



AEROSPACE INFORMATION REPORT

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Superseding AIR1081

House Noise-Reduction Measurements for Use in Studies of Aircraft Flyover Noise

RATIONALE

This document is not currently used for regulatory purposes but is useful for researchers and students. However, it contains useful measurement data for homes built prior to 1970 including 1/3 octave transmission loss data. This document should be stabilized to maintain those data. In addition, FAA and A-21 are currently working on an updated method for doing these tests.

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1. INTRODUCTION

This AIR describes the results of some house noise reduction measurements that were made in five locations in the U.S. in 1966¹, 1964², 1967³, and 1969⁴. The houses used in these tests included a wide range of construction types of single and multiple family dwellings. The house noise reductions also cover a wide range. The average house noise reduction developed in this AIR should be used only when such an average is needed.

The principle objective of this AIR is to use these noise reduction measurements to develop curves showing the noise reduction of aircraft flyover noise when the noise passes from the outside to the inside of houses located in various climates. The noise-reduction data presented herein can be applied to measurements of aircraft noise made outdoors in order to estimate the noise levels indoors.

2. HOUSE NOISE REDUCTION DATA

The measurements were obtained by recording the sound pressure levels inside a house under study and outside the dwelling at a distance from any outside surfaces of the house. The noise signals received by the two microphones during aircraft flyovers were recorded simultaneously on magnetic tape. Later, the two recordings obtained for each flyover were played back through a sound level meter, a band-pass filter (or a frequency weighting network), and a graphic level recorder. The maximum values of the rising and falling noise signals resulting from the aircraft flyover were then read from the graphic level charts. The noise reduction is expressed as a difference in the maximum sound pressure levels measured in the individual octave bands, as a difference between calculated perceived noise levels, and as a difference between A- or N-weighted sound levels.

The 1966¹ house noise reduction measurements were made in Boston and New York and included tests in 18 rooms in six houses; measurements in Miami were made in eight rooms in four houses. The noise reduction measurements are summarized in Table I, which also provides some dimensions of the individual rooms and median noise reduction values for those rooms where the noise reduction from more than one flyover was measured.

References 2, 3, and 4 present data from measurements of house noise reduction of aircraft noise in 60 different rooms with windows closed and in 46 different rooms with windows open. This additional data provides a broader base from which average house noise reduction values can be obtained and therefore greater confidence in the results can be placed; they do not, however, significantly change the averages obtained using the data in references 1 and 2 only.

Reference 3 contains information on house noise reduction for aircraft flyover noise obtained for houses used in extensive tests by NASA of subjective judgments of aircraft noise at Wallops Station, Virginia, in October and November, 1969. In these tests, four rooms in a brick veneer house and four rooms in a wood siding house were used. The house noise reduction tests were made on December 11 and 12, 1968. There were 25 overflights of propeller and jet aircraft for the noise reduction measurement in one house and 22 overflights of the same aircraft for measurements in the other. Tests were made with windows closed only. The results of these tests are presented in Table III. The average of the data for the wood siding house agree well with the data from the Miami and Los Angeles tests: The brick veneer house noise reduction data are higher than the Miami and Los Angeles data but not as high as the New York and Boston data. The brick veneer data are averaged in with the data for the lighter house constructions on the basis that there probably are only a small number of brick veneer houses in warm climates.

Results from reference 4 are given in Tables IV through VII. Table IV presents a description of the house and rooms tested and the source of the aircraft noise. Tables V, VI, and VII present house noise reduction data with windows open and closed for houses located in or near Los Angeles, New York, and Boston, respectively.

- 2.1 Variability In Measurements From Reference 1: Previous measurements have shown that there is considerable variability in the house noise reduction data obtained with different aircraft flyovers. The noise reduction values vary with the type of aircraft and with flight paths as well as with measurement positions inside and outside the rooms. To illustrate this, Fig. 1 shows the house noise reductions observed for a bedroom of a Miami house from eleven successive flyovers. Two measurement graphs are shown, one for windows closed and one for windows open. The shaded bands indicate the range of the measured noise reductions; individual flyovers are identified by distinctive symbols. The heavy line represents the median for the respective sets of windows-open or windows-closed measurements. In this room, the noise reduction ranged from 11 to 20 PNdB for windows closed and from 8 to 12 PNdB with windows open. The noise reductions in dBA showed similar variations.
- 2.2 Comparisons of House Noise Reduction Measurements From References 1 and 2: Referring now to the noise reductions measured in different rooms, Fig. 2 shows the range of median noise reduction values measured for the rooms in the Boston and New York houses in tests described in reference 1. Two sets of curves are again shown, one for rooms with windows closed and one for those with windows open. The heavy line indicates the median value for all the rooms measured. The noise reduction, expressed as a difference in PNdB, ranged from 23 to 34 PNdB for houses with windows closed and from 11 to 28 PNdB with windows open. There is a shift of 10 PNdB between the median values for houses with windows closed (30 PNdB) and those with windows open (20 PNdB).

Figure 3 shows a similar comparison of the house noise reduction measurements for the Miami houses. The noise reduction, expressed as a difference in PNdB, ranged from 15 to 24 PNdB for rooms with windows closed and from 5 to 13 PNdB with windows open. There was 11 PNdB difference between the median noise reduction for houses with windows closed and those with windows open. The noise reductions in terms of dB(A), in Figures 2 and 3, were comparable to the reductions expressed in terms of PNdB.

A comparison of window areas showed that, on the average, the Boston and New York rooms had somewhat lower ratios of window area to exposed wall surfaces than did the Miami rooms. The windows in several of the Miami houses were not tightly fitted, in contrast to the generally well-fitted windows found in the Boston and New York test houses. In addition, the roofs of several of the Miami houses were of relatively light-weight construction.

The data in references 1 and 2 were examined to compare the differences in house noise reduction values measured by three separate quantities: the change in perceived noise level and the noise reduction in terms of the change in A- or N-weighted sound level.

The differences between PNL and A-weighted noise reduction values obtained from the measurements reported in reference 1 are summarized in the first column of Table II. In comparison, the results of PNL and A-weighted measurements in Los Angeles houses in 1964, reference 2, are tabulated in the second column of Table II. The standard deviations listed in Table II are comparable, or only slightly larger, than the standard deviations of A-weighted measurements and calculated perceived noise levels, for current jet aircraft flyover noise signals.

The differences in N-weighted levels in the third column of Table II show, on the average, somewhat closer agreement with the differences in perceived noise level than do the A-weighted measurements. However, the range of differences and the standard deviations are quite similar to those shown in the first and second columns. Thus, it is expected that either the N-weighted or A-weighted sound level measurements can be used as good predictors of house noise reduction, expressed as a difference in perceived noise levels.

3. GENERALIZED VALUES OF HOUSE NOISE REDUCTION

In studying the impact of noise on people living near airports, there is a need for curves of noise reduction vs. frequency to indicate the amount by which a noise recorded outside should be attenuated to represent the noise inside a house. These curves may be used in studies of the effects of the noise of aircraft operating from airports in general at all times of the day and in all seasons of the year.

- 3.1 House Noise Reduction By Categories: Information on house noise reduction for aircraft noise obtained from the four references is correlated in four categories:

1. Warm climate houses, windows open, Table VIII
2. " " " " closed, " IX
3. Cold " " " " open, " X
4. " " " " closed " XI

The curves of the averages for these four categories are plotted in Fig. 4 (dashed lines for warm climate, solid lines for cold climate), together with their averages and dot dash lines for averages of:

1. Windows open and windows closed, warm climate,
2. Windows open and windows closed, cold climate and,
3. Overall average for warm and cold climate

The average curves for warm or cold climate house noise reduction are provided for studies of the impact of noise on people living near airports in warm or cold climates. The overall average curve is provided for studies of noise from aircraft which operate from airports in both warm and cold climates. Table XII presents the average house noise reductions for warm and cold climates and Table XIII presents the overall average.

- 3.2 Response Characteristics For Octave-Band Filters For Use in Simulating Indoor Noise From Outdoor Noise Recordings: The data in Tables XII and XIII contain smoothed average values sufficient for specifying the response of filters used to provide simulated indoor noise levels from outdoor noise recordings. The value for the noise reduction in the octave band centered at 125 Hz is increased by 0.5 dB to simplify the construction of the filter. The tolerance on the octave band response of the filter is ± 0.5 dB in the pass bands.

4. REFERENCES

- 1) Bolt, Beranek, and Newman, Inc., Report 1387, "Methods for Improving the Noise Insulation of Houses with Respect to Aircraft Noise," November 1966.
- 2) D. E. Bishop, "Reduction of Aircraft Noise Measured in Several School, Motel and Residential Rooms," J. Acoust. Soc. Am., 39, 907-13, May 1966.
- 3) NASA Tests at Wallops Station, Virginia, in November 1967, unpublished data as of this date.
- 4) Bolt, Beranek, and Newman, Inc., Measurements of House Noise Reduction, unpublished data as of this date.

TABLE I
SUMMARY OF A PORTION OF THE AIRCRAFT NOISE REDUCTION MEASUREMENTS

HOUSE	ROOM DESCRIPTIONS				MEASUREMENT CONDITIONS	NOISE REDUCTION IN dB (MEDIAN VALUE) Octave band center frequency in Hz										
	Type	Floor Area sq/ft	Exposed Wall Area sq/ft	Window Area sq/ft	Door Area sq/ft	Window	No. of Measurements	PNdB	dB	63	125	250	500	1000	2000	4000
Miami #1*	Bedroom	110	168	45	-	Open	6	9	9	11	10	8	9	9	9	15
						Closed	5	17	17	16	12	13	14	18	20	20
Miami #2*	Living Room	288	108	29	-	Open	6	10	9	11	9	9	9	9	12	12
						Closed	2	18	19	14	13	14	20	21	23	20
Miami #3*	Bedroom	190	101	25	-	Open	1	8	10	15	2	9	12	12	7	8
						Closed	3	22	22	18	18	18	21	24	26	24
	Bedroom	121	198	71	-	Open	2	5	4	4	4	5	5	2	5	9
						Closed	4	17	16	16	13	13	16	18	25	24
Miami #4*	Living Room	210	135	30	-	Closed	1	21	22	17	8	20	20	24	28	28
	Back Bedroom	90	152	28	-	Open	3	9	11	2	10	11	12	11	5	6
						Closed	4	20	22	8	17	15	17	20	23	25
New York #1	Living Room	260	296	42	-	Open	9	12	13	7	8	9	8	10	13	13
						Closed	1	23	23	12	13	18	20	23	22	26
	Front Bedroom	130	184	28	-	Open	1	8	8	10	3	7	11	7	5	9
						Closed	2	15	17	7	13	13	14	18	16	15
	Living Room	240	128	32	19	Open	2	17	21	13	16	17	21	22	23	22
New York #2						Closed	2	26	28	17	18	25	30	34	27	31
	Kitchen	96	80	8	18	Open	2	12	11	21	12	11	14	13	11	11
	Bedroom	110	96	22	-	Open	1	22	22	23	19	21	22	22	22	23
						Closed	1	28	33	20	21	25	26	29	35	39
	Kitchen	150	94	11	20	Open	4	23	23	14	18	17	19	23	23	24
						Closed	2	31	31	16	22	25	28	33	35	36
	Living Room	130	164	17	-	Open	2	28	28	14	25	22	24	27	27	30
	Bedroom	140	78	14	-	Open	5	20	19	17	15	14	17	20	25	29
						Closed	2	33	33	18	23	25	30	34	40	42

* Unfurnished

TABLE I (Continued)
SUMMARY OF A PORTION OF THE AIRCRAFT NOISE REDUCTION MEASUREMENTS

HOUSE	ROOM DESCRIPTIONS				MEASUREMENT CONDITIONS	NOISE REDUCTION IN dB (MEDIAN VALUE) Octave band center frequency in Hz									
	Type	Floor Area sq/ft	Exposed Wall Area sq/ft	Window Area sq/ft	Door Area sq/ft	No. of Measure- ments	PNdB	dBA	63	125	250	500	1000	2000	4000
Boston #1	Kitchen	240	324	20	16	3 Open Closed	14 32	14 34	8 15	14 22	13 21	13 26	13 32	14 34	13 35
	Living Room	266	297	78	-	1 Open	21	23	14	20	22	24	24	22	21
	Bedroom	238	279	13	-	1 Open Closed	20 34	20 33	17 15	15 21	19 22	16 27	16 30	18 38	23 42
Boston #2	Kitchen	64	85	28	17	1 Open	20	19	10	18	19	18	19	21	21
	Living Room	156	213	31	19	2 Open Closed	27 27	31 33	15 20	20 29	25 23	28 26	29 36	33 37	33 32
	Bedroom	132	196	41	-	3 Open	23	26	16	16	21	22	26	28	29
Boston #3	Kitchen	143	178	18	18	1 Open Closed	11 29	10 29	15 16	14 20	7 20	10 26	11 30	10 32	10 32
	Living Room	220	230	32	18	1 Open Closed	18 30	18 29	16 20	18 19	16 22	16 27	17 29	18 33	20 35
	Bedroom	120	74	11	-	2 Open Closed	22 33	21 33	16 22	14 19	16 26	14 32	18 34	24 39	26 43
Boston #4	Living Room	160	83	31	18	2 Closed	30	31	14	17	24	28	36	43	45
	Kitchen	81	75	14	17	1 Closed	23	23	20	12	17	15	22	27	28
	Bedroom	110	174	22	-	2 Closed	29	29	12	16	22	26	29	36	36

NOTE: Average difference in PNdB between windows open and closed for Table I is 10 PNdB

TABLE II

Comparison of House Noise Reduction Values Expressed as Differences Between
Noise Reduction in Terms of the Change in Perceived Noise Level
and the Noise Reduction in Terms of the Change in
A- and N- Weighted Sound Levels

	NR _{PNdB} -NR _{dBA}		NR _{PNdB} -NR _{dBN}
	Boston, New York, Miami (1966)	Los Angeles (1964)	Los Angeles (1964)
Average Difference	-0.6 dB	-1.0 dB	-0.1 dB
Range of Differences	+1 to -9 dB	+4 to -7 dB	+4 to -6 dB
Standard Deviation	1.8 dB	1.7 dB	2.1 dB
Number of Operations	105	81	81

TABLE III

Average Attenuation of Aircraft Noise in 4 Rooms
in Each of 2 Houses at Wallops Station, Virginia,
Windows Closed, Reference 3

Frequency, Hz	63	125	250	500	1000	2000	4000
House No. 1*	17.1	23	21	20	27.8	30.3	30.5
House No. 2**	16.2	21.1	21.3	20.2	21.3	24	25

*House No. 1 has a brick veneer siding.

**House No. 2 has wood siding.

TABLE IV
DESCRIPTIONS OF HOUSES TESTED

	California #1	California #2	New York #3	New York #4	Massachusetts #1
Major aircraft sources	Takeoff	Landing	Takeoff	Takeoff	Takeoff, sideline
No. of floors	1	1	1	2	1
No. of bedrooms	2	3	3	3	1
Size (sq. ft.)	1500	1200	1200	1100	600
Approx. Age	16	25	30	40	30
Exterior walls	Stucco, plaster	Stucco, plaster	Brick veneer, plaster	Asphalt shingles, plaster	Cedar shingles, plaster

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TABLE V
SUMMARY OF AIRCRAFT NOISE REDUCTION MEASUREMENTS IN dB

	A/C Oper.	A Level	Octave Band Center Frequencies in Hz (CPS)								No. of Meas.
CALIFORNIA #1			63	125	250	500	1000	2000	4000	8000	
LIVING ROOM											
Existing - windows open	T/O	22.2	14.8	12.2	17.5	19.6	20.3	23.0	25.5	-	8
Existing - windows closed	T/O	28.0	15.2	15.1	21.9	23.7	25.6	27.5	31.0	-	5
BEDROOM											
Existing - windows open	T/O	9.7	11.2	5.00	9.8	7.1	7.1	8.1	10.3	-	8
Existing - windows closed	T/O	23.3	19.3	15.0	20.2	21.4	22.9	24.3	32.5	-	8
FAMILY ROOM											
Existing - sliding door open	T/O	6.6	5.5	5.1	7.2	5.5	4.1	4.9	6.6	-	8
Existing - sliding door	T/O	22.4	16.1	13.4	20.8	22.5	21.9	22.6	23.0	-	7
CALIFORNIA #2											
LIVING ROOM											
Existing - windows open	L	11.4 0.8	10.2 3.3	8.8 1.1	11.6 0.7	10.5 1.5	11.9 1.0	12.4 0.7	13.8 0.4	15.4 1.0	10
Existing - windows closed	L	26.3 0.9	14.8 3.1	17.5 0.9	21.3 2.0	24.3 1.9	27.1 0.8	27.3 1.4	31.8 1.3	32.4 2.8	8
BEDROOM NO. 1											
Existing - windows closed	L	25.6 2.3	18.9 4.6	15.8 2.4	24.1 1.6	24.3 2.0	28.5 2.5	26.6 3.1	30.0 1.9	28.0 2.7	8
KITCHEN											
Existing - windows open	L	9.1 1.6	12.3 2.9	6.5 3.0	11.0 3.0	9.4 1.1	9.0 0.8	9.6 0.7	10.9 1.6	14.3 1.8	8
Existing - windows closed	L	20.3 0.8	18.1 4.1	15.4 2.8	20.3 2.4	18.9 0.7	20.9 1.1	21.4 0.8	23.1 0.7	25.7 1.5	8
BEDROOM NO. 2											
Existing - windows open	L	14.6 1.3	12.6 3.8	8.6 1.8	13.0 3.3	15.3 1.7	15.8 1.6	15.0 1.4	16.4 1.5	18.4 1.9	8
Existing - windows closed	L	32.8 2.5	15.4 4.7	18.4 1.5	24.9 2.1	31.6 1.1	34.0 2.4	36.0 3.3	36.8 4.7	38.9 3.6	8
BEDROOM NO. 3											
Existing - windows open	L	18.5 2.6	13.6 4.7	12.4 1.3	18.5 1.7	17.0 2.2	19.4 3.1	21.3 1.0	20.4 4.0	26.3 1.8	8
Existing - windows closed	L	32.3 1.3	17.1 6.4	19.2 2.0	28.3 1.5	27.8 1.4	30.5 2.2	35.5 1.4	40.5 2.0	45.3 1.6	10

NEW YORK #3	A/C Oper.	A Level	Octave Band Center Frequencies in Hz (CPS)								No. of Meas.
			63	125	250	500	1000	2000	4000	8000	
LIVING ROOM											
Existing - windows open	L	18.9	11.1	10.4	13.9	18.4	20.1	21.8	23.1	-	7
		3.2	4.6	2.6	2.5	2.9	4.1	5.6	8.2	-	
Existing - windows closed	T/O	25.6	9.9	11.7	19.3	24.6	30.4	35.1	35.3	-	6
		3.8	5.8	3.5	5.0	3.7	5.0	3.5	5.5	-	
KITCHEN											
Existing - windows open	L	16.6	5.1	7.5	11.4	15.1	18.7	18.7	15.9	19.0	9
		2.9	4.4	3.3	3.4	2.3	3.5	5.5	6.9	3.9	
Existing - windows closed	L	22.6	15.8	13.8	19.3	24.0	27.0	28.3	21.8	-	8
		2.0	4.2	5.0	2.3	0.9	2.4	2.0	6.5	-	
BEDROOM NO. 1											
Existing - windows open	T/O	17.4	8.9	6.4	12.9	14.6	20.0	21.0	21.1	-	7
		2.4	5.1	2.6	2.1	2.6	2.2	7.5	4.2	-	
Existing - windows closed	T/O	17.3	17.0	11.0	14.7	16.0	19.7	19.0	22.0	-	5
		4.1	2.4	3.0	3.6	3.8	5.8	8.4	6.7		
BEDROOM NO. 2											
Existing - windows open	T/O	13.7	19.0	13.3	13.2	13.0	13.2	14.2	17.0	19.3	6
		4.8	7.2	3.3	4.2	5.2	5.8	7.9	7.6	2.9	
Existing - windows closed	T/O	19.3	20.7	16.0	16.0	18.0	22.0	25.2	27.0	27.0	5
		3.8	3.9	1.0	4.0	3.2	3.1	3.4	2.6	9.2	
BEDROOM NO. 3											
Existing - windows open	T/O	16.0	11.7	8.7	11.7	13.0	14.8	13.8	19.2	-	6
		2.1	4.5	4.0	2.2	3.6	4.2	6.9	4.9		
Existing - windows closed	T/O	19.0	13.0	10.6	17.0	17.4	21.6	27.6	30.4	-	5
		4.1	2.1	2.3	1.4	0.8	5.4	5.0	2.5		
	L	23.0	24.0	16.0	18.5	24.0	31.5	26.0	16.0	-	2
		2.8	1.4	2.8	0.7	2.8	7.7	4.2	5.6	-	
NEW YORK #4											
LIVING ROOM											
Existing - windows open	T/O	17.8	11.6	12.8	14.4	17.0	17.8	20.2	19.6	22.2	4
		4.8	5.7	5.4	6.5	4.6	5.7	4.5	4.9	4.8	
Existing - windows closed	T/O	25.3	11.8	13.7	22.2	23.8	25.5	28.3	30.7	29.6	6
		2.6	2.9	3.6	3.5	2.1	2.3	1.6	5.0	9.0	
KITCHEN											
Existing - windows open	T/O	18.6	18.0	13.3	19.3	16.6	17.6	19.6	16.0	21.6	3
		6.2	5.2	6.4	6.7	6.2	4.2	6.0	1.0	5.3	
		15.0	11.5	13.0	17.5	15.0	15.5	15.0	22.0	21.0	2
		0.0	3.5	1.4	2.1	0.0	3.5	1.4	4.2	0.0	
Existing - windows closed	T/O	26.2	21.2	21.2	26.0	23.7	29.5	21.0	32.7	32.3	5
		5.0	2.3	2.8	4.6	4.0	2.3	9.3	4.2	6.7	
	L	21.5	16.5	12.0	21.5	17.0	20.5	22.0	27.0	34.0	2
		0.7	4.9	4.2	0.7	2.8	3.5	4.2	4.2	0.0	

TABLE VI (Continued)

SUMMARY OF AIRCRAFT NOISE REDUCTION MEASUREMENTS IN dB

	A/C Oper.	A Level	Octave Band Center Frequencies in Hz (CPS)								No. of Meas.
NEW YORK #4			63	125	250	500	1000	2000	4000	8000	
BEDROOM NO. 1											
Existing - windows open	T/O	15.5 1.8	14.2 5.2	12.0 4.0	11.2 3.4	11.0 4.0	10.0 3.5	10.0 6.4	18.0 4.9	21.0 4.8	4
	L	10.5 0.7	7.0 2.8	11.0 1.4	11.0 1.4	9.5 3.5	12.5 3.5	11.0 1.4	16.5 4.9	18.5 4.9	2
Existing - windows closed	T/O	23.2 3.0	19.5 1.8	16.5 3.0	20.0 2.8	22.7 2.3	26.0 3.7	30.0 4.9	28.2 3.0	25.0 8.8	4
	L	20.3 3.6	15.6 2.6	14.6 3.4	17.0 2.0	21.6 5.1	24.3 3.0	24.0 0.0	27.0 3.6	22.6 2.1	3
BEDROOM NO. 2											
Existing - windows open	L	12.0 3.0	18.0 6.8	12.8 3.9	11.2 3.7	14.0 3.1	11.8 4.1	12.2 2.2	14.8 3.1	11.3 4.6	6
Existing - windows closed	T/O	27.7 4.3	23.0 7.0	20.5 1.8	23.7 2.7	31.2 6.4	37.5 5.7	37.0 4.7	27.0 6.3	17.0 1.7	5
	L	26.5 0.7	26.5 2.1	20.5 2.1	24.5 3.5	27.0 2.8	28.5 0.7	29.5 2.1	27.5 2.1	22.0 0.0	2
BEDROOM NO. 3											
Existing - windows open	L	16.0 1.4	16.7 3.1	19.0 1.9	13.8 1.7	15.0 1.4	15.8 1.5	16.3 2.6	16.8 2.6	17.7 6.4	6
Existing - windows closed	L	27.1 3.3	25.0 3.4	22.9 3.6	23.8 3.0	31.9 1.7	38.0 1.7	38.1 2.1	34.8 2.9	27.3 6.4	8

TABLE VII
SUMMARY OF AIRCRAFT NOISE REDUCTION MEASUREMENTS in dB

MASSACHUSETTS #1	A/C Oper.	A Level	Octave Band Center Frequencies in Hz (CPS)								No. of Meas.	Notes
			63	125	250	500	1000	2000	4000	8000		
LIVING ROOM Existing - windows open	T/O	11.5	8.0	14.2	10.5	9.2	11.2	11.5	13.0	8.2	4	A
		1.7	1.1	2.2	1.8	2.0	1.7	1.0	0.7	3.9		
Existing - windows closed	L	7.0	7.0	15.0	12.0	10.0	11.0	8.0	6.0	5.0	1	B
		14.3	15.1	12.4	13.6	14.2	14.6	15.4	14.9	13.6		
Existing - windows closed with storm sash in place	T/O	0.9	1.2	1.2	0.4	0.7	1.2	1.4	1.3	1.5	10	C
		25.7	17.2	18.5	21.5	29.2	34.0	35.7	28.5	23.2		
Existing - windows closed with storm sash in place	T/O	5.1	2.8	1.0	1.8	3.1	2.4	1.9	1.7	3.5	4	C
		28.2	20.1	19.8	23.8	31.2	36.1	37.1	29.1	23.2		
Existing - windows closed storm sash in place	T/O	1.6	2.8	1.6	2.0	1.4	2.0	1.7	4.9	2.9	23	C
		28.0	8.4	21.6	23.6	29.6	34.8	40.0	38.2	33.6		
Existing - windows closed storm sash in place	T/O	2.4	3.2	2.6	2.6	1.8	3.4	2.6	1.6	3.8	5	C
		30.0	14.0	21.5	28.8	32.5	38.0	43.8	44.3	36.5		
Existing - windows closed storm sash in place	T/O	4.4	2.9	3.4	1.7	2.4	0.8	2.2	1.7	3.1	4	C
		20.5	9.0	14.3	17.8	21.3	22.8	29.0	34.5	37.5		
Existing - windows in rooms below closed and storm sashes in place	T/O	2.5	3.6	1.3	2.5	3.5	1.3	1.6	2.6	1.7	4	C

NOTES:

- A - Takeoffs from Runway 22L
 B - Landings on Runway 22L
 C - Takeoffs from Runway 4R

TABLE VIII

WARM CLIMATE HOUSES, WINDOWS OPEN

The average house attenuation for each group tested is multiplied by the number of rooms in the group and the total for all groups divided by the total number of rooms tested

Octave Center frequency, Hz		63	125	250	500	1000	2000	4000
Miami	8 Rooms	88	76	88	104	88	72	88
Playa Del Rey ⁴	3 Rooms	31.5	22.3	34.5	32.2	31.5	36.0	42.4
Westchester ⁴	4 Rooms	48.7	36.3	54.1	56.1	56.1	58.3	61.5
Total	15 Rooms	168.2	134.6	176.6	192.3	175.6	166.3	191.9
Average		11.2	8.9	11.7	12.8	116.5	11.1	12.8

Note: ⁴ Data from references

TABLE IX

WARM CLIMATE HOUSES, WINDOWS CLOSED

The average house attenuation for each group tested is multiplied by the number of rooms in the group and the total for all groups divided by the total number of rooms tested

Octave Center frequency Hz		63	125	250	500	1000	2000	4000
Miami ¹	8 Rooms	144	136	144	180	200	216	232
Los Angeles ²	4 Rooms	76	64	80	86	100	100	106
Wallops ³ (Brick)	4 Rooms	68.5	92	84	80	111	121	122
Wallops (Wood)	4 Rooms	65	84.5	85	81	85	96	100
Playa Del Rey ⁴	3 Rooms	50.6	43.4	62.9	67.6	70.4	74.4	86.5
Westchester ⁴	5 Rooms	84.3	86.3	118.9	126.9	141.0	146.8	162.2
Total	28 Rooms	488.4	506.2	574.8	621.5	707.4	754.2	808.7
Average		17.4	18.1	20.6	22.2	25.2	27.0	28.8

Note: ^{1, 2, 3, 4} Indicate data from references 1, 2, 3 and 4

TABLE X

COLD CLIMATE HOUSES, WINDOWS OPEN

The average house attenuation for each group tested is multiplied by the number of rooms in the group and the total of all groups divided by the total number of rooms tested

Octave Center frequency Hz		63	125	250	500	1000	2000	4000
New York - Boston ¹	18 Rooms	270	288	314	324	360	396	414
New York ^{4A}	5 Rooms	55.8	46.3	61.1	74.1	86.8	89.5	96.3
New York ^{4B}	5 Rooms	78.5	69.9	69.9	73.6	73.0	78.3	85.2
Winthrop ^{4C}	3 Rooms	30.1	41.6	36.1	33.4	36.8	34.9	33.9
Total	31 Rooms	434.4	445.8	483.1	506.1	556.6	598.7	629.4
Average		14.0	14.3	15.6	16.3	18.9	19.3	20.2

Note: ¹, 4A, 4B and 4C Data from reference 1 (see Figure 2) and reference 4

TABLE XI

COLD CLIMATE HOUSES, WINDOWS CLOSED

The average house attenuation for each group tested is multiplied by the number of rooms in the group and the total of all groups divided by the total number of rooms tested.

Octave Center frequency, Hz		63	125	250	500	1000	2000	4000
New York - Boston ¹	18 Rooms	306	360	396	486	567	630	638
New York ^{4A}	5 Rooms	76.4	63.1	86.3	100	100.7	135.2	136.5
New York ^{4B}	5 Rooms	100.5	94.8	115.7	133.3	156.5	154.4	153.4
Winthrop ^{4C}	4 Rooms	59.7	81.4	97.7	122.5	142.9	156.6	140.1
Total	32 Rooms	542.6	599.3	695.7	841.8	967.1	1076.2	1068.0
Average		17.0	18.6	21.7	26.3	30.2	33.5	33.4

Note: ¹, 4A, 4B and 4C Data from reference 1 (see Figure 2) and reference 4

TABLE XII A

AVERAGE HOUSE NOISE REDUCTION, WARM CLIMATE

	63	125	250	500	1000	2000	4000	8000
Windows open	11.2	8.9	11.7	12.5	11.6	10.9	12.8	
Windows closed	<u>17.4</u>	<u>18.1</u>	<u>20.6</u>	<u>22.2</u>	<u>25.2</u>	<u>26.9</u>	<u>28.3</u>	
Total	28.6	27.0	32.3	34.7	36.8	37.8	41.1	
Average	14.3	13.5	16.2	17.4	18.4	18.9	20.6	20.6
Smoothed Values	14	14	16	17.5	18.5	20	20.5	20.5

TABLE XII B

AVERAGE HOUSE NOISE REDUCTION, COLD CLIMATE

	63	125	250	500	1000	2000	4000	8000
Windows open	14.0	14.3	15.6	16.3	18.9	19.3	20.2	
Windows closed	<u>17.0</u>	<u>18.6</u>	<u>21.7</u>	<u>26.3</u>	<u>30.2</u>	<u>33.5</u>	<u>33.4</u>	
Total	31.0	32.9	37.3	42.6	49.1	52.8	53.6	
Average	15.5	16.5	18.7	21.3	24.6	26.4	26.8	26.8
Smoothed Values	15.5	16.5	18.5	21.5	24.5	26.5	27.0	27.0

TABLE XIII

GRAND AVERAGE OF HOUSE NOISE REDUCTIONS

	63	125	250	500	1000	2000	4000	8000
Warm climate	14.3	13.5	16.2	17.4	18.4	18.9	20.6	20.6
Cold climate	<u>15.5</u>	<u>16.5</u>	<u>18.7</u>	<u>21.3</u>	<u>24.6</u>	<u>26.4</u>	<u>26.8</u>	<u>26.8</u>
Total	29.8	30.0	34.9	38.7	43.0	45.3	47.4	47.4
Average	14.9	15.0	17.5	19.4	21.5	22.7	23.7	23.7
Smoothed Values	15.0	15.0	17.5	20.0	21.5	23.0	23.5	23.5