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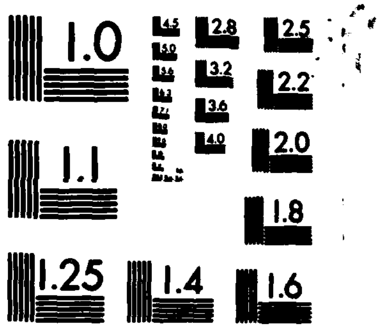

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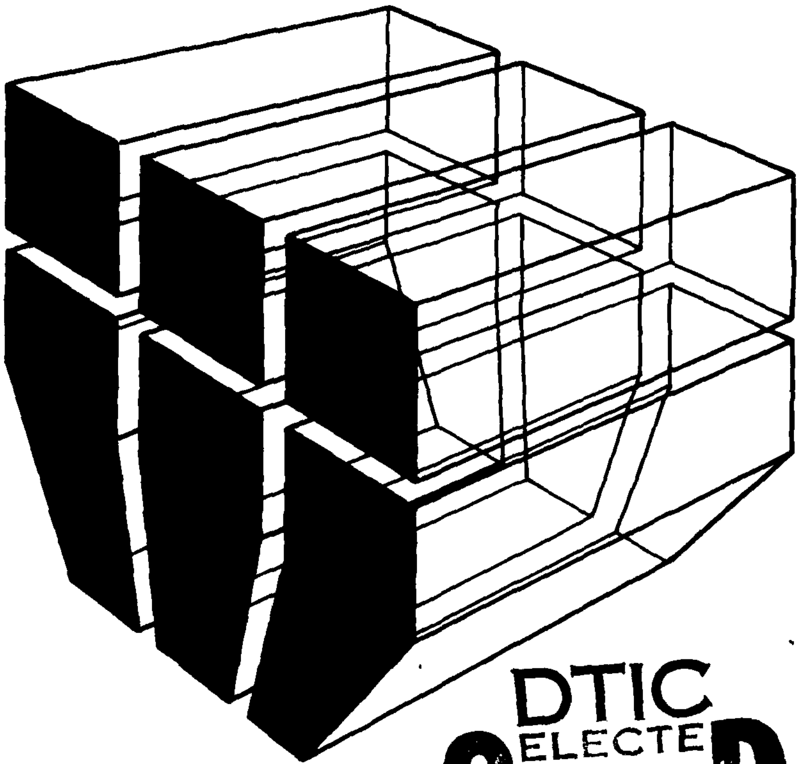
TECHNICAL REPORT N-184
September 1984
Noise Source Emissions Characterization and Measurement Standardization

ROTARY-WING AIRCRAFT NOISE MEASUREMENTS: ANALYSIS OF VARIATIONS AND PROPOSED MEASUREMENT STANDARD

by
Paul D. Schomer



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Army Installation Compatible Use Zone (ICUZ) Program seeks to safeguard Army Installation operational capability. As part of ICUZ, helicopter noise is assessed using a computerized model developed by the U.S. Air Force and modified by the U.S. Army Construction Engineering Research Laboratory (USA-CERL) for rotary-wing aircraft use. Helicopter source emissions data are required as input to this model. This report explores the statistical variations in helicopter source emissions characterization and recommends a draft measurement standard designed to minimize the effects of these variations.

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FOREWORD

This work was performed for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality Technology"; Technical Area A, "Installation Environmental Management Strategies"; Work Unit 011, "Noise Source Emissions Characterization and Measurement Standardization." The OCE Technical Monitor was Gordon Velasco, DAEN-ECE-I.

This study was done by the Environmental (EN) Division, U.S. Army Construction Engineering Research Laboratory (USA-CERL). Dr. R. K. Jain is Chief, EN.

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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ROTARY-WING AIRCRAFT NOISE MEASUREMENTS: ANALYSIS OF VARIATIONS AND PROPOSED MEASUREMENT STANDARD

1 INTRODUCTION

Background

On 20 May 1981, the Army instituted the Installation Compatible-Use Zone (ICUZ) Program.[1] Under ICUZ, Army installations work with local civilian communities to find ways to prevent or lessen the encroachment of off-installation housing and other noise-sensitive land uses into areas that may be impacted by Army training noise.[2]

Vital to the success of ICUZ is the Integrated Noise Contour System (INCS), a noise-prediction tool developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL). INCS assesses helicopter noise using a computerized model (NOISEMAP) developed by the U.S. Air Force for fixed-wing aircraft and modified by USA-CERL for use with Army rotary-wing aircraft. The NOISEMAP[3] computer program creates distance-scaled noise zone maps using data on the type, frequency, and time of flight operations. These maps, when overlaid on a map of an installation and its surroundings, identify existing or potential conflicts between noise levels produced by flight operations and noise-sensitive land uses on or near an installation. With NOISEMAP, maps also can be created that predict how changes in field operations, time of day, use intensity, and aircraft will alter an installation's noise-impact profile. The Army Environmental Hygiene Agency (AEHA) can make noise predictions for any Army installation using USA-CERL's modified NOISEMAP program.

One important data set needed for NOISEMAP is the individual noise emissions pattern associated with each type of rotary-wing aircraft in the Army inventory. These patterns form a standard module of data for the NOISEMAP prediction program. Source emission data were obtained during tests at Fort Rucker, AL, for most rotary-wing aircraft used routinely in Army training and operations.[4] Supplementary measurements were taken at Fort Campbell, KY, for two other aircraft the UH-60A (Blackhawk) and the CH-47C.[5]

Measurements at Forts Campbell and Rucker both included data on the UH-1H aircraft. For data collection, these measurements used essentially the same test plan and apparatus and were taken at the same time of year on flat, open terrain, and had similar weather conditions. The results for the UH-1H were 3.3 dB lower at Fort Campbell than at Fort Rucker.

Objectives

The objectives of this study were to (1) analyze helicopter sound exposure level (SEL) data variations with aircraft, location, and time, and (2) propose a standard measurement procedure for rotary-wing aircraft to accommodate or eliminate this observed variation.

Approach

Using essentially the same procedures and equipment as used at Forts Rucker and Campbell, many supplemental measurements were made on the UH-1H aircraft at the Decatur, IL Airport. These measurements were made with Illinois National Guard equipment at three separate times (about a month apart) and used several different aircraft and pilots. The measurements were taken to add to the statistical data base for the UH-1H aircraft in order to recommend a standard measurement procedure that would be robust enough to accommodate the statistical variation in measurements, and hopefully to learn the primary cause of the observed variation.

Mode of Technology Transfer

It is recommended that the proposed standard procedure be transmitted to DARCOM and other DOD and Federal agencies for their consideration, discussion, modification, and use.

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[1] *Installation Compatible Noise Use Zones* (Department of the Army, Office of the Adjutant General, 20 May 1981).

[2] Paul Schomer, "Noise Impact Prediction and Control," *Military Engineer*, Vol 74, No. 479 (April 1982).

[3] R. D. Horonjeff, R. R. Kandukuri, and N. H. Reddingius, *Community Noise Exposure Resulting From Aircraft Operation: Computer Program Description*, Air Force Report AMRL7R-73-109/ADA004821 (1974).

[4] B. Homans, L. Little, and P. Schomer, *Rotary-Wing Aircraft Operational Noise Data*, Technical Report N-38/ADA 051999 (USA-CERL, 1978).

[5] P. D. Schomer, A. Averbuch, and R. Raspet, *Operational Noise Data for UH-60A and CH-47C Army Helicopters*, Technical Report N-131/A118796 (USA-CERL, June 1982).

2 HELICOPTER DATA ANALYSIS

The rotary-wing measurements at Fort Rucker included level flyovers at 300 ft, ascents, descents, turns, takeoffs, and landings. Based on the original measurements and the variation found among operations, the later measurements at Fort Campbell included level flyovers at 300 and 1000 ft, takeoffs, and landings. Both measurements also included in-ground and out-of-ground effect hovers. For the UH-1H, the measurements at Fort Rucker were taken at an indicated air speed (IAS) of 80 knots. At Fort Campbell, a range of speeds (including 80 knots) was used.

Figure 1 shows the test equipment layout used at Forts Rucker and Campbell. Briefly, six microphones were connected by cables to the USA-CERL field acoustical measurement van. For part of each measurement set, the aircraft flew (in both directions) over the microphone array at 300 ft above ground level (AGL) and at an IAS of 80 knots. The data gathered by the six microphones for several traversals of the array by each aircraft and for the several aircraft measured were all analyzed. They were then averaged to form curves that indicate the sound exposure level versus distance for the UH-1H aircraft flying at 80 knots IAS. Details on this data analysis procedure are available elsewhere.[6] The data are corrected from the measurement day to the standard day (59°F and 70 percent relative humidity).

The current analysis at Decatur Airport focuses specifically on the data gathered for UH-1H aircraft flying at a constant, level altitude of 300 ft AGL and a constant IAS of 80 knots. Further, this analysis centers on the sound exposure level developed for a slant distance of 500 ft. Table 1 shows the data developed at this slant distance for the UH-1H aircraft measurements at Forts Rucker and Campbell. When these data were summed separately, the results illustrated the apparent problem; the measurements differed by 3.3 dB.

Figure 2 shows a site layout of Decatur Airport with the general location of measurements and Figure 3 shows a detailed layout. To facilitate the data reduction and study some related issues, a new microphone layout was used for these measurements. Again, six microphones were connected to the USA-CERL field acoustics measurement van. However, this time the microphones were placed in two lines separated by about 300 ft (the line of microphones in the grass was limited by the requirement that it had to be at least 50 ft from the edge of the active runway). One line of microphones was placed on a hard surface taxiway; the other was placed on mowed grass. The aircraft overflew one line of microphones or the other in both directions. Appendix A offers more detail on the measurement set at Decatur. Like the earlier tests, all flight operations were performed at a constant IAS of 80 knots and 300 ft AGL.

Only sideline data are used for the following analysis, since these are automatically at slant distances of approximately 400 ft. These data require no correction for small changes in helicopter height because at these sideline distances, small changes in helicopter altitude will not vary the slant distance. (USA-CERL's previous experience shows the pilots in the UH-1H are able to follow a line on the ground from an altitude of 300 ft AGL, but the altimeters frequently err by 20 to 50 ft.) The data thus yield two sets of numbers: the set gathered at a slant distance of about 400 ft with the microphones over a hard reflecting surface, and that gathered at a slant distance of about 400 ft with the microphones over a soft (mowed grass) surface. The soft surface data correspond most nearly to the data gathered at Forts Rucker and Campbell.

The 407 ft slant distance data gathered at Decatur were converted to a slant distance of 500 ft by adding (23.7-10) log (407/500). The factor (23.3-10.0) corresponds to a 4-dB decay in SEL for a doubling of distance. Table 2 combines the data from Forts Rucker and Campbell with those gathered at Decatur corrected to a 500-ft slant distance. The data for Decatur were not corrected to the standard day, but the measurement days closely approximated the standard day and, at a 500-ft slant distance, the change between standard and measurement days would be very small (a few tenths of a dB at most). Overall, the data for Decatur lie approximately midway between the data gathered at Forts Rucker and Campbell.

The individual aircraft data in Table 3 shows that large variations between aircraft should be expected. At Decatur, one aircraft (598) was measured on three separate days and one other aircraft (039) was measured on two separate days. Both aircraft varied by about 4 dB from one measurement period to the next.

In terms of statistical averages, the mean (energy) levels at Fort Rucker and Decatur lie within one standard deviation of each other. Also, the Fort Campbell data are almost within one standard deviation

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[6] B. Homans, et al.; P. D. Schomer, et al.

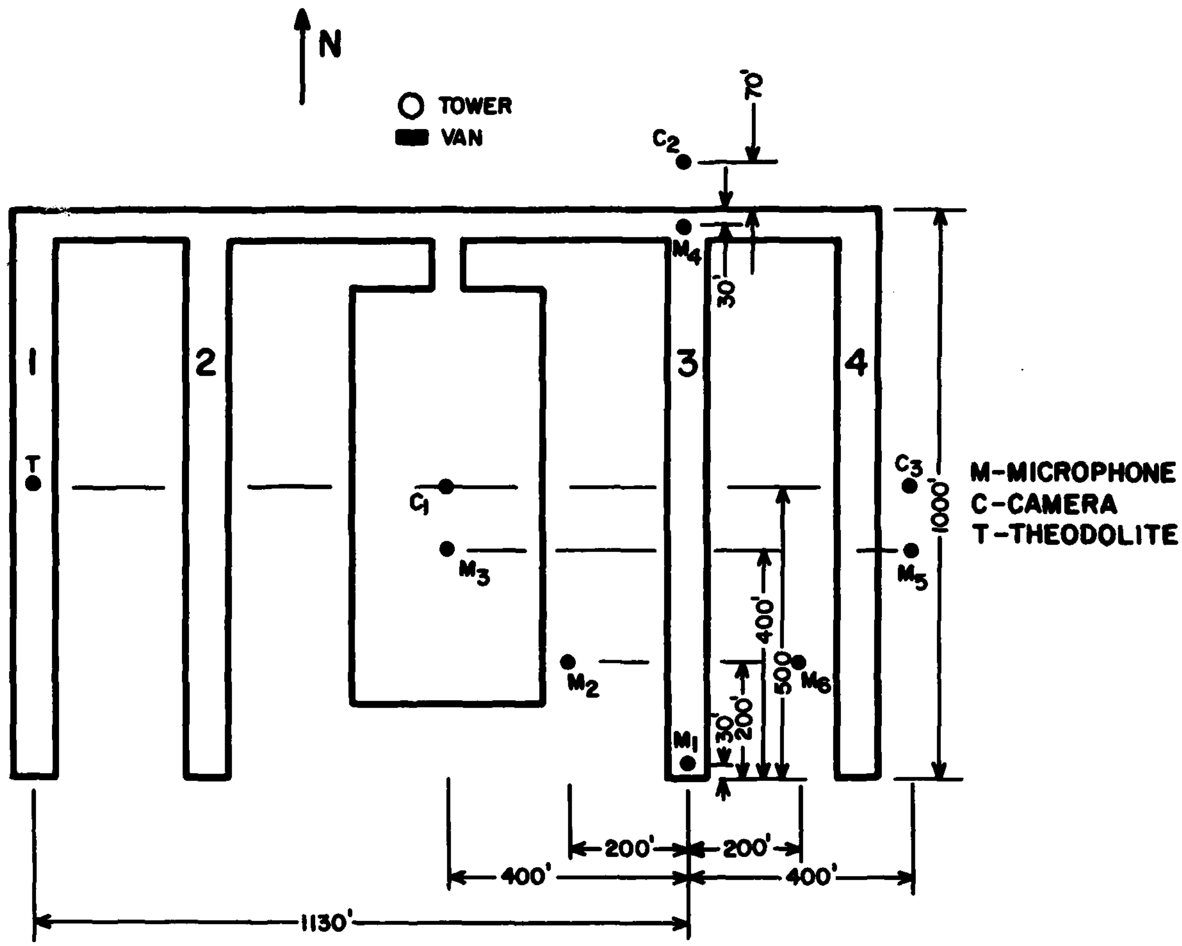

Figure 1. Equipment layout.

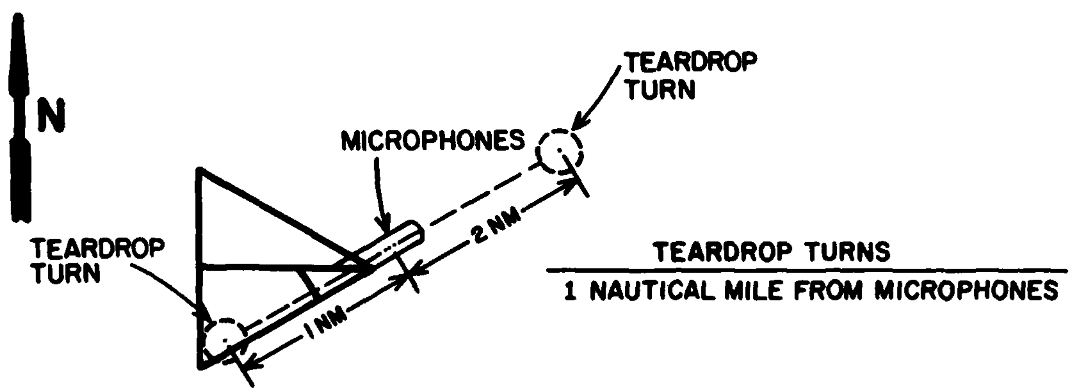

Figure 2. General site plan at the Decatur Municipal Airport.

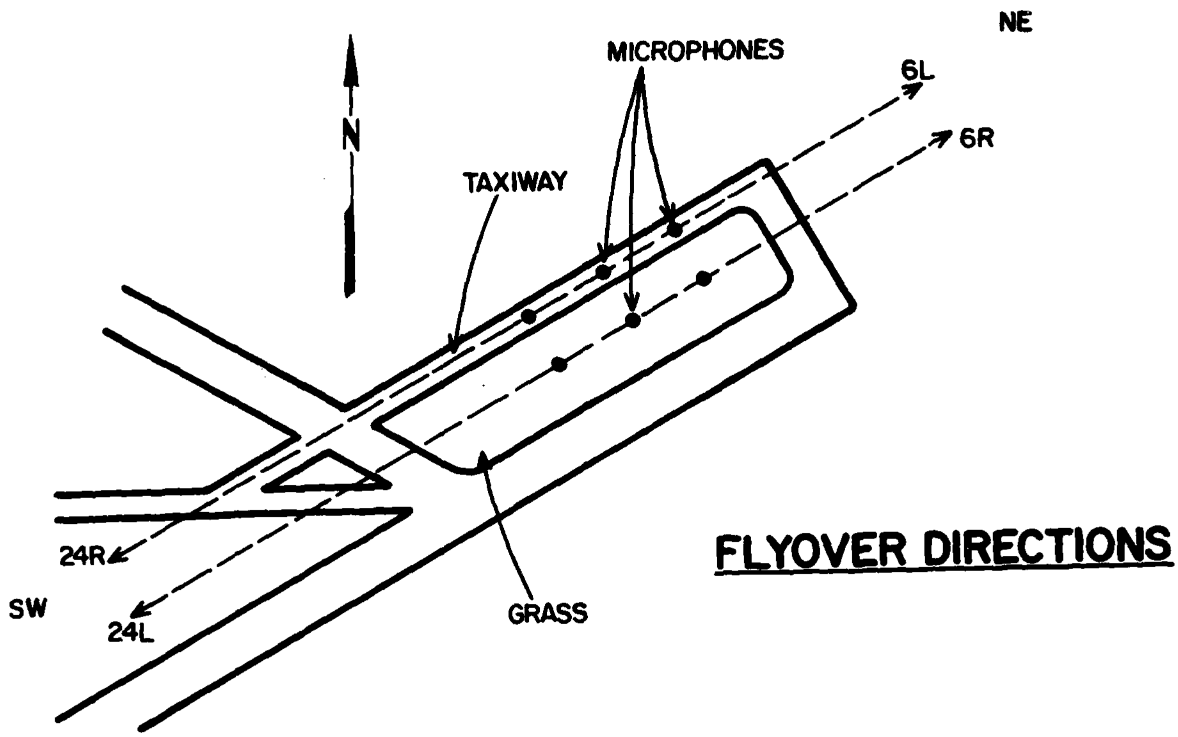

Figure 3. Microphone locations for measurements at the Decatur Municipal Airport.

Table 1

Comparison of Fort Rucker and Fort Campbell Data

Base	Mean SEL (dB) at 500 ft Slant Distance
Fort Rucker	93.6
Fort Campbell	90.3

Table 2

Comparison of Fort Rucker, Fort Campbell and Decatur Mean Data

Base	Mean SEL (dB) at 500 ft Slant Distance	No. of Data Points	Standard Deviation
Fort Rucker	93.6	6	+1.2 −1.5
Fort Campbell	90.3	2	–
Decatur Airport	92.4	9	+1.2 −1.8
All data	92.7	17	+1.3 −2.0

Table 3

Comparison of Fort Rucker, Fort Campbell, and Decatur Airport Data

Base	Date	Tail Number	Load*	SEL (dB) at 500 ft Slant Distance	Mean Energy (dB)	Standard Deviation (dB)	Time of Day	Wind Speed (k/hr)	Wind Direction**	Air Temp	Relative Humidity (%)	Absolute Humidity
Fort Rucker	16 Apr 74	690	N	92.0			0910–0940	1–3	In line	61	54	.9
	16 Apr 74	690	M	95.2			1030–1100	1–3	In line	65	44	.9
	16 Apr 74	332	N	94.2		+0.5	1400–1440	1–2	In line	81	50	1.6
	18 Apr 74	673	M	91.8	93.6	–0.5	1530–1600	1–2	In line	75	28	.7
	23 Apr 74	374	N	93.8			0910–0940	2–5	In line	66	80	1.6
	23 Apr 74	374	M	93.9			1100–1140	2–5	In line	73	50	1.2
Fort Campbell	19 Jun 80		N	90.3	90.3	–	1230–1420	2	In line	89	40	1.7
	20 Jun 80	194	N	90.3			1840–1950	4	In line	73	40	1.1
Decatur	23 Apr 82	761	N	94.0			1000–1100	17	In line	60	35	.6
	23 Apr 82	598	N	93.8			1100–1145	17	In line	60	35	.6
	11 May 82	492	N	91.4			0725–0800	14	In line	74	47	1.1
	11 May 82	039	N	91.4			0810–0845	15	In line	78	40	1.1
	11 May 82	768	N	91.0	92.4	+0.4	0915–0940	15	In line	81	35	1.1
	11 May 82	598	N	90.1		–0.5	1020–1045	16	In line	83	35	1.1
	8 Jun 82	039	N	92.8			0915–0950	8	In line	67	85	2.1
	8 Jun 82	030	N	91.2			1220–1255	9	Cross	73	80	2.0
	9 Jun 82	598	N	93.6			0930–1000	0	–	69	90	2.2

* M = maximum load; N = normal or moderate load.
** With respect to *line of flight*.

of the entire data set. Thus, the site-to-site variation should be expected.

At all three sites, the measurements were made over grass in the spring, with temperatures in about the 60° to 90°F range, and sunshine to partly cloudy conditions. At Forts Rucker and Campbell, the winds were relatively light to moderate; at Decatur, they were usually higher (Table 3). No correlation could be found between the variation in noise level and meteorological variables such as wind speed, wind direction, temperature, relative humidity, and absolute humidity. Measurement procedures, instrumentation, and calibration have been checked and rechecked and are not a source of this variation. The variation appears to be related to the aircraft's day-to-day operation, its maintenance, and the pilot's technique.

3 NEW MEASUREMENT PLAN FOR HELICOPTER NOISE

The relatively large variations among aircraft and time periods suggest that future rotary-wing measurements should be made in two groups at two separate times, preferably at two separate locations. Each group of measurements should include at least three aircraft flown twice–once by the pilot and once by the copilot.

Figure 4 shows the suggested microphone layout for future rotary-wing aircraft measurements. Again, the array consists of six microphones wired to a central measurement van. Based on the previous work at Fort Rucker, Fort Campbell, and Decatur Airport, this array is now optimized to gather most of the data at a 500-ft slant distance to the sideline. The array consists of four sideline microphones and two centerline microphones. Any opposing set of microphones can be designated as "centerline" microphones for any run. Level flyovers will be made over the array at an altitude of 300 ft AGL (and possibly 1000 ft AGL) at various IAS. Hover measurements can be taken in the center of the array where all microphones are automatically 500 ft from the aircraft. Landings and takeoffs can be performed at the center of the array with all distances known and readily usable. Appendix B contains a draft standard measurement plan based on this array.

4 CONCLUSIONS AND RECOMMENDATIONS

Helicopter SEL data have been studied for variations in aircraft, location, and time. The variation in mean measured levels among sites falls within the range to be expected given the variation in measured levels among aircraft at a site. The variation in noise levels among aircraft does not appear to be related to instrumentation, procedures, or weather. Rather, it appears to be related to the aircraft's day-to-day operation, its maintenance, and the pilot's technique.

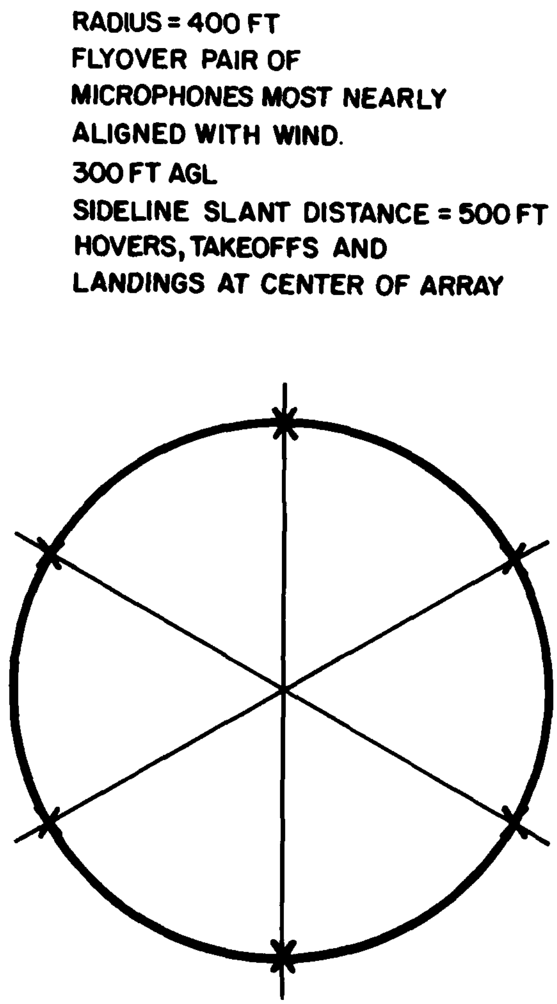

Figure 4. Proposed new test site microphone layout.

A standard measurement procedure has been proposed to accommodate or eliminate this variation. Future SEL measurements for rotary-wing aircraft should include at least two sites with at least three aircraft at each site. Each aircraft should be flown twice–once by the pilot and once by the copilot.

METRIC CONVERSIONS

1 ft	=	0.3 m
1 in.	=	25.4 mm
1 gal	=	4.5 L
1 knot	=	30.85 m/sec
°F–32/1.8	=	°C

APPENDIX A: MEASUREMENT PROCEDURE– DECATUR AIRPORT

USA-CERL collected direct flyover and hover data from UH-1H helicopters in April, May and June 1982 at the Decatur Airport. The test site was oval-shaped. Three microphones were placed down the center of the taxiway and three were placed parallel to them, 50 ft from the runway on a grass surface. This arrangement was used to provide data from both hard and soft surfaces. Hover points were chosen 430 ft from the closest pair of parallel microphones on the landing field's northeast end. The standard altitude was 300 ft AGL. Manual records were kept of the fly-bys in error of the 300-ft standard so that the data could be corrected. Hover data were taken at 5, 50, and 500 ft AGL.

Tests were taken with the helicopters flying at four different headings; 6L, 24R, 6R, and 24L. Fly-bys over the taxiway were indicated by 6L and 24R, and those over the grassy surface by 6R and 24L. The fly-bys' altitudes were calculated by focusing the helicopter through a camera lens with respect to a calibrated pole and using the similar triangles theorem. Figure A1 shows a ground-level view of the field as observed from the southwest.

Energy averages were taken for the 0.5-sec LEQMAX (maximum equivalent level during any half-second of a flyover) and the SEL of the data at different headings. Most of the data showed the LEQMAX to be roughly 87.0 ± 3.0 dB with the SEL roughly 93.0 ± 3.0 dB, including both surfaces.

Hover data were recorded for 1 minute at each of the three altitudes. The hover data in Figures A2 and A3 show a rapid drop in energy with respect to distance at a 5-ft altitude with little variance over the different ground surfaces. At 50- and 500-ft altitudes, levels did not decay quite as rapidly. However, the difference between the levels over the hard and soft surfaces increased more with distance.

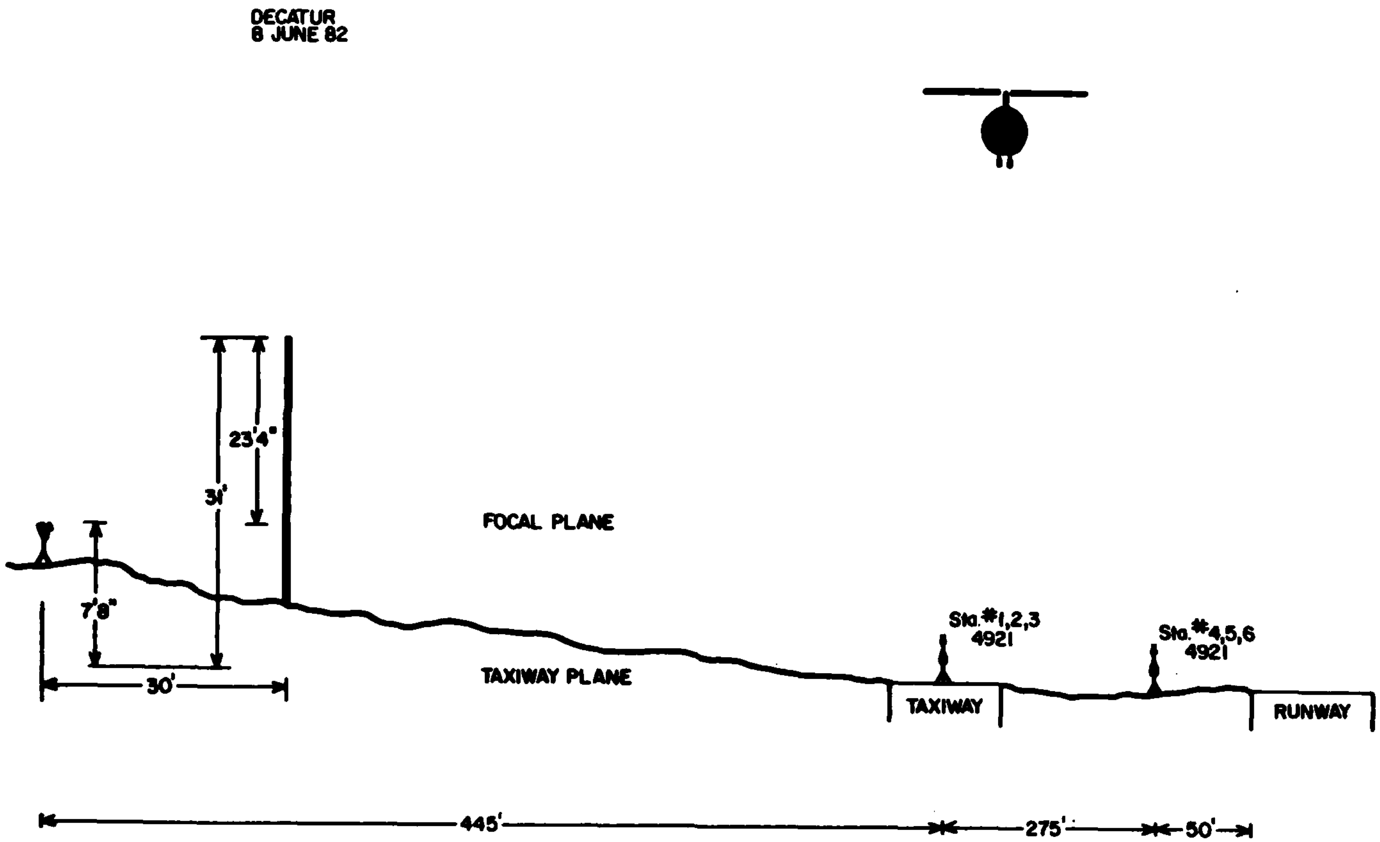

Figure A1. Ground-level view of landing field as seen from the southwest.

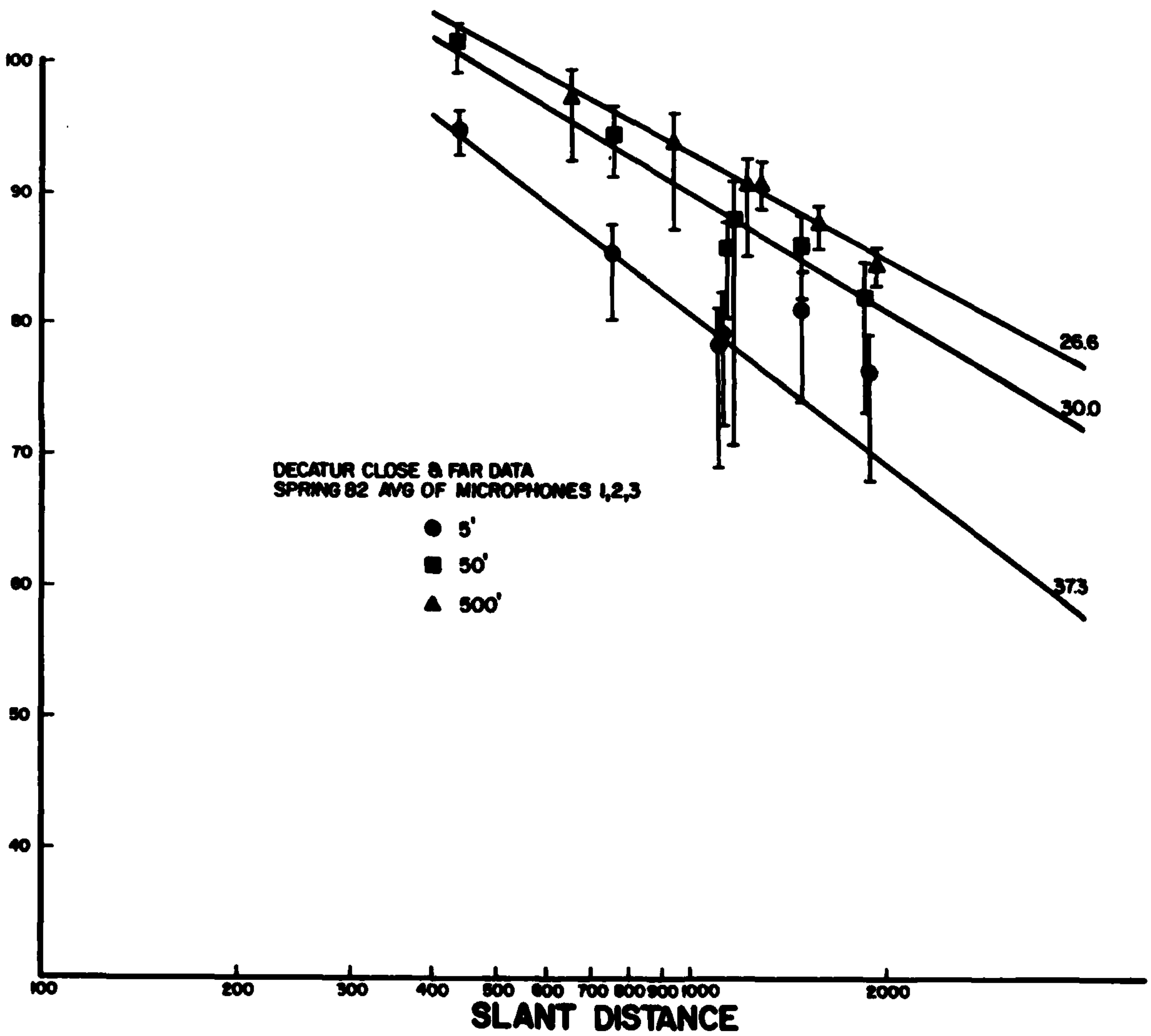

Figure A2. Average of close and far data for microphones 1 through 3 at Decatur.

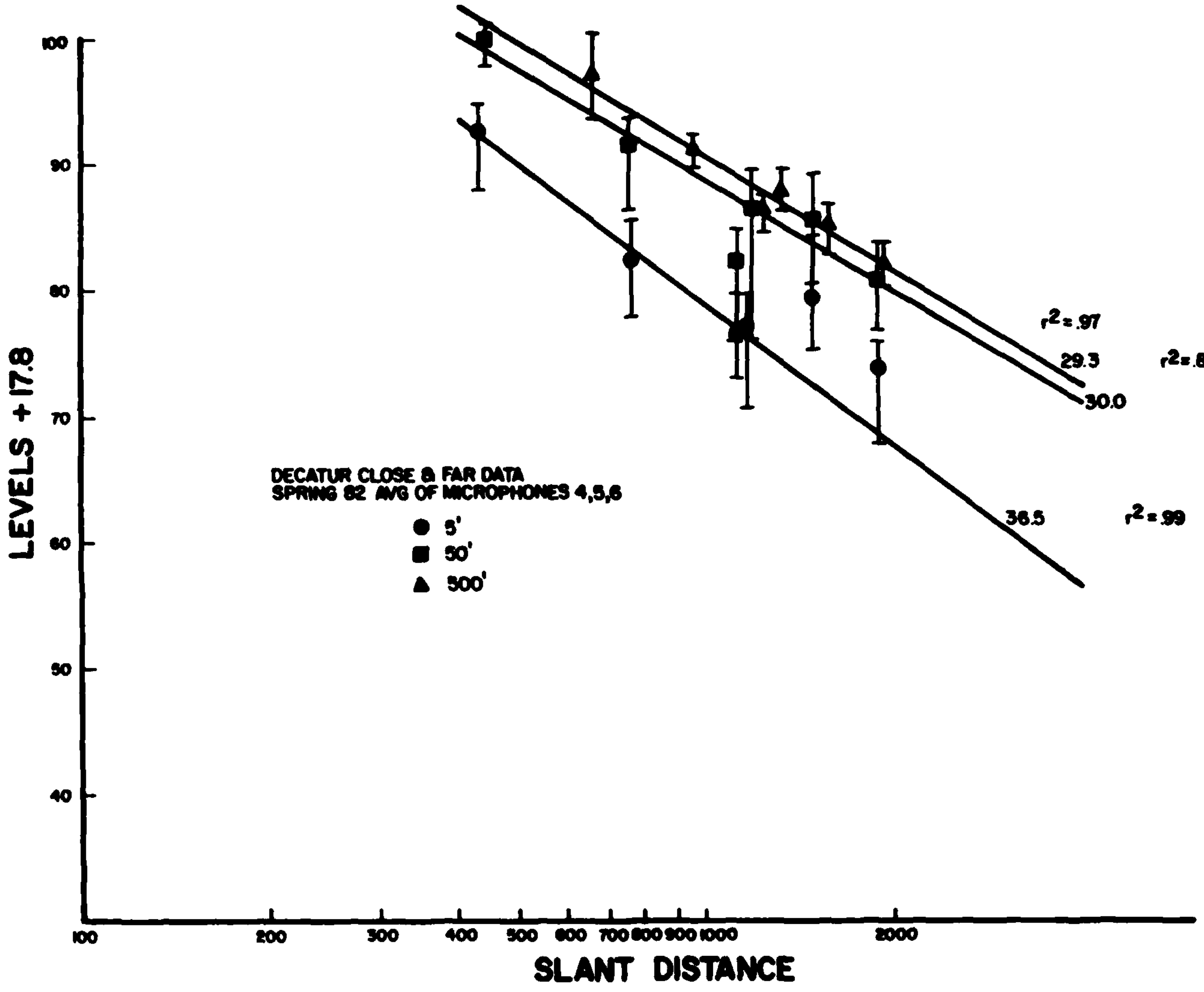

Figure A3. Average of close and far data for microphones 4 though 6 at Decatur.

APPENDIX B: TEST PLAN FOR HELICOPTER NOISE MEASUREMENTS

1.0 Purpose

The purpose of this test plan is to define measurement and analysis procedures for rotary-wing aircraft environmental noise emissions data. These data are required in support of the Army's Installation Compatible Use Zone (ICUZ) program.

2.0 Scope

This plan applies to all Army rotary-wing aircraft as tested for the ICUZ program. It does not relate to hearing conversation requirements or any other Army programs. All measurements are made in terms of sound pressure level and sound exposure level.

3.0 References

3.1 American National Standard Institute (ANSI) Standard ANSI S1.4-1983, "Description of Sound Level Meters."

3.2 ANSI S1.11-1971 (R 1966), "Specifications for Octave, Half-Octave and Third-Octave Band Filter Sets."

3.3 ANSI S1.26-1978, "Method for the Calculation of Absorption of Sound by the Atmosphere."

3.4 International Organization for Standardization (ISO) Standard 1966, "Acoustics–Description and Measurement of Environmental Noise–Part 1: Basic Quantities and Procedures" (1971).

3.5 ISO 3891, "Acoustics–Procedure for Describing Aircraft Noise Heard on the Ground" (1978).

4.0 Definitions

4.1 Weighted sound pressure, in pascals–The root mean square sound pressure determined by using a frequency-weighting network (see ANSI S1.4-1983).

4.2 Sound pressure level, in decibels–Given by the formula:

$$L_p = 10 \lg \frac{p^2}{p_o^2}, \qquad \text{[Eq B1]}$$

where p is the root mean square sound pressure in pascals and

po is the reference sound pressure (20 μPa).

4.3 A-weighted sound level, in decibels–The sound pressure level of A-weighted sound is given by the formula:

$$L_{pA} = 10 \lg \frac{p_A^2}{p_o^2}. \qquad \text{[Eq B2]}$$

4.4 Equivalent continuous weighted sound pressure level, in decibels–Value of the weighted sound pressure level of a continuous, steady sound that, within a specified time interval, T, has the same mean square sound pressure as a sound under consideration whose level varies with time. It is given by the formula:

$$L_{Weq,T} = 10 \lg \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p_W^2(t)}{p_o^2} dt, \qquad \text{[Eq B3]}$$

where W is frequency weighting used (i.e., A, B, C, D, F)

$L_{Weq,T}$ is the equivalent continuous weighted sound pressure level in decibels, determined over a time interval, T, starting at t_1 and ending at t_2

P_o is the reference sound pressure (20 μPa) and

$p_W(t)$ is the instantaneous weighted sound pressure of the sound signal.

NOTE: Equivalent continuous A-weighted sound pressure level during time interval, T, is also called "time interval average sound level," $L_{A,T}$, in decibels, with the averaging time interval usually indicated in the format–for example, 1-hour average sound level, L_{A1h}.

4.5 Sound exposure level, in decibels–The sound exposure level of a discrete noise event is given by the formula:

$$L_{WE} = 10 \lg \frac{1}{t_o} \int_{t_1}^{t_2} \frac{p_W^2(t)}{p_o^2} dt, \qquad \text{[Eq B4]}$$

where W specifies the frequency weighting (i.e., A, B, C, D, F)

$p_W(t)$ is the instantaneous weighted sound pressure

$t_2 - t_1$ is a stated time interval long enough to encompass all significant sound of a stated event

p_o is the reference sound pressure (20 μPa) and

t_o is the reference duration (1 sec).

4.6 Measurement time interval–Interval over which the squared-weighted sound pressure is integrated and averaged.

5.0 Instrumentation

Microphones, microphone systems, associated amplifiers, and recording devices shall meet the requirements of ANSI S1.4-1983 Type 1.

5.1 *Tape Recorders*

5.1.1 AM tape recorders shall be equalized at 7.5 or 15 in./sec to have uniform frequency characteristics over the range 20 to 5000 Hz. The dynamic range shall be greater than 60 dB.

5.1.2 FM tape recorders shall have IRIG-B, narrow-band electronics at 60 in./sec and shall have a dynamic range greater than 50 dB.

5.1.3 Digital tape recorders shall have a flat response in the frequency range 20 to 6000 Hz and shall have a dynamic range greater than 60 dB.

5.2 *One-Third Octave Band Analyzer*

The one-third octave band analyzer shall meet the requirements of ANSI S1.11 Class 3, or IEC 225.

5.3 *Acoustical Calibration*

The entire instrumentation system, including the microphone and its cable, shall be calibrated at a convenient frequency before and after each test series in accordance with the manufacturer's recommendations. An acoustical calibrator with an accuracy of ± 0.5 dB or better is required. If a wind screen is used, it shall not degrade the system below the requirements of ANSI S1.4-1983 for Type 1 sound level meters.

The frequency response of the system with filters and microphones shall be checked periodically (at least annually). If the microphone is not part of the system during this check, it shall be checked separately and certified using the manufacturer's approved test procedure.

5.4 *Anemometer*

An anemometer shall measure wind speed to an accuracy of ±10 percent for winds in excess of 1 m/sec. Wind direction shall be measured to ±5 degrees. These measurements shall be made approximately 10 m AGL.

5.5 *Helicopter Position Determination*

Equipment shall be available to determine the height of the helicopter where it is over the microphone array and to determine its lateral distance from the planned flight track. The tolerance of measurements of the helicopter altitude and its lateral distance from the presumed flight track shall be 5 percent of the nominal helicopter height above ground level.

6.0 Test Site Layout and Operations

6.1 *Layout*

The test site shall be a large, open, level grassy field. The test array (Figure 4) consists of six equally spaced microphones in a circular array with a radius of 400 ft. No trees or other large reflecting objects should be within 150 ft of any microphone or anywhere within the circle formed by the microphone array.

6.2 *Equipment Placement*

Recordings shall be made from each microphone. These can be with individual recorders or all microphones can be recorded in combination. If a large, central recording facility is used, it shall be located at least 150 ft from the nearest microphone. If individual portable instrumentation is used (with or without a human operator), it shall be located no closer than 25 ft to any microphone. All microphones shall be located on a grassy surface at least 25 ft from the nearest hard surface.

6.3 Test Operations

6.3.1 Table B1 lists the flight operations to be performed.

6.3.2 Each flight operation shall be recorded and a separate channel shall be available for voice cue information. This voice track shall note the beginning and end of each flight operation and any unusual occurrences.

6.3.3 Any one of the three pairs of opposing microphones can be designated the direction of flight for level flyovers, takeoffs, and landings. The pair shall be chosen that best aligns with prevailing wind direction.

Table B1

Test Operations

A. Level Flyovers at 300 ft AGL

1. Eight flyovers at typical cruise speed (IAS)
2. Four flyovers at IAS above cruise (at 10 to 20 nautical mile intervals) up to maximum IAS.
3. Four flyovers at IAS below cruise (at 15 to 30 nautical mile intervals) down to 40 nautical mile IAS.

Note: Each pair of flyovers shall be a set with one in each direction.

B. Level Flyovers at 1000 ft AGL

1. Four flyovers at typical cruise speed

C. Landings and Takeoffs

1. Two landings and two takeoffs, each to and from the center of the microphone array

D. Hovers

1. In-ground effect for 2.5 minutes at center of array
2. Out-of-ground effect for 2.5 minutes at center of array (1 to 2 rotor diameters above ground)

E. Idle Speed for 2.5 minutes at Center of Array

7.0 Data Analysis

7.1 *Hover and Idle Measurements*

Hover and idle data shall be analyzed as the one-third octave equivalent spectrum and the overall A-weighted equivalent level during at least 128 sec of the 2.5-min test.

7.2 *Dynamic Flight Operations*

The level flyover, takeoff, and landing data shall be analyzed as follows: the A-weighted sound exposure level shall be determined for all time from the first time the level rises to within 10 dB of the maximum 1-sec A-weighted (true integration) level until the last time the level falls below 10 dB down from the maximum 1-sec A-weighted level. The one-third octave spectrum shall be determined for the 2-sec (time integration) at which the maximum A-weighted sound level occurs.

8.0 Data Reduction

8.1 *Slant and Measurement Distances*

For level flyovers, the position data shall be used to determine slant and measurement distances at individual microphones. These are determined trigonometrically at the instant the maximum 2-sec A-weighted equivalent level occurs. It is assumed that the helicopter continues in straight and level flight at constant speed during any level flyover test.

8.2 *Data Conversion*

The SEL data recorded by each microphone shall be converted to a set of standard SEL versus distance curves by using the one-third octave spectrum which is present during the 2-sec when the A-weighted maximum level occurs. The slant distance is calculated for the time at which the maximum 2-sec A-weighted level occurs. The corresponding 2-sec spectrum is converted from the calculated measurement distance, d_m (separately for each microphone), for the measurement day temperature and relative humidity to the reference distance (d_r) at standard temperature (59°F) and relative humidity (70 percent). This calculation is done using the methods for sound decay in ANSI S1.26-1978 and includes a term 20 log (d_r/d_m) to account for spherical spreading and a term −10 log (d_r/d_m) to account for the duration effect on SEL with distance. These results are used to form the SEL at the distances listed in Table B2.

Table B2

SEL-Versus-Distance Distances

100 ft
200 ft
500 ft
1,000 ft
2,000 ft
5,000 ft
10,000 ft

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