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SOUND INSULATION AND THE APARTMENT DWELLER

BY

T. D. NORTHWOOD

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SOMMAIRE

La plupart des exigences actuelles en matière d'isolation du bruit sont fondées sur l'expérience obtenue avec les constructions traditionnelles et ceci se constate dans la forme des courbes de nivellement standard. Etant donné que les constructions non traditionnelles ont fréquemment des caractéristiques d'isolation du bruit tout à fait différentes, la forme souhaitée de la courbe d'isolation, c'est-à-dire l'importance relative des diverses bandes de fréquence devient une considération importante. Pour obtenir des lumières sur ce point le problème a été étudié en considérant directement les activités et les besoins des occupants des appartements. La conclusion provisoire est que le type le plus courant des courbes de nivellement y compris les courbes de la catégorie "transmission du bruit" de l'ASTM ont approximativement la forme voulue pour évaluer l'isolation du bruit dans les habitations.

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Sound Insulation and the Apartment Dweller

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Most of the existing sound-insulation requirements are based on experience with traditional construction, and this is reflected in the shape of the standard grading curve. Since nontraditional constructions frequently have quite different sound-insulation characteristics, the desired shape of insulation curve, i.e., the relative importance of the various frequency bands, becomes an important consideration. To gain insight on this point, the problem was approached by considering directly the activities and needs of apartment dwellers. The tentative conclusion is that the most common type of grading curves, including the ASTM Sound Transmission Class curve, are of approximately the correct shape for rating sound insulation between dwellings.

IN the preceding paper,¹ Professor Brandt described the assortment of sound-insulation requirements used in continental Europe and Great Britain. He has emphasized the empirical basis of these requirements, aimed simply at keeping new construction as good as the best of old construction. My intention is to try another approach, based not on the properties of buildings old and new, but on the properties of people. How much noise do the inhabitants of buildings make? How much intruding noise will they tolerate? Therefore, how much sound insulation is required?

These questions are difficult to answer in the case of dwellings, because human domestic activities vary tremendously and erratically in noise output. Correspondingly, the sound-insulation requirement varies from almost nil, when everybody is doing the same thing at the same time, to an impractically high value, when there is a cocktail party next door to a man trying to sleep. A practical objective would be to satisfy most of the people most of the time.

As a preliminary, we might note that many of the existing requirements are based on the performance of a 9-in. brick wall, which formerly was widely used for the separation of dwelling units. Incidentally, it was used primarily as a fire wall, and it was only when

lighter, thinner, and cheaper fire walls became accepted that the need for sound-insulation requirements became pressing. As many people have lived in multi-dwelling structures, over the years we have accumulated some subjective information, mostly rather qualitative, about the performance of traditional buildings. In particular, tenant surveys about noise have been made in Great Britain, Sweden, and the Netherlands.²⁻⁴ These surveys indicate that about two-thirds of tenants separated by a 9-in. brick wall are reasonably satisfied with the sound insulation that it provides. Taking this as a definition of "soundproofness," it may seem a simple matter to determine the acceptability of alternative structures by comparing their transmission losses with that of the brick wall.

But if you attempt such a comparison for a typical modern wall, it turns out to be something of a problem. In Fig. 1, for example, are shown transmission-loss characteristics for a brick wall and two other structures. Perhaps intuition will tell you that the brick wall is

² O. Brandt and I. Dalén, *Byggmästaren* 31, 145 (1952).

³ C. Bitter and P. Van Weeren. "Sound Nuisance and Sound Insulation in Blocks of Dwellings, I," Res. Inst. Public Health Eng. Rept. No. 24, TNO (1955).

⁴ P. G. Gray, A. Cartwright, and P. H. Parkin. "Noise in Three Groups of Flats with Different Floor Constructions," Natl. Building Studies Res. Paper No. 27 (Her Majesty's Stationery Office, 1958).

¹ O. Brandt, "European Experience with Sound-Insulation Requirements," J. Acoust. Soc. Am. 36, 719 (1964).

FIG. 1. Sound insulation of three walls.

the best, yet if you examine various frequency ranges you may begin to wonder. At high frequencies, the cavity wall is definitely the best and the brick wall is poorest. If you take the average, either the traditional 9-frequency average or a full 11-frequency average, there is only a decibel or two to choose among them. We shall return to these curves after an examination of the questions that I posed earlier.

First, let us consider the sort of domestic noises that may be troublesome. Again, the tenant surveys provide a qualitative guide. High on the list of obnoxious noises from next door are voices and radio and television noises, and, fortunately, there is quantitative information available on both kinds of noise. (Another equally important category is impact noises such as footsteps, which are initiated as a vibration in the structure itself, and are thus already half-way to their destination next door or downstairs. I leave this topic, however, to Dr. Schultz in Paper S3.)

FIG. 2. Half-octave-band spectra of typical household noises.

There is surprisingly little quantitative information available on domestic noises generally, but the spectra of typical household noises are shown in Fig. 2. The bottom one is a well-designed room air-conditioner in good condition. Next is a vacuum cleaner—not usually a problem because it is rarely used at critical times of day. Most household appliances produce noise in the range between these two curves. The next curve shows the peak levels occurring, in a typical room, because of normal conversational speech. There is considerable variation in speech level, depending on the speakers and on the number of participants in a conversation. A curve showing peak levels of radio noise is also included, but this is dealt with more fully later. I have ventured to sum all these up in the curve labeled “standard household noise.” This is intended to denote something close to the maximum levels that commonly occur in dwellings.

FIG. 3. Distribution of sound levels of radio programs. [After Van den Eijk.⁵]

Radio noise has been examined in a more systematic way by J. Van den Eijk of the Netherlands.⁵ (Incidentally, I am told that they do not have commercials on Netherlands Radio; this might affect the applicability of the results to the American scene, but we shall use them anyway.) Van den Eijk, with the assistance of suitable electronic gadgetry, set up a continuous watch on radio programs, and determined for each octave band the distribution of peak levels as a function of time. Thus, he could determine, for example, the octave-band levels exceeded 5% or 10% of the time. Some of his data are shown in Fig. 3.

So much for the noisy noises. Now, we have to con-

⁵ J. Van den Eijk, in *Proceedings of the Third International Congress on Acoustics, Stuttgart, 1959*, edited by L. Cremer (Elsevier Publishing Co., Amsterdam, 1961), Vol. 2, p. 1041.

sider the people on the quiet side of the partition. The intruding noise will not be heard at all if in each frequency band it is always below the ambient level in the quiet area (or alternatively below the thresholds of audibility of the listeners). Even if the intruding noise is heard, it won't necessarily be disturbing, but there is a good chance that it will be if it conveys some sort of information to the listener. By information, I mean something a little more subtle than intelligible speech, which of course would be most intolerable. In faintly discernible speech, a good deal can be conveyed just by the pattern of speech tones; a quarrel for example, or a nagging wife, can be identified without understanding a word. The dropping of a shoe—especially only one shoe—conveys information that may catch the listener's attention and thus disturb him.

Consequently, my inclination is to assume that one should try to ensure that the probability of intruding sound being heard at all is reduced to a reasonably small number. To determine this, all we need are some statistics on quiet ambient levels in dwellings. Unfortunately, the information available is very sketchy. The ambient sound may be locally produced or it may be a random collection of external noises, from other parts of the building or from outdoors. During the most critical periods, locally produced noise is likely to be minimal, and in these circumstances a spectrum similar in shape to the well-known NC curves, descending in level with increasing frequency, appears to be appropriate. There will be considerable variation in absolute level with location and time of day, but we will assume an average value in the range NC-20 to NC-30. Let us consider this quiet ambient level in conjunction with the noisy noises discussed earlier.

Figure 4 shows the curves of standard household noise and the NC-25 contour (the latter adjusted to the same half-octave series as the upper curve). Subtracting these gives the sound insulation required to reduce standard household noise to the NC-25 level in each band. There is, of course, a random fluctuation in both these levels, with the result that the curve found here probably corresponds to about a 50% probability of intrusion. To get down to a reasonable value, say 10% to 20%, would require that the sound insulation be raised perhaps 5 dB. Thus, it appears that the German grading curve, also shown, is about the right shape and not far from the right level. Incidentally, I am being rather loose in sound-insulation terminology here: strictly speaking, the insulation curve derived in Fig. 4 is a sound-level difference, but for medium-size domestic rooms the level difference is nearly the same as the sound-transmission loss.

A similar result is obtained if one uses Van den Eijk's data for radio noise (Fig. 5). Here, the crucial importance of the middle-frequency range is still more evident, but again the general form of the German curve is appropriate.

FIG. 4. Derivation of sound insulation required to reduce standard household noise (Fig. 2) to a level corresponding to NC-25.

I might note, however, that the German method of comparing test curves with the grading curve tends to diminish the importance of the shape of the standard curve. An average deficiency of 2 dB is allowed, without limit on the deficiency in any one band. The dashed curve in Fig. 4 and 5, assuming a 2-dB deficiency across the board, still looks pretty good, but very commonly the total deficiency may be concentrated as a sag of 6 or 8 dB in the crucial middle-frequency range between

FIG. 5. Sound insulation required to reduce radio noise to NC-25. [After Van den Eijk.⁶]

250 and 1000 cps. The current ASTM rating system uses a family of curves of the same shape as the German curve, but allows no deficiencies in the middle-frequency range and no more than 3 dB in the outer segments. Hence, for many structures, an ASTM Class 50 or so would be roughly equivalent to the German requirement.

From these rather sketchy data, our tentative conclusion is that a requirement similar to the German curve, possibly 3 or 4 dB lower, is an appropriate minimum requirement for dwelling separation. It is also concluded, however, that deficiencies in the middle-frequency region should be severely limited. In terms of the ASTM rating system, the requirement might be a sound-transmission class 50 or so.

With this criterion in hand, let us return again to Fig. 1. We can now see at a glance that the low- and middle-frequency transmission losses of two of these walls are inadequate. It will be noted that both walls have a sound-transmission Class 47 as compared to Class 54 for the brick wall. Using the Class 50 criterion that I suggested earlier, the brick wall would be com-

fortably above the requirement, whereas the other two would be rejected.

Finally, I must emphasize again the rather speculative nature of this analysis, based as it is on very sketchy information about both noisy and quiet dwelling conditions. A more comprehensive survey of the distribution of dwelling noises is being organized and this should ultimately enable us to be more quantitative about these matters.

It should be realized, however, that the practical results will not be greatly different: we may become slightly more sophisticated in defining the insulation requirements, thus providing the building designer with a more precise objective. But the real impetus toward better design and construction will only begin after a definite requirement has been adopted. I am therefore impelled to echo Professor Brandt's closing comment: our present approximate answers are needed *now*, to arrest the steady downward trend in sound-insulation performance being brought about by new building techniques.

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