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NOISINESS JUDGMENTS OF HELICOPTER FLYOVERS

TECHNICAL REPORT

January 1967

by

Karl S. Pearsons

Bolt Beranek and Newman Inc.
15808 Wyandotte Street
Van Nuys, California 91406

Under Contract FA65WA-1260

FEDERAL AVIATION AGENCY

AIRCRAFT DEVELOPMENT SERVICE

TECHNICAL REPORT

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[redacted]

ABSTRACT

Judgment tests were conducted in which 21 college students judged the noisiness or unwantedness of eight recorded helicopter flyover noises vs a jet transport flyover noise and a shaped band of noise. Tests were conducted in an anechoic chamber using mainly the method of paired comparisons. These judgment tests indicate that the calculated perceived noise level is the best predictor of noisiness, followed closely by the N-weighted sound pressure level and the A-weighted sound pressure level, and finally, the overall sound pressure level. Duration and pure-tone corrections applied to the calculated perceived noise level did not improve the prediction accuracy of this measure.

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I. INTRODUCTION

The recent increase in the use of helicopters has brought with it additional noise exposure to many people. The heliports of the city have further complicated the problem by bringing the noise closer to the city dwellers. To better understand people's assessment of helicopter noise, Bolt Beranek and Newman has conducted judgment tests to determine the noisiness of typical helicopter flyovers under FAA Contract No. FA65WA-1260. During the tests, subjects were asked to judge the noisiness or unwantedness of helicopter flyover noise signals vs jet transport flyover signals and a shaped band of noise.

Section II of this report describes the apparatus, stimuli, and general procedure employed during these tests. Section III presents a summary and discussion of the test results. The conclusions are presented in Section IV.

II. TEST DESCRIPTION

A. Subjects

Twenty-one college students were employed as subjects for this test. The group included 13 males and 8 females ranging in age from 17 to 23 years with a median age of 20. All subjects were audiometrically screened prior to the test. The screening level was held to within 20 dB of the new ISO standard threshold (Ref. 1).

B. Stimuli

Eight sound stimuli representative of five different types of helicopters were chosen, as shown in Table I. The large helicopters are represented by the Vertol CH-46 and Sikorsky S-61 types while the smaller helicopters are represented by the Sikorsky CH-34, the Kaman HH-43D and the Hughes 269A. The Sikorsky CH-34 and the Hughes 269A are powered by piston engines; the remainder are powered by turbine engines. Included in the table are overall sound pressure levels (OASPL) determined from method of adjustment tests described later. Also presented are the equivalent measures of the calculated perceived noise level (PNL), the N-weighted (N-level) and A-weighted sound pressure levels (A-level).

Table I also lists the time durations of the sound samples as measured with an N-weighting network.* Time duration is defined in Table I as the amount of time the signal is within 10 dB or 20 dB of the maximum N-level.

Spectra of the sound stimuli are given in Figs. 1-3. These spectra were determined by taking the maximum level of the sound samples in each one-third octave band.

Figure 1 shows the two stimuli employed as standards during this test; a DC-8:30 flyover and the simulated jet flyover noise. The time pattern of the simulated jet flyover noise is similar to that of an actual flyover. No attempt was made to simulate Doppler shifts and the spectrum shape shown in Fig. 1 remained constant throughout the sample duration.

The spread of the measurement data is also shown in Fig. 1. This spread is typical of all of the sound samples employed during the test.

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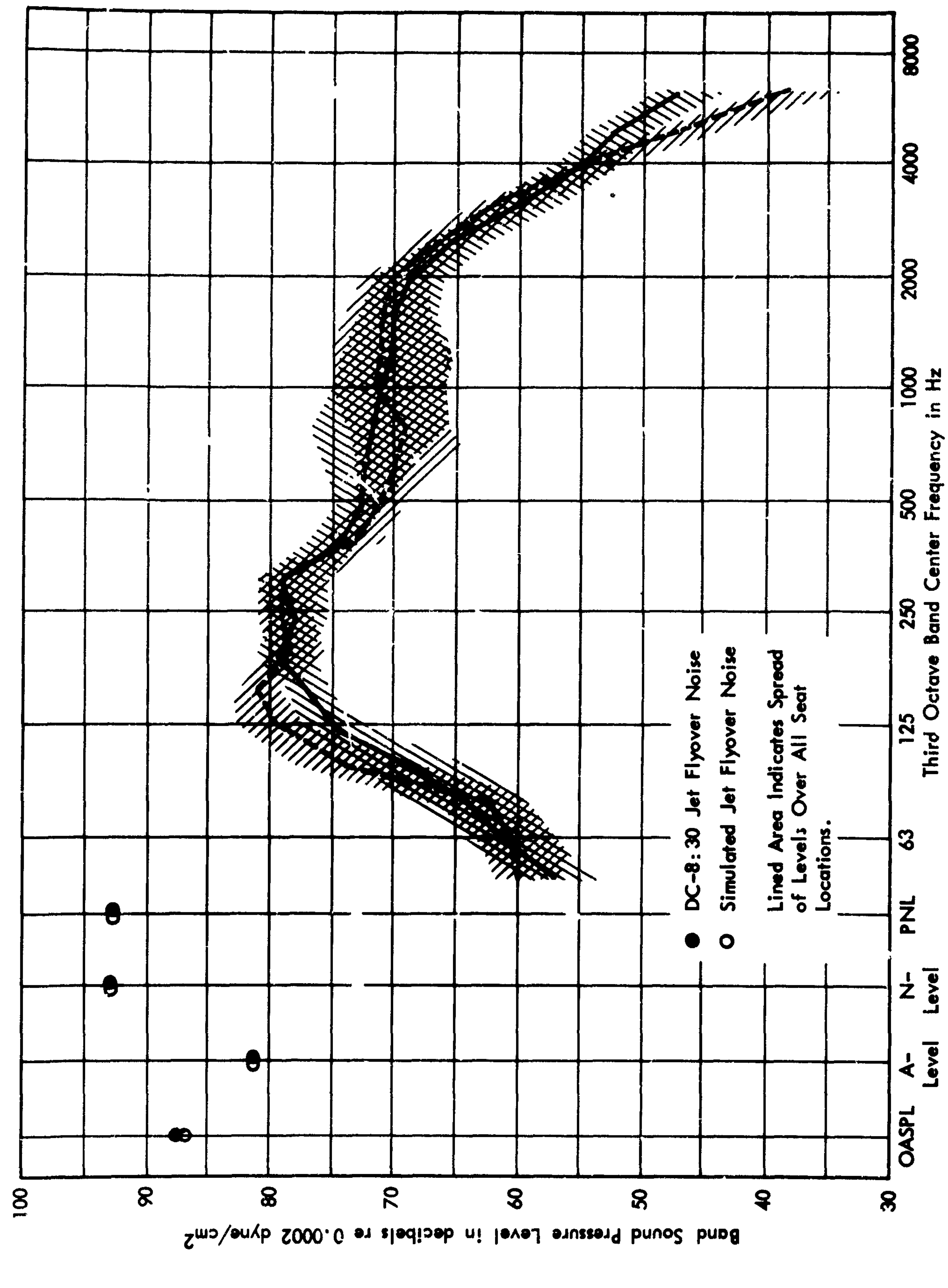
* The N-weighting network has a response equal to the inverse 40-noy curve (Ref. 2).

TABLE I

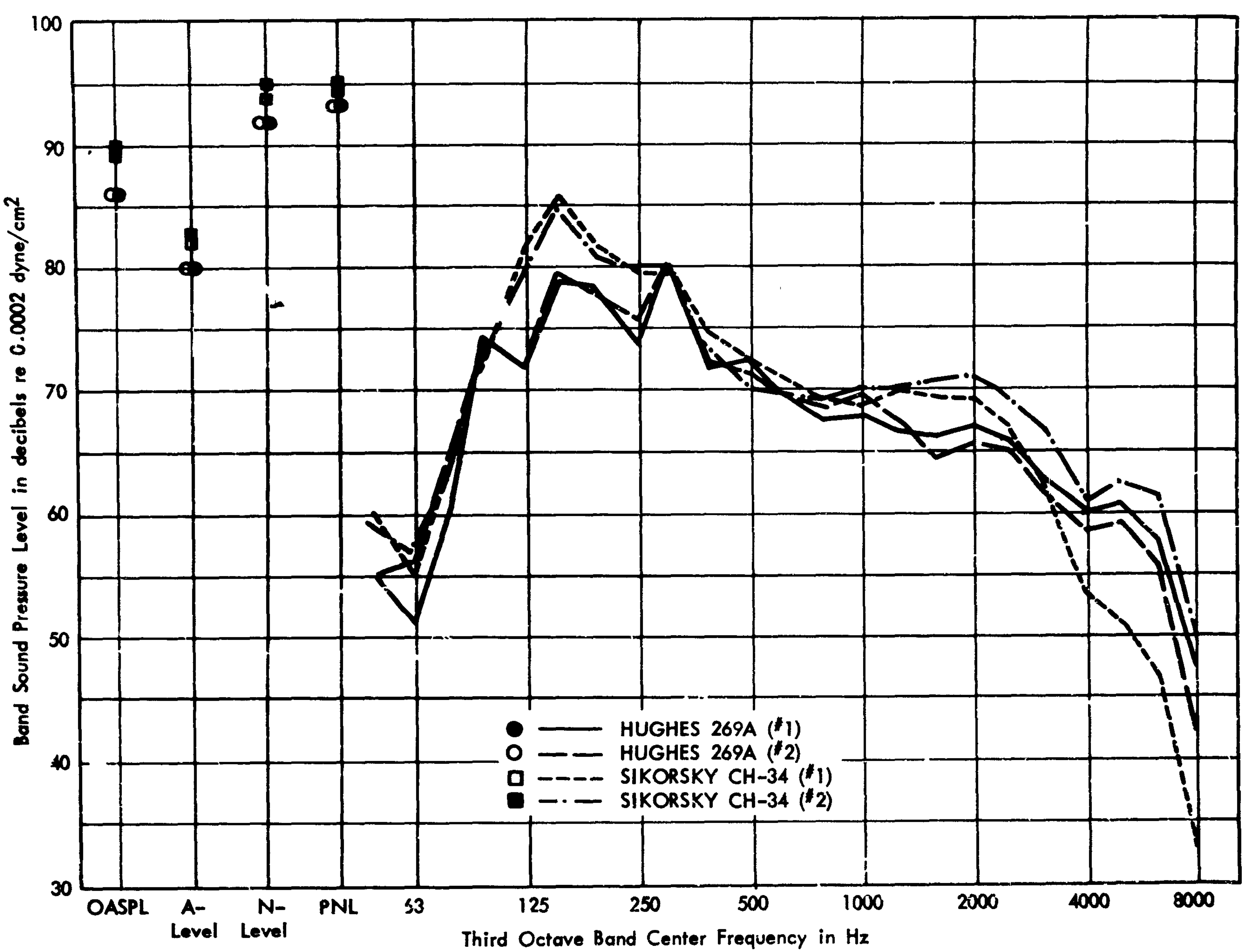
LEVELS OF HELICOPTER NOISE USED IN PAIRED-COMPARISON JUDGMENT TESTS

Noise Stimulus	Overall SPL	A-Level	N-Level	Calc. PNL	Dur_{10}	Dur_{20}
DC-8:30 (Std. Noise)	88	81.5	93	93	14.6	27.7
Simulated Jet Noise (Std. Noise)	87	81.5	93	93	16.0	32.5
Hughes 269A(#1)	92,88,84,80	86,82,78,74	98,94,90,86	99,95,91,87	7.0	23.2
Hughes 269A(#2)	92,88,84,80	86,82,78,74	98,94,90,86	99,95,91,87	13.7	29.8
Kaman HH-43B	93,89,85,81	85,81,77,73	98,94,90,86	99,95,91,87	5.3	9.8
Vertol CH-46(#1)	96,92,88,84	83,79,75,71	97,93,89,85	97,93,89,85	2.6	9.6
Vertol CH-46(#2)	101,97,93,89	90,86,82,78	104,100,96,92	103,99,95,91	4.0	19.3
Sikorsky CH-34(#1)	96,92,88,84	88,84,80,76	100,96,92,88	100,96,92,88	12.8	26.3
Sikorsky CH-34(#2)	95,91,87,83	89,85,81,77	101,97,93,89	101,97,93,89	4.8	17.0
Sikorsky S-61	93,89,85,81	89,85,81,77	100,96,92,88	100,96,92,88	10.6	20.0

Dur_{10}, Dur_{20} = Duration of time signal is within 10 or 20 dB respectively of the maximum N-weighted SPL.



Band Sound Pressure Level in decibels re 0.0002 dyne/cm²
100
90
80
70
60
50
40
30
OASPL
A- Level
N- Level
PNL
63
125
250
500
1000
2000
4000
8000
Third Octave Band Center Frequency in Hz
● DC-8: 30 Jet Flyover Noise
O Simulated Jet Flyover Noise
Lined Area Indicates Spread of Levels Over All Seat Locations.


Band Sound Pressure Level in decibels re 0.0002 dyne/cm²
100
90
80
70
60
50
40
30
OASPL
A-Level
N-Level
PNL
63
125
250
500
1000
2000
4000
8000
Third Octave Band Center Frequency in Hz
HUGHES 269A (#1)
HUGHES 269A (#2)
SIKORSKY CH-34 (#1)
SIKORSKY CH-34 (#2)

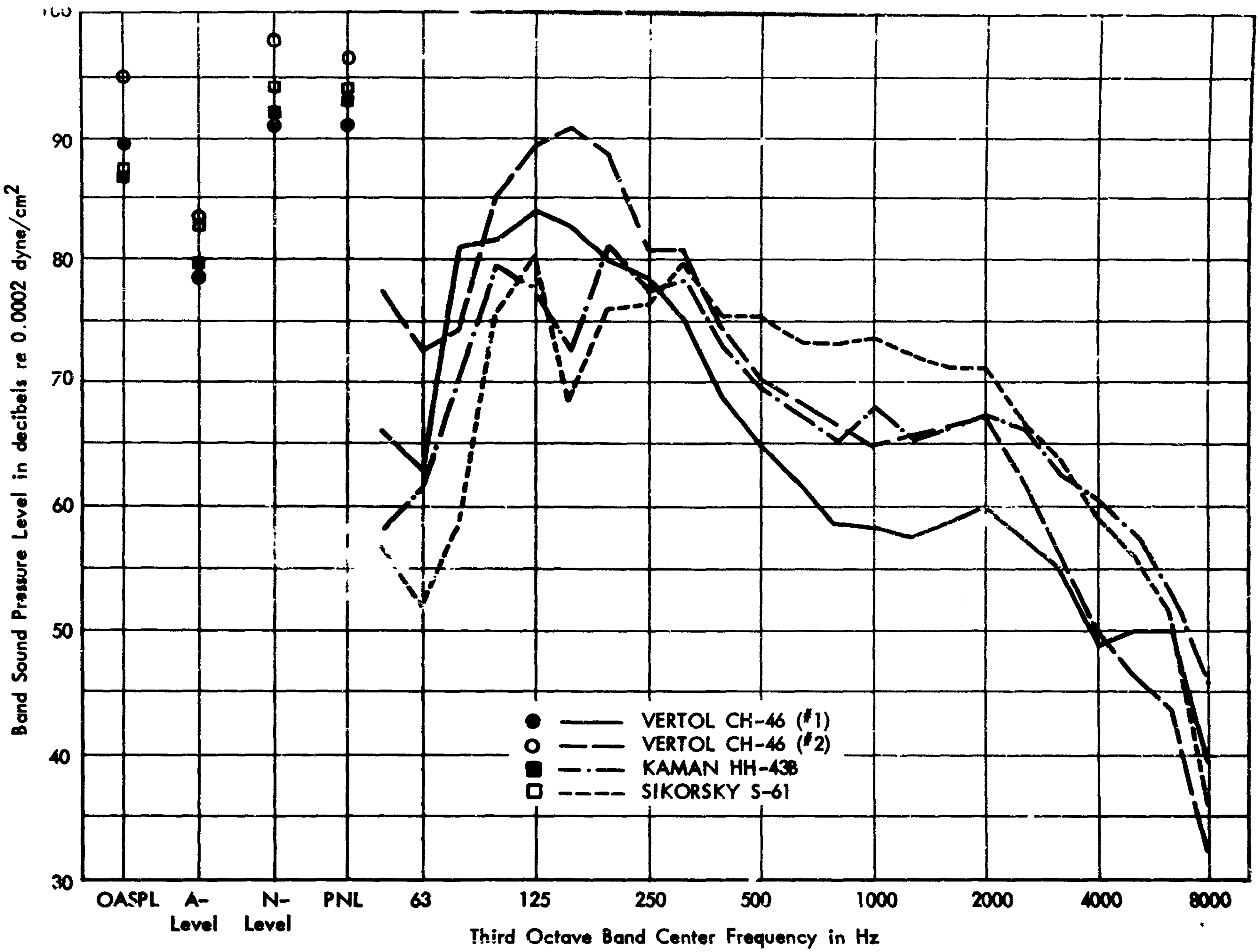


FIGURE 3 COMPARISON SOUND STIMULI FOR HELICOPTER JUDGMENT TESTS

The levels of the stimuli shown in Figs. 2 and 3 are average levels of the comparison sounds used in the method of paired comparison described later in the report. The stimuli were actually presented at levels of +6, +2, -2, and -6 dB, relative to the sound pressure levels shown in the figures.

Two typical time histories of the helicopter flyover noise samples are shown in Fig. 4. The strong modulation shown for the Vertol CH-46 helicopter noise in this figure is caused by the prominent blade slap present in the recorded sample.

C. Equipment

A Zenith 110-T audiometer was used for the audiometric screening of the subjects. A block diagram of the equipment used in the presentation of the test stimuli to the subjects is shown in Fig. 5. The equipment consisted of an Ampex AG-350 tape recorder, a Daven attenuator, and an Altec Lansing 165-watt power amplifier. A power attenuator, placed between the amplifier and loudspeaker, was constructed to reduce the output of the amplifier in 10-dB steps to provide an increased signal-to-noise ratio.

The loudspeaker system consisted of an Altec Lansing 515-B low-frequency unit coupled with an Altec Lansing 288-C driver with a 311-90 horn. The speaker for the voice channel was a small utility 6-in. loudspeaker driven by a Heathkit 15-watt amplifier. An electronic switch with a 100-millisecond rise-decay time was employed to reduce any audible transients in the re-recording process during the preparing of the master test tape.

Measurements of the sound stimuli presented to the subjects were made at the subject's ear position (without the subject present) for each seat location. These measurements were made with a Bruel and Kjaer 4133 1/2-in. microphone, a Bruel and Kjaer 2630 battery-operated cathode follower, a Bruel and Kjaer 2203 sound level meter, and a Kudelski Nagra III-B tape recorder. The original field recordings of the helicopter and jet transport flyover noise were made using the same measuring instrumentation. The one-third octave band analyses of the sound samples were made with a Bruel and Kjaer 2112 spectrometer and Bruel and Kjaer 2105 graphic level recorder.

D. Procedure

The judgment tests were conducted in an anechoic chamber 8' x 10' x 7.5' high, located at the Bolt Beranek and Newman facilities in Van Nuys, California. Two methods were employed

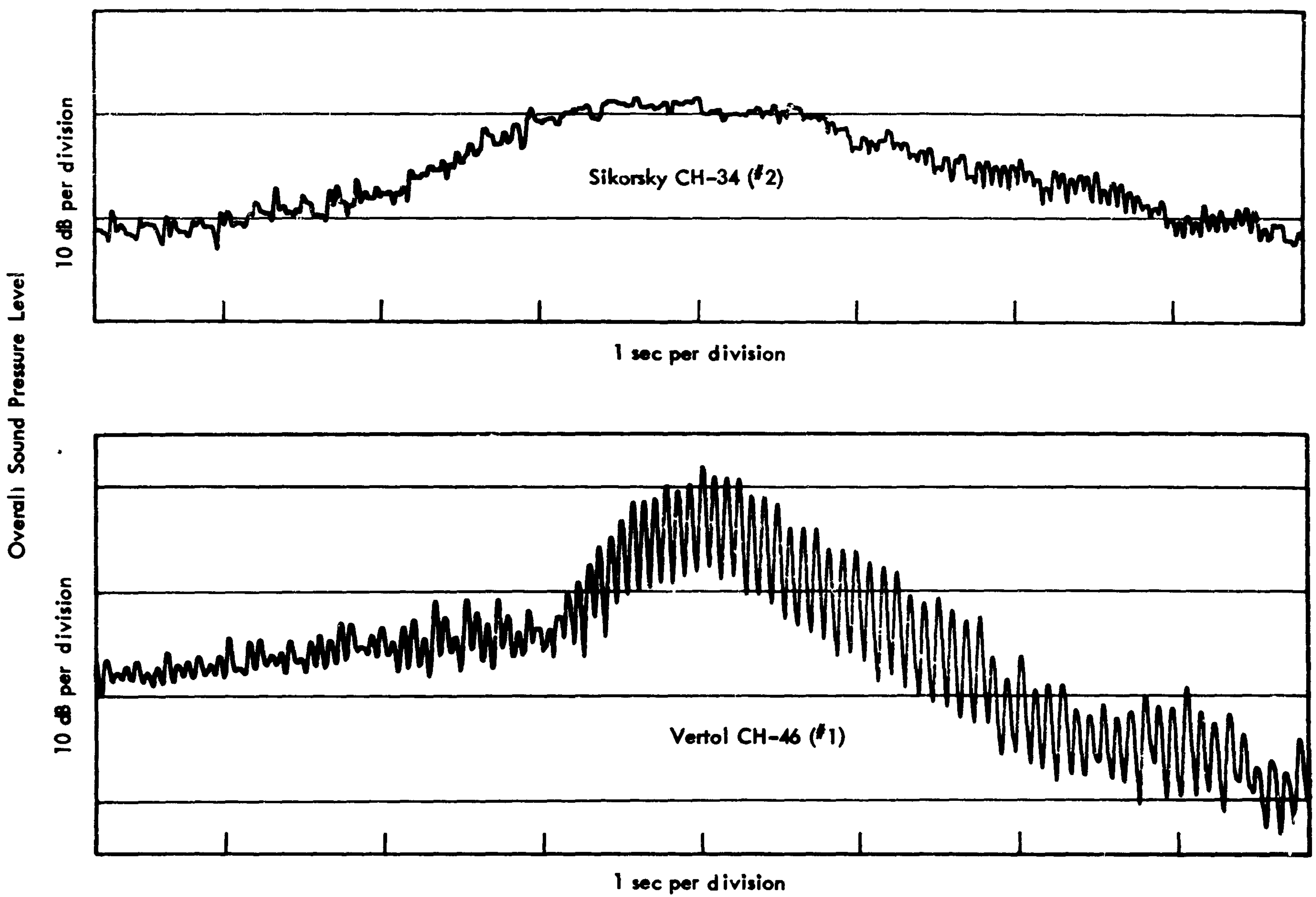
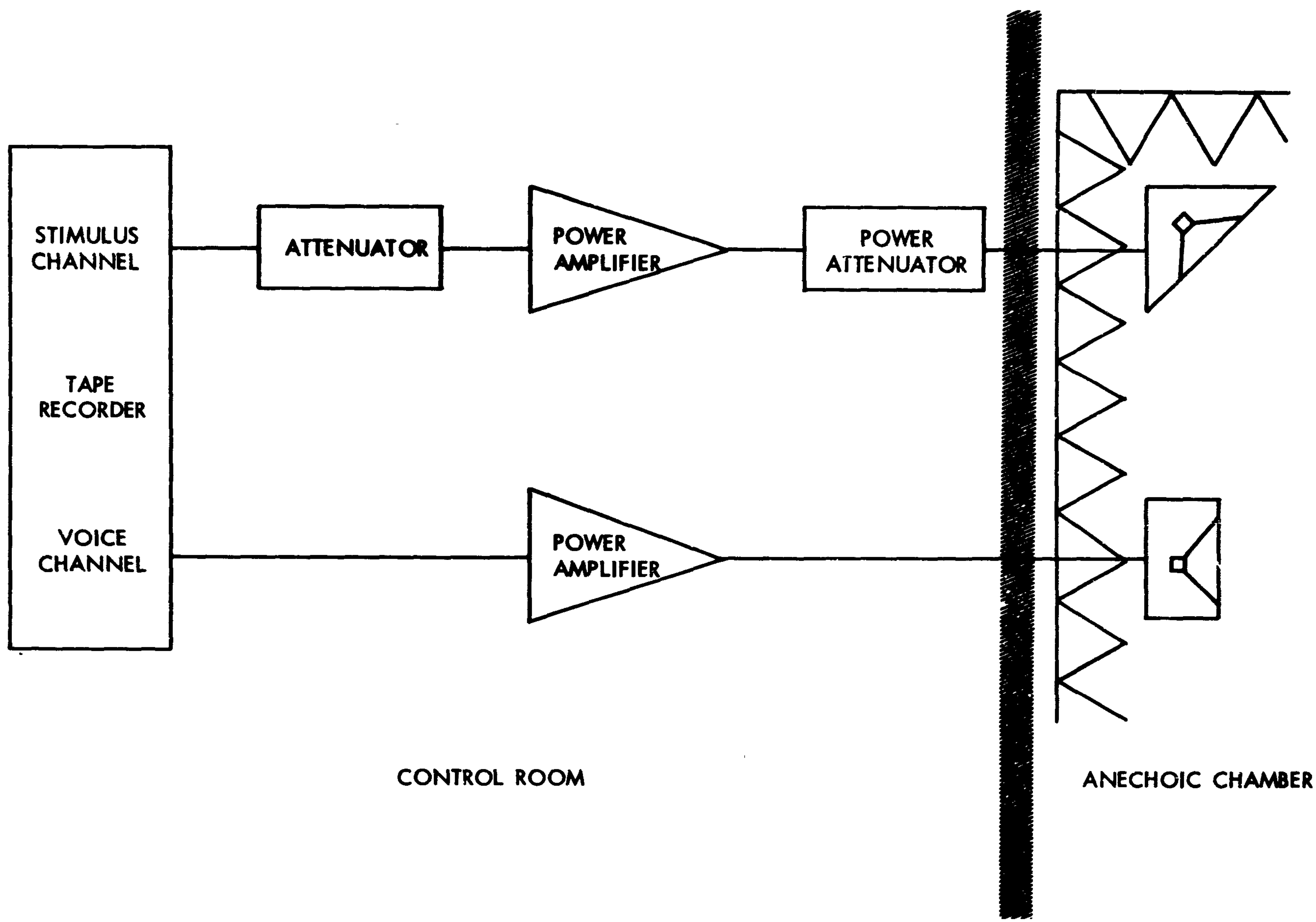


FIGURE 4. TIME HISTORIES OF TWO HELICOPTER NOISE SAMPLES


STIMULUS
CHANNEL
TAPE
RECORDER
VOICE
CHANNEL
ATTENUATOR
POWER
AMPLIFIER
POWER
ATTENUATOR
POWER
AMPLIFIER
CONTROL ROOM
ANECHOIC CHAMBER

during the series of judgment tests: the method of adjustment and the method of paired comparison.

The method of adjustment was used in preliminary tests to obtain levels for the more detailed paired-comparison tests. In the method of adjustment, subjects were asked to adjust the level of a comparison sound until they judged that it was just as noisy or disturbing as the standard sound. The actual instructions for this test are given in Appendix A.

For the paired-comparison method, a tape was prepared for presenting the sound samples to the subjects. In preparing the tape, the sound samples were paired using both A-B and B-A orders to eliminate any time-error bias occasioned by the order in which the signals were presented. The test pairs were then randomized using a random number table and recorded on magnetic tape. During presentation of the paired-comparison tape, the subjects were asked to choose which of the two sound stimuli was the noisier and to respond by punching the appropriate positions on an IBM port-a-punch card. The actual instructions and a typical answer card are given in Appendix A.

A plan view of the seating arrangement is shown in Fig. 6. With this arrangement three to six subjects were tested at one time until the entire group of 21 subjects completed four 45-min. test sessions. To avoid the possible effect of fatigue, the 45-min. test sessions were conducted on separate days. A total of 132 sample pairs were tested.

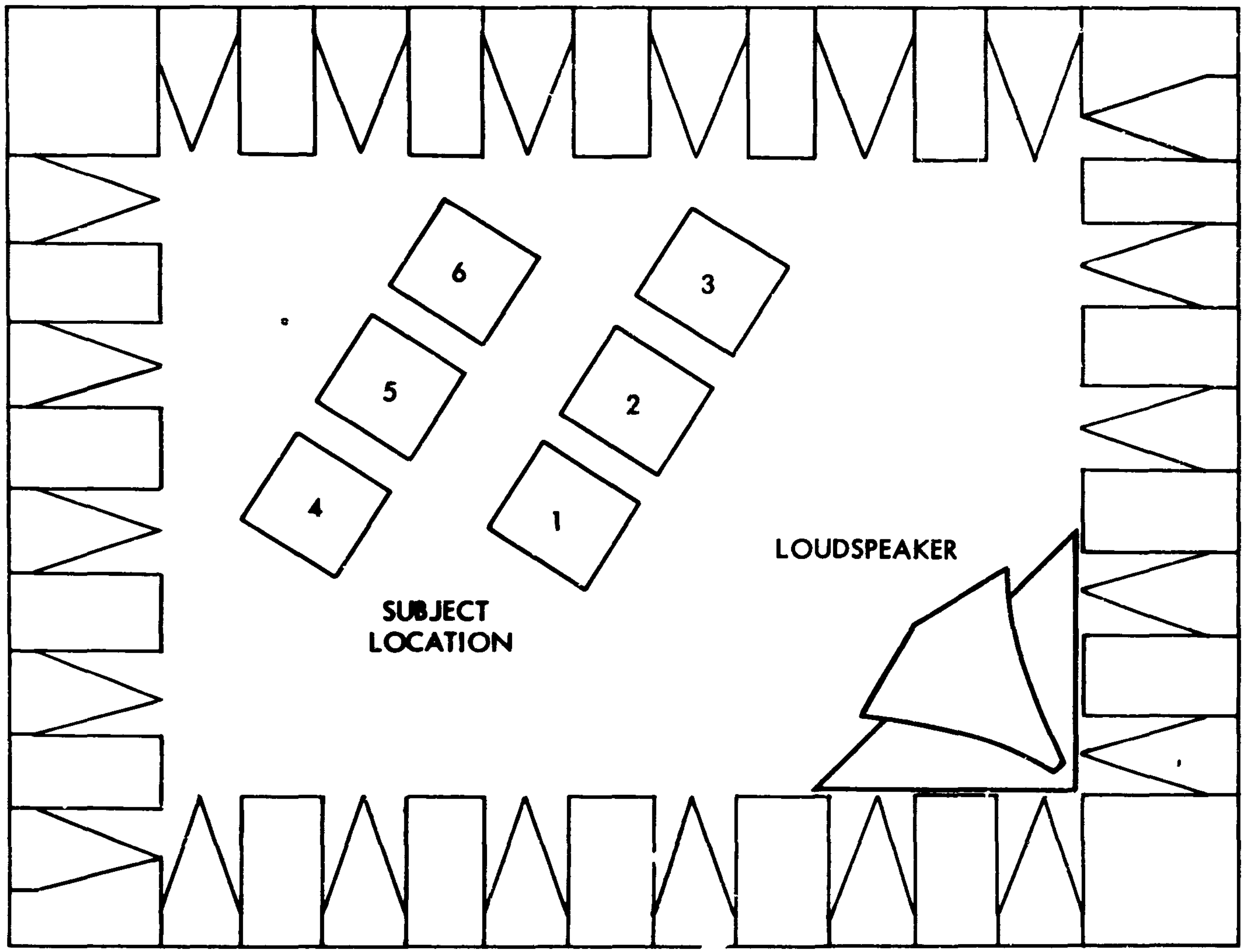


FIGURE 4. PLAN VIEW OF

III. JUDGMENT TEST RESULTS

The subjects' responses, recorded on IBM cards, were entered into a digital computer for sorting and analysis. A computer-generated display of typical results is shown in Fig. 7. The standard in this case was a DC-8 flyover; the comparison, a Sikorsky S-61 flyover. The dashed line represents the results obtained when the standard stimulus was presented first. The solid line represents the results obtained when the comparison stimulus was presented first.

We considered that the two sounds were equally noisy or acceptable when 50% of the subjects stated that one sound was noisier than the other. Since this level of equal noisiness should be independent of the order of presentation of the stimuli, we averaged the two values at the 50% point obtained from the two different orders of presentation. For the data shown in Fig. 7, this averaged 50% level is 86.4 dB (i.e., an average of 83.5 dB and 89.3 dB).

To provide an idea of the spread of the judgments, the results shown in Fig. 7 are plotted on probability paper in Fig. 8. The results of this plot indicate that for the case when the standard is presented first, the standard deviation is 3.4 dB, and when the comparison is presented first, the standard deviation is 4.9 dB. The standard deviations for all stimulus pairs ranged from 2.5 to 9 dB with an average of 5.4 dB. This compares closely with the standard deviation of 5 dB obtained in a related British study (Ref. 3).

It is interesting to note that the values for equal noisiness at the 50% points determined using probability paper (Fig. 8), are quite comparable to those obtained with linear paper (Fig. 7 In comparing all of the results obtained using the computer's graphical output with those obtained using probability paper, the average difference is only 0.5 dB with a standard deviation of 1 dB.

Tabulations of the mean levels of the helicopter stimuli judged equally noisy to the two standards employed in the test are given in Tables II and III. The two tables also show the mean differences in levels between the helicopter signals and the standards in terms of the overall sound pressure levels, A- and N-weighted levels, calculated perceived noise levels, and the calculated perceived noise levels adjusted for signal duration and discrete frequency content. Signal duration corrections were determined for both 10-dB- and 20-dB-down duration times. The differences are also plotted in Figs. 9 and 10.

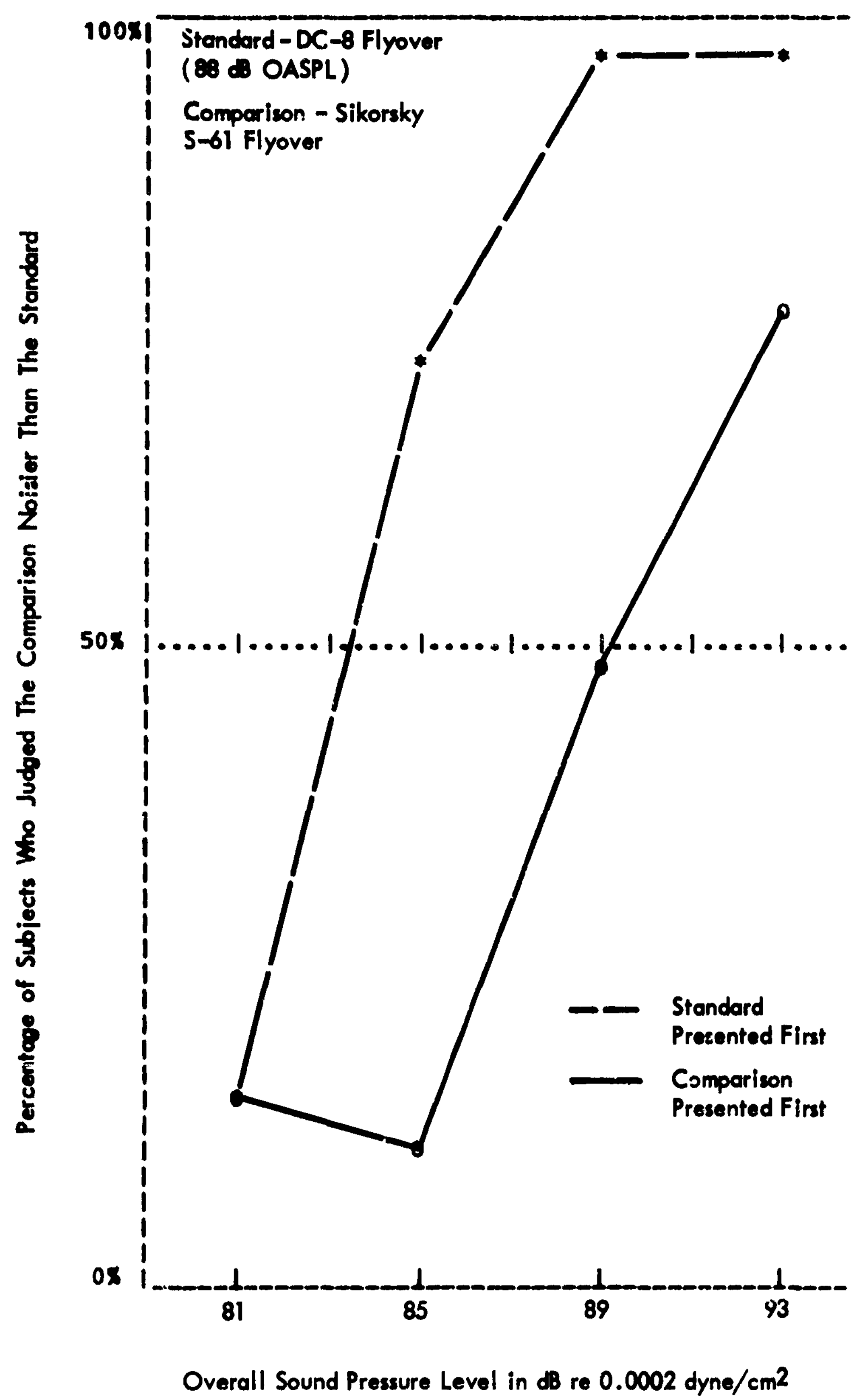


FIGURE 7. AMPLE OF RESULTS OF HELICOPTER JUDGMEI

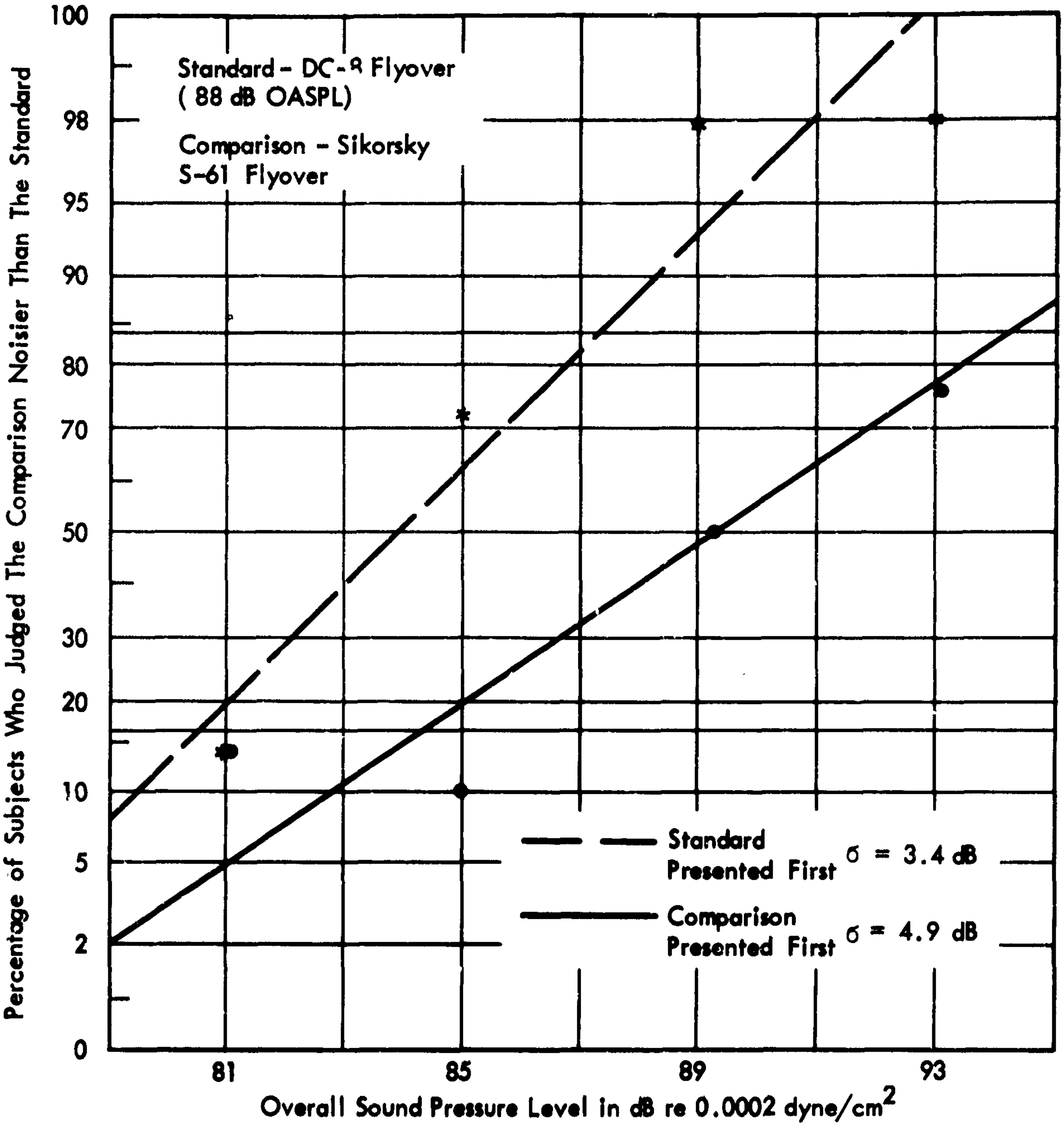


FIGURE 8. SAMPLE OF RESULTS OF HELICOPTER JUDGMENT TESTS PLOTTED ON NORMAL PROBABILITY PAPER

TABLE II

HELICOPTER PAIRED-COMPARISON JUDGMENT TESTS

Standard

Simulated Jet Flyover Noise

OASPL = 87 dB re 0.0002 $dynes/cm^2$
A-Level = 81.5 dB re 0.0002 $dynes/cm^2$
N-Level = 93 dB re 0.0002 $dynes/cm^2$
Calculated PNL = 93 PNdB

Helicopter Type	Comparison Level*				Comparison Level Minus Standard Level					
	OASPL (dB)	A-Level (dB)	N-Level (dB)	PNL (PNdB)	OASPL (dB)	A-Level (dB)	N-Level (dB)	PNL (PNdB)	PNL** (PNdB)	PNL*** (PNdB)
Hughes 269A(#1)	34.4	78.1	90.4	91.2	-2.6	-3.4	-2.6	-1.8	-5.3	-2.8
Hughes 269A(#2)	86.8	80.3	92.3	93.4	-0.2	-1.2	-0.7	0.4	0.3	0.6
Kaman HH-43B	87.5	79.4	92.0	92.8	0.5	-2.1	-1.0	-0.2	-5.8	-6.3
Sikorsky S-61	87.0	82.3	93.6	93.7	0.0	0.8	0.6	0.7	-1.4	-1.8
Sikorsky CH-34(#1)	88.5	80.3	92.8	92.8	1.5	-1.2	-0.2	-0.2	-1.3	-1.3
Sikorsky CH-34(#2)	84.6	77.9	90.3	90.5	-2.4	-3.6	-2.7	-2.5	-8.6	-5.8
Vertol CH-46(#1)	93.8	81.1	95.2	94.9	6.8	-0.4	2.2	1.9	-8.9	-4.2
Vertol CH-46(#2)	94.2	82.3	96.2	95.8	7.2	0.8	3.2	2.8	-4.2	0.2
	Standard Deviation				3.8	1.7	2.1	1.8	3.4	2.6
	Mean Difference				1.4	-1.3	-0.2	0.1	-4.4	-2.7

* Level of comparison stimulus judged equally noisy to standard stimulus.

** Includes duration (10-dB-down) and pure-tone adjustments (Refs. 6,7).

*** Includes duration (20-dB-down) and pure-tone adjustments (Refs. 6,7).

TABLE III

HELICOPTER PAIRED-COMPARISON JUDGMENT TESTS

Standard

DC-8:30 Jet Flyover Noise

OASPL = 88 dB re 0 0002 dynes/cm^2
A-Level = 81.5 dB re 0.0002 dynes/cm^2
N-Level = 93 dB re 0.0002 dynes/cm^2
Calculated PNL = 93 PNdB

Helicopter Type	Comparison Level*				Comparison Level Minus Standard Level					
	OASPL (dB)	A-Level (dB)	N-Level (dB)	PNL (PNdB)	OASPL (dB)	A-Level (dB)	N-Level (dB)	PNL (PNdB)	PNL** (PNdB)	PNL*** (PNdB)
Hughes 269A(#1)	82.3	76.2	88.2	89.1	-5.7	-5.3	-4.8	-3.9	-6.9	-4.1
Hughes 269A(#2)	85.5	79.2	90.9	92.1	-2.5	-2.3	-2.1	-0.9	-0.5	0.1
Kaman HH-43B	87.1	79.2	91.5	92.4	-0.9	-2.3	-1.5	-0.6	-5.7	-5.9
Sikorsky S-61	86.4	81.9	92.9	93.1	-1.6	0.4	-0.1	0.1	-1.5	-1.6
Sikorsky CH-34(#1)	85.8	77.8	90.0	90.1	-2.2	-3.7	-3.0	-2.9	-3.5	-3.2
Sikorsky CH-34(#2)	81.8	75.3	87.4	87.7	-6.2	-6.2	-5.6	-5.3	-10.9	-7.8
Vertol CH-46(#1)	90.5	78.0	91.8	91.6	2.5	-3.5	-1.2	-1.4	-11.7	-6.7
Vertol CH-46(#2)	95.3	83.6	97.2	96.9	7.3	2.1	4.2	3.9	-2.6	2.1
			Standard Deviation		4.4	2.8	3.0	2.8	4.2	3.4
			Mean Difference		-1.2	-2.6	-1.8	-1.4	-5.4	-3.4

* Level of comparison stimulus judged equally noisy to standard stimulus.

** Includes duration (10-dB-down) and pure-tone adjustments (Refs. 6,7).

*** Includes duration (20-dB-down) and pure-tone adjustments (Refs. 6,7).

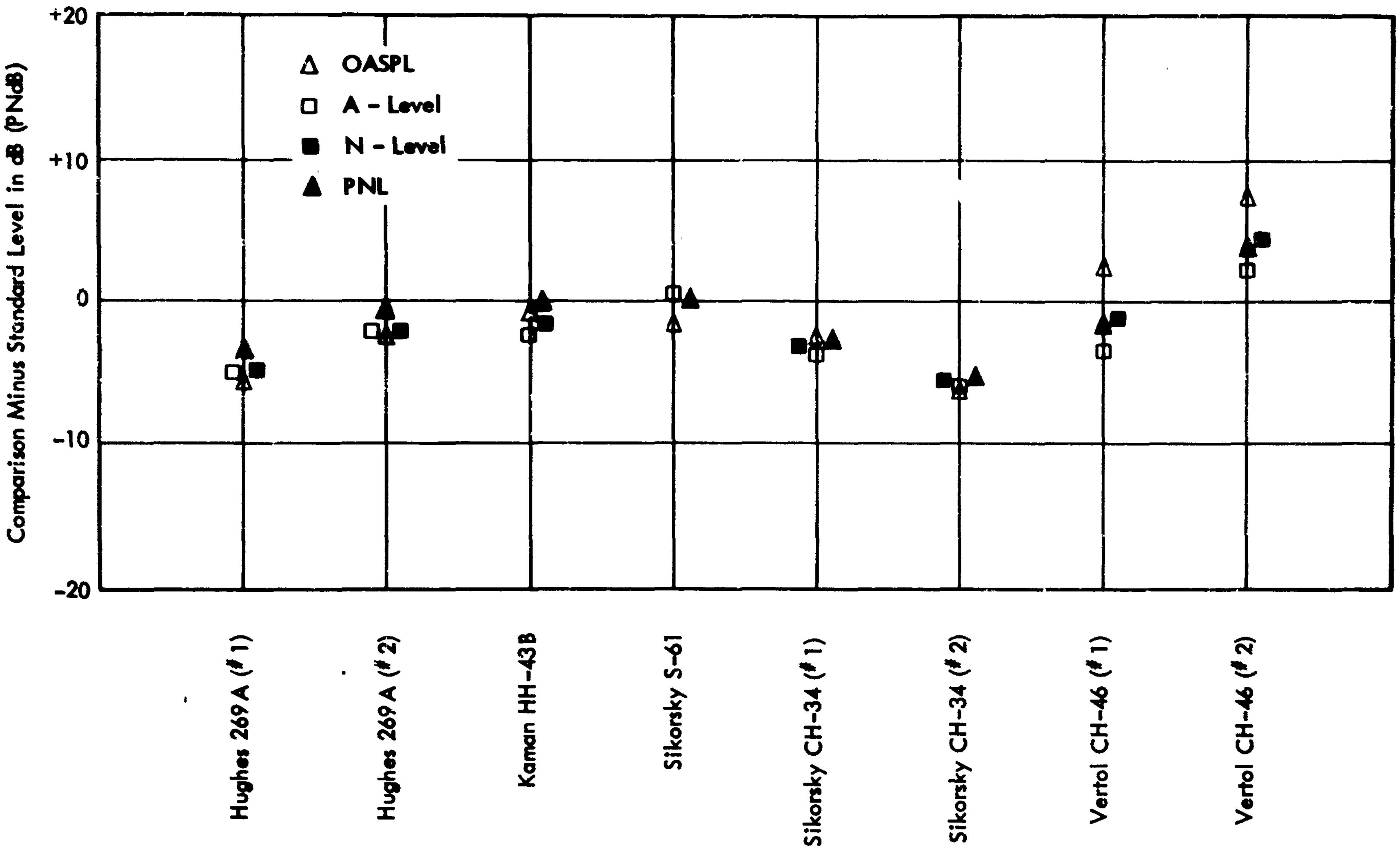


FIGURE 9. EQUAL NOISINESS JUDGMENTS OF HELICOPTER FLYOVERS IN TERMS OF OASPL, A-LEVEL, N-LEVEL, PNL USING A DC-8:30

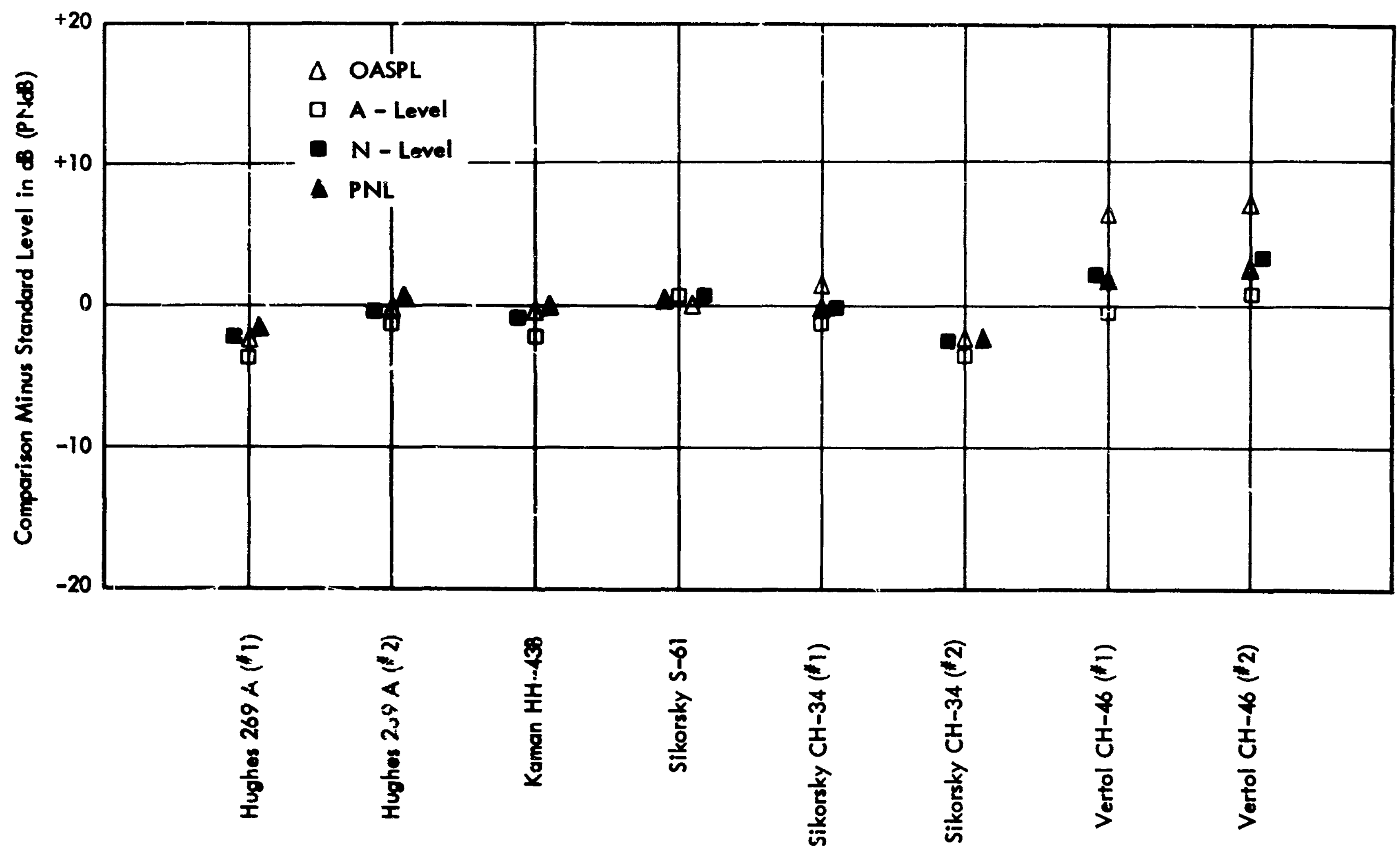


FIGURE 10. EQUAL NOISINESS JUDGMENTS OF HELICOPTER FLYOVERS IN TERMS OF OASPL, A-LEVEL, N-LEVEL, PNL USING SIMULATED JET FLYOVER AS A STANDARD

If the measures of the standard and comparison noise stimuli were identical (differences were zero) when the two samples were judged to be equally noisy, then these measures would be perfect predictors of the judgment results for the pair of sounds.

Further, if the objective measures of noise were perfect estimates of subjective judgments, and if experimental errors and subject variability were nil, both the mean values and the standard deviations of the differences would approach zero. Assuming the variability introduced by experimental errors and subject differences is independent of the sound measure, the measure showing first the smallest standard deviation and then the smallest mean difference would be the best predictor. Obviously, a measure with a small mean difference between comparison and standard levels accompanied by a large standard deviation is not an accurate predictor.

From the standard deviations and means in Tables II and III, it appears that all measures tested predict the noisiness of helicopters fairly well with PNL being the most accurate, followed closely by N-level and A-level and finally OASPL. The standard deviations for the PNL and A- and N-level differences are comparable and are less than those for the OASPL differences shown in Tables II and III. Further, the mean difference of PNL is less than that for the A-level difference. This difference is only significant, however, at the 90% level of confidence using the students' t-test (Ref. 4) for the simulated jet flyover standard. In comparing the results tabulated in Tables II and III, we note that the mean differences and standard deviations of Table II are always less than those for Table III. This is probably due to the more complex nature of the DC-8:30 jet flyover (standard for Table III) compared to the simulated jet flyover (standard for Table II).

In order to check the possible differences in judged noisiness between the two standards, we first note the level of both standards relative to that of a comparison sample; then, we take the difference in these relative levels. The mean and standard deviation of the eight differences (one for each comparison) for the four objective measures are shown in Table IV. As expected, the standard deviations are all the same (1.5 dB) since they represent the same variation around different means. The mean differences are significantly smaller at the 90% level of confidence for A- and N-level and calculated PNL than for OASPL. In other words, if judgments had been made comparing the noisiness of the two standards, PNL and A- and N-level would have been more accurate in predicting the noisiness than OASPL.

TABLE IV

AVERAGE DIFFERENCES BETWEEN STANDARDS*

	Level (Simulated Jet Flyover) Minus Level (DC-8:30)			
	OASPL (dB)	A-Level (dB)	N-Level (dB)	PNL (PNdB)
Standard Deviation	1.5	1.5	1.5	1.5
Mean Difference	2.5	1.3	1.6	1.5

* The differences were determined by taking differences between each standard judged equally noisy to one comparison sound.

These conclusions are in agreement with those of some British investigations. One study (Ref. 5) found PNdB preferable to OASPL as the measure of the noisiness of simulated rotor noise of helicopters. Another study in England (Ref. 3) using 4-sec. samples of recorded helicopter noise, found that the various objective measures ranked in their accuracy for predicting the noisiness of helicopter flyovers as follows: loudness level (Zwicker), PNL, A-level, loudness level (Stevens), and OASPL, with OASPL being the least accurate predictor.

Recent studies (Refs. 6 and 7) suggest additional adjustments for duration and pure-tone content to increase the accuracy of the calculated perceived noise level. The results of applying these adjustments are indicated in the last two columns of Tables II and III. The time duration adjustments were made relative to the duration of the standard.

The pure-tone adjustment changes the results very little, since the pure-tone content of most of the samples was quite small. However, the duration adjustment affects the results quite markedly. As shown in the next to the last column of Tables II and III, this duration adjustment for durations measured 10 dB down from the maximum level increases the calculated difference between the standard and comparison perceived noise level when they are judged to be equally noisy. The duration adjustment also increases the standard deviation of the difference to values comparable to those for the OASPL. A possible explanation for this increased error may involve the shape of the time history for the flyover samples under test. If we look at the time history for one of the helicopter flyovers shown in Fig. 11, we note that the helicopter time history is quite different in shape from the jet aircraft flyover noise time history also shown in the figure. The jet aircraft flyover noise level increases at a near uniform rate to a maximum level and decays at about the same rate. The noise level of the helicopter flyover time pattern on the other hand, appears to increase at two different rates. It increases at one rate then abruptly changes to another until it reaches the maximum level. During the decay portion, the process is reversed.

The choice of the 10-dB-down points as a measure of duration was not critical during early tests of the development of the duration adjustment (Ref. 7), since the stimuli possessed regular time patterns and could be represented by durations measured at 10 or 20 dB down from the maximum level. However, since the 10-dB-down duration for the helicopter flyover

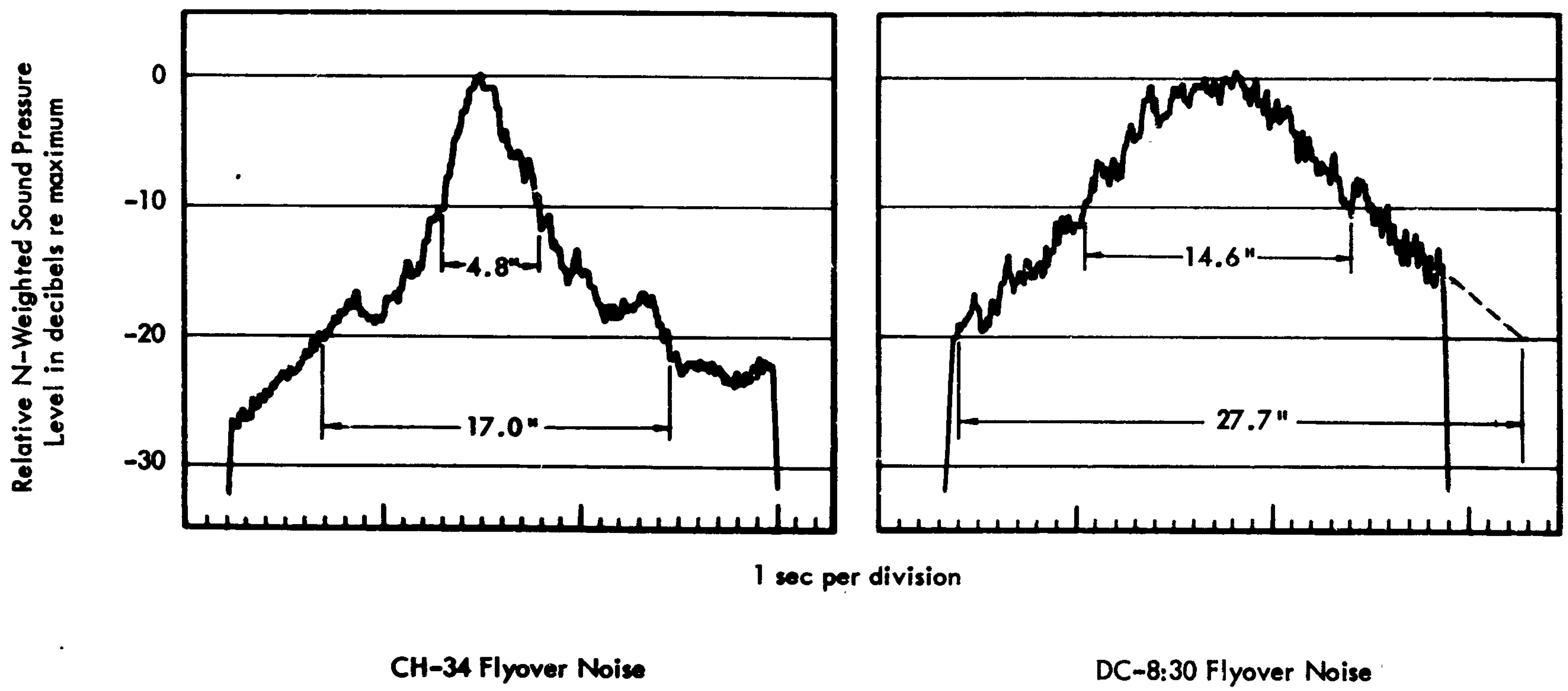


FIGURE 11. TIME HISTORIES OF TWO SOUND SAMPLES

samples may not be representative of the time history, the 20-dB-down points were tried in an effort to determine a better measure of the subjected assessment of the helicopter flyover noise samples.

Since the duration adjustment is given only as a function of the 10-dB-down duration, the measured duration was converted to a 10-dB-down duration by assuming a triangular shaped time history. With this assumption, the 20-dB-down duration was converted to a 10-dB-down duration by dividing it by two.

The results shown in the final column of Tables II and III and Figs. 12 and 13 indicate that this 20-dB-down duration adjustment provides some improvement over the 10-dB-down adjustment. However, based upon size of the standard deviation, the adjusted PNL is still not as accurate as the PNL without duration and pure-tone adjustment.

This suggests that more basic work might be carried out involving additivity of spectral content and duration factors in calculating perceived noise level. This research would include development of better measures of time duration insofar as they relate to noisiness assessments.

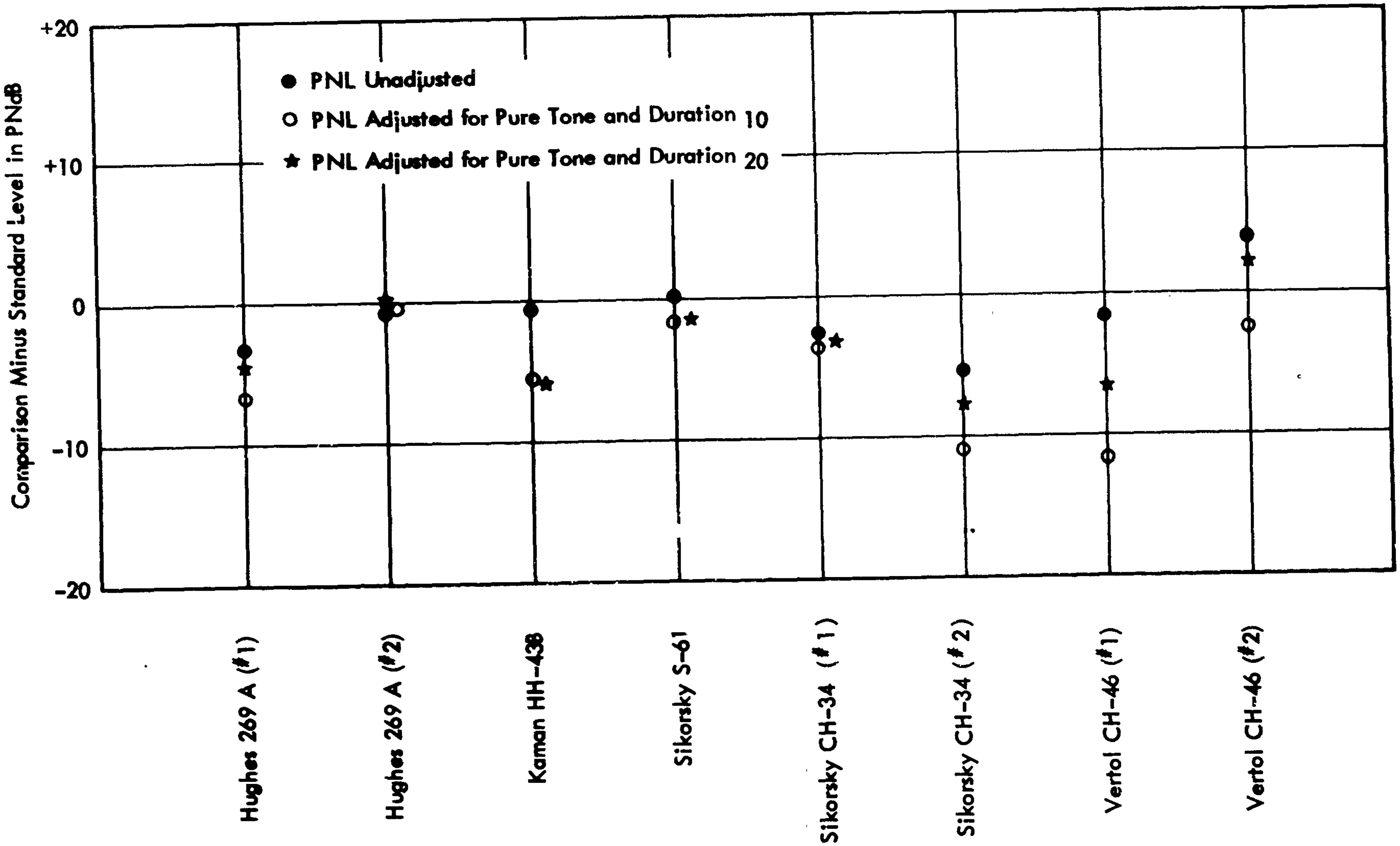


FIGURE 12. EQUAL NOISINESS JUDGMENTS OF HELICOPTER FLYOVERS IN TERMS OF PNL USING A DC-8:30 FLYOVER AS A STANDARD

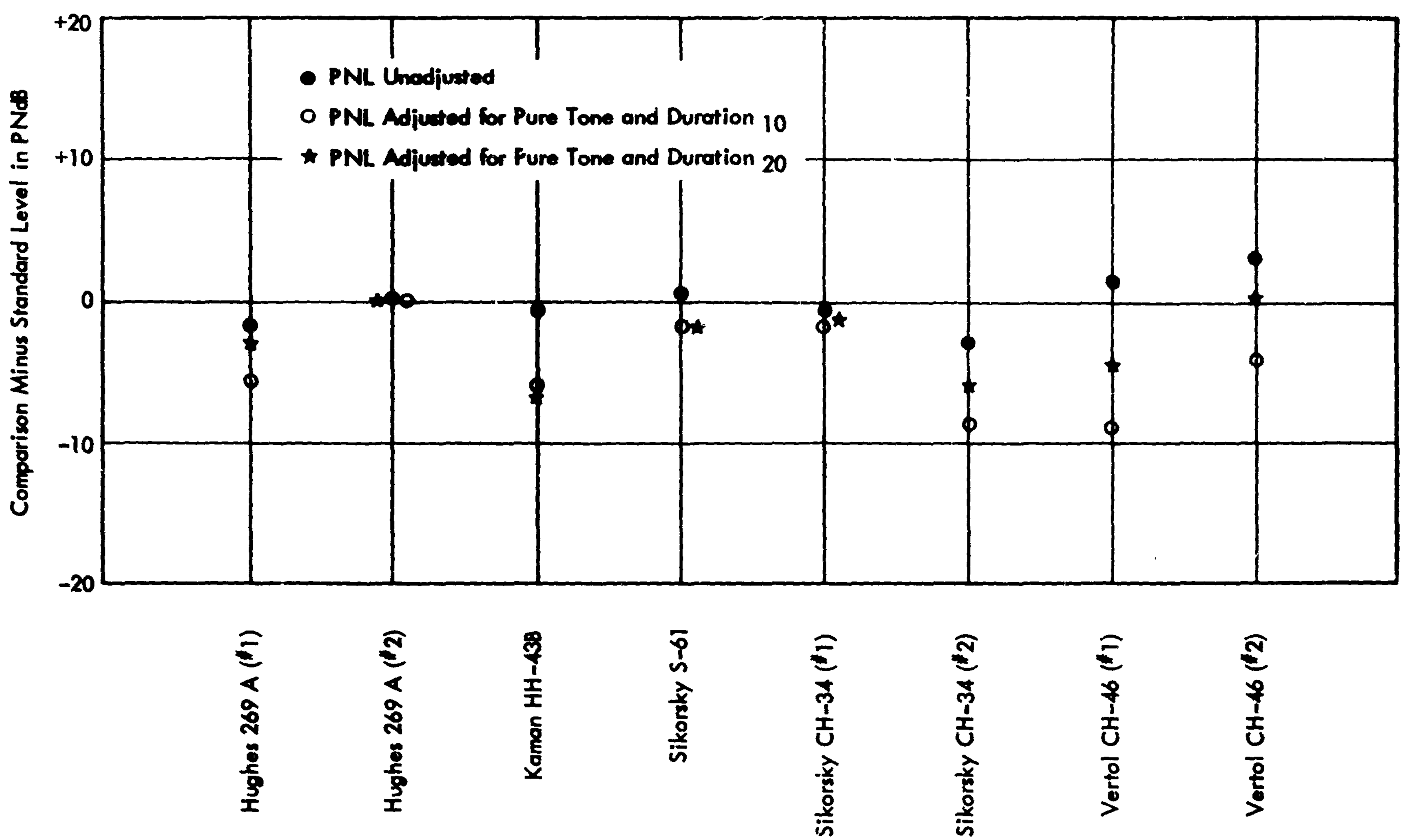


FIGURE 13. EQUAL NOISINESS JUDGMENTS OF HELICOPTER FLYOVERS IN TERMS OF PNL USING A SIMULATED JET FLYOVER [illegible]

IV. CONCLUSIONS

As a result of investigations carried out under this contract, the following conclusions were reached:

1) As a predictor of the noisiness of helicopter flyovers, the calculated perceived noise level provides the most accurate measure of the four objective measures included in this investigation. The N-level and A-level, although slightly less accurate, were also reasonable predictors, followed finally by the overall SPL.

2) Duration and pure-tone corrections did not improve the predictability of the noisiness of the helicopter flyover noise samples under test, possibly due to inadequate duration measures or a factor in the additivity of the duration adjustment not previously tested.

REFERENCES

1. International Standards Organization, "Standard Reference Zero for the Calibration of Pure-Tone Audiometers," ISO Recommendation R-389.

2. D. E. Bishop, Federal Aviation Agency SRDS Report No. RD-65-130, Part II, December 1965.

3. D. W. Robinson, J. M. Bowsher, "A Subjective Experiment with Helicopter Noises," J. Roy. Aeron. Soc. 65, 635-637 September 1961.

4. W. J. Dixon, F. J. Massey, Jr., Introduction to Statistical Analysis, McGraw-Hill Book Company, Inc., New York, 1951.

5. G. W. Crosse, I. M. Davidson, T. J. Hargest, M. J. Porter, "A Controlled Experiment on the Perception of Helicopter Rotor Noise," J. Roy. Aeron. Soc. 64, 629-632, October 1960.

6. K. D. Kryter, K. S. Pearsons, "Judged Noisiness of a Band of Random Noise Containing an Audible Pure Tone," J. Accust. Soc. Am. 38, 106-112, 1965.

7. K. S. Pearsons, "The Effects of Duration and Background Noise Level on Perceived Noisiness," Tech. Report FAA-ADS-78, April 1966

APPENDIX A

Instructions for Judgment Tests

INSTRUCTIONS

Judgments of Noisiness [Method of Adjustment]

The purpose of these tests is to determine the relative noisiness of various sounds.

When you move the control switch to "standard" the light will glow and you will hear a noise; this noise will repeat itself over and over until you move the switch. When you move the switch to "comparison" you will then hear a different noise. The overall intensity of the comparison noise may be controlled by turning the knob on the "level control."

Your job is to listen first to the standard noise, then to listen to the comparison noise, and then to adjust the intensity of the comparison noise until it sounds as noisy to you as the standard. By equally noisy, we mean that you would just as soon have one as the other in or outside your home periodically 20 to 30 times during the day and night. Stated another way, we mean by equally noisy that the comparison noise would be no more nor no less disturbing to you in or outside your home than the standard noise.

You may turn back and forth between the two noises as often as you wish and listen to each as long as you wish. It is suggested that before you proceed to equate the comparison noise to the standard noise you make the comparison noise much more intense than the standard; then make the comparison noise much less intense than the standard. With those limits established, adjust the intensity of the comparison noise until it would be just as noisy as the standard noise in or outside your home.

You will notice that you can switch from the standard to comparison and vice versa only during the brief pause that exists between the end and the beginning of each noise. When you feel the two noises are equally noisy, press the "finished" button and turn the switch to comparison. Leave the switch in the comparison position until the light goes out. Then switch to the neutral position. Proceed with the next judgment when the standard light goes on.

INSTRUCTIONS

Judgments of Noisiness [Method of Paired Comparison]

The purpose of these tests is to determine the relative noisiness of different sounds. The tests are part of a program of research designed to obtain information that will be of aid in the planning of military and civilian airports and for noise control purposes in general.

When the tests start, you will hear a number followed by two noises presented in quick succession. The number represents a pair of sounds. Your job is to punch a hole in Column 1 or 2 corresponding to the noise (the first or second) which you feel is noisier or more objectionable. Please make a judgment for each pair of noises, even though you feel you may be guessing.

In making this judgment, assume that the noise would occur at your home 20 to 30 times during the day and night. Please remember to include in your judgment the total effect of the sound which may include intensity level, duration, and type of sound, rather than maximum intensity level alone.

Please write on the back of your answer card your name, age, occupation, sex, seat number, and the date. Please remember to use the same seat location each time you take the test.

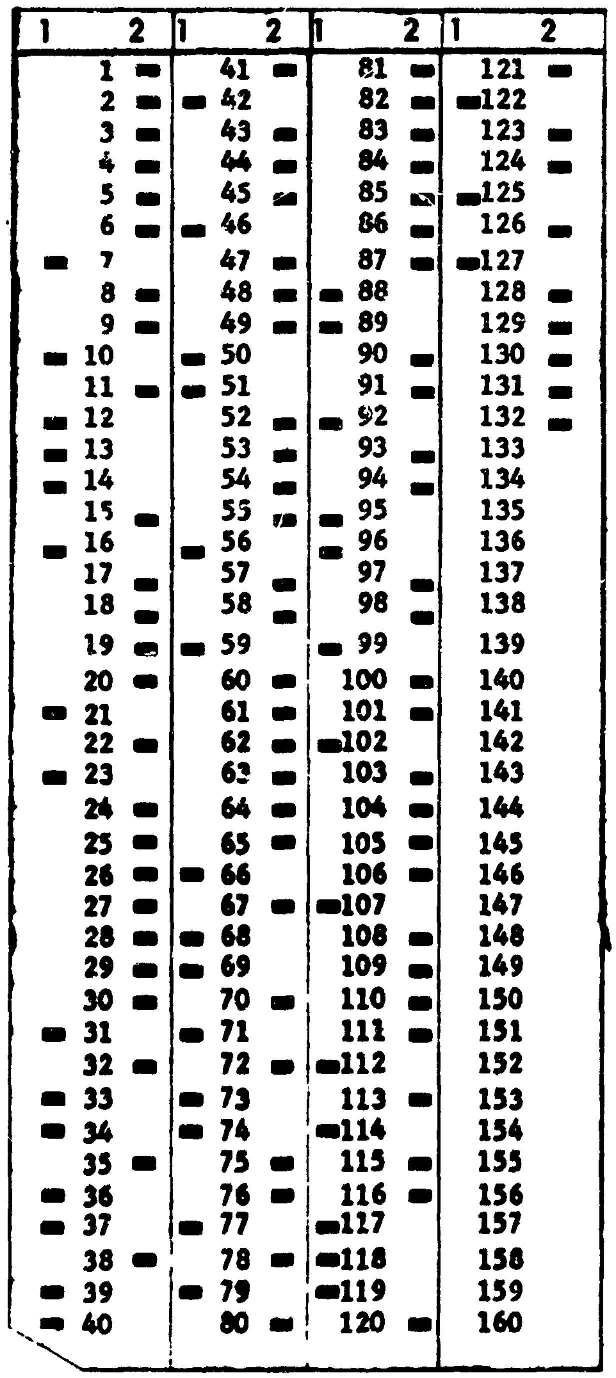


FIGURE A-1. SUBJECT'S ANSWER CARD