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SOUND INSULATION IMPROVEMENTS TO A DRY-LINED BLOCKWORK SEPARATING WALL.

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INTRODUCTION

Bickerdike Allen Partners were appointed by a major building contractor to investigate a problem of poor separating wall sound insulation in a block of flats in Torquay and to make recommendations to remedy the problem.

The complaint related to airborne sound insulation between adjacent master bedrooms and their ensuite bathrooms on each floor. (See figure 1). Sound insulation tests had already been carried out by the Building Research Advisory Service in flats 59 and 60 and their results indicated that the airborne sound insulation was significantly worse than the numerical performance requirement deemed to satisfy the then Building Regulations (1976).

This paper records the investigation undertaken leading to the remedial specification adopted in all flats.

CONSTRUCTION

The separating wall was constructed of 100mm autoclaved aerated concrete blocks laid on their sides to form a 225mm block wall. This is dry-lined on both sides in 13mm plasterboard on plaster dabs, creating a small cavity of approximately 12mm. The overall mass of this construction is approximately 200 kg/m^2.

One end of the separating wall is terminated by the inner leaf of the external cavity wall. This is constructed of 100mm autoclaved aerated concrete blockwork, dry-lined. The other end of the separating wall is terminated at a structural concrete wall between the bathroom and foyer.

The separating wall and the external wall both sit on a continuous concrete floor slab. This is a 325mm thick concrete waffle slab with 200mm deep moulds at 800mm centres. The plasterboard ceiling in each room is fixed via timber battens to the underside of the waffle downstands.

ANALYSIS OF THE PROBLEM

Sound insulation measurements

Airborne sound insulation measurements were carried out between flats 41 and 42 for comparison with the earlier BRAS results. The results are shown on figure 2. The measured sound insulation is somewhat lower than that measured in flats 59 and 60 by BRAS.

On subsequent visits, airborne sound insulation measurements were carried out between other pairs of flats using one-third octave bands as required under the Building Regulations. These results were found to give better agreement with the earlier results of BRAS. (See figure 3).

Vibration measurements on room surfaces

A steady-state pink noise source was run continuously in flat 42 whilst a series of sound level and vibration measurements were carried out to determine the degree to which each of a number of vibrating surfaces was contributing to the received sound level in flat 41. Using an accelerometer, vibration measurements were made on the following surfaces:

1. On the separating wall
   - on the plasterboard over a dab
   - with the lining removed on the block face
   - with the lining removed on a dab
2. On the inner leaf of the external wall
   - positions as for 1 above
3. On the floor slab

The acoustic power radiated by a vibrating surface is proportional to the space-time average mean square velocity of the surface:

$$W = \rho c S v^2 \sigma \text{ watts}$$

where:

ρc = the characteristic impedance of air = 415 mk rayls.
S = the area of the panel, m^2.
σ = radiation ratio (dimensionless).
v^2 = space-time average mean square velocity of the panel, m/s.

Using a radiation ratio of 1, the contribution that each surface was making to the reverberant sound pressure level in the receiving room was assessed. The results for the separating wall in the 125 Hz octave band and those for the flanking wall in the 125 and 250 Hz octave bands must be viewed with suspicion as the critical frequencies of the walls respectively lie in these frequency regions. A radiation ratio of 1 can only be expected above the critical frequency. The measurements made on the plasterboard linings away from the dab position were disregarded in view of the high critical frequency of plasterboard. The other three measurement positions gave relatively repeatable results.

The resulting reverberant levels were subtracted from the measured source room level to obtain a notional normalised level difference value for each element. The results of this exercise are shown in figure 4.

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Outcome of measurement exercise
Comparison between the measured airborne level difference and the notional values for the individual elements led to the following conclusions:

i) Flanking transmission via the common floor slab was not responsible for the poor sound insulation. Nor would it prevent the construction as a whole meeting the requirements of the Building Regulations (1976).

ii) The flanking wall was not contributing significantly to the poor sound insulation but there was some uncertainty as to whether it would permit party wall grade to be met if improvement were made to the separating wall only.

iii) The highest levels of vibration were measured on the separating wall itself. However, the measured level difference was poorer than could be justified by these measurements.

A detailed physical inspection was carried out to look for other factors which might explain this result.

Physical inspection
An area of dry-lining was removed from the separating wall and from the inner leaf of the external wall for a physical inspection. A mortarless gap of approximately 25mm width was discovered between the top block of the separating wall and the underside of the waffle slab. Some gaps were found in the mortar joints of the separating wall, but none appeared to pass right through the wall. No gaps were found in the mortar joints of the external wall. A further gap in the separating wall was noted at the base where the blocks had not been bedded in mortar and a long thin gap of up to 4mm height could be seen under the skirting.

Discussion leading to possible remedial measures
The 1976 Building Regulations gave a number of deemed-to-satisfy separating wall constructions calling for a mass of 415 kg/m^2 in line with a plastered 9'' brickwork wall on which the numerical performance standard was originally based. The mass of the separating wall under investigation was approximately 200 kg/m^2, including linings. Despite this apparent shortcoming, the block manufacturers were able to supply three sets of field test results undertaken by an independent laboratory which indicated that the numerical requirements could be met if the wall was plastered (or rendered and plastered) rather than dry-lined. Even allowing for the larger wall area under investigation here, party wall grade should still be met without exceeding 23dB aggregate adverse deviation from the curve.

OUTCOME OF PILOT STUDY

In view of this information it was decided to proceed with a pilot study on one separating wall. A specification was prepared for the dry-linings to be removed from both sides of the wall, the gap at the top of the wall to be sealed, the mortar joints to be filled and a thick coat of sand-cement render to be applied to both sides prior to plastering.

Although the pilot study resulted in an average improvement of 8 dB, the achieved result was still 4 dB less than party wall grade. (See figure 5). Spot accelerometer measurements suggested that the performance of the separating wall itself was still less than party wall grade. However there was still some doubt as to whether party wall grade could be achieved by improving the wall because accelerometer measurements on some ceilings suggested that they may have been contributing to the sound transmission between flats.

FURTHER REMEDIAL SPECIFICATION

Two possible courses of action were now open to improve the sound insulation of the separating wall:

- Increase the mass of the party wall by rebuilding it in a denser material. The advantages of this approach were that no additional space would be taken up and, if brickwork were adopted, it would represent a 'deemed-to-satisfy' construction. However, this solution would represent considerable inconvenience to the client and residents.

- Introduce a secondary isolated layer into the construction.

At first, it was considered that this latter solution would take up an impracticably large amount of space - if plasterboard were to be used the supporting studs would normally be at least 70mm thick. However, the client proposed that we should consider a plasterboard laminated wall lining system made by British Gypsum. This comprises two layers of plasterboard bonded together and supported on a metal channel system within the thickness of the plasterboard. This freestanding panel (mass 40 kg/m^2) is installed on one side of the deficient wall creating a cavity containing a 25mm glass fibre quilt.

Following discussions with the manufacturer, a remedial drawing and specification were prepared and the following works implemented generally throughout the flats.

- Strip off the dry-lining on one side of the separating wall and from the external flanking wall.
- Pack the gap between the top of the blockwork wall and the underside of the slab.
- Point the blockwork joints.
- Install the laminated plasterboard partition 25mm from the separating wall enclosing a 25mm glass fibre quilt.

RESULTS

The results of the measurements carried out in three pairs of flats is given in figure 6. The measured result exceeds party wall grade by approximately 5 dB and represents a 17 dB improvement in sound insulation overall.

REFERENCES

[1] J.A.Macadam 'The measurement of sound powers radiated by individual room surfaces in lightweight buildings'. BRE current paper CP 33/74

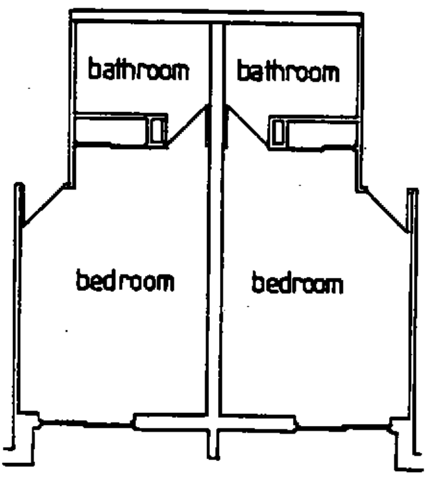

Figure 1 Plan

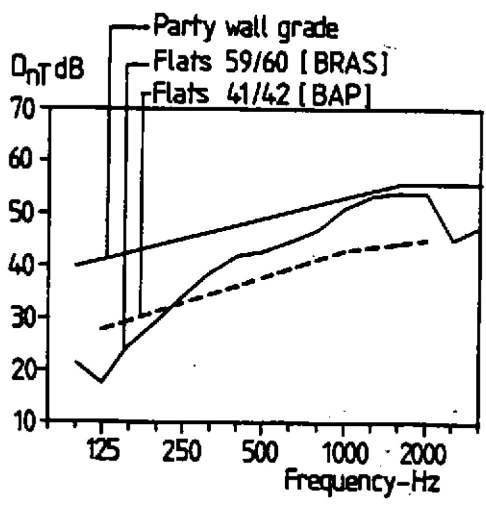

Figure 2 Before treatment

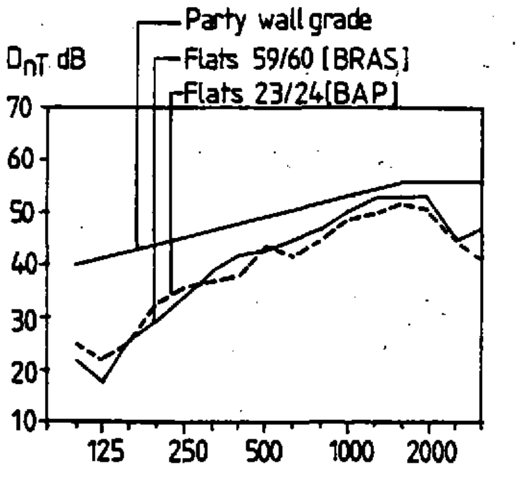

Figure 3 Before treatment

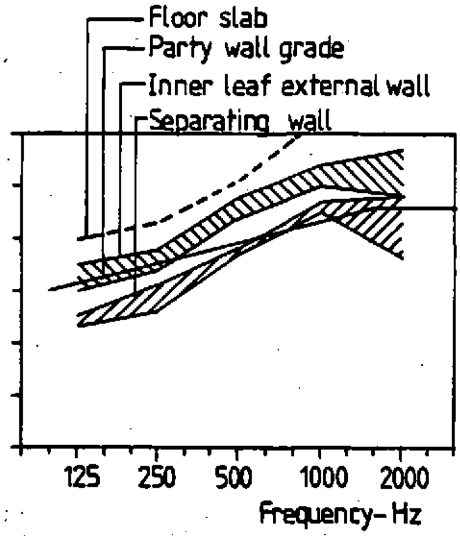

Figure 4 Flanking transmission

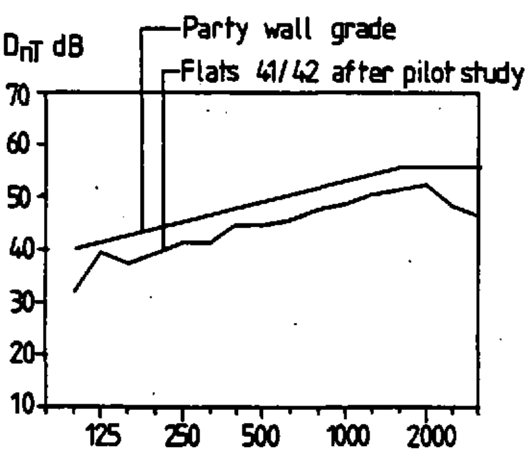

Figure 5 Result of pilot study

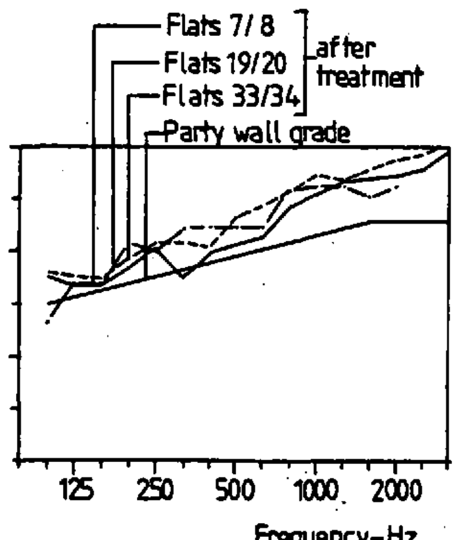

Figure 6 Result of final treatment

ACOUSTIC PRIVACY IN OFFICES - REAL & IMAGINED

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RATING PRIVACY BY NUMBERS

If acoustic privacy is required between adjacent rooms the sound insulation of the whole ensemble of elements of construction common to both rooms must reach an appropriate standard.

A typical method of assessing the quality of sound insulation [1] suggests that the arithmetical sum of the Speech Interference Level (SIL) and the Sound Reduction Index (SRI) can provide a useful rating number.

if SIL + SRI = 65 then speech privacy is "fair" :
if SIL + SRI = 70 then speech privacy is "good" : (1)
if SIL + SRI = 75 then speech privacy is "confidential" :

where SIL = average Sound Pressure Level in the octaves centred on 0.5, 1.0 & 2.0 kHz.
SRI = average Sound Reduction Index in the 1/3 octave range 0.1 to 3.15 kHz.

In practice, many typical SIL values are in the range 30 to 45 dB. from air-conditioning or quietly occupied offices but the range can be much larger; we have measured SIL's as low as 22 dB. SIL values in cellular offices are likely to be in the lower part of the range quoted because of the insulation given by the partitions which, even if of poor quality, will reduce the background noise from external workstations. In busy open-plan offices the SIL's are likely to be above this range. However,the hubbub of voices from busy workers is not constant - those who work early or late, and flexible-time working encourages this trend, will often experience SIL's as low as in a cellular office. Sometimes, air-conditioning will provide a fairly steady background noise but the popular use of Variable Air Volume (VAV) systems leads to a very variable noise output and such air-conditioning systems cannot be relied upon for a useful SIL.

SRI's of practical constructions range, within 20 to 45 dB. and sometimes more. 45 dB. is roughly obtained from a plastered 112 mm. brickwall which provides a total barrier between two rooms (spanning between massive walls, floor & slab ceiling). 20 dB. may be found from a demountable partition with an open perforated tile ceiling passing above the partition leaving an empty void above.

The assessment by Equations 1 shows that the 45 dB. wall will be pretty good even in unusually quiet background noise conditions and the the 20 dB. wall will be pretty poor even in unusually noisy background noise conditions.

It looks about right therefore to aim at about 35 dB. SRI for an averagely good privacy rating in averagely noisy room conditions.

RATING PRIVACY BY INTELLIGIBILITY

Another assessment method [2], specifically offered for open-plan offices, uses the Articulation Index (AI). This is conventionally the fraction of words understood at the test position when a phonetically balanced list of words is read out at the source position - this reference however calculates the AI by using a broadband loud-speaker noise source with constant output. The example given in the reference shows source and receiver noise levels at several frequencies and at a distance of 3 m.; the noise level differences are dismally poor (about 12 to 20 dB.) and yet the assessment is given that this is "adequate managerial privacy". The SIL is shown to be about 35 dB. and by the first assessment method given above ("by numbers") the SIL + SRI is only about around 50/55 (deeming a poor partition to exist where none really exists); this is judged to be unacceptable.

Reference [3] gives further, general, guidance to noise, and vibration, nuisance in buildings. Reference [4] covers the special problems of curtained walled buildings.

RATING THE RATINGS

Can the difference between these two assessments be related to different expectations of what privacy means in the two unlike environments? In part, the answer to this question is "Yes". In the cellular office with, usually, no visual contact with the next office there is no apparent need to keep the voice down or face away from an unwanted listener and normal voice levels will be used. In the open-plan office, if you can see "Fred" sitting only 3 m. away, and you do not want him to hear what you say, you make sure that he will not hear by speaking quietly, facing the other way or even changing your location for another. So the privacy obtained is modified by the discipline of the speaker and the visual environment.

WHAT'S TO BE DONE?

In an existing building with cellular offices and poor privacy, it is often found that gaps in partitions have been left and, worse, have been hidden by light-weight sticky tapes, porous foams, or wallpapers. These are fairly easy to locate with a loudspeaker noise source in one room and listening close to the partition in the other room. Once found they can be controlled with reasonable ease though often with a redecoration expense falling on some unwilling party.

More difficult is the transmission via a false ceiling void common to both rooms. The void is often used as a return air plenum of an air-conditioning system and therefore any barriers inserted into the void above the partitions will require changes to the air conditioning system; given that this is possible (in practical AND financial senses) then the acoustic problem is just beginning.

Why does the sound of the speech reach the void? Often because the ceiling is light in weight and very porous, or with many gaps to permit the passage of the sound. The gaps will include, in all probability, heat outlets in the light fittings and return air grilles in the ceiling. It is possible to deal with these weak points on an individual basis - possible but expensive. Sealing the tiles, adding weight to them, putting attenuators on return air grilles and light fittings, sealing air diffusers which over partitions - all these are in principle possible but in practice the benefit in improved sound insulation is often hardly worth the effort and expense.

Ceiling Void Barriers.

Ceiling void barriers are a better bet but still a problem. If the structural ceiling slab is formed from pre-cast concrete troughs, the sealing of the barrier to the slab is very difficult. Supply air ducts, cable trays, etc. are also difficult to seal as is the junction at the bottom of the barrier to the top of the false ceiling.

The barriers can be flexible or rigid sheets - Figure 1, derived from Reference [5], can be adapted to suit the most convenient material selected so long as reasonable mass for the barrier and air-tightness of its fitting are obtained.

An interesting possibility is shown in Figure 2; this was proposed by Heckl [6] and is an unusual use of a sound absorbant material as a sound insulator.

Figure 3 gives a possible and practical method for sealing for this bottom junction. Timber battens may be cut to fit inside the trays of metal ceiling tiles, the battens are bedded in mastic and can thus provide a fairly flush surface to fix the barrier's skirt.

Open Voids.

If the ceiling void must be left open, either because of the airconditioning or the sheer impossibility of providing an effectively sealed barrier, then the transmission can be somewhat lessened, but should not be guaranteed, by:

(a) filling perforated metal ceiling tile trays with heavy flexible material sheet so that the perforations become closed,
(b) sealing tile joints as well as possible (demountability may be compromised),
(c) fitting purpose-made attenuators to light fittings and return-air grilles,
(d) applying thick (say, 50mm.) sound absorbing material such as glass-fibre to the underside of the structural ceiling AND to the top surface of the false ceiling. The minimum extent of the treatment to be 1m. each side of the partition whose effective insulation is to be increased - but the more the better.

False Floors

False foors, currently a fashionable solution to the problem of where to put the power and telephone cables (surely OK in computer rooms where the cables are numerous and easy access is essential - but in offices ? - think of the building volume increase!), have not been found to be a serious noise leakage path. The floor panels are relatively heavy and well sealed compared to the typical ceiling tile.

Other Leak Points.

Under-window casings for fan-coil units, heaters, induction units and so on often pass from room to room through the partitions. They are largely hollow and will be open to the rooms on each side by the grilles needed for the heating or air-conditioning; noise transmission via this path is an obvious possibility and is frequently found on site.

The essential requirement is to block the passage of noise along the hollow casing with a suitably noise-insulating construction; the "spaghetti-junction" of pipes and conduits found inside does not permit the use of pre-formed sheets of, say, plasterboard to provide these barriers. A practical alternative is to form a barrier with half-filled plastic bags of dry sand; half-filled because they can then be packed around the irregularly shaped casing and its contents to provide a true barrier. Naturally, this internal wall of sand-bags must be positioned at the ends of the critical partition lines.

Doors between adjacent offices are so obvious a noise transmission path that it is astonishing how often they are ignored at design stage. Given that a problem exists, the possibilities for remedial work include:

(a) increase the panel weight of hollow doors,
(b) change hollow doors for solid cored units,
(c) fit effective seals to all edges, including the threshold,
(d) fit a second door to the same opening, hanging it on the opposite side of the frame. Make the two facing surfaces of the doors sound absorptive by lining with suitable material.

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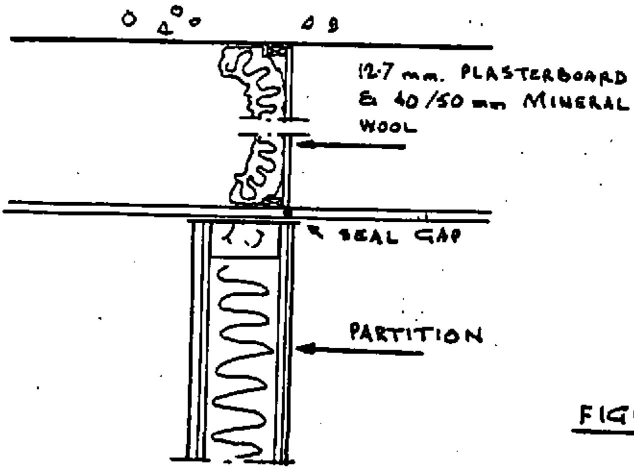


FIGURE 1

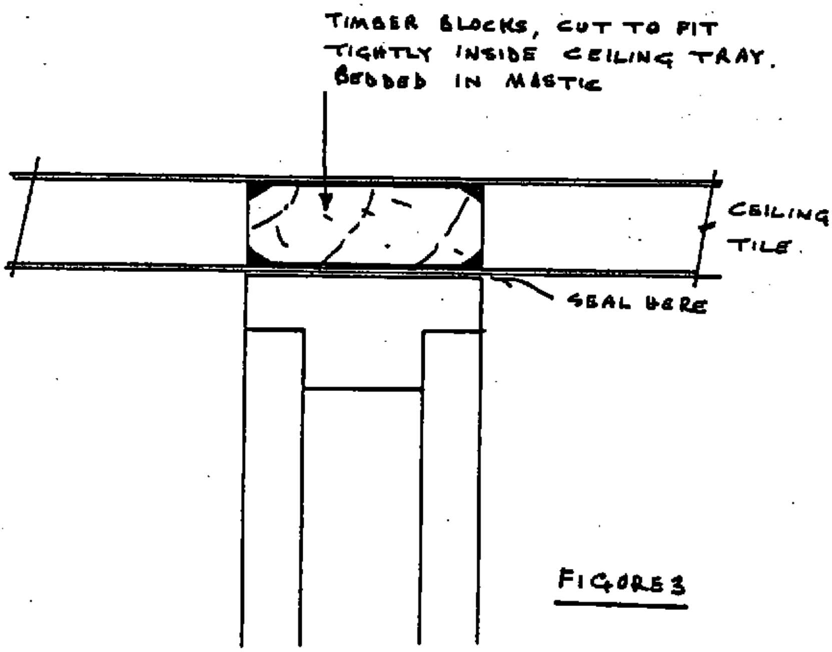
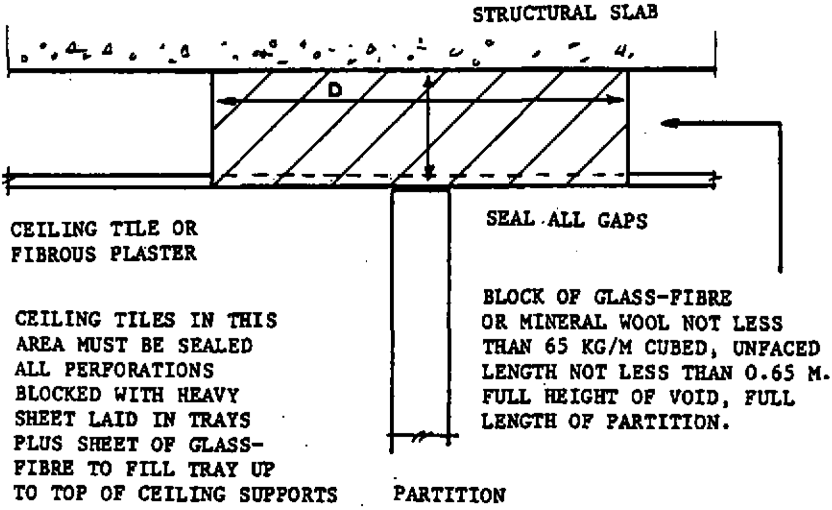


FIGURE 3



ROOM-TO-ROOM NOISE REDUCTION VIA CEILING VOID ALONE.

FREQUENCY, HZ	125	250	500	1K	2k
D = 0	19	16	20	29	42
D = 0.31 M	25	31	37	53	60+
D = 0.62 M	41	47	52	60+	60+

(AFTER M. HECKL.)

FIGURE 2