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IMPACT AND AIRBORNE SOUND INSULATION IN A SERIES OF APARTMENT BUILDINGS

by

D. Olynyk

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March 1964

PREFACE

The Division, through its Building Physics Section, has long been interested in various aspects of building acoustics. One of the obvious problems is that of noise transmission through constructions. Activities in this subject were confined for many years to laboratory measurements on test panels, although it was realized that there were many complications in practice which made it highly desirable to make measurements in actual buildings.

The development of staff and facilities has made it possible to begin such field studies which have been initiated with measurements of the sound transmission between dwelling units in five apartment buildings in Ottawa. The co-operation of the owners in making these studies possible is greatly appreciated.

The author, a graduate in engineering physics and a research officer with the Division, has been assigned responsibility for sound transmission studies.

Ottawa
March 1964

N.B. Hutcheon
Assistant Director

IMPACT AND AIRBORNE SOUND INSULATION IN A SERIES OF APARTMENT BUILDINGS

by

D. Olynyk

This report represents the beginning of a program of measurements of sound insulation in typical apartment buildings. The five buildings reported on here have essentially the same floor and similar wall structures: the floor consisted of open-web steel joists supporting a $2\frac{1}{2}$-in. concrete floor slab, with lath and plaster below; the walls were of heavy masonry (8-in. dense-aggregate concrete blocks or heavier). Finish floors were parquet or vinyl-asbestos tiles cemented to the concrete.

Emphasis in this study was on vertical transmission through the floors (both airborne and impact sound). In addition, one party wall was tested for airborne sound transmission in one building (Building E).

DESCRIPTION OF BUILDINGS

Five buildings in the Ottawa area, all of recent construction, were examined. In all but two cases the apartments were unfurnished. Details of construction are listed below.

Building A

1. 3/8-in. parquet floor in both living room and bedroom.

2. Ceiling: 2-in. insulation batts, metal lath and plaster.

3. Exterior walls: 4-in. brick and 8-in. dense-aggregate block.

4. Joists running from exterior wall to corridor walls.

5. Party and corridor walls: 8-in. hollow dense-aggregate concrete block, carried up to concrete floor slab.

6. Volume of living room: 1750 ft^3; bedroom: 1160 ft^3.

Building B

Similar to Building A except for the following:

1. Vinyl-asbestos tile in bedroom.

2. Joists running from party wall to party wall.

3. Volume of living room: 1440 ft^3; bedroom: 1000 ft^3.

Building C

Similar to Building A except for the following:

1. Vinyl-asbestos tile in bedroom.

2. Joists running from party wall to party wall.

3. Party walls: 12-in. concrete blocks.

4. Volume of living room: 2000 ft^3; bedroom: 1070 ft^3.

Building D

Similar to Building A except for the following:

1. Vinyl-asbestos tile in both living room and bedroom.

2. Joists running from party wall to party wall.

3. No insulation batts in ceiling space.

4. Volume of living room: 1540 ft^3; bedroom: 1060 ft^3.

Building E

Identical to Building B except that in Building B the heating outlets are in the ceilings, whereas in Building E the outlets are in the floor. Thus in Building E the floor slab is pierced by heating ducts. Volume of living room: 1440 ft^3; bedroom: 1000 ft^3.

DESCRIPTION OF TESTS

The impact tests, designed to determine the performance of a floor under disturbances, such as footsteps, followed Recommendation

R-140-1960 of the International Organization for Standardization. The procedure uses a standard tapping machine, which contains five small metal hammers that fall freely at a specified repetition rate on the floor under test. The resulting impact noise transmitted into the room below is measured in a series of third-octave frequency bands.

Since the sound level in the receiving room depends on the sound absorption of the room it is customary to adjust results to correspond to a standard absorption. The measured levels in the receiving room are adjusted to a reference absorption equivalent to 10 square metres (108 sq ft) of perfect absorber.

The impact curves in Figures 1 to 7 show the spectrum level of transmitted noise; thus the lower the curve the better the performance of the floor. Single-figure Impact Noise Ratings (INR) following a recently proposed U.S. Federal Housing Administration requirement (FHA Bulletin 750), are also shown. A positive rating indicates that the construction tested is superior to the minimum requirement.

The airborne sound transmission loss of the floor in each apartment building was measured following the method of ISO R-140 and ASTM E90-61T. It is given by:

$$TL = \Delta L + 10 \log (S/A_2)$$

where ΔL is the measured level difference, decibels
S is the surface area of the transmitting surface, square feet
A_2 is the absorption of the receiving room, sabins

The last term is a standard correction term that normalizes the measurements to allow for variations in the area of sound-transmitting surface and the sound absorption in the receiving room. In some cases S is not well-defined; for example a living room may not be separated from another room or a hall. Fortunately the correction is not sensitive to small errors: a 25 per cent error in S would amount to 1 decibel in the final determination.

In some of the present measurements, when the airborne transmission loss was very high, it was difficult to produce a high enough level of transmitted sound to be safely above the level of extraneous noise in the receiving room. A few of the high frequency observations (identified in the results) must for this reason be regarded as minimum values.

As a single-figure rating for airborne sound loss the ASTM Sound Transmission Class (STC) is used (See ASTM E90-61T: "Laboratory Measurement of Airborne Sound Transmission Loss of Building Floors and Walls." Appendix). This is comparable numerically to the traditional nine-frequency average, but is more sensitive to deficiencies in the frequency range of most importance in speech and domestic noises.

RESULTS

The single-figure ratings for all constructions are summarized in Table I. Impact sound spectra, over the range 100 to 4000 c/s, are given in Figures 1 to 7. Figures 6 and 7 are measurements taken in the same building at separate times in two different sets of apartments, the second set being one for which complaints about inadequate insulation had been received. In Figure 8 the airborne sound transmission losses of the five living room floors are plotted for frequencies at one-octave intervals between 125 and 4000 c/s. Figure 9 shows, for airborne sound transmission loss: (1) Comparisons between living room floors in different sets of apartments in the same building, and (2) Comparisons between the bedroom and living room floors (both parquet) in the same apartment. An arrow at some of the higher frequencies indicates that the observation was limited by the ambient noise level and is to be regarded as a minimum value. Figure 10 compares bedroom and living room floors of the tile and parquet respectively for airborne sound transmission loss in the same apartment. Figure 11 shows the airborne sound transmission loss of a typical party wall in Building E. Excessive ambient noise made measurements at 125 c/s impossible.

CONCLUSIONS

The impact insulation requirements of most other countries range from about INR = -2 to INR = +6. Thus all the floors here reported fall below what is generally regarded as acceptable, although they are superior to other types commonly used in Canada (e.g. wood joist or reinforced concrete slab construction).

It is to be noted that a parquet floor surface appeared significantly superior (averaging about 3 db) to a vinyl-asbestos tile surface. Other evidence suggests that by adding a slightly resilient layer between parquet and the concrete surface the construction could be made significantly better. Airborne transmission should be the same for the two types of floor surface, and is the same for Building E, although there is an anomalous result in the second test at Building E. The spread of 8 db among impact tests for each type of floor cannot be fully explained, but a few comments and speculations will be offered below.

With one exception the airborne transmission losses comfortably exceed the CMHC minimum requirement of 45 db (roughly equivalent to Sound Transmission Class 45). European evidence indicates that a Sound Transmission Class 45 floor would not be regarded as acceptable by more than about 50 per cent of tenants. Hence it is not surprising that the exceptionally low case (Building A bedrooms, apartments 510 to 610, Sound Transmission Class 41) is the one region where complaints have been received. The cause of the low value is possibly due to some unsuspected flanking path in this part of the structure.

The Sound Transmission Class 47 obtained in the one airborne transmission measurement through a party wall is consistent with laboratory measurements on similar 8-in. block walls. This is probably a reasonably acceptable construction, although it would not quite meet European standards.

It will be noted that Building C is one of the better buildings. This can probably be attributed to the extra heavy construction of the supporting walls. In studies by others the weight of supporting walls has been found to influence the performance of the floors also.

Measurements in Buildings B and E should permit a determination of the effect of piercing the floor slab with warm air heating outlets. It might be surmised that such openings would result in an easy transmission path, at least into the floor-ceiling space. The comparison, in fact, shows no significant difference in airborne insulation and the reverse sort of effect for impact. Hence, it appears that the floor outlets are, if anything, superior to the ceiling outlets, from the viewpoint of impact. One can speculate that possibly, in the latter case, impact vibrations are transmitted directly to the heating ducts through their supports, and that the noise is then transmitted via the ducts to the space below.

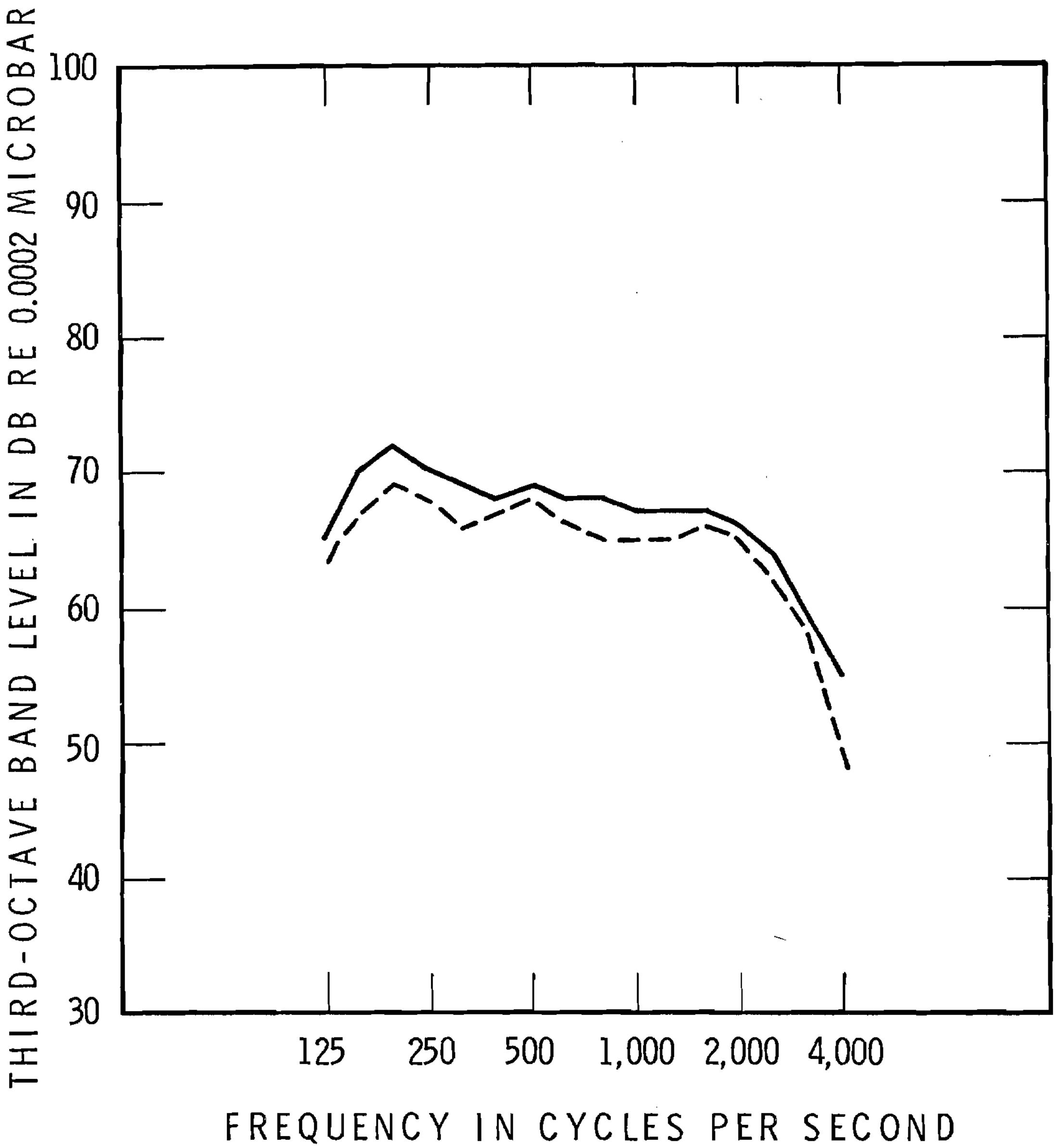
The most interesting inconsistency is between the two sets of impact measurements made at Building A. The apartments studied were nominally identical, and stacked one above the other. Airborne losses between living rooms were identical, but the floor between 610 and 510 appears 3 or 4 db better from the viewpoint of impact than the floor below. Presumably some minor difference in construction practice was introduced at this stage.

Another source of speculation regarding Building A is the rather low airborne loss (even between living rooms) as compared to Buildings B and E. It is doubted that the direction of the floor joists (from outer wall to corridor wall in this building) is itself a factor that would make this building inferior to Building B or E. There may, however, be some resultant difference in structure that is significant, for example the joists between walls and floor slab, or the service connections. One possibility is that the sound-absorbing batts alleged to be in the floor-ceiling space were omitted. It would then be consistent with Building D, which had a similarly low airborne loss, and which has no absorption in the joist space.

TABLE I

SUMMARY OF SINGLE-FIGURE RATINGS
FOR ALL CONSTRUCTIONS

	Impact Noise Rating (INR) (and floor surface)		Sound Transmission Class(STC) (and location)
Floor Tests	Between Living Rooms	Between Bedrooms	
Building A - 1st test	-12 parquet	-11 parquet	48 living room
Building A - 2nd test	-9 parquet	-7 parquet	48 living room 41 bedroom
Building B	-11 parquet	-17 tile	55 living room
Building C	-4 parquet	-11 tile	54 living room
Building D	-9 tile	-10 tile	49 living room
Building E	-7 parquet	-12 tile	54 living room 54 bedroom
Party Wall Test			
Building E			47



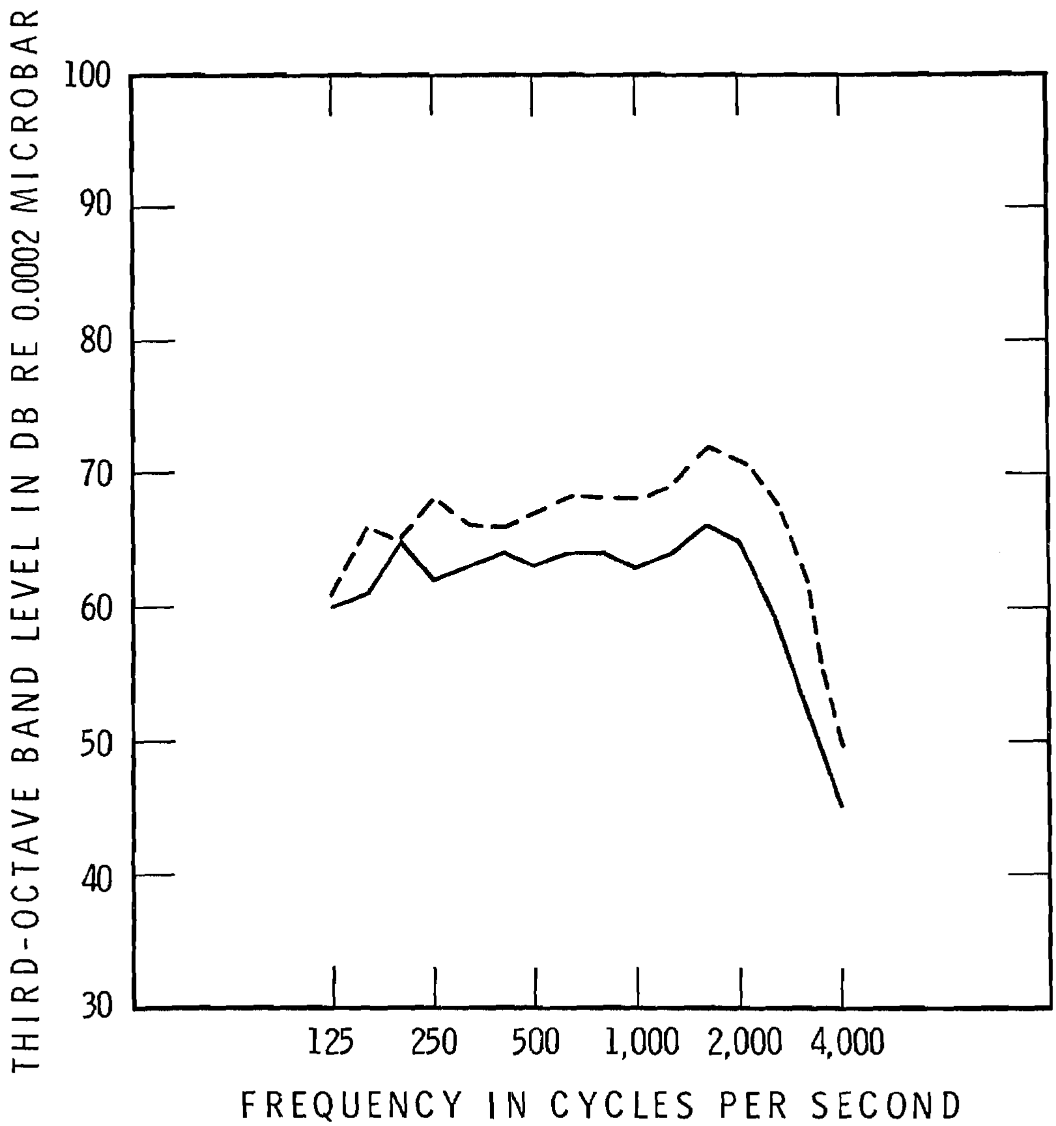
		Impact Noise Rating
——— Living Room	(Parquet)	-12
- - - - - Bedroom	(Parquet)	-11

Apts. 510 and 410 used
Measurements Taken on 17 July, 1963

FIGURE 1

IMPACT SOUND SPECTRA - BUILDING A

BR 3081-1



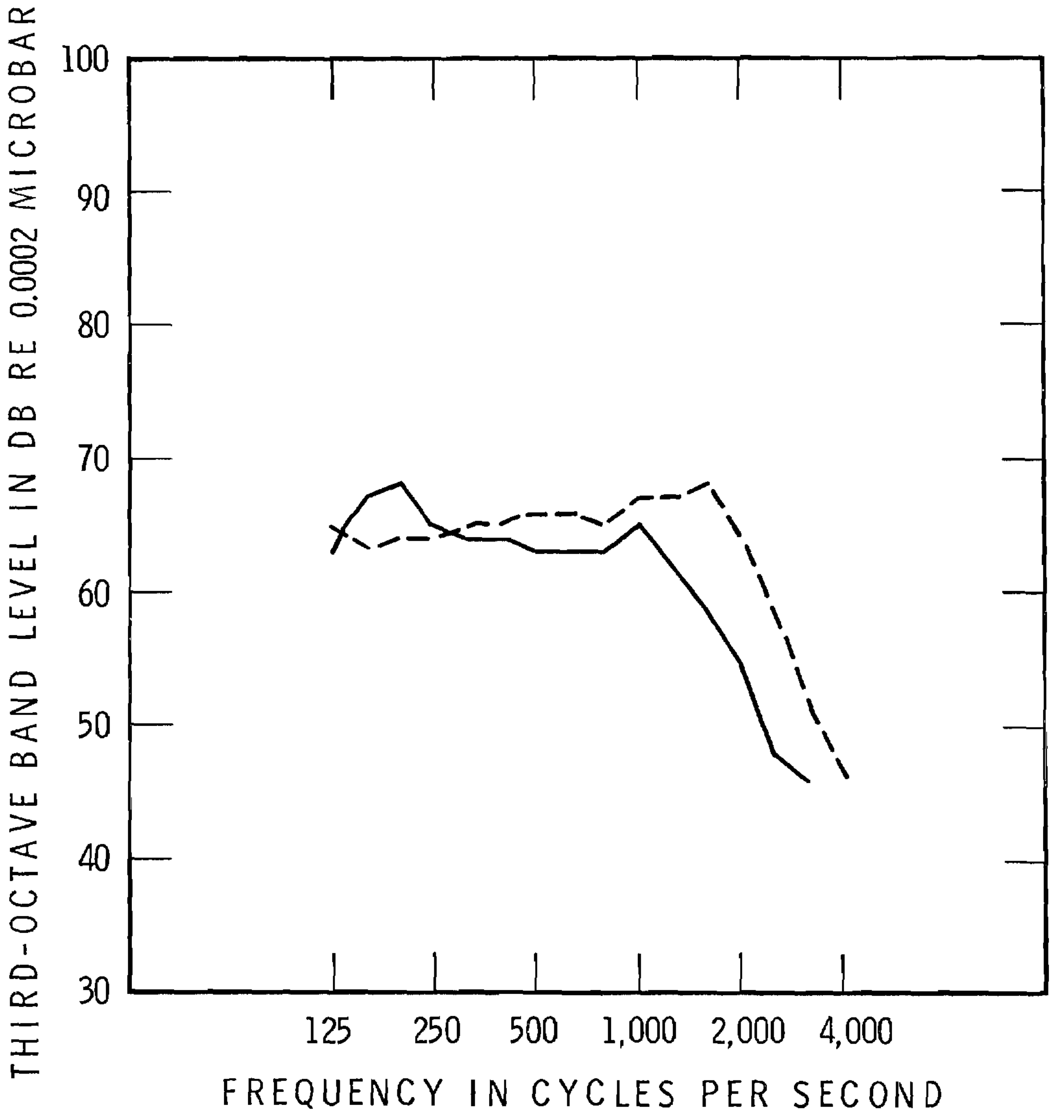
			Impact Noise Rating
————	Living Room	(Parquet)	-11
– – – – –	Bedroom	(Tile)	-17

Apts. 505 and 405 used
Measurements Taken on 18 July, 1963

FIGURE 2

IMPACT SOUND SPECTRA - BUILDING B

BR 3081-2



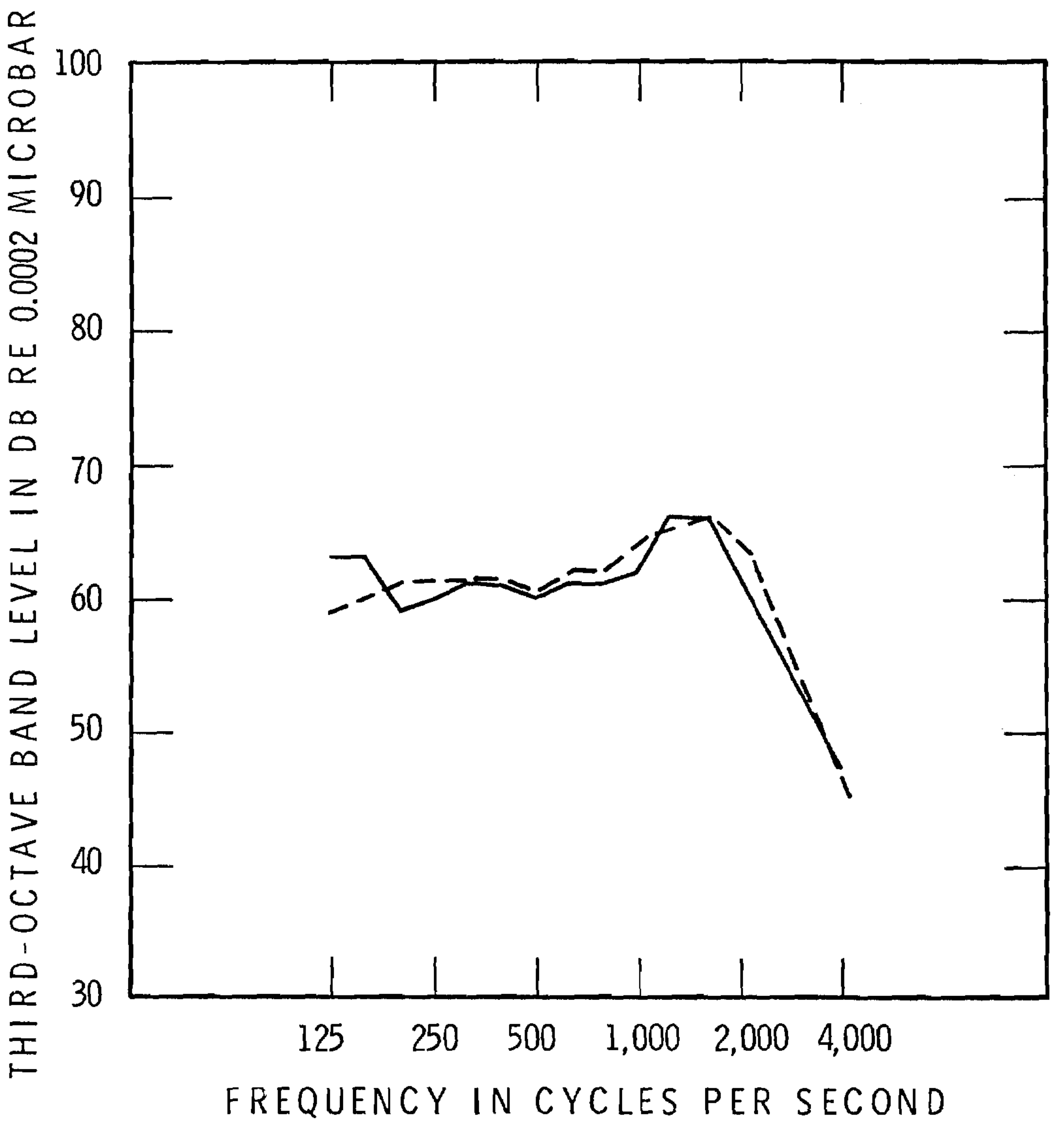
		Impact Noise Rating
———————	Living Room (Parquet)	-4
– – – – – –	Bedroom (Tile)	-11

Apts. 7 and 11 used
Measurements Taken on 23 July, 1963

FIGURE 3

IMPACT SOUND SPECTRA - BUILDING C

BR 3081-3



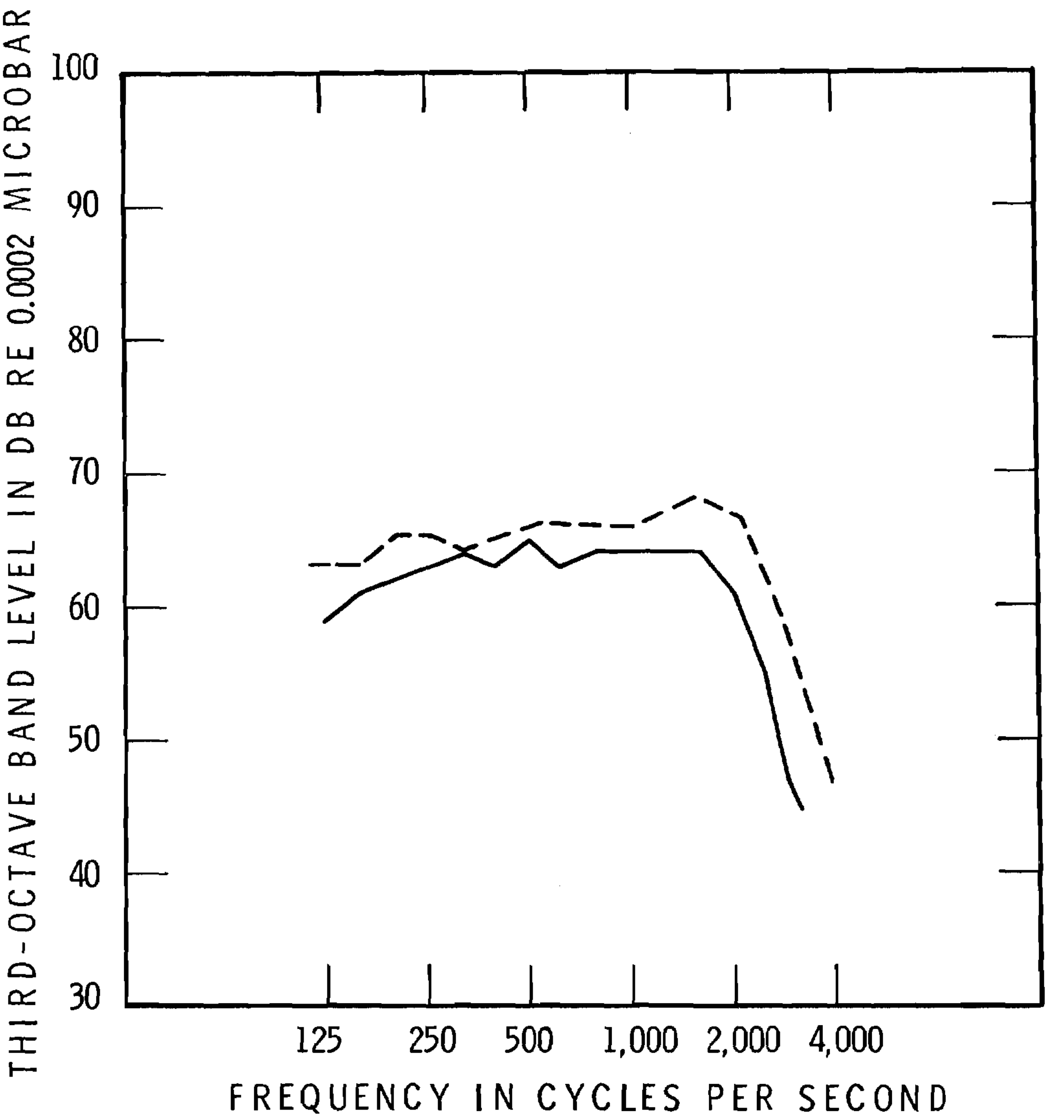
		Impact Noise Rating
——— Living Room	(Tile)	-9
- - - - - Bedroom	(Tile)	-10

Apts. 4 and 7 used
Measurements Taken on 31 July, 1963

FIGURE 4

IMPACT SOUND SPECTRA - BUILDING D

BR 3081-4



		Impact Noise Rating
———— Living Room	(Parquet)	-7
– – – – – Bedroom	(Tile)	-12

Apts. 608 and 508 used
Measurements Taken on 29 Aug., 1963

FIGURE 5

IMPACT SOUND SPECTRA - BUILDING E

AR 3081-5

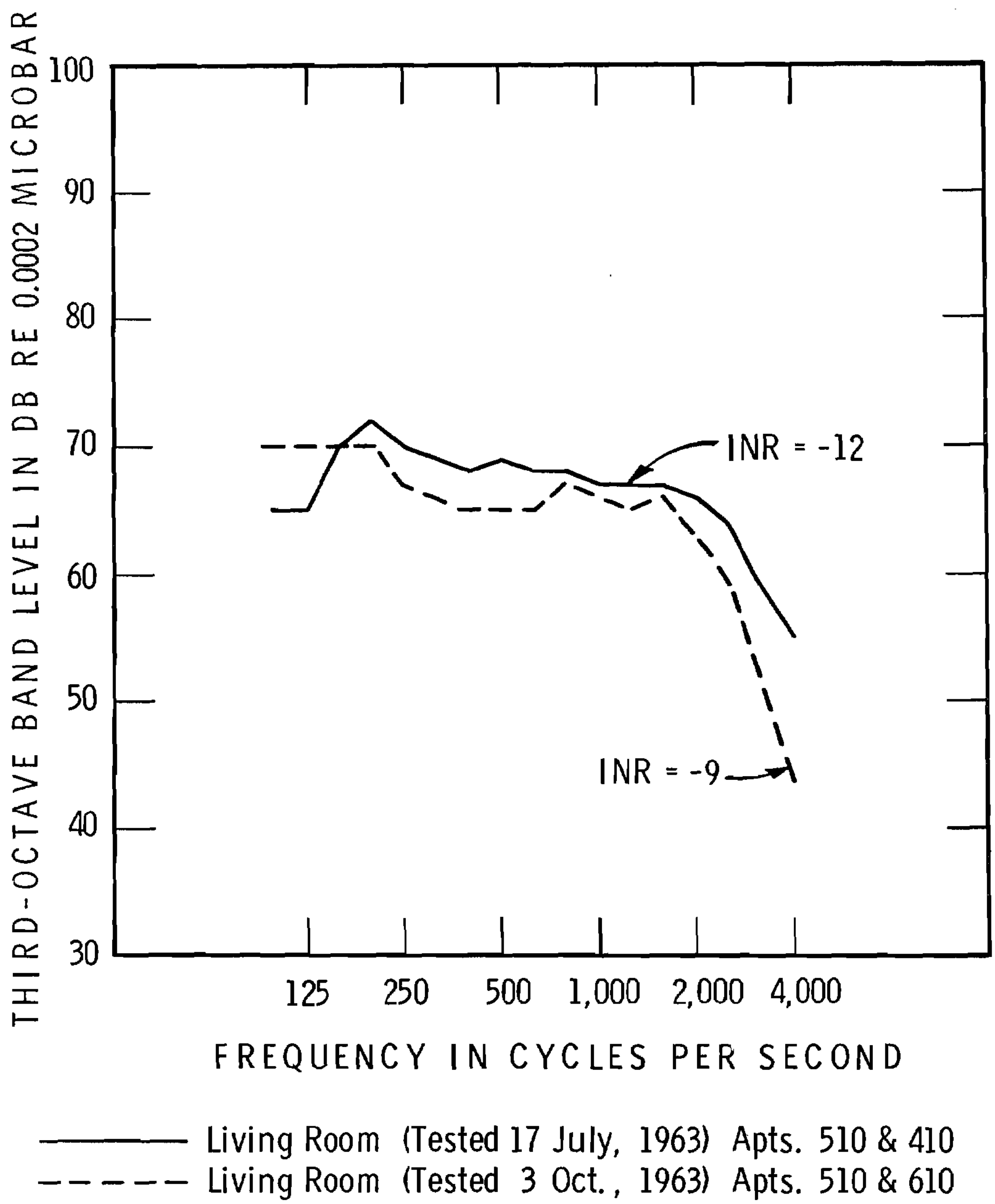
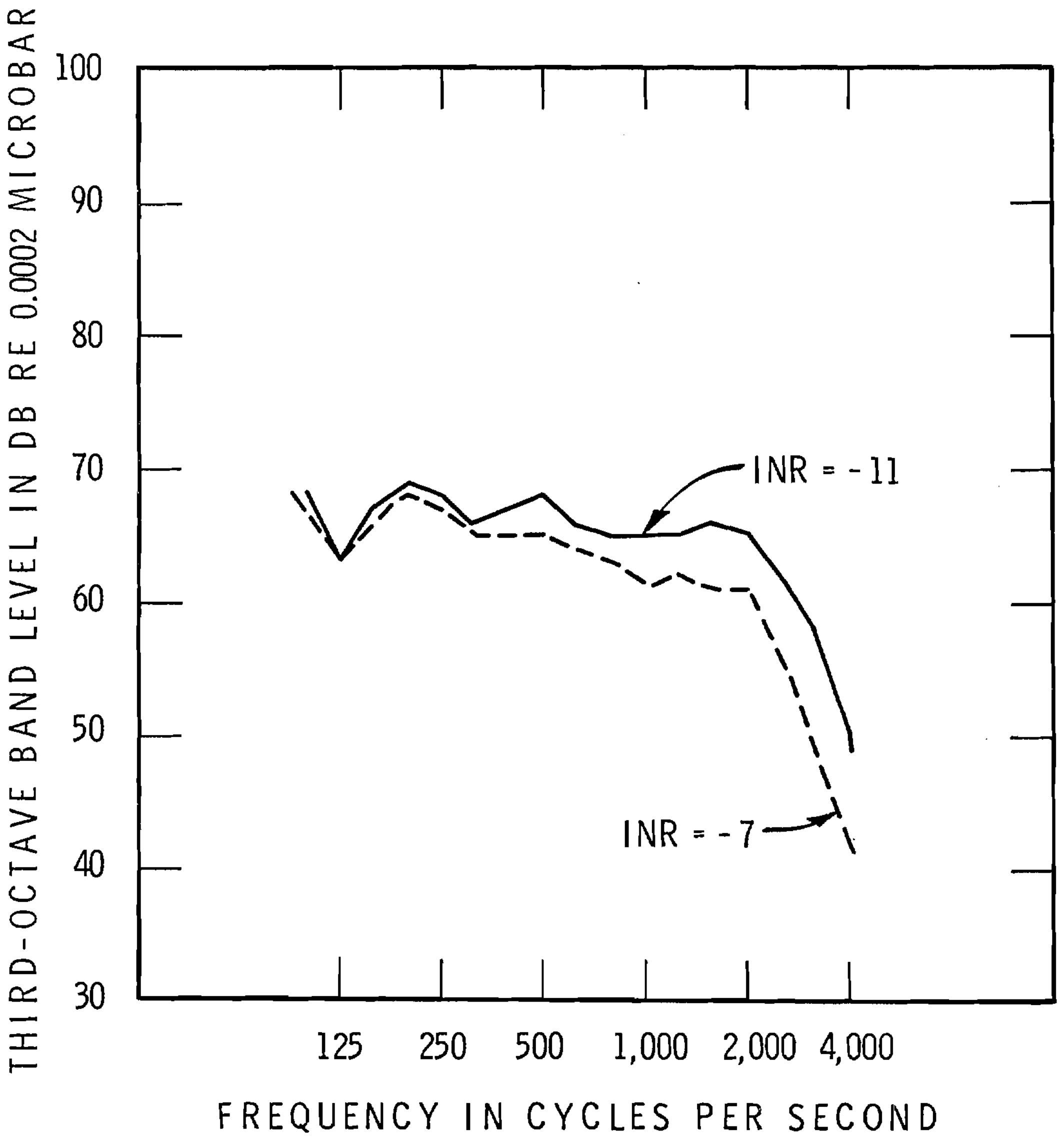


FIGURE 6

IMPACT SOUND SPECTRA - BUILDING A

BA 3081-6

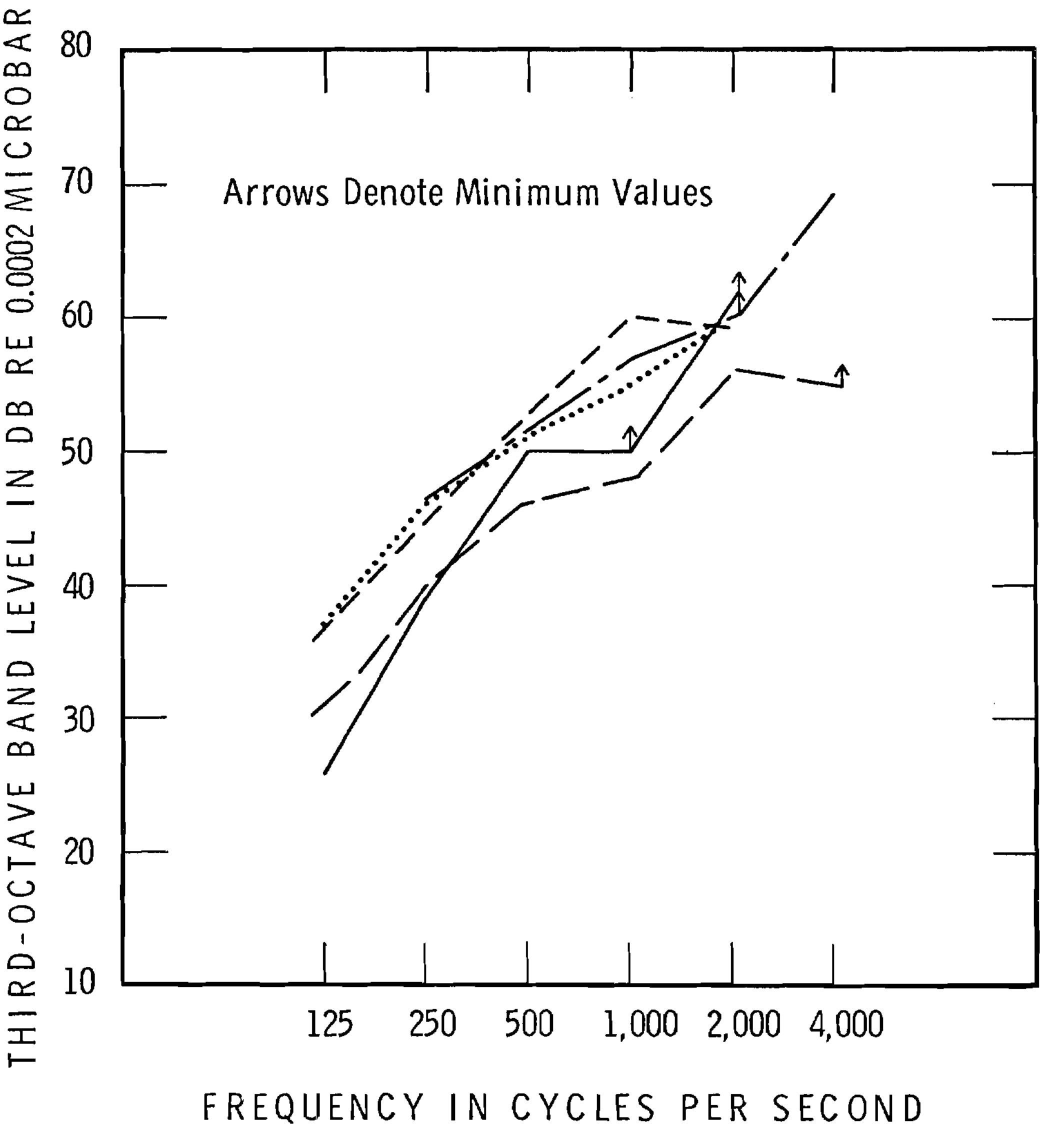


——— Bedroom (Tested 17 July, 1963) Apts. 510 & 410
– – – – – Bedroom (Tested 3 Oct., 1963) Apts. 510 & 610

FIGURE 7

IMPACT SOUND SPECTRA - BUILDING A

RA 3081-7



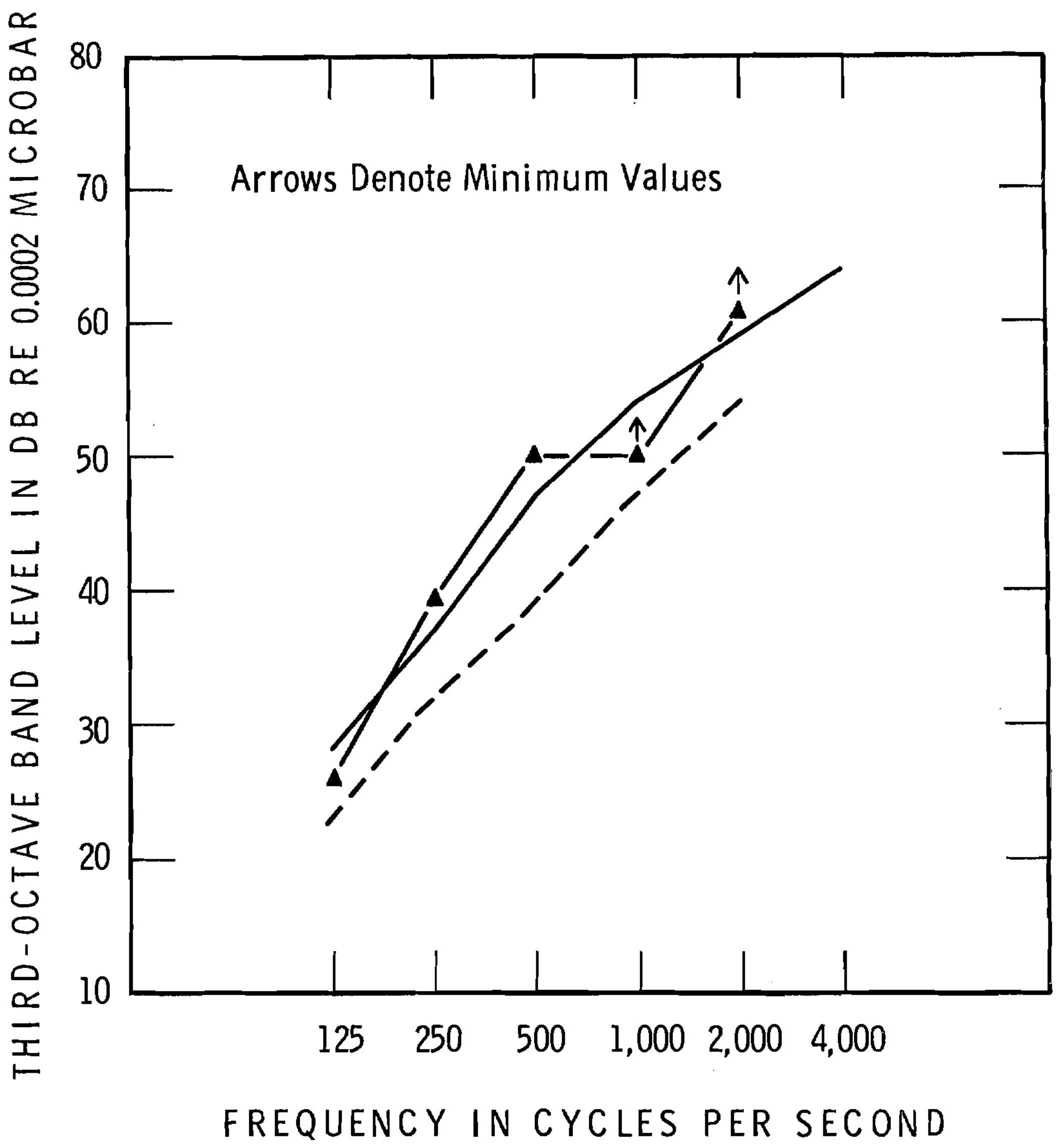
	Sound Transmission Class
Building A	48
Building B	55
Building C	54
Building D	49
Building E	54

Measurements Taken in July, August 1963

FIGURE 8

AIRBORNE SOUND TRANSMISSION LOSS OF LIVING ROOM FLOORS

SA 3081-8

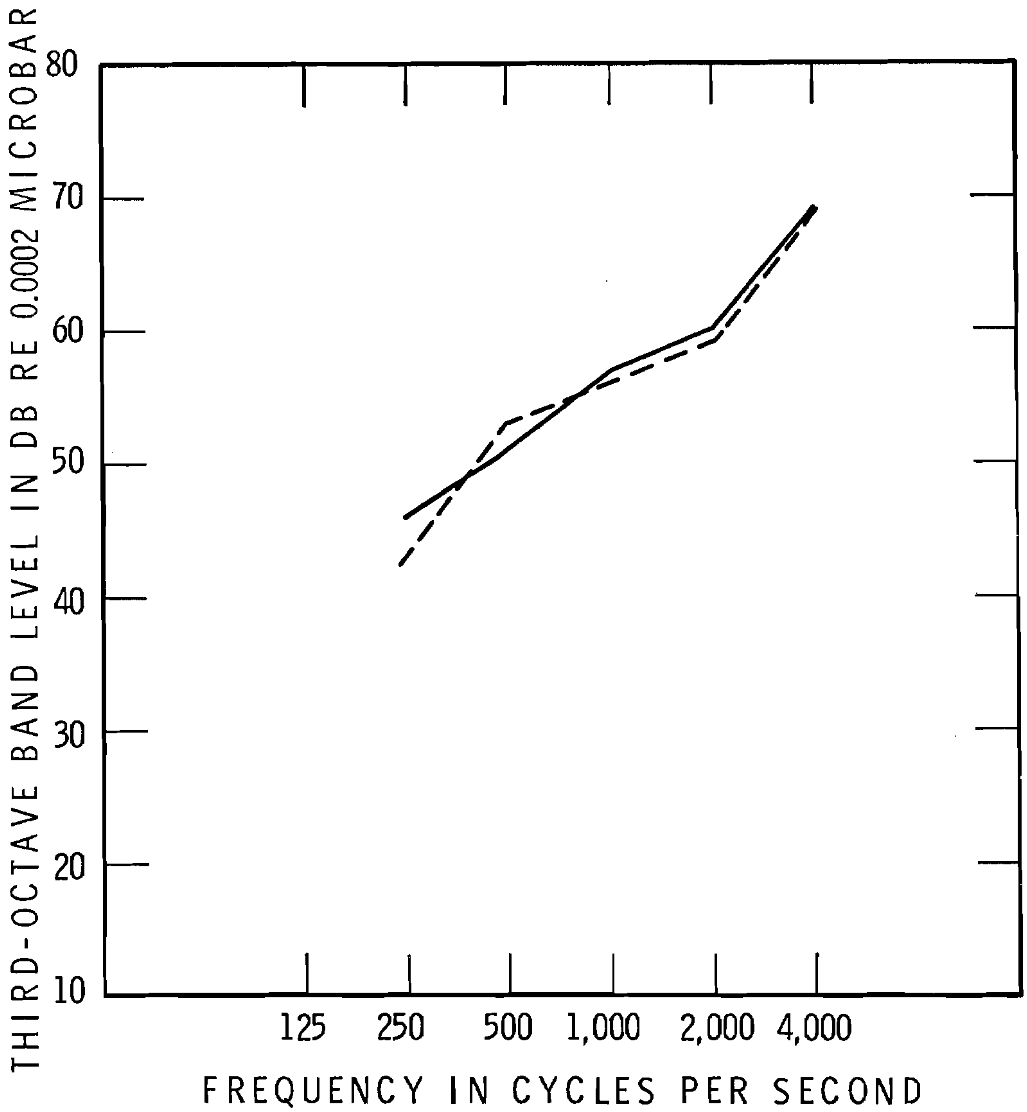


———	Living Room	STC = 48	(Apt. 510 & 610)	3 Oct 1963
– – – –	Bedroom	STC = 41	(Apt. 510 & 610)	3 Oct 1963
▲——▲	Living Room	STC = 48	(Apt. 410 & 510)	17 July 1963

FIGURE 9

AIRBORNE SOUND TRANSMISSION LOSS OF FLOORS - BUILDING A

BA 3081-9



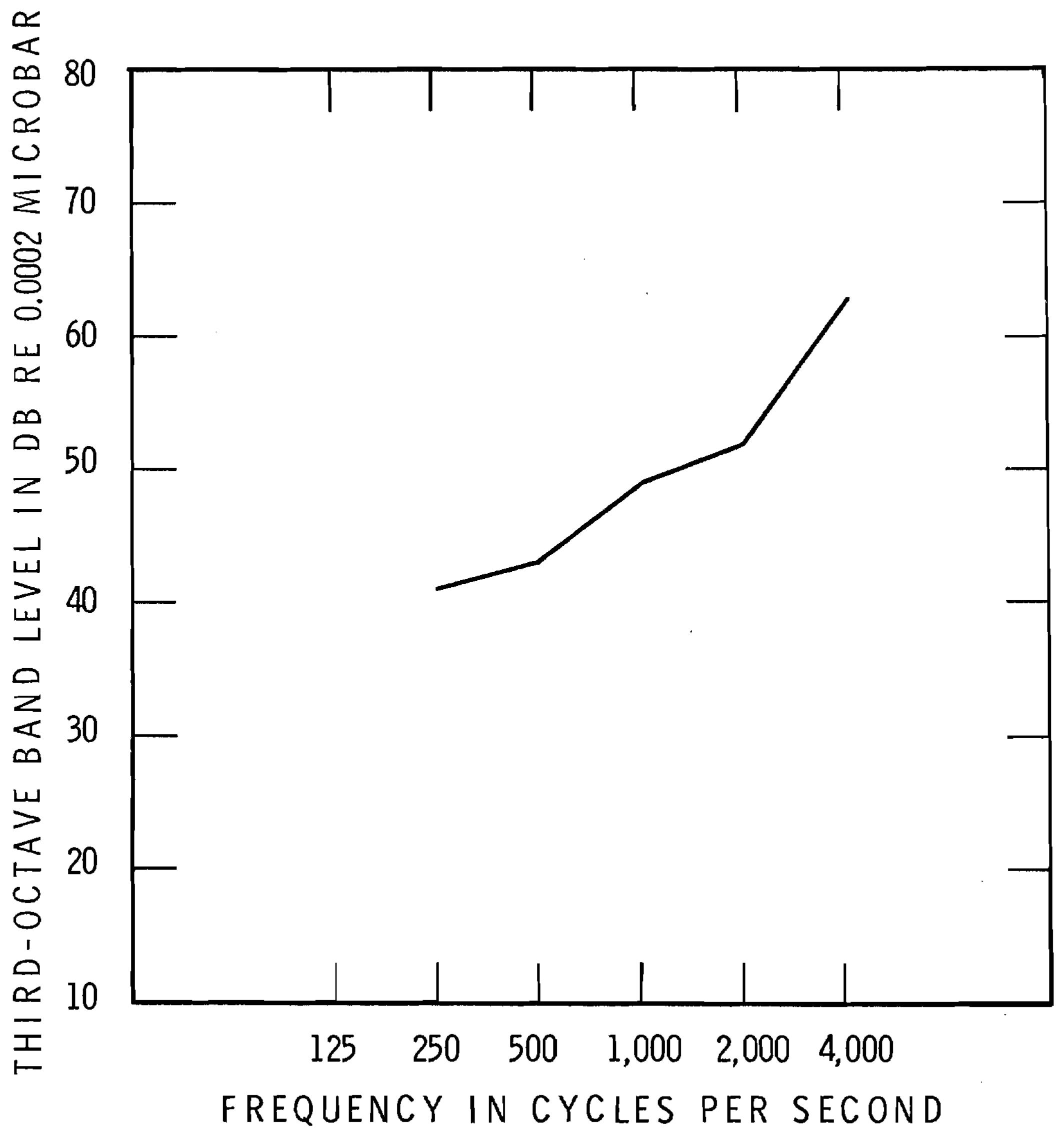
——————— Living Room STC = 54 (Apt. 506 & 606)
– – – – – – Bedroom STC = 54 (Apt. 506 & 606)

Measurements Taken on 26 Aug., 1963

FIGURE 10

AIRBORNE SOUND TRANSMISSION LOSS OF FLOORS - BUILDING E

BA 3081-10



(Living Room 606 ⟷ Living Room 605)
STC = 47

Measurements Taken on 26 Aug., 1963

FIGURE 11

AIRBORNE SOUND TRANSMISSION LOSS OF PARTY WALL IN BUILDING E

BR 3081-11