres for a seated capacity of 2000. Light-weight materials are used for the building, which is under a flight path and close to a motorway. This would not have been possible with very low background noise levels, and a criterion of NC25 was chosen. The resulting acoustic has been enthusiastically received by audiences and orchestras alike, with no mention of services noise being intrusive.

Background noise levels in studios

Both the BBC and the Independant Broadcasting Authority impose strict criteria on the background noise levels permissible in recording studios. The IBA criteria are the less stringent, being approximately NC25 for studios and "on-air" control rooms and NC20 for monitoring rooms and booths.

The BBC curves are defined in one-third octave bands from 50 Hz to 4kHz. There are three curves:

Type 1 - Radio other than types 2 and 3
Type 2 - Radio talks, continuity and recitals and all categories of Television
Type 3 - Radio drama

These criteria have been established by the BBC's Acoustic Research Department after an extensive survey of noise levels in existing studios. There are separate criteria for noise from mechanical ventilation and for other noise sources such as clocks, cameras and break-in from outside. They approximate to NR curves as follows:

Type	Ventilation	All sources(including ventilation)
1	NR15	NR20
2	NR10	NR15
3	NR5	NR10

Until recently, the curves for ventilation noise had to be matched closely to provide a smooth spectrum; on average to within 2.5 dB with no frequency exceeding either adjacent frequency by more than 5dB. A greater allowance was permitted at frequencies below 250 Hz. The purpose of this curve-matching was to provide some masking noise and to ensure that there was no "rumble" or "hiss" in the background noise. The limits for curve matching have now been changed, so that the average of the third-octave bands lies between 0 and 10 dB below the criterion, with no frequency band exceeding the average of the two adjacent bands by more than 5dB.

Many studios have been built to the BBC's curve-matching specifications by selecting attenuators in the air supply ductwork to match the curve at low frequencies. This almost invariably results in noise levels which are well below the curve at high frequencies. It is then necessary to add flow noise from secondary attenuators, diffusers or perforated plates. Although this system has proved effective, it is time-consuming and tends to require careful tuning and strict control of the airflow in the system. A recent installation at the BBC Newcastle studios has instead used electronically generated white noise from loudspeakers in the ceiling void. The background noise levels with and without this "sound-conditioning" system are shown for one studio in figure 2.

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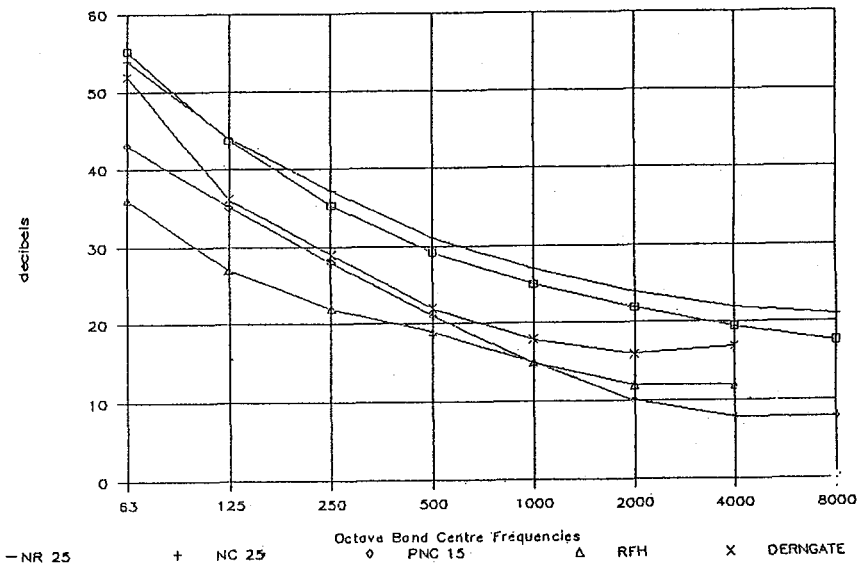
Figure 1



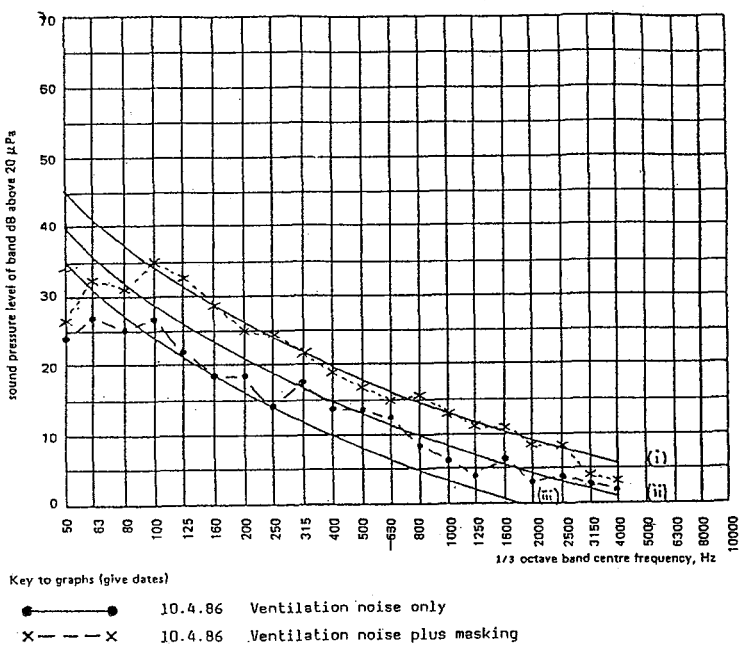


Figure 2

Background noise in studio with and without electronic sound conditioning