

Technical Notes covering Building Acoustics, Industrial Noise, Environmental Noise,
Structural Vibration, Machine Vibration

FUTURE NOISE AND VIBRATION CONTROL IN BUILDING SERVICES

Buildings designed today are more likely than not to be "rum bly" and "hissy". Trends in building design are for light-weight steel framed buildings and for compact plant rooms and services. These trends can lead to higher vibration levels in slabs, low-frequency noise problems due to space limitations on silencers and high-frequency noise problems due to higher duct air velocities.

NOISE CRITERIA

The starting point of any acoustics project involving noise in buildings is the establishment of suitable noise criteria for the most important building spaces.

In most commercial and residential buildings it is desirable to have a certain level of noise ambient (to which people become accustomed) which serves to mask other intrusive noises.

It was learnt in the 1950's that a single dB(A) number does not properly reflect the noise ambience of an acoustic space, rather, that reference must be made to the frequency content of the noise. For this reason, Noise Criterion or NC curves were proposed (see Figure 1). These were published in 1957 and are still widely used in the US to this present day. There was considerable criticism in the US that in offices designed to NC curves, the air-conditioning noise was too "rumbly" and "hissy".

The Noise Rating (NR) curves, popular in Europe, were meant to be applied to both internal and external environments.

The difference between the NR and NC curves are minor, except for the fact that the NR curves extend below 63Hz. One would therefore expect that buildings designed to NR curves will also be "rumbly" and "hissy".

A curiosity in Australia is the standard relating to internal noise levels, AS2107. In 1987, this standard broke from using NR curves and specified dB(A) values except for studios, theatres and auditoria. While it is true that the A-weighting curve follows closely the NR or NC curves, it is not possible to specify a particular spectrum shape. Buildings designed to AS2107 can therefore potentially be far worse than those designed with NR and NC curves.

At the present time in the US, ASHRAE is leading the fight back to controlling "rumbly" and "hissy" buildings with RC

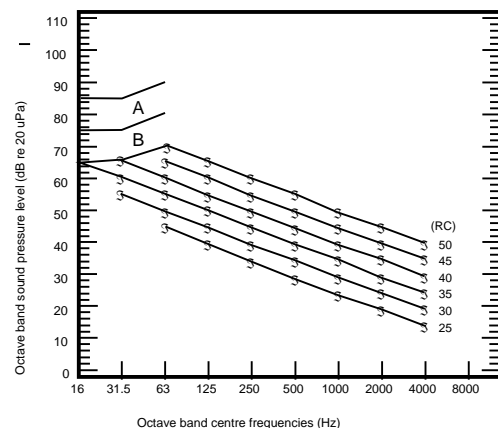
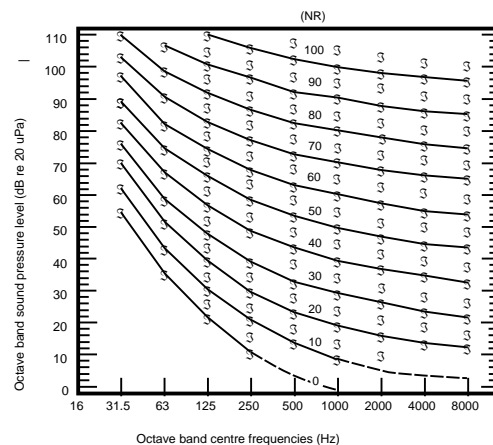
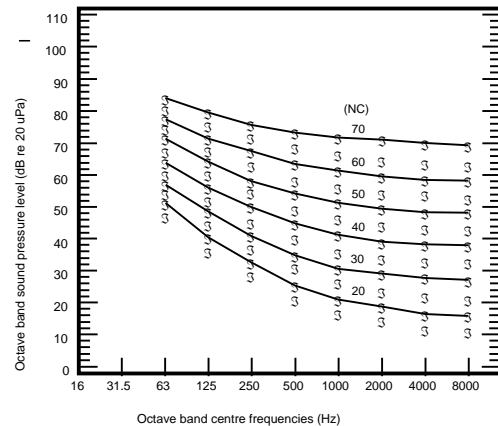
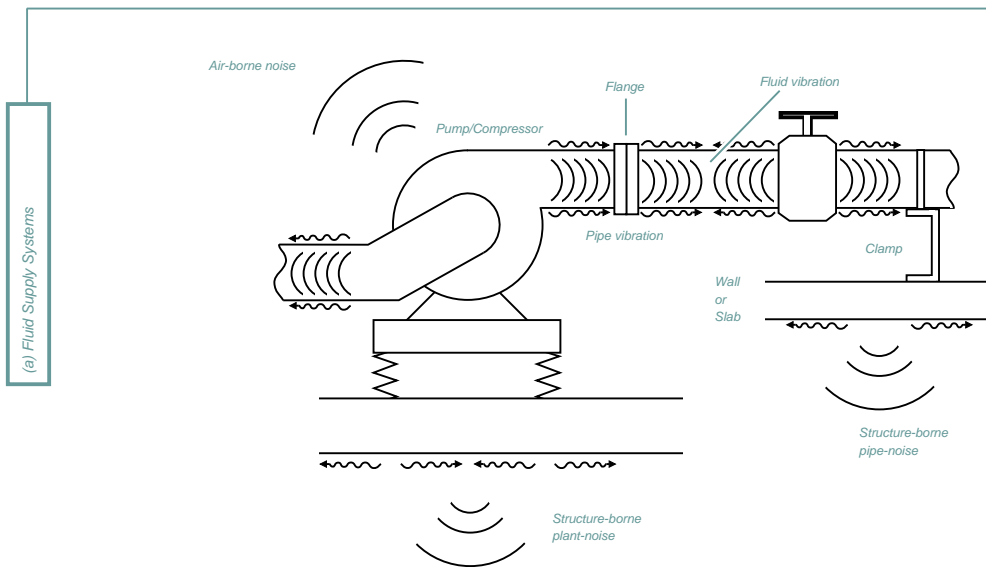


fig 1: Noise Rating Curves



curves (see Figure 1). But the odds are stacked against progress because trends in building design are for light-weight steel framed buildings and for compact plant rooms and services.

Compared with NC and NR, the RC curves are a somewhat more stringent design criterion at the very low and very high frequencies. Noise control design is therefore likely to become more expensive.

Table I shows a comparison of common noise criteria and has been compiled by reference to space type.

MASKING NOISE IN OPEN PLAN OFFICES

The popularity of open plan offices continues and there is no reason to believe a fundamental change will occur in the future.

The principal disadvantage of open plan office space is of course loss of privacy and in particular, speech privacy. Speech intrusion can also cause loss of concentration and can be extremely disruptive—for example, open plan offices do not work well with computer programmers, research analysts and some consultants.

The most important tools available to improve speech privacy are;

- (i) partitions or partial height screens
- (ii) the use of a relatively high noise ambient to mask the speech, and,
- (iii) carpets and sound absorbing ceilings to inhibit noise propagation.

The obvious noise source in buildings which one could utilise to provide masking is mechanical plant noise.

The concept of putting electronic masking noise into a building to sterilise it has caught the imagination of architects, project managers and sales people alike. However, the concept of doubly paying for noise control is not very clever.

Firstly, one pays the cost of reducing noise from mechanical plant and then, because noise levels are too

low, one pays the additional cost of a sound masking system to artificially raise the noise ambient.

The philosophy of the future might be to design noise from mechanical plant at a level and with the required sound spectrum rather than below a given level.

Research shows that, if one has solid partitions in the range STC36-STC63 and a light-weight fibreglass ceiling of STC20, one would require a level of NC37-NC40 masking noise in order to ensure speech privacy. This is typical of the average office situation.

For standard mineral fibre ceiling tiles (STC37), the level can be reduced to NC19-NC27 which is very quiet.

In open plan spaces, the speech privacy requirement cannot ideally be met. That is to say, the necessary ambient noise level required for privacy is higher than that required for face-to-face intelligibility and general comfort. Thus, a compromise must be made to arrive at an ambient noise level that best satisfies the privacy and comfort requirements together.

HYDRAULICS

Perhaps the most difficult source of noise defying quantitative study in acoustics is hydraulics noise. The subject of piping system noise and vibration is much more complex than one would perceive from a casual inspection.

Figure 2 shows the typical noise sources in supply and waste pipe systems. In fluid supply systems, the first noise and vibration generator is the pump or compressor. Surface vibration in the equipment is transmitted to the plant room floor via the vibration isolators supporting the equipment. This vibration then re-radiates noise in the building space below. The pump or compressor also transmits vibration along the pipe by three means;

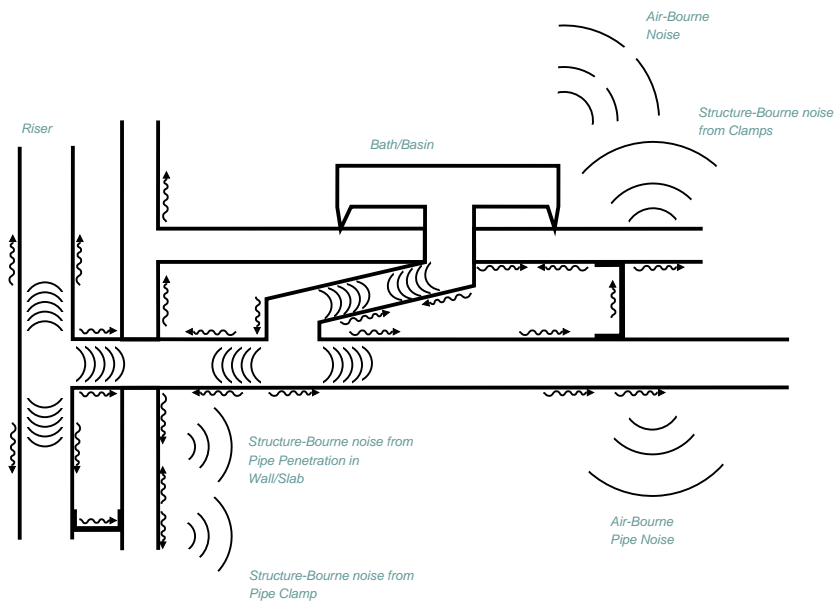
- (i) Surface vibration in the equipment mechanically forces vibration in the pipe walls;
- (ii) Fluid vibration is transmitted in the pipe due to the rotary action of the equipment impeller;
- (iii) Fluid vibration imparts vibration in the pipe walls.

The consideration of "sloshing" of vibrational energy backwards and forwards between pipe and fluid is the key to understanding what makes certain treatments work and not others. For example, inter-position of flanges or resilient bellows (see Figure 2 (a)) make very little difference because of this action.

fig 2:

TABLE 1 - COMPARISON OF AMBIENT NOISE CRITERIA					
OCCUPANCY	dB(A)-5 ^a	NR ^b	NC ^c	RC ^d	SUBJECTIVE COMMENT
Concert halls, opera halls, studios for sound reproduction, live theatres (>500 seats)	20-25	20	10-20	15-20	very quiet
Bedrooms in private homes, live theatres (seats), cathedrals and large churches, television studios, large conference and lecture rooms (>50 people).	20-25	25	20-25	20-30	
Living rooms in private homes, board rooms, conference and lecture rooms (20-50 people), multi-purpose halls, churches (medium and small), libraries, bedrooms in hotels, etc.	25-30	30	30-40	25-30	
Public rooms in hotels, etc., ballrooms, hospital open wards, middle management and small offices, school classrooms, small courtrooms,	30-35	35	30-40	30-40	quiet
Toilets and washrooms, drawing offices, reception areas (offices), corridors, lobbies, department stores.	40-50	40	35-45	35-40	moderately noisy
Kitchen in hotels, hospitals, etc., laundry rooms, computer rooms, canteens, supermarkets, landscaped offices.	40-50	45	40-50	40-45	noisy

^a AS2107-1977 Office Buildings. NOTE: NC, NR and RC values may be compared directly. dB(A) values are numerically higher by 5dB(A) approximately. Therefore, in order to compare criteria numerically this column is represented as dB(A)-5.
^b CIBSE Guide
^c Noise and Vibration Control. Leo L Beranek. McGraw-Hill(1971).
^d 1991 ASHRAE Handbook



(b) Waste Systems



Vibration in bends is caused by local hydrodynamic turbulence in the fluid. This hydrodynamic turbulence dies very quickly but it creates acoustic waves in the fluid which travel long distances unabated.

Vibration in the walls of the pipe is transferred to structural walls and slabs by the clamps which support them. The vibration in the structural walls then re-radiates noise into adjoining spaces. Vibration in waste pipe systems is very similar (see Figure 2 (b)). In this case, however, the vibration generators are all passive, generally being hydrodynamic turbulence caused at pipe bends and discontinuities.

In the case of steel pipes, there is as much energy in the walls as there is in the fluid. In the case of cast iron pipes, the heavy wall ensures that most of the energy

is contained in the fluid. For plastic pipes, most of the energy is contained in the pipe wall.

Research shows that for supply pipes, using plastic instead of copper results in 5-10dB(A) noise reduction when the pipes are fastened resiliently or rigidly to a stud wall. The principal source of noise in this case would most likely be at the tap (faucet) itself. If plastic is used as the supply pipe, vibration energy is concentrated in the pipe wall and then dissipated quickly by damping in the pipe walls. If copper were used, there would be more vibration energy remaining in the fluid and this energy is transmitted with little attenuation.

For waste water pipes however, cast iron is preferred to copper and plastic and provides a 15dB(A) additional noise reduction. This occurs because the energy is created locally in the pipe and at bends. Any reduction in local vibration is desirable and this is achieved by materials with high fluid to pipe energy ratios.

Other methods of hydraulics noise attenuation in buildings are summarized in Table 2.

LIFTS

Air-borne noise from lifts (see Figure 3) is generally never a problem, typical noise levels in lift plant rooms being 75-80dB(A) for modern machines. This noise level is easily attenuated by concrete slabs and walls which make up the lift motor room. Similarly, structure-borne noise from lift machines has largely been eliminated by the use of vibration isolation.

Structure-borne vibration from the lift car rollers has been substantially treated by the use of rubber tyres. In office buildings, roller noise is not perceived as a problem at all. However, in residential buildings, lift noise in bedrooms common with the lift shaft can be a problem, noise levels being in the range 35-40dB(A) from passing lifts.

ACTIVE NOISE AND VIBRATION CONTROL

Without doubt, active noise and vibration control is today's buzzword. Of particular interest is whether active noise control will displace passive silencing systems in buildings. There are a number of factors to be considered including system performance, cost and reliability.

Even ignoring the potential problem of reliability, costs today would not make active noise control a viable option. The cost of a HVAC speaker unit is of the order of \$4000 with \$3500 for a controller (1991 prices).

For a typical HVAC duct of size 1500 x 500mm, possibly three units would be required at a cost of \$15,500. This is to be compared to \$8,000 for a splitter silencer performing the same task.

THE EFFECT OF COMPUTER TECHNOLOGY ON NOISE AND VIBRATION ANALYSIS AND DESIGN

The nuts and bolts hardware in the HVAC industry - silencers, mufflers, acoustic louvres and vibration isolation systems - have remained relatively unchanged for decades. What has changed, however, is design technology. In particular, the influence of computers in design has been enormous and will no doubt continue to be beneficial in the future.

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**TABLE 2 - HYDRAULICS NOISE
- OTHER ATTENUATION TECHNIQUES**

DESCRIPTION	BENEFIT (IMPROVEMENT)
Use of sound absorption behind wall or ceiling covering pipes.	5dB(A) if vibration isolated
Doubling the mass of the wall or ceiling covering pipes	3-4dB(A) if vibration isolated
Use of resilient furring channels on dry walls.	6-10dB(A)
Use of Rubber Clamps or similar material	6-10dB(A) for structure borne noise. 0dB(A) for airborne noise. Effective in reducing structure borne noise if placed between duct clamps and pipe wall. Of no benefit for airborne noise
Use of damping material on copper waste pipes or Fibreglass and heavy Aluminium foil	6-10dB(A) if vibration isolated, otherwise 2-3dB(A)
Lagging (e.g. : Pyrotek 4525)	15dB (A)

fig 3: Noise and Vibration Sources in Lifts

