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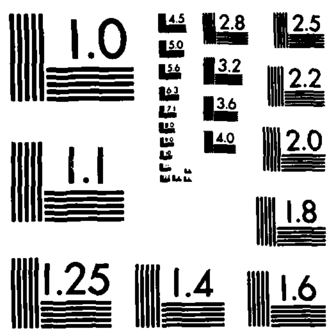
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Helicopter Noise Exposure Curves for Use in Environmental Impact Assessment

by
J. Steven Newman
Edward J. Rickley
Tyrone L. Bland

November 1982
Final Report

U.S. Department of Transportation
Federal Aviation Administration
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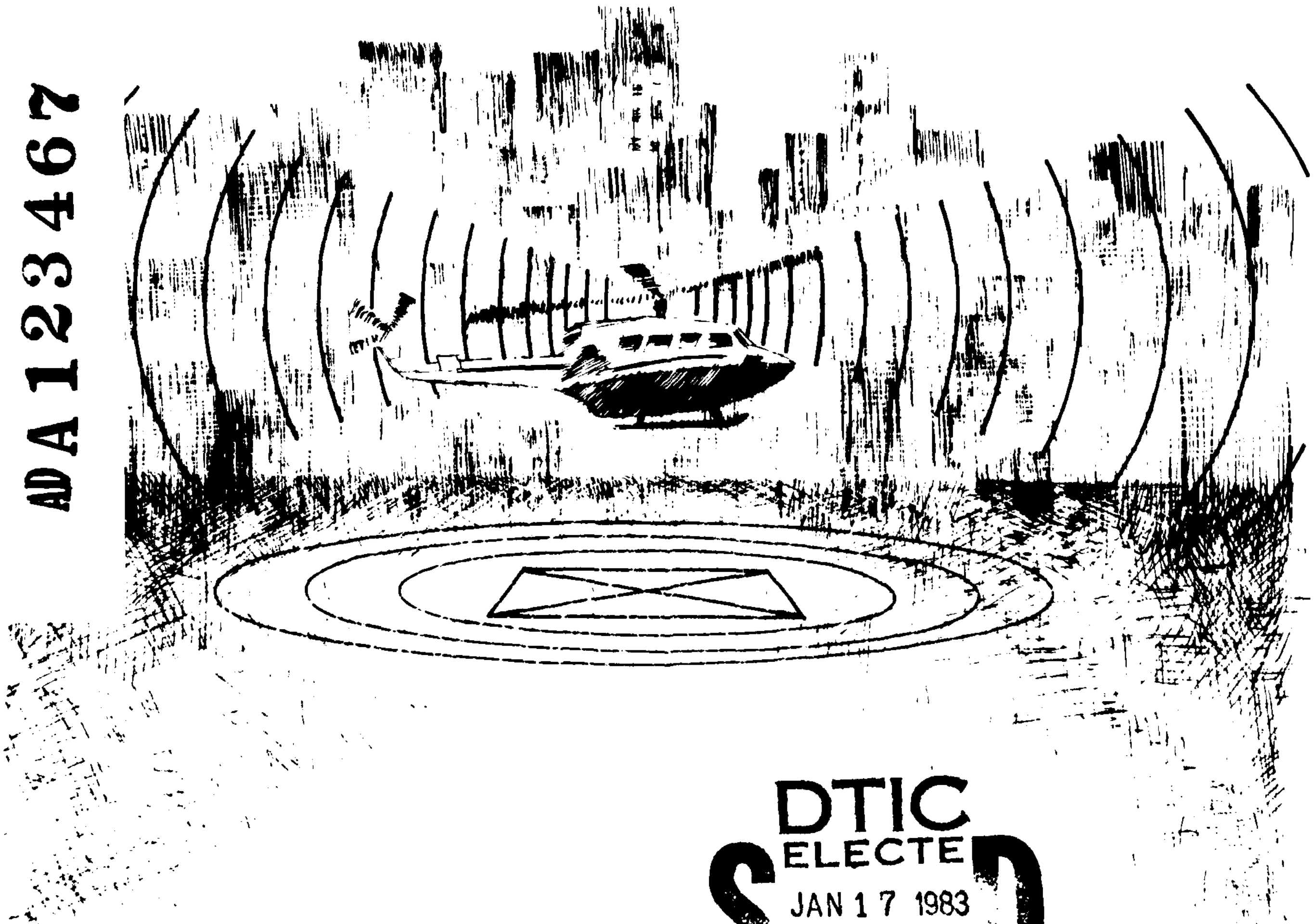

FOREWARD

The FAA has been conducting controlled helicopter noise measurement programs since 1976. The data have been used for a variety of purposes, including evaluation of proposed U.S. and international noise standards and validation of helicopter noise prediction methodologies.

This report documents the results of FAA measurement programs conducted in 1976, 1978, and 1980 in a single report with data formatted specifically for environmental impact analyses. In recognition of growing public concern over potentially adverse noise impact associated with helicopter operations, the FAA encourages helicopter and heliport operators to analyze noise impact as part of the normal heliport planning process. The data base contained in this report provides the noise input information necessary to develop helicopter noise exposure footprints or contours using a computer model such as the FAA Integrated Noise Model (INM).

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1. U.S. Department of Transportation, Transportation Systems Center, Kendall Square Cambridge, Mass 02142
2. Wilson Hill Associates, 1025 Vermont Ave., NW., Washington, D.C. 20005

16. Abstract

This report establishes the current (1982) FAA helicopter noise data base for use in environmental impact assessment. The report sets out assumptions, methodologies, and techniques used in arriving at noise-exposure-versus-distance relationships. Noise data are provided for 15 helicopters, including five flight regimes each: takeoff, approach, level flyover, hover in-ground-effect (HIGE) and hover out-of-ground effect (HOGE). When possible, level flyover data are presented for a variety of airspeeds. Sound exposure level (SEL) is provided for all operational modes except hover. In the case of hover operations (both HOGE and HIGE), the maximum A-Weighted Sound Level (L_{AM}) is identified as a function of distance. The report also includes a discussion of helicopter performance characteristics required for full computer modeling of helicopter/heliport noise exposure.

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HELICOPTER NOISE DATA BASE APPENDICES

GLOSSARY

AIR:	Aerospace Information Report
APP:	Approach operational mode
BRC:	Best Rate of Climb
CERL:	Construction Engineering Research Laboratory
CPA:	Closest Point of Approach
dB:	Decibel
DUR(A):	"10 dB-Down" Duration of L_A Time History
d:	Distance
Δ	Delta, or Change in Value
$\Delta 1$:	Correction term obtained by correcting SPL values for atmospheric absorption and flight track deviations per FAR 36, Amendment 9, Appendix A, Section A36.11, Paragraph d
$\Delta 2$:	Correction term accounting for changes in event duration with deviations from the reference flight path
EGA:	Excess Ground Attenuation
EPNL:	Effective Perceived Noise Level (sometimes abbreviated L_{EPN})
EPNdB:	Effective Perceived Noise Level expressed in decibels
EV:	Event, test run number
FAA:	Federal Aviation Administration
FAATC:	Federal Aviation Administration Technical Center
FAR:	Federal Aviation Regulation
FAR-36:	Federal Aviation Regulation, Part 36
g:	Acceleration due to gravity, 32 feet per second, per second
h:	Height above microphone
H-V:	Height - Velocity performance envelope

HIGE:	Hover in Ground Effect
HMA:	Heliport Maneuver Area
HOGE:	Hover Out of Ground Effect
ICAO:	International Civil Aviation Organization
IFR:	Instrument Flight Rules
IGE:	In Ground Effect
INM:	FAA's Integrated Noise Model
IRIG-B:	Inter-Range Instrumentation Group B (established technical standard)
K(A):	The constant used to correct SEL for distance duration effects in $\Delta 2$
Kts:	Knots
L_A:	A-Weighted Sound Level expressed in decibels
L_{AE}:	Sound Exposure Level expressed in decibels (See SEL)
L_{AM}:	Maximum A-Weighted Sound Level expressed in decibels
L_D:	D-Weighted Sound Level expressed in decibels
L_{DM}:	Maximum D-Weighted Sound Level expressed in decibles
FLO:	Level Flyover operational mode
LFO(v):	Level Flyover as a function of speed
MTOGW:	Maximum Takeoff Gross Weight
NASA:	National Aeronautics and Space Administration
NWS:	National Weather Service
OASPLM:	Maximum Overall Sound Pressure Level in decibels
OGE:	Out of Ground Effect
PNLM:	Maximum Perceived Noise Level
PNLTM:	Maximum Tone Corrected Perceived Noise Level
RPM:	Rotorcraft Flight Manual
RH:	Relative Humidity in percent
RMS:	Root Mean Square
RPM:	Revolutions per minute

SAE:	Society of Automotive Engineers
SD:	Standard Deviation
SEL:	Sound Exposure Level expressed in decibels. The integration of the dBA time history, normalized to 1 second (also represented as L_{AE})
SL:	Sideline
SL-N:	Sideline-North microphone location
SL-S:	Sideline-South microphone location
SPL:	Sound Pressure Level expressed in decibels
SR:	Distance from the noise source to receiver
T/O:	Takeoff
TOSS:	Takeoff Safe Speed
TSC:	Department of Transportation, Transportation Systems Center
VASI:	Visual Approach Slope Indicator
VFR:	Visual Flight Rules
V_H:	Maximum speed in level flight with maximum continuous power
V_{NE}:	Never-Exceed Speed
V_y:	Velocity for best rate of climb
V_R:	Reference velocity (airspeed)
V_T:	Test velocity (airspeed)
WAT:	Weight, Altitude, and Temperature
1976 Data:	Data reported in Ref. 3
1978 Data:	Data reported in Ref. 1
1980 Data:	Data reported in Ref. 2
α_i:	Atmospheric Absorption Coefficient for the i-th 1/3 octave Sound Pressure Level
Category A Transport Helicopters	Helicopters Certificated to FAR Part 29 requirements for Category A.

1.0 Introduction - Helicopter noise is a factor coming under closer scrutiny in the early planning stages for a heliport. While airspace and real estate requirements have traditionally been key determinants in planning a heliport, the potential noise impact of helicopter operations on surrounding areas is emerging as the controlling issue. As a consequence, it is becoming increasingly necessary to analyze the potential noise exposure or noise "dose" associated with the planned heliport or with the planned operations at an existing heliport. Noise exposure is usually determined using a computer-based simulation model, such as the FAA's Integrated Noise Model (INM). Such simulation models employ two basic types of information, noise data and performance data, in the process of computing exposure. The objective of this report is to establish the noise data base for helicopters. The noise data relating sound exposure to distance are provided in tabular and graphical form in the appendices to this report. Later chapters of this document provide generalized information on helicopter performance for certain operational modes. The reader should consult the appropriate Rotorcraft Flight Manual (RFM) for detailed guidance in modeling the performance of any specific helicopter.

Previous studies (Ref 1, 2, 3, 4) have provided extensive documentation of helicopter noise levels for a variety of operational regimes. One study (Ref. 5) prepared for the Air Force provided noise-versus-distance curves derived from published FAA data. This report undertakes the objective of constructing the best possible noise-distance relationships utilizing knowledge gained from detailed tests conducted by the FAA in 1976, 1978, and 1980 and working closely with helicopter manufacturers and operators. Procedures used in developing the noise curves are documented including specific engineering practices and approximations applied as necessary.

The state-of-the-art in helicopter noise research and development is changing rapidly at this time (August 1982) as both the FAA and NASA are implementing joint research and development noise reduction programs with major U.S. helicopter manufacturers. In recognition of the increased activity in this area, we can presume that new data will become available from time to time. These new data may be in the form of more information for a given helicopter model or for an entirely new helicopter model. The FAA welcomes every opportunity to examine helicopter acoustical data for inclusion in, or revision of the data base, and will revise that data base as appropriate.

2.0 Helicopter Noise Data - One objective of this report is the thorough documentation of data used in developing noise-distance relationships. The following paragraphs provide a brief synopsis of each primary reference used in developing final noise curves as presented in Appendices A through P.

FAA-EE-79-03 (Ref. 1) - This report presented the results of a 1978 FAA test in which acoustical, tracking, meteorological and cockpit data were acquired for eight helicopters. Data from this test were reported with and without corrections to standard acoustical day conditions of 77°F, 70% RH. Data were provided for 6-degree approaches, takeoffs, and 500 foot level-flyovers.

FAA-EE-81-16 (Ref. 2) - This report presented the results of a 1980 FAA test in which acoustical, tracking, meteorological, and cockpit data were acquired for the S-76, A-109, UH-60A, and 206-L helicopters. Data were reported with and without corrections to standard acoustical day conditions of 77°F, 70% RH. Data were provided for 6-degree approaches, takeoffs, and level flyovers with speed and altitude variations.

FAA-EE-77-94 (Ref. 3) - This report presented results of a 1976 FAA test which included hover, level flyover and approach operations. Meteorological and cockpit data were provided along with acoustical, data although tracking information was unavailable. The level flyover events included speed variations which permitted derivation of speed-versus-noise-level functions.

CERL Technical Report N-38 (Ref. 4) - This document provided Sound Exposure Level (SEL) versus distance curves for eight helicopter types including the UH-1H, UH-1M, and UH-1B models which are closely related to the UH-1N. This document also provided important information on the noise characteristics associated with ground effect hover as well as takeoff, approach, and level flyover.

Table 2-1 presents a list of the 15 helicopters which comprise the FAA Helicopter Noise Data Base contained as appendices to this report. Also listed is(are) the year(s) in which the helicopter was tested along with the types of operations involved in the test. The table also lists in the right hand column the modes of operation in which estimates were made for the specific noise curves. Estimation procedures are discussed at length in later sections of this report.

TABLE 2-1

FAA Helicopter Noise Data Base

1. Bell-212 (10,500 lbs MGTOW)

   a. 1976: App, H, LFO(v)
   b. 1978: T/O, App, LFO

2. Sikorsky S-61 (19,000 lbs MGTOW)

   a. 1976: App, H, LFO(v)
   b. 1978: T/O, App, LFO

3. Sikorsky S-64 (42,000 lbs MGTOW)

   a. 1976: App, H, LFO(v) — T/O estimate

4. Boeing Vertol CH-47C (45,000 lbs MGTOW)

   a. 1976: App, H, LFO(v) — T/O estimate

5. Hughes 300-C (1,900 lbs MGTOW)

   a. 1976: App, H, LFO(v) — T/O estimate

6. Hughes 500-C (2,550 lbs MGTOW)

   a. 1976: App, H, LFO(v)
   b. 1978: T/O, App, LFO

7. Bell 47-G (2,950 lbs MGTOW)

   a. 1976: App, H, LFO(v) — T/O estimate

8. Bell 206-L (4,000 lbs MGTOW)

   a. 1976: App, H, LFO(v)
   b. 1978: T/O, App, LFO
   c. 1980: T/O, App, LFO(v)

9. Boelkow BC-105 (5,070 lbs MGTOW)

   a. 1978: T/O, App, LFO — H estimate

10. Aerospatiale SA-330J (15,532 lbs MGTOW)

   a. 1978: T/O, App, LFO — H estimate

11. Aerospatiale SA-341G (3,970 lbs MGTOW)

    a. 1978: T/O, App, LFO — H estimate

12. Sikorsky S-65 (37,000 lbs MGTOW)

    a. 1978: T/O, App, LFO — H estimate

13. Agusta A-109 (5,730 lbs MGTOW)

    a. 1980: T/O, App, LFO(v) — H estimate

14. Sikorsky S-76 100% RPM (10,000 lbs MGTOW)

    a. 1980: T/O, App, LFO(v)

15. Sikorsky UH-60A (20,250 lbs MGTOW)

    a. 1980: T/O, App, LFO(v) — H estimate

16. Sikorsky S-76 107% RPM (10,000 MGTOW)

    a. 1980: T/O, App, LFO(v) — H estimate

    b. Hover data provided by Sikorsky, (9/82).

App	Approach
H	Hover
LFO(v)	Level Flyover at various speeds
T/O	Takeoff
LFO	Level Flyover at one speed
MGTOW	Maximum Gross Takeoff Weight

3.0 Noise Data Analysis - The noise data reported in the three primary references (Ref. 1, 2, 3) were developed using essentially the same basic methodologies. Data reduction was carried out at the U.S. Department of Transportation, Transportation Systems Center (TSC), Noise Measurement and Assessment Facility, in Cambridge, Mass. Reduction procedures in each case employed one-half-second samples of data acquired using a one-third-octave Real Time Analysis System. The effective dynamic response of the system was equivalent to sound level meter SLOW response, exponential averaging with a one-second time constant. The one significant exception was that 1976 data did not include atmospheric absorption corrections. The noise units or metrics developed in this report are the A-weighted Sound Level (L_A) and the Sound Exposure Level (L_{AE}).

The following paragraphs provide additional details.

1976 Test

DATA REDUCTION SYSTEM (Ref. 3)

The noise data plus the calibration signals recorded on the magnetic tape were fed into a modified GenRad 1921 Real Time Analysis System made up of a GenRad 1925 Multi-filter and GenRad 1926 Multichannel RMS Detector. Necessary gain adjustments were made in the multifilter using the recorded calibration signals.

The GR-1925 Multifilter consisted of a set of parallel contiguous one-third-octave filter channels from 25 Hz to 10 KHz, plus a standard A-weighted network and an unfiltered channel with a flat frequency response to provide Overall Sound Pressure Levels (OASPL). All outputs from the multifilter were fed into the GR-1926 Detector which sampled and computed the RMS level in dB for each channel for a one-half-second integration period. These levels were then converted to digital outputs and were fed into a Wang 720C computer which was programmed to store the digitized data in the Wang 730 Disc System. The analysis system had a dynamic range of 60 dB.

Data stored in the Wang 730 Disc System were processed as follows:

Hover Test -- Data from thirty-eight (38) one-half-second integration periods were averaged on an energy basis and data printed out for the average maximum and minimum Sound Pressure Level (SPL) in each one-third-octave frequency band (25 Hz to 10 KHz). The average A-Weighted sound level (L_A) was also computed along with FAR-36 certification metrics.

Level Flyover and Approach Tests -- Data stored on magnetic discs were processed according to FAR-36 procedures without corrections for temperature, humidity and aircraft position for each level flyover and approach condition. In addition, the processed data included a time history of L_A at one-half-second time intervals during flyover plus the one-third-octave-band spectra for about ten one-half-second intervals during the flyover, including the spectrum recorded at the time of maximum noise. The one-third-octave-band spectra were time-referenced to the helicopter's visual overhead position.

1980/1978 Tests (Ref. 1, 2)

Noise Data Reduction - The analog magnetic tape recordings analyzed at the TSC facility in Cambridge, Massachusetts, were fed into magnetic disc storage after filtering and digitizing using the GenRad 1921 one-third octave real-time analyzer. Recording system frequency response adjustments were applied, assuring overall linearity of the recording/reduction system. The stored 24 one-third octave sound pressure levels (SPLs) for each of the one-half second integration periods making up each event comprise the base of "raw data." Data reduction followed the basic FAR-36 procedures. The following sections describe the steps involved in arriving at the final corrected sound level values.

Spectral Shaping - The raw spectral data were adjusted by sloping the spectrum at -2 dB per one-third octave for those one-third octaves (above 1.25 kHz) where the signal-to-noise ratio was less than 5 dB. This procedure was applied in cases involving no more than 9 "missing" one-third octaves. The shaping of the spectrum over this range (up to 9 bands) deviated from the FAR 36 procedures in that the extrapolation includes four more missing bands than normally allowed. However, in this specific case, it was felt that use of the technique was justified as the high frequency spectral shape for most helicopters was observed to fall off regularly at 2 dB per one-third octave.

Corrected Data: Position and Atmospheric Absorption Corrections - "As Measured" data were used as the basis from which to compute the "Corrected" data. The process of correcting data for position and atmospheric absorption included:

- Adjusting the measured 24 one-third octave SPLs of the maximum noise spectra to the standard acoustical data conditions utilizing 10-meter meteorological data.

- Adjusting for the change in atmospheric absorption associated with the difference in slant range between the actual and reference position of the helicopter at the time of maximum noise.
- Adjusting for the spherical spreading associated with the difference in slant range between the actual and reference positions of the helicopter at the time of maximum noise.

Analysis System Time Constant/Slow Response - The TSC data analysis system utilizes a dynamic response time in the processing software which is equivalent to the sound level meter "slow response" characteristics. As cited above, this effective response is required under provisions of FAR-36.

4.0 Noise Curve Development and Application - The first topic addressed in this section is the principal data extrapolation technique used in developing air-to-ground noise curves. This subject is followed by a discussion of techniques used in establishing ground-to-ground noise curves. Following the background presentations are descriptions of the specific methodologies employed for each of the heliccpter operational categories along with a discussion of noise curve application.

4.1 Air-to-Ground Data Extrapolation Procedure - This procedure is the principal data extrapolation (data decay) method used to extend sound exposure level curves beyond the actual measured slant ranges. The one-third-octave sound pressure level spectrum for each selected event is the starting point for any given extrapolation. Each spectrum is initially adjusted to standard acoustical day conditions of 77°F and 70% RH. Each band sound pressure level in the spectrum is then "decayed" to longer slant distances using the following increments to be added algebraically to the reference sound pressure levels:

1. $\Delta SPL_i = 20\log(d_R/d_1)$

where d_R is the reference distance, d_1 is the adjustment distance and SPL_i is the ith one-third-octave band sound pressure level.

2. $\Delta Atmo. = \alpha_i(d_R-d_1)$

where α_i is the 77°F, 70% RH, atmospheric absorption coefficient for the ith one-third-octave band.

The extrapolated spectrum is then used to compute L_{AM} at the given slant distance (L_{AM_1}).

In order to arrive at a value for SEL at the new distance (SEL_1) it is necessary to consider the change in event duration. The most thorough data base available (assembled by the FAA and CERL Ref. 1 and 12) indicates that the change in duration correction is related to distance as follows:

$$\Delta = 7\log(d_1/d_R)$$, where (7) is the "duration constant"

Thus the value of SEL at the new or adjusted slant distance is given as

$$SEL_1 = L_{AM_1} + (SEL_R - L_{AM_R}) + 7 \log (d_1/d_R)$$

where ($SEL_R - L_{AM_R}$) represents the reference duration correction.

It is worthwhile noting that the change in duration correction with distance remains controversial. The method recently suggested by the Society of Automotive Engineers (SAE) Aerospace Committee A-21 (Aircraft Noise) incorporates a duration constant of 10 at slant distances less than 800 meters and a duration constant of 6 at slant distances greater than 800 meters. This procedure, however, has been derived for turbine-engine fixed-wing aircraft and (as shown by FAA and CERL data) is not applicable to helicopters.

Thus, starting with the standard acoustical day spectrum for a reference distance, along with reference L_{AM} and SEL, it is possible to derive the entire SEL versus distance air-to-ground noise curve.

In the case of the 1978 and 1980 data sets, the full range of essential information was available. In the case of 1976 data, it was necessary to compute the SEL using the relationship $SEL = L_{AM} + 7 \log(DUR)$ where (DUR) is the "10dB-down" duration time expressed in seconds. The 1976 data were reported with complete A-weighted time histories.

In addition to the "spectrum-decay" extrapolation technique outlined above, an empirical curve fit procedure was used for some of the 1980 test helicopters. A comparison was then made among spectrum-decay values, empirical curve fit values,and measured data. The noise curves reported in this document represent those in best agreement with measured data.

4.2 Ground-to-Ground Data Extrapolation Procedure - The topic of ground-to-ground and low-angle propagation has been explored at great length for conventional fixed wing aircraft. After several years of study, the SAE A-21 Committee on Aircraft Noise recently adopted Aerospace Information Report (AIR)-1751 (Ref. 7) which provides procedures for computing "lateral attenuation" for overground and low-angle propagation paths. The lateral attenuation algorithm described in AIR-1751 combines installation effects of engine shielding with excess ground attenuation (EGA). The AIR-1751 procedure has been derived from noise level data for turbojet and turbofan-powered airplanes and its applicability to propeller-driven airplanes and helicopters has not been established. The procedure of AIR-1751 will be adopted for the use in the FAA Integrated Noise Model (INM) (fixed-wing aircraft data base) beginning with INM Version 3.8 to be made available in the Fall of 1982.

An alternative methodology (Ref. 6) currently being used in INM Version 2.7 computes separate values for excess ground attenuation and engine shielding, rather than lumping the two together as in AIR-1751. The (fixed wing aircraft) engine shielding consideration is clearly not applicable to helicopters. The EGA function, however, does provide a useful means for estimating the additional attenuation over and above spherical spreading losses and atmospheric absorption. In order to validate this procedure, FAA hover-in-ground-effect (HIGE) measurements (Ref. 3) have been examined for eight helicopters. While the range of measurements is limited to a distance of 150 meters, the attenuation rates are reasonably in line with the EGA values of Reference 6.

Two techniques have been developed for synthesizing ground-to-ground propagation curves. The first involves taking the one-third octave standard-day-corrected spectrum for hover-in-ground-effect (HIGE) at some reference distance. This spectrum is then extrapolated for spherical spreading and atmospheric absorption (as discussed in Section 4.1) to distances of interest. This extrapolated spectrum is then modified by the application of the excess ground attenuation function of Reference 6.

The second technique, used when a spectrum is unavailable, involves extrapolating the measured L_{AM} value at a rate of 22 dB per decade of distance to account for spherical spreading and atmospheric absorption losses. The constant (22) has been observed (FAA analysis of CERL data) to be "typical" for helicopter hover spectra. Once again, the excess ground attenuation function of Reference 6 is applied.

The resultant noise curve (with EGA applied) is then to be used only during the hover operation where propagation is assumed to be strictly ground-to-ground.

4.3.0 Takeoff - Takeoff noise curves have been constructed using the Section 4.1 extrapolation procedure, starting from fully corrected noise measurement data (1978 and 1980). In the case of 1976 test data, the takeoff noise curves have been estimated using the procedure outlined below.

4.3.1 Takeoff Noise Curve Estimation - In some cases, noise data are available for every operation with the exception of takeoff. Therefore, an analysis has been conducted which relates takeoff noise levels to the noise levels for approach and level flyover operation. This analysis utilizes FAA data along with information provided by France, Italy, U.K., USSR, and Germany published in a working paper of the International Civil Aeronautical Organization (ICAO) at the Working Group B Meeting of the Committee on Aircraft Noise (Ref. 13).

A population of data has been constructed for each mode of operation and a regression performed between EPNL and the base-ten logarithm of weight. As the slope of the regression line was found to be very similiar for each operation a single delta or difference in EPNL can be established between operational modes regardless of helicopter weight.

An analysis of FAA 1978 and 1980 controlled test data is presented in Table 4.3-1 in which an average difference of 2.0 dB is observed between approach EPNL and takeoff EPNL. The approach/takeoff comparison was used because variability in takeoff and approach sound levels has been observed to be less then the variability observed for the level flyover operation. That is, over the sample population of helicopters, the noise-weight relationship is more stable for takeoff and approach then for level flyover. The average difference of 2.0 EPNdB (where App - T/O = 2.0) is transferable to the SEL metric as both EPNL and SEL represent time-integrated or "energy dose" measures of sound.

TABLE 4.3-1

	Δ EPNL (App - T/O)
SA-330J	1.3
BO-105	1.2
Bell 206L	2.8
S-61	-0.1
S-65	3.3
Bell 212	2.9
H-500C	.5
SA-341G	-3.2
UH-60A	6.6
S76-100%	2.6
S76-107%	3.4
A-109	2.1

Average Δ EPNL (App - T/O) = 1.95

Standard Deviation (SD) = 2.36

Note: The result is rounded off to difference of 2.0 dB

4.3.2 Sensitivity of Noise Level to Torque - The question of takeoff power (torque) effect on noise level has been examined (Ref. 2) for the UH-60A Black Hawk. It appears that noise levels are relatively insensitive to changes in torque. This is in contrast to an extreme sensitivity to changes in main rotor RPM observed for the S-76 (Ref. 2).

The data presented in Table 4.3.2 show no statistically significant change in sound level from changes in torque up to almost 15 percent.

4.3.3 Application of Takeoff Noise Curves - Takeoff noise curves are specified for particular maximum gross takeoff weights, and the "Best Rate of Climb" (BRC) as defined for Vy, the speed for best rate of climb. Climb gradients are referenced to sea level pressure, standard day temperature conditions. Takeoff curves are to be used with "conventional" departure procedures as discussed in Section 5.

4.4.0 Approach - Approach noise curves have been developed using the Section 4.1 extrapolation procedure in all cases. Approach operations were conducted along a glideslope of 6 degrees in both the 1978 and 1980 FAA noise tests. In the 1976 FAA test, approaches were conducted at descent angles of 3, 6, and 9 degrees. All of the noise curve data presented in this report are for 6-degree approaches.

In the case of 1976 test data, the one-third octave spectra were not corrected to standard day conditions prior to application of the Section 4.1 decay program. This is not considered a significant source of error as the slant range for the measurements was on the order of 400 feet.

4.4.1 Sensitivity of Approach Noise to Airspeed and Descent Angle - Two analyses have been conducted to assess sensitivity of approach noise levels to operational procedures.

The first study (Ref. 2) investigated the effect of variation in approach speed on noise level. In Table 4.4-1, data are shown for UH-60A Black Hawk

TABLE 4.3-2

UH-60A Black Hawk Noise-Torque Sensitivity Analysis

Takeoff at Hover Power +10% (approximately 60%)

Run #	SEL(dB)	L_{AM}(dB)	Torque (%)
21	85.3	76.8	78
23	85.4	77.6	82
25	85.3	77.6	84
27	85.5	77.8	87
29	84.7	77.2	83
31	86.7	78.0	86
33	86.4	77.9	85
	AVG = 85.6	AVG = 77.5	AVG = 83.6
	S D = .7	S D = .4	S D = .3

Takeoff at Maximum Power (100%)

Run #	SEL(dB)	L_{AM}(dB)	Torque (%)
35	86.1	78.2	99
37	86.6	78.1	98
39	86.2	77.6	95
41	85.6	76.1	98
	AVG = 86.1	AVG = 77.5	AVG = 97.5
	S D = .4	S D = 1.0	S D = 1.7

SEL Δ = Hover + 10% - Max Power = -0.5

L_{AM} Δ = Hover + 10% - Max Power = 0 approaches at a 6-degree angle with three different airspeeds: Vy, (Vy + 10), and (Vy - 10). The differences in SEL are very minor; however, a trend is evident in the values of L_{AM} showing a reduction in noise level with a reduction in speed. This decrease in intensity, however, is offset in the SEL (energy metric) by an increase in duration.

A second study (Ref. 3) investigated the effects of descent angle on noise level. Data are presented for both EPNL (similiar to SEL) and L_{AM}. A summary of the results is presented in Figure 4.4-1 and a brief descriptive excerpt is presented below.

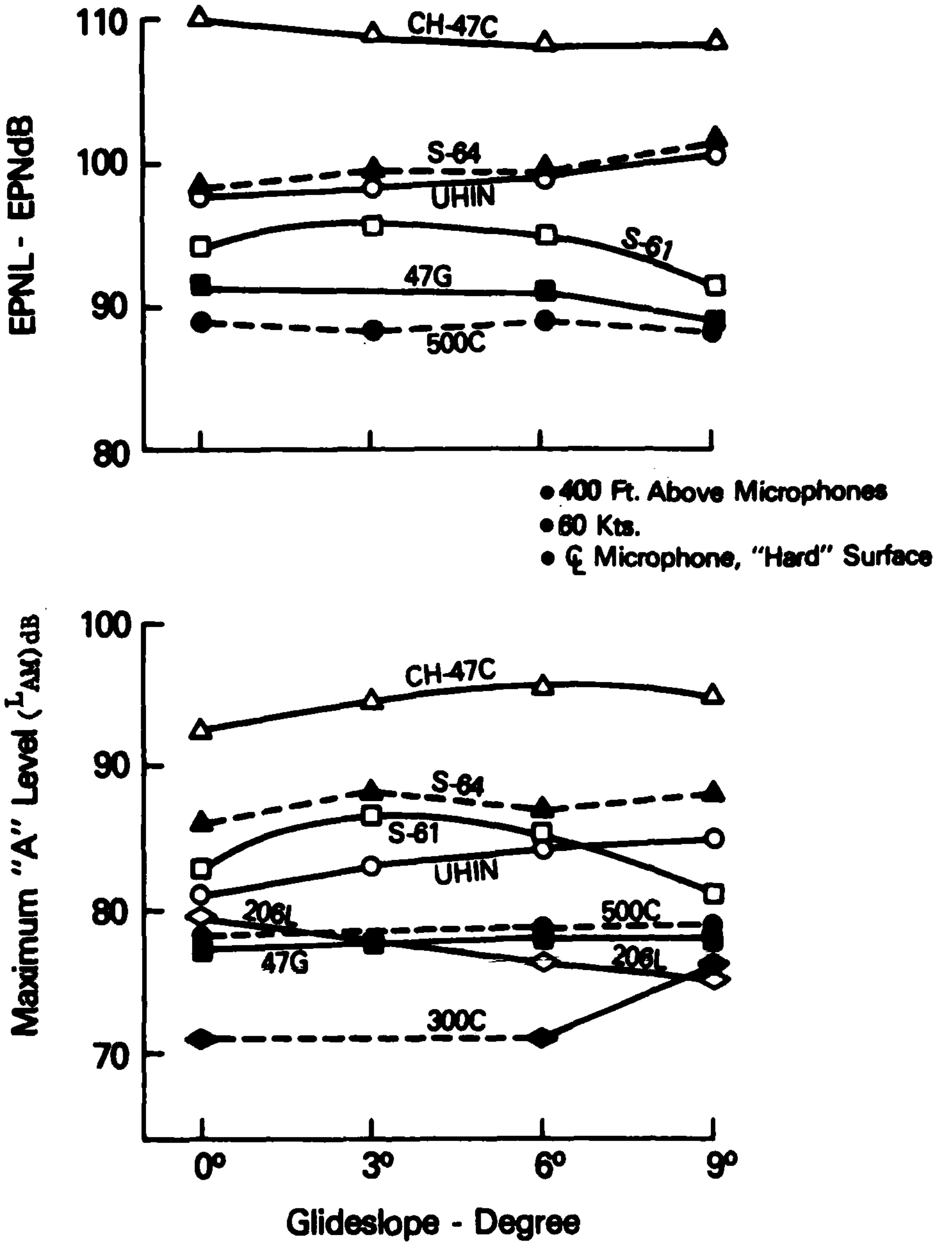
> "The effect of glideslope on approach noise level is shown on Figure 4.4-1 for both maximum A-weighted level and EPNL. The zero degree glideslope was taken from level flyover data at the approach airspeed of 60 kts and raised 2dB to account for the 400 foot (120m) altitude of the approaches compared to 500 feet (150m) for the level flyovers. As shown on Figure 4.4-1, the noise levels do not vary appreciably with glideslope. However, the approach noise for the UH-1N and CH-47C is less than during a high speed flyover because of the low airspeed during approach and resulting lower levels of compressibility blade slap. Nearly all of the helicopters had some blade slap during most of the approaches. Usually, however, this slap did not occur at the time of peak noise and therefore was not a major factor in determining noise level."

4.4.2 Application of Approach Noise Curves - The approach noise curves presented in this document are well suited for most normal descent operations in view of the relative insensitivity of approach noise levels to operational procedures.

TABLE 4.4-1

UH-60A Black Hawk

Run No.	SEL(dB)	L_{AM}(dB)	Torque (%)
APP (Best rate of climb + 10 kts)			
22	98.2	91.9	18
24	97.2	91.2	25
26	98.1	91.5	30
28	97.7	91.3	19
	AVG = 97.8	AVG = 91.5	AVG = 23.0
	S D = 0.5	S D = 0.3	S D = 5.6
APP (Best rate of climb)			
38	96.9	88.8	34
40	96.0	89.1	23
42	97.0	90.0	19.5
	AVG = 96.7	AVG = 89.3	AVG = 25.5
	S D = 0.5	S D = 0.6	S D = 7.6
APP (Best rate of climb - 10 kts)			
30	97.3	91.0	26
32	97.2	88.7	35
34	95.5	87.6	31
36	95.8	88.4	25
	AVG = 96.4	AVG = 88.9	AVG = 29.3
	S D = 1.0	S D = 1.4	S D = 4.6



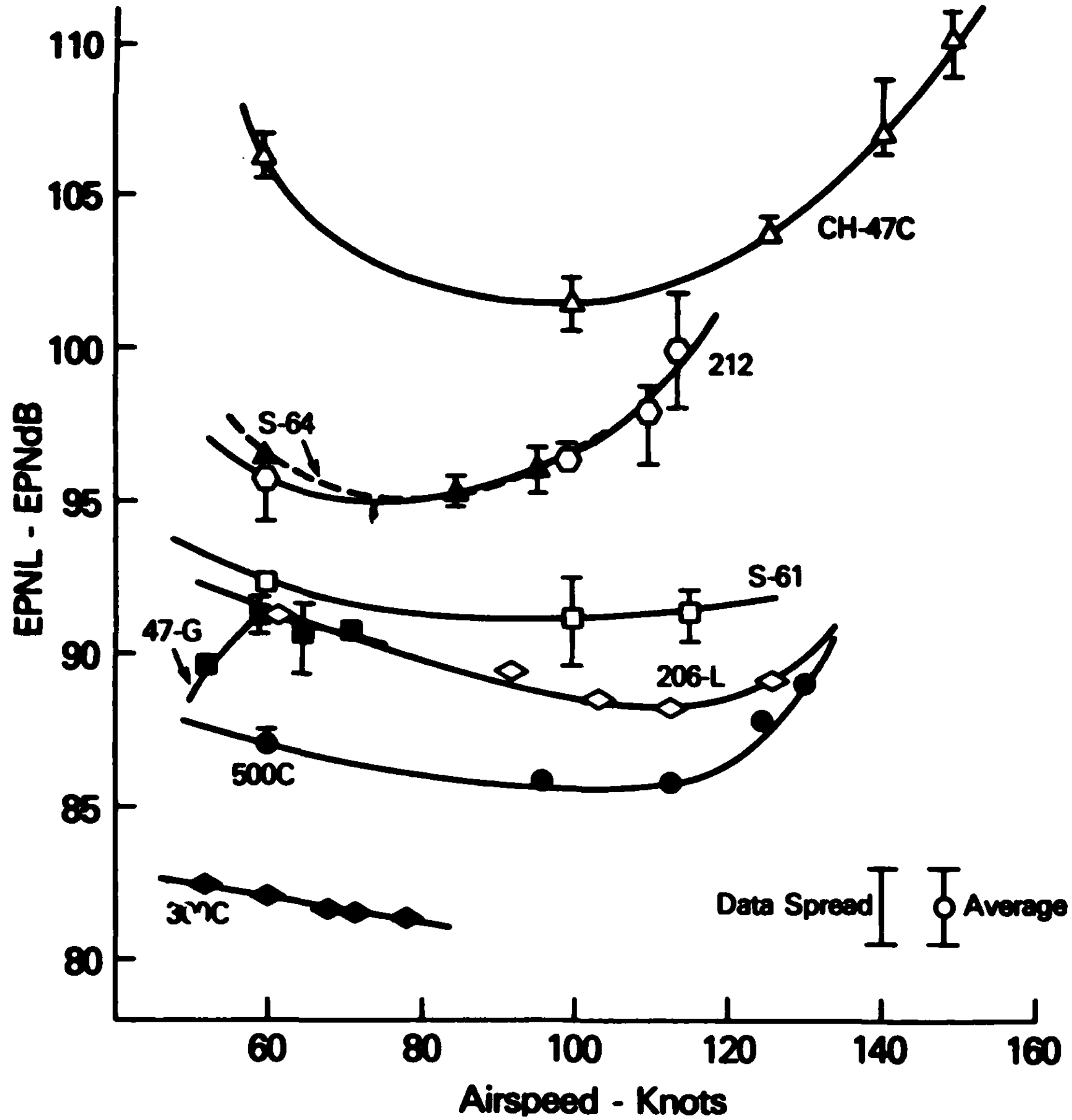
Effect of Glideslope Angle on Noise Level

FIGURE 4.4-1

4.5.0 <u>Level Flyover</u> - Noise data acquired in the 1976 FAA measurement program (Ref. 3) included level flyovers at a variety of airspeeds, all at an altitude of 500 feet above ground level. These data provide a means to quantify the sound exposure (SEL) and intensity (L_{AM}) variations with airspeed. Similiar speed-variation level flyovers were conducted in the 1980 (Ref. 2) measurement program.

When a helicopter increases its airspeed, two acoustically-related events take place. First, the noise event duration is decreased as the helicopter passes more quickly. Second, the source acoustical emission characteristics change. These changes reflect the aerodynamic effects of increased lift as well as increased form drag which accompany an increase in speed. The increased lift tends to mean that less power is required to maintain level flight; however, at a certain speed the increase in form drag (imposing a greater power requirement) balances the gain due to lift. Thus, for higher speeds, disproportionately more power will be required to achieve an increase in airspeed. These counteracting influences lead to a noise-intensity-versus-airspeed relationship which can be approximated by a parabolic curve. Figure 4.5-1 presents a family of speed-versus-noise-level relationships developed from 1976 test data (Ref. 3). Table 4.5-1 shows a series of parabolic equations which were fitted to these curves in a U.S. Air Force report (Ref. 5). Figure 4.6-1 presents a typical noise level-speed plot developed from the 1980 FAA measurement program (Ref. 2).

The noise-versus-speed information cited above has been used to develop a series of level flyover noise curves for each of the helicopters tested in 1976 and 1980. In the 1978 test, level flyover data were acquired for a speed of 0.9 V_H only (V_H is the speed for maximum continuous power).



Effect of Airspeed on Noise Level

FIGURE 4.5-1

TABLE 4.5-1

ADJUSTMENT TO REFERENCE SOUND EXPOSURE LEVEL FOR NONREFERENCE AIRSPEED/POWER CONDITIONS

$$\Delta dB = a(V - V_{ref})^2 \quad \text{decibels}$$

Helicopter	a $x10^{-3}$	V_{ref} knots
CH-3C (S-61)	0.63	100
CH-47C (114)	3.4	100
CH-54B (S-64)	3.8	80
HH-53 B/C (S65A)	0.83	100
OH-6A (500)	2.2	90
TH-55A (300)	1.7	80
UH-1N (212)	4.1	80
UH-13 (47G)	2.5	50

HELICOPTER NOISE MEASUREMENT DATA

500 FOOT LEVEL FLYOVER

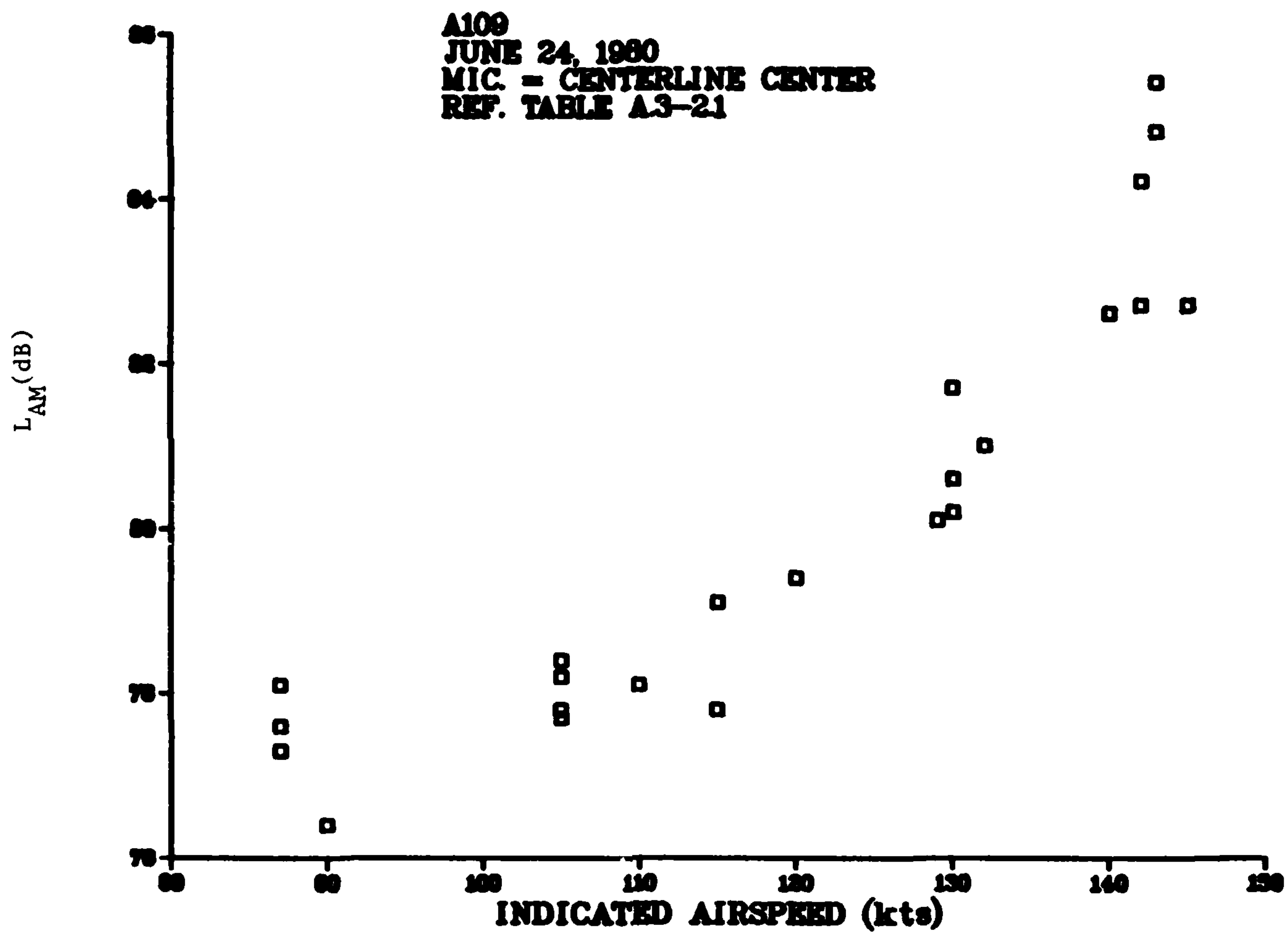


FIGURE 4.6-1

It is worth noting that in every case noise curves have been checked against, or calibrated to, measurement data (for best fit) out to as great a slant distance as possible.

4.5.1 <u>Application of Level Flyover Noise Curves</u> - The level flyover noise curves contained in this document may be used to model the cruise condition.

4.6.0 <u>Hover</u> - Noise curves have been generated using the Section 4.1 extrapolation procedure along with the incorporation of additional attenuation called EGA. As described in Section 4.1, the extrapolation procedure employs individual reference spectra. For any specific helicopter (1976 test data) the reference spectrum is a single ensemble average one-third octave spectrum which has been derived by logarithmically combining (19 second average), one-third octave sound pressure levels for a variety of source emission directivity angles. Each of the directivity - indexed spectra in turn represents the logaithmic average for two diametrically opposed microphone locations each 500 feet from the helicopter. The derived ensemble average spectrum reflects the following: 1) up-wind/down-wind propagation, 2) source directivity and 3) variability of source intensity as a function of time. In the case of the S-76 (manufacturer provided data), eight spectra were used, (each a different emission angle) for a single microphone. Hover noise curves for 1978 and other 1980 test helicopters are estimates, generated using a regression equation for noise level versus log-weight, for 1976 test helicopter along with a generalized noise versus distance function.

Noise curve tables for Hover present L_{AM} values, not SEL values. In order to computer SEL for a stationary hover it is necessary to consider the duration of the hover event in seconds.

$$SEL = L_{AM} . 10 \log (\text{Duration}) \text{ dB}$$

A contour for hover can be drawn manually using a compasss and calculated from the noise distance curve and the equation above. This simple technique provides the ability to quickly estimate noise exposure in the vicinity of a helipad where hover or flat-pitch idle thrust operations are dominant contributions to the cumulative noise exposure. This technique assumes omnidirectional radiation of acoustical energy. While the instantaneous sound field around a halicopter is known to be highly directional and time variant, the actual hover operation of helicopter most often involves considerable changes in azimuth heading as well as random variations in noise emission. These factors support the omnidirectional assumption as reasonable when analyzing spacial and time average noise impact.

In the case of taxi-hover the event duration is estimated using the taxi speed of the helicopter (v) and the distance to the observer (d) yielding

$$SEL = L_{AM} + 7 \log \left(\frac{d}{v}\right) - 1.6 \text{ dB}$$

where (d) is expressed in feet and (v) is expressed in knots the constant (-1.6) accounts for the difference in units and L_{AM} is specified for distance, (d).

Using this expression, individual SEL versus distance curves can be developed for various constant velocities.

An alternative procedure useful with computer noise models would be to develop a single SEL-distance curve for a reference taxi-velocity (V_R) and then adjust SEL as a function of velocity. In using INM Version 2.7 this would involved specifying the SEL versus distance curve for a reference velocity taken to be V_R and adjusting as a function of velocity using the velocity correction algorithm:

$$dB = 10 \log \left(\frac{z}{160}\right)$$

This is a variation on the normal INM velocity-duration correction which uses an arbitary reference velocity of 160 kts. The variable z is computed from the helicopter velocity (V) as follows:

$$z = 160 \times \left(\frac{V}{V_R}\right)^{7/10}$$

This methodology assumes that L_{AM} values are not changing significantly with airspeed over the brief acceleration period.

4.6.1 In Ground Effect/Out of Ground Effect Hover - When a helicopter is operating "In Ground Effect" (IGE), the helicopter is close enough to the ground plane to experience "upwash" on the rotor system which in-turn results in higher lift, and lower induced drag on rotor blades. The net effect is a reduction in the power required to maintain flight. When a helicopter is not assisted in achieving lift by ground plane up-wash, then, it is said to be "Out of Ground Effect" (OGE). As it requires more energy to hover OGE than IGE, it is logical to expect OGE noise levels will be higher than IGE noise levels. Examination of U.S. Army data (Ref. 5) shows that OGE noise levels exceeded IGE noise levels by 3 dB on the average for the 5 helicopters tests. This increment has been applied to IGE hover data to construct OGE hover noise tables in appendices of this report.

The study of ground-to-ground and low angle sound propagation of helicopter noise is a relatively undeveloped area and limited data are available. As new data are acquired or more information becomes available the FAA will incorporate appropriate information as revisions or refinements to the noise curves in this report.

4.6.2 Flat Pitch-Idle Thrust Operation - A FAA noise measurement survey conducted in Phoenix, Arizona in July 1982 (Ref. 15) provides some insight into the difference in L_{AM} values between HIGE and Flat-Pitch/Idle-Thrust (Idle) operation. The Idle operation in some cases, can be the dominant source of noise exposure. Many areas adjacent to the helipad, but not located along ingress/egress routes will primarily be affected by Idle operation which is the quietest mode of operation but often of long duration. Many operators will Idle for 10, 20, or 30 minutes if necessary, to avoid a shut-down, start-up cycle, each cycle shortening the remaining period before another engine overall is required. The data shown in the table below displays considerable variability (as one would expect), exhibiting a slight trend to reduce the L_{AM}(HIGE) - L_{AM}(Idle) difference at greater distances. It is observed that the 206-L and SA-350 A-Star exhibit similiar differences while the Alouettee III has a smaller difference between L_{AM}(HIGE) and L_{AM}(Idle). While these survey data represent a small statistical sample they still provide a means to project a reasonable average delta (L_{AM}(HIGE) - L_{AM}(Idle)) useful in developing Idle operation noise contours. An increment of (-12) dB is the suggested delta to be applied to HIGE noise levels in order to estimate Idle noise levels.

L_{AM}(HIGE) Minus L_{AM}(Idle) Expressed in Decibels (dB)

HELICOPTER	HELIPAD 1 HELIPAD to MIC. DIST.			HELIPAD 2 HELIPAD to MIC. DIST.	
	130 ft	240 ft	400 ft	145 ft	280 ft
Bell 206-L	13.2	-	9	14.5	11
Alouette III	5.5	-	-	6.5	5.5
A-Star	14.5	17.8	11	15.5	15

NOTE: L_A values represent slow response averaging for HIGE and 60-70 second Leq averaging for Idle.

4.6.3 Application of Hover Noise Curves - The following notes provide guidance for the proper use of hover noise curves in general and specific guidance for use with the FAA's INM.

1. The IGE data tables include excess ground attenuation influences for ground-to-ground (zero degree) propagation.

2. The OGE data tables include excess ground attenuation influences for low angle (near zero degree) propagation.

3. IGE and OGE data are to be used primarily for ground-to-ground or low angle propagation scenarios.

4. With certain cautions OGE data can be used for direct climb profiles by applying the adjustments shown below. These adjustments will produce an air-to-ground noise/distance function by removing the zero degree EGA influence. When this procedure is used it is necessary to assure than an appropriate, angle dependent, lateral attenuation or EGA function is applied in computing the sound levels for locations at elevation angles between zero and thirty degrees.

CPA Distance (feet)	Adjustment
200	+2 dB
400	+2.5 dB
600	+3.5 dB
1000	+6.0 dB
2000	+8.5 dB
4000	+9.8 dB
6000	+10.0 dB
10000	+10.0 dB

Special Notes for INM Use

1. As the INM 2.7 automatically applies EGA and shielding, it is necessary to suppress these functions from operating on the IGE and OGE ground-to-ground curves contained in the appendices of this report. This is accomplished by applying the adjustments shown above (cancelling zero degree EGA) then applying an additional +3 dB adjustment to effectively suppress the shielding adjustment applied for zero-degree propagation. Conversely, if INM Version 3.8 is to be used then the AIR-1751 zero degree attenuation function must be surpressed (see Sec 4.2). The next result (INM output) is an IGE or OGE ground-to-ground noise distance curve similar to those presented in the appendices of this document.

2. When using the OGE air-to-ground noise curve for direct climb profiles, a small error is present at low angles (less than 30°) which tends to create less noise exposure (1-3 dB). The normal INM 2.7 EGA algorithm applied to

air-to-ground OGE noise curve yields valid results, however, the influence of the angle dependent INM 2.7 shielding algorithm (inappropriate with rotorcraft) creates the small error at low angles. In the case of INM Version 3.8, the AIR-1751 function cannot be surpressed for low angles and consequently will lead to somewhat lower levels than appropriate during the brief, transitional (low angle propagation) flight regimes.

5.0 Helicopter Operational Procedures

5.1 Takeoff Performance - Rotorcraft Flight Manuals (RFM) are published for each helicopter certificated under existing Federal Aviation Regulations (FAR's). These manuals provide operating limitations, normal and emergency flight procedures and some performance information. While the RFM may be the best (published) source for performance information there are many commonly used operational procedures which are simply not specified. It is therefore essential that the engineer or planner undertaking a helicopter noise impact analysis speak directly with helicopter operators and/or pilots to review in detail the way in which helicopters are flown into and out of the heliport or airport under study.

The following excerpt from Reference 11 provides an introduction to some commonly used operational procedures

Excerpt

Baseline Flight Profiles

Three distinctly different flight profiles can be developed for heliport operations, which identify all potential terminal maneuvers and flight phases applicable to both visual flight rules (VRF) and instrument flight rules (IFR) operations. These profiles are presented in Figures 5.1-1, 5.1-2, and 5.1-3. The operational model for a given heliport can contain various combinations of flight phases, from any or all of the profiles, depending on site-specific conditions and the capabilities of the helicopters which would use the heliport. The subject profiles represent the possible operational needs of helicopters, and reflect the various requirements of applicable certification and operating regulations.

Figure 5.1-1 shows the Horizontal Flight Profile, depicting the use of a significantly large Heliport Maneuver Area (HMA) to support flight operations when hover-out-of-ground-effect (HOGE) is not possible. For takeoff, a vertical lift off to an in-ground-effect (IGE) hover is made followed by acceleration IGE to the airspeed for best rate of climb (Vy). Upon reaching Vy, climb is initiated and sustained until reaching cruising altitude. For landing, approach is made at a comfortable airspeed and descent gradient until approaching the ground plane. The aircraft is leveled off at IGE hover and decelerated within the confines of the Heliport Maneuver Area. A variation of this technique, which may be used when the HMA surface is suitable, is a running landing.

Figure 5.1-2 shows the Direct Flight Profile, depicting takeoff and landing without the use of an appreciable HMA. The helicopter must be capable of hover OGE to utilize this profile. For takeoff, a vertical lift off to an IGE hover is made followed by an accelerating climb. The needed initial climb gradient is sustained until clear of controlling obstacles, then acceleration to Vy is resumed (if necessary) and climbout is continued at Vy. Landing approach is initiated at a comfortable airspeed and descent gradient with deceleration accomplished along the flight path to an IGE hover. When hovering performance capability is marginal, the direct profile landing may be used by completing a decelerating approach to touchdown on the landing surface. In the latter procedure, care must be used to ensure that sink rate is controlled throughout the approach and that hover altitude and nearly zero groundspeed are attained at the moment of touchdown.

Figure 5.1-3 shows the Vertical Flight Profile defined for use by Transport Category A helicopters to ensure safe operation in the event of engine failure when operating from a heliport lacking an adequately sized HMA. For takeoff, a near vertical climb is inititated with slight backwards

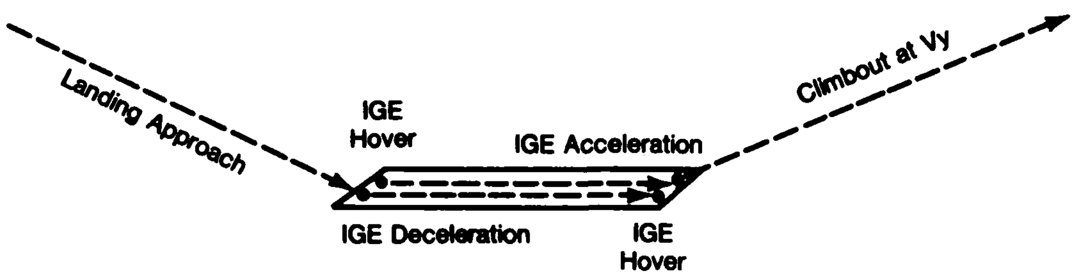


Figure 5.1-1 Horizontal Flight Profile

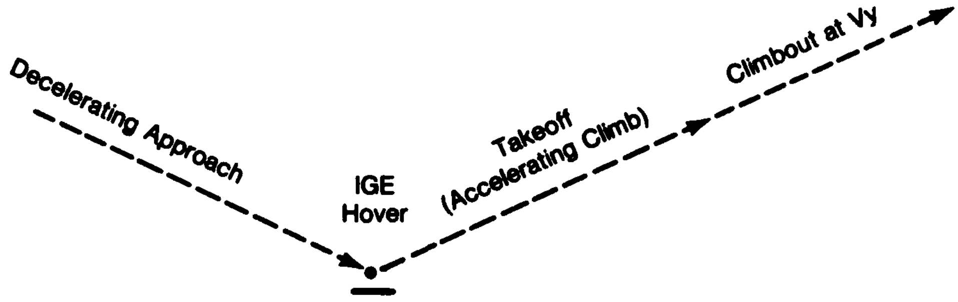


Figure 5.1-2 Direct Flight Profile

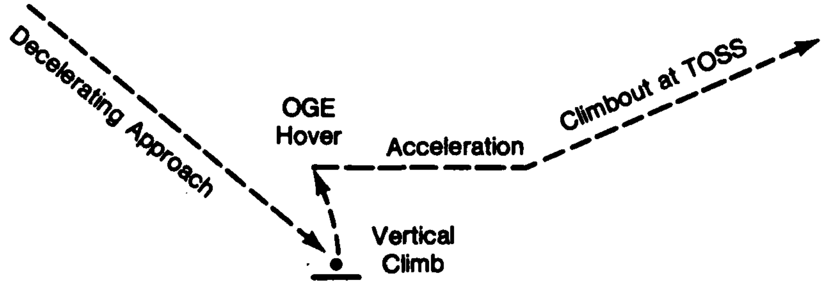


Figure 5.1-3 Vertical Flight Profile

Flight Profiles for Heliport Operations

motion to retain visual contact with the heliport landing area. Climb is continued until reaching a critical decision height from which acceleration into forward flight is initiated. Failure of one engine before reaching the decision height results in a decision to immediately land. Failure of one engine after initiating acceleration results in a decision to continue the takeoff, descending if necessary to attain takeoff safety speed (TOSS) for climbout. For landing, the approach profile is similar to the Direct Profile landing, but approach beyond the critical decision point is continued directly to touchdown on the landing surface as described in the procedure for marginal hover capability. Utilization of the Vertical Profile procedure generally requires reduction in takeoff gross weight (TOGW) below the maximum certified TOGW which would be based on Horizontal Profile procedural performance capability.

An important point to note is the fact that each flight profile can be structured to represent various levels of performance which can result in different requirements for real estate and airspace. Further, the flight profiles presented do not necessarily represent the only available choices to the operators. Rather some blending or combination of phases of one profile can be made with others. A case in point, would be the blending of Horizontal and Direct procedures when the HMA permits some measure of IGE acceleration, but not enough to reach Vy as in the strict Horizontal case.

In heliport planning, the choice of flight profiles or combinations thereof, with attendant implications for real estate and aircraft performance will vary with the type of flight operations. Consideration must therefore be given to such conditions as night time operations, instrument or failure state operations and the impact of operating regulations.

<u>End of Excerpt</u>

5.2 Helicopter Operation Pairing With Noise Curves - The following table lists the type of operation along with the INM noise curve which should be used in modeling noise exposure:

OPERATION	NOISE CURVE
Flat Pitch/Idle Thrust	IGE-H minus 12 dB
IGE Hover	IGE-H
OGE Hover	OGE-H
Vertical Ascent	OGE-H
Direct Profile Ascent	OGE-H, T/O
Vy Takeoff	T/O
Approach	A
Level Flyover (cruise)	LFO (v)

As a matter of refinement, when acoustical data become available for specific transitional flight regimes every effort will be made to incorporate those new data.

6.0 Helicopter Performance

6.1 Takeoff Performance Approximation - A procedure is described in Reference 11 which is useful in approximating helicopter departure performance. The following paragraphs are excerpted from that document and provide a method for "getting inside the ballpark" when no other information is available. While this methodology may suffice for a cursory analysis, the INM user is cautioned to use 1) Rotorcraft Flight Manual Data and 2) talk with pilot/operator for aircraft specific information when conducting a noise impact analysis intended to withstand close scrutiny.

Excerpt

The total real estate and airspace requirements for a heliport may be determined by computing the HMA and the departure flight profile required for the specific helicopters to be operated from a heliport. As helicopter performance is the primary factor in determining these parameters, it becomes the baseline criteria. However, performance is a function of weight, altitude and temperature (WAT) so no single performance figure can be assigned to a given helicopter. The Heliport Manuever Area size is determined by the distance required to accelerate to a given climb airspeed in order to meet a specific departure profile. In this study, three flight profiles were developed which identify all potential terminal maneuvers. 1) The Horizontal Flight Profile which requires a relatively large HMA, 2) the Direct Flight Profile which requires no appreciable HMA and 3) the Vertical Flight Profile which is defined for use by Transport Category A helicopters. Each flight profile requires different real estate requirements and the ability of a given helicopter to utilize a specific profile is dependent upon its level of performance.

Various helicopter design parameters which influence performance have been analyzed in order to devise a means for making generalized performance estimates. In order to be consistent with existing FAA categorization of helicopters the following two categories are used: Normal Category helicopters -- helicopters of less than 6000 lbs. TOGW, and Transport Category helicopters -- helicopters of more than 6000 lbs. TOGW. Distinctions between the certification requirements of the two categories have tended to govern design tradeoffs to the extent that 6000 pounds now provides a natural division in characteristics.

Performance levels reflect the variance of these design parameters within a category by approximately defining a 95% confidence interval on the category mean. Performance levels are defined as follows:

<u>Performance Level I</u> -- Most (about 95%) modern helicopters in the category are able to perform at this level or better.
Poor
Lowest 5%

<u>Performance Level II</u> - Approximately 50% modern helicopters in the category can perform at this level or better, and 50% cannot. Level II defines the mean within the category.
Average

<u>Performance Level III</u> - Few modern helicopters in the category can perform at this level or better.
Excellent
Top 5%

Consequently, Levels I and III are approximate, not absolute, lower and upper bounds within the (Normal and Transport) category and Level II defines the expected mean value. For purposes of this report "modern" helicopters include those reflecting design philosophies of the 1960-1980 time-frame.

These generalizations are based on single main rotor helicopters; the configuration which dominates current operational helicopters.

Utilizing the performance achievable at each of the three performance levels, data have been developed in tabular form for both the Conventional and Direct climb profiles. Data are presented (for both Normal and Transport Category helicopters) for pressure altitudes ranging from sea level to 10,000 feet and for four temperature levels. The temperature levels are based on standard day conditions for each altitude and are also provided for conditions 10°C, 20°C, and 30°C greater than the standard day. A further breakdown was made to show the effect of off-loading weight by showing climb gradients for each of three proportional weights -- 100%, 90%, and 80% of the limiting TOGW. Eighty percent of TOGW is an approximation of the minimum weight for a productive load.

Utilizing these data, a heliport planner can determine first the HMA required and then, based upon the desired/required climb profile, the specific climb gradient for a Performance Level I, II, or III helicopter based on the heliport's pressure altitude and temperature standard. The planner will also be able to determine a percentage reduction TOGW that may be required by each Performance Level to meet a specific gradient for his present or planned heliport.

The process outlined above provides planners information not generally available to the helicopter pilots who must fly the aircraft to and from the heliports designed for their benefit. It is granted that Conventional Climb data are usually provided in the RFM in the form of best rate of climb. This permits computation of climb angle or gradient if Vy is known.

Direct Climb data are not available in any form. The computational procedure used herein (Ref. 11) could be accomplished by pilots during flight planning but it is tedious and presupposes pilot access to extensive data on the characteristics of a standard atmosphere. If heliports are to be developed based on a knowledgeable, general appreciation of helicopter performance capabilities, then they certainly should be used with an explicit appreciation of the precise helicopter capabilities which may be expected in conjunction with the known heliport real estate and airspace constraints, as tempered by reasonable expectations of the weather.

End Excerpt

6.2 Takeoff Performance Tables - These sections contain tables and figures from References 10 and 11 which provide takeoff performance estimates.

The distance required to accelerate to various airspeeds for given acceleration rates and attitudes is provided in table 6.2-1 and figure 6.2-1. Estimates have not been identified as representative of particular helicopter types or categories. It is believed that these IGE acceleration distances are conservative. These estimates would typically be used to determine the distance to attain Vy for a "Conventional" takeoff. The following paragraph from Reference 11 provides additional insight to the use of these figures.

Excerpt

When only IGE hover is possible, then a Transport Category helicopter must accelerate to a climb speed above that prescribed by its limiting height-velocity (H-V) diagram, or when minimum IFR speed (or minimum IFR climb speed if applicable) must be attained before initiating climb, a level acceleration within a Heliport Maneuver Area is required. At altitudes below the HOGE ceiling, as may occur in either of the latter two conditions, acceleration rate is limited by practical rather than performance considerations. The acceleration rate attainable for departure from hover which is related to the amount of nose-down rotation normally should not be expected to exceed 10°. The resulting practical limit on acceleration rate is then about .18g for all helicopters that are operating below their HOGE ceiling. In the former case, when a helicopter is within its HIGE ceiling limitation, but is not able to hover OGE, an acceleration of .18g may not be safely attainable. A lesser, more tentative rotation is required to ensure that the desired height above the ground may be sustained.

End Excerpt

Tables 6.2-2 and 6.2-3 provide climb gradients (RUN/RISE) for various combinations of pressure altitude, weight and performance level. These climb gradients would be attained at a speed of Vy, and are identified as "Conventional Climb" parameters.

Tables 6.2-4 and 6.2-5 provide climb gradients for Direct Climb, at various pressure altitudes, weights and performance levels. The climb gradients shown assume a horizontal velocity component of 10 kts.

6.3 Approach Operations - FAA Report No. FAA-RD-80-58 (Ref. 9) stated that VFR approach angles of 6 to 9 degrees were common for commercial operations with passengers on board. Approach angles rarely became as steep as 12 degrees. The average approach angle was given as "approximately 8 degrees." The acoustical measurement data base reflects an approach angle of 6 degrees and is considered to be representative of approaches in that region. Significant deviations in noise level would likely occur only in the case of a blade-slap approach regime. As a future refinement, the FAA intends to study further the effect of approach angle on noise level and will provide data base revisions as they become available.

TABLE 6.2-1

HELIPORT MANEUVER AREA

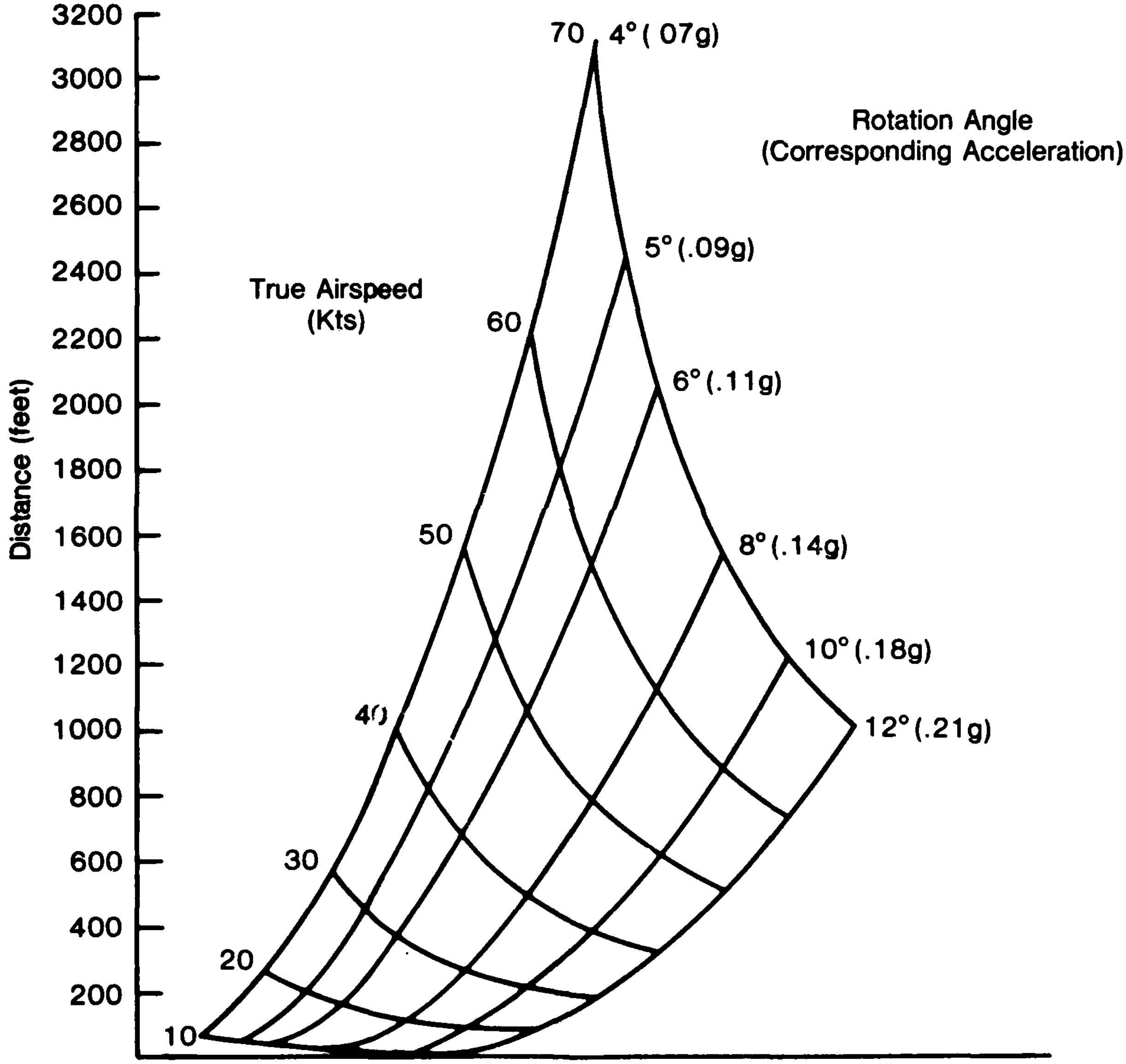
ACCELERATION DISTANCES

Distances (in feet) Required to Accelerate to Various Airspeeds
for the Indicated Constant Acceleration Rates
and Corresponding Changes in Attitude

Acceleration Rate	Attitude Change	Airspeed at End of Acceleration (Knots) 10	20	30	35	40	45	50	55	60	65	70
.04g	2.3°	111	443	998	1358	1774	2245	2772	3354	3991	4684	5433
.06g	3.4°	74	296	665	905	1183	1497	1848	2236	2661	3123	3622
.08g	4.6°	55	222	499	679	887	1123	1386	1677	1996	2342	2716
.10g	5.7°	44	177	399	543	710	898	1109	1342	1597	1874	2173
.12g	6.8°	37	148	333	453	591	748	924	1118	1330	1561	1811
.14g	8.0°	32	127	285	388	507	641	792	958	1140	1338	1552
.16g	9.1°	28	111	249	340	443	561	693	838	998	1171	1358
.18g	10.2°	25	99	222	302	394	499	616	745	887	1041	1207
.20g	11.3°	22	89	200	272	355	449	554	671	798	937	1087

Reference 11

Figure 6.2-1



Distance Required to Accelerate to Various Airspeeds for Various Initial Rotation Angles (Acceleration Rate Assumed Held Constant Throughout Maneuver)

Distance for Acceleration to Various Airspeeds

Reference 11

TABLE 6.2-2

CLIMB GRADIENTS FOR CONVENTIONAL CLIMB

STANDARD DAY TEMPERATURES

NORMAL CATEGORY HELICOPTERS

PRESSURE ALTITUDE (feet)	TEMP (°C)	I: Percent Max. TOGW 100%	I: 90%	I: 80%	II: Percent Max. TOGW 100%	II: 90%	II: 80%	III: Percent Max. TOGW 100%	III: 90%	III: 80%
S.L.	+15	10.05	8.08	6.28	5.62	4.79	3.93	3.98	3.46	2.90
500	+14	10.49	8.38	6.49	5.80	4.94	4.05	4.10	3.56	2.98
1,000	+13	10.97	8.71	6.70	6.00	5.09	4.16	4.22	3.67	3.06
1,500	+12	11.48	9.05	6.93	6.21	5.26	4.28	4.35	3.78	3.14
2,000	+11	12.03	9.42	7.16	6.43	5.42	4.41	4.49	3.89	3.23
2,500	+10	12.63	9.81	7.41	6.65	5.60	4.54	4.63	4.00	3.32
3,000	+ 9	13.28	10.23	7.67	6.90	5.79	4.67	4.78	4.12	3.42
3,500	+ 8	13.98	10.67	7.95	7.15	5.98	4.82	4.93	4.25	3.51
4,000	+ 7	14.76	11.15	8.24	7.43	6.18	4.96	5.10	4.38	3.62
4,500	+ 6	15.61	11.67	8.55	7.71	6.40	5.12	5.27	4.51	3.72
5,000	+ 5	16.55	12.23	8.88	8.02	6.62	5.28	5.44	4.66	3.83
6,000	+ 3	18.76	13.48	9.60	8.69	7.11	5.62	5.83	4.96	4.06
7,000	+ 1	21.54	14.97	10.41	9.45	7.66	6.00	6.25	5.29	4.31
8,000	- 1	25.16	16.76	11.34	10.33	8.27	6.41	6.72	5.65	4.58
9,000	- 3	30.04	18.96	12.41	11.35	8.96	6.87	7.25	6.05	4.87
10,000	- 5	36.99	21.71	13.67	12.54	9.75	7.38	7.84	6.49	5.19

Reference 10

TABLE 6.2-3

CLIMB GRADIENTS FOR CONVENTIONAL CLIMB

STANDARD DAY TEMPERATURES

TRANSPORT CATEGORY HELICOPTERS

PRESSURE ALTITUDE (feet)	TEMP (°C)	PERFORMANCE LEVELS I Percent Max. TOGW 100%	I 90%	I 80%	II Percent Max. TOGW 100%	II 90%	II 80%	III Percent Max. TOGW 100%	III 90%	III 80%
S.L.	+15	6.78	5.81	4.80	4.52	3.97	3.35	3.44	3.05	2.59
500	+14	7.00	5.99	4.93	4.65	4.08	3.44	3.53	3.13	2.66
1,000	+13	7.24	6.17	5.07	4.79	4.19	3.53	3.63	3.21	2.73
1,500	+12	7.48	6.36	5.21	4.93	4.31	3.62	3.73	3.30	2.80
2,000	+11	7.74	6.56	5.36	5.07	4.43	3.72	3.84	3.39	2.88
2,500	+10	8.01	6.77	5.52	5.23	4.55	3.82	3.95	3.48	2.95
3,000	+ 9	8.29	6.99	5.68	5.39	4.69	3.92	4.06	3.58	3.03
3,500	+ 8	8.60	7.22	5.85	5.55	4.82	4.03	4.18	3.68	3.11
4,000	+ 7	8.92	7.46	6.02	5.73	4.96	4.14	4.30	3.78	3.20
4,500	+ 6	9.25	7.71	6.20	5.91	5.11	4.26	4.42	3.89	3.28
5,000	+ 5	9.61	7.98	6.39	6.10	5.26	4.38	4.55	4.00	3.37
6,000	+ 3	10.40	8.56	6.80	6.51	5.59	4.63	4.83	4.23	3.56
7,000	+ 1	11.29	9.20	7.25	6.95	5.95	4.90	5.13	4.48	3.76
8,000	- 1	12.31	9.92	7.74	7.45	6.34	5.19	5.46	4.75	3.97
9,000	- 3	13.49	10.73	8.28	8.00	6.76	5.51	5.82	5.04	4.20
10,000	- 5	14.87	11.66	8.88	8.61	7.23	5.86	6.22	5.36	4.45

Reference 10

TABLE 6.2-4

CLIMB GRADIENTS FOR DIRECT CLIMB

STANDARD DAY TEMPERATURES

NORMAL CATEGORY HELICOPTERS

PRESSURE ALTITUDE (feet)	TEMP (°C)	I Percent Max. TOGW 100%	I 90%	I 80%	II Percent Max. TOGW 100%	II 90%	II 80%	III Percent Max. TOGW 100%	III 90%	III 80%
HOGE Limit (ft.)		600	4,500	7,200	5,000	9,200	13,400	10,200	13,900	19,600
S.L.	+15	35.76	4.24	2.51	3.55	1.70	1.03	1.40	0.92	0.53
500	+14	234.23	4.81	2.73	3.98	1.82	1.08	1.48	0.96	0.55
1,000	+13	NC	5.55	2.98	4.52	1.95	1.14	1.58	1.01	0.57
1,500	+12	NC	6.54	3.27	5.21	2.09	1.20	1.68	1.06	0.59
2,000	+11	NC	7.92	3.61	6.14	2.26	1.26	1.80	1.11	0.61
2,500	+10	NC	9.99	4.04	7.44	2.45	1.33	1.94	1.17	0.64
3,000	+ 9	NC	13.42	4.56	9.38	2.68	1.41	2.09	1.24	0.66
3,500	+ 8	NC	20.29	5.22	12.62	2.94	1.49	2.27	1.31	0.69
4,000	+ 7	NC	41.01	6.10	19.15	3.25	1.59	2.48	1.39	0.72
4,500	+ 6	NC	NC	7.30	38.52	3.63	1.69	2.72	1.48	0.75
5,000	+ 5	NC	NC	9.05	NC	4.11	1.81	3.01	1.58	0.79
6,000	+ 3	NC	NC	16.93	NC	5.50	2.10	3.80	1.81	0.86
7,000	+ 1	NC	NC	105.11	NC	8.16	2.47	5.08	2.12	0.95
8,000	- 1	NC	NC	NC	NC	15.28	2.99	7.53	2.52	1.05
9,000	- 3	NC	NC	NC	NC	97.06	3.74	14.10	3.10	1.17
10,000	- 5	NC	NC	NC	NC	NC	4.94	86.91	3.98	1.32

NC = No Climb Capability

Reference 10

TABLE 6.2-5

CLIMB GRADIENTS FOR DIRECT CLIMB

STANDARD DAY TEMPERATURES

TRANSPORT CATEGORY HELICOPTERS

PRESSURE ALTITUDE (feet)	TEMP (°C)	I Percent Max. TUGW 100%	I 90%	I 80%	II Percent Max. TUGW 100%	II 90%	II 80%	III Percent Max. TUGW 100%	III 90%	III 80%
HOGE Limit (ft.)		2,600	4,200	7,300	6,000	9,600	12,700	12,000	15,000	18,100
S.L.	+15	5.91	3.62	1.94	2.23	1.26	0.88	0.86	0.64	0.49
500	+14	7.39	4.15	2.11	2.46	1.34	0.93	0.91	0.66	0.50
1,000	+13	9.79	4.84	2.29	2.73	1.44	0.98	0.96	0.70	0.52
1,500	+12	14.36	5.79	2.51	3.07	1.54	1.03	1.01	0.73	0.54
2,000	+11	26.56	7.17	2.78	3.48	1.66	1.09	1.08	0.76	0.57
2,500	+10	158.40	9.37	3.10	4.02	1.79	1.15	1.14	0.80	0.59
3,000	+ 9	NC	13.37	3.49	4.73	1.94	1.23	1.22	0.84	0.62
3,500	+ 8	NC	23.11	3.98	5.73	2.12	1.31	1.30	0.89	0.64
4,000	+ 7	NC	81.98	4.64	7.25	2.33	1.39	1.40	0.94	0.67
4,500	+ 6	NC	NC	5.51	9.75	2.58	1.49	1.50	0.99	0.71
5,000	+ 5	NC	NC	6.78	14.82	2.89	1.61	1.63	1.05	0.74
6,000	+ 3	NC	NC	12.23	NC	3.77	1.88	1.93	1.19	0.82
7,000	+ 1	NC	NC	54.24	NC	5.32	2.25	2.37	1.37	0.91
8,000	- 1	NC	NC	NC	NC	8.80	2.79	3.01	1.59	1.02
9,000	- 3	NC	NC	NC	NC	23.88	3.61	4.10	1.89	1.15
10,000	- 5	NC	NC	NC	NC	NC	5.05	6.26	2.32	1.32

NC = No Climb Capability

Reference 10

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HELICOPTER NOISE DATA BASE APPENDICES

APPENDIX	TITLE
A	BELL 212 NOISE CURVE DATA
B	SIKORSKY S-61 NOISE CURVE DATA
C	SIKORSKY S-64 NOISE CURVE DATA
D	BOEING VERTOL CH-47C NOISE CURVE DATA
E	HUGHES 500C NOISE CURVE DATA
F	BOELKOW BO-105 NOISE CURVE DATA
G	BELL 47G NOISE CURVE DATA
H	PUMA SA-330J NOISE CURVE DATA
I	BELL 206L NOISE CURVE DATA
J	AUGUSTA A109 NOISE CURVE DATA
K	AEROSPATIALE GAZELLE SA-341G NOISE CURVE DATA
L	HUGHES 300C NOISE CURVE DATA
M	SIKORSKY CH-53 NOISE CURVE DATA
N	SIKORSKY S-70 NOISE CURVE DATA
O	SIKORSKY S-76-100% RPM NOISE CURVE DATA
P	SIKORSKY S76-107% RPM NOISE CURVE DATA

APPENDIX A

BELL 212 NOISE CURVE DATA

TABLE

FIGURE

TABLE: A1

BELL 212 TAKEOFF/APPROACH DATA TABLE

Military Designation: UH-1N

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	92.5	98.6
400	88.3	94.6
600	85.6	92.1
1000	82.1	89.0
2000	76.8	84.5
4000	71.4	79.3
6000	67.4	76.0
10000	61.8	71.3

Takeoff Notes

Vy (Speed for best rate of climb) = 55 kts

BRC (Best rate of climb) = 1350 feet per minute (fpm)

Climb Angle (degrees) = 14°

Climb Gradient (Run/Rise) = 4.0

Takeoff Weight = 10,500 lbs

Approach Notes

Vy (Speed for best rate of climb) = 55 kts

Approach Angle (degrees) = 6°

BELL 212 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE A1

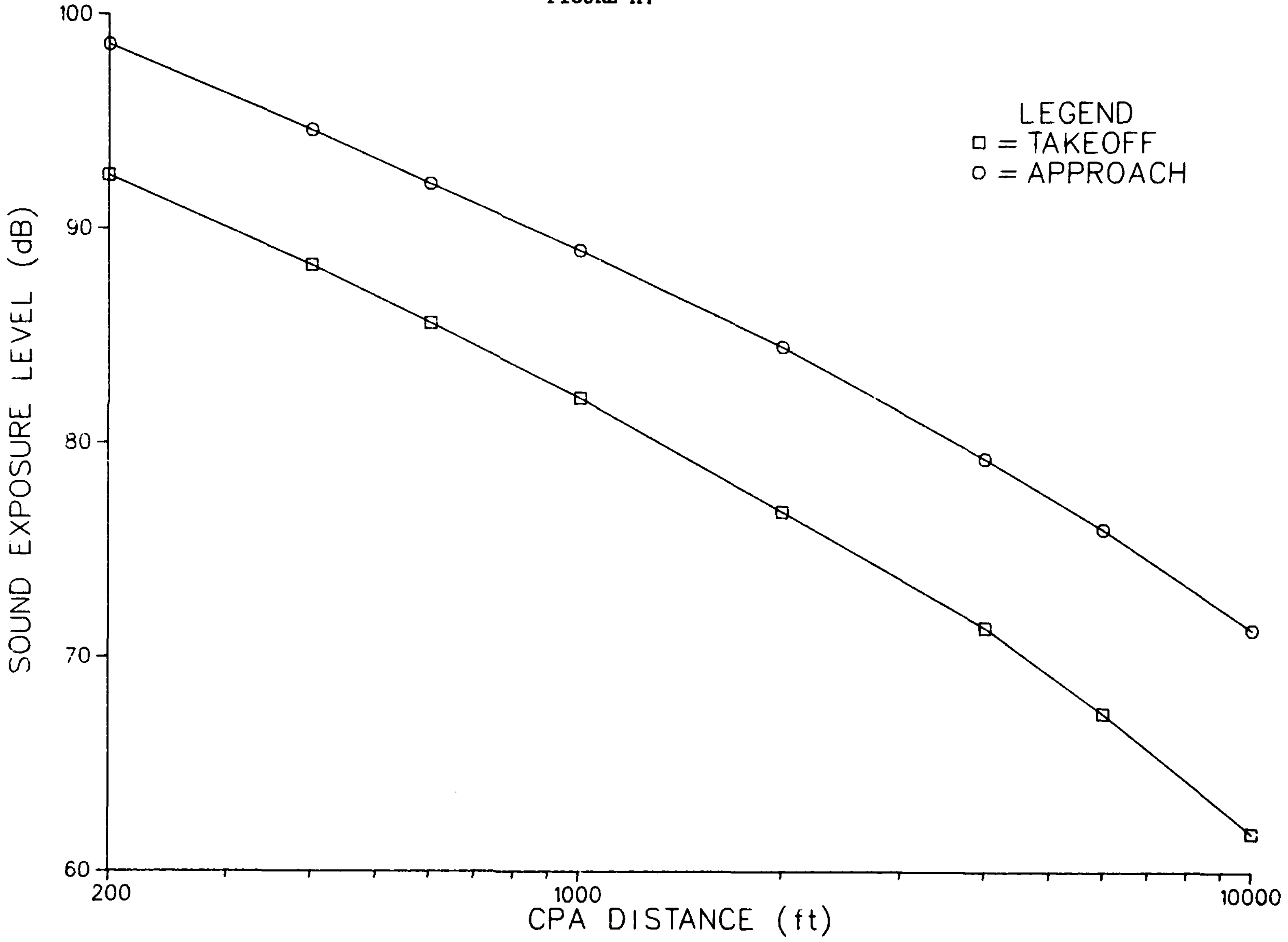


TABLE: A2

LEVEL FLYOVER DATA TABLE

Military Designation: UH-1N

CPA Distance (FT)	V= 80 kts SEL (dB)	V= 90 kts SEL (dB)	V= 100 kts SEL (dB)	V= 110 kts SEL (dB)	V= 115 kts SEL (dB)
200	92.3	92.7	93.9	95.9	97.2
400	88.2	88.6	89.8	91.8	93.1
600	85.7	86.1	87.3	89.3	90.6
1000	82.4	82.8	84.0	86.0	87.3
2000	77.8	78.2	79.4	81.4	82.7
4000	72.7	73.1	74.3	76.3	77.6
6000	69.4	69.8	71.0	73	74.3
10000	64.7	65.1	66.3	68.3	69.6

BELL 212 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE A2

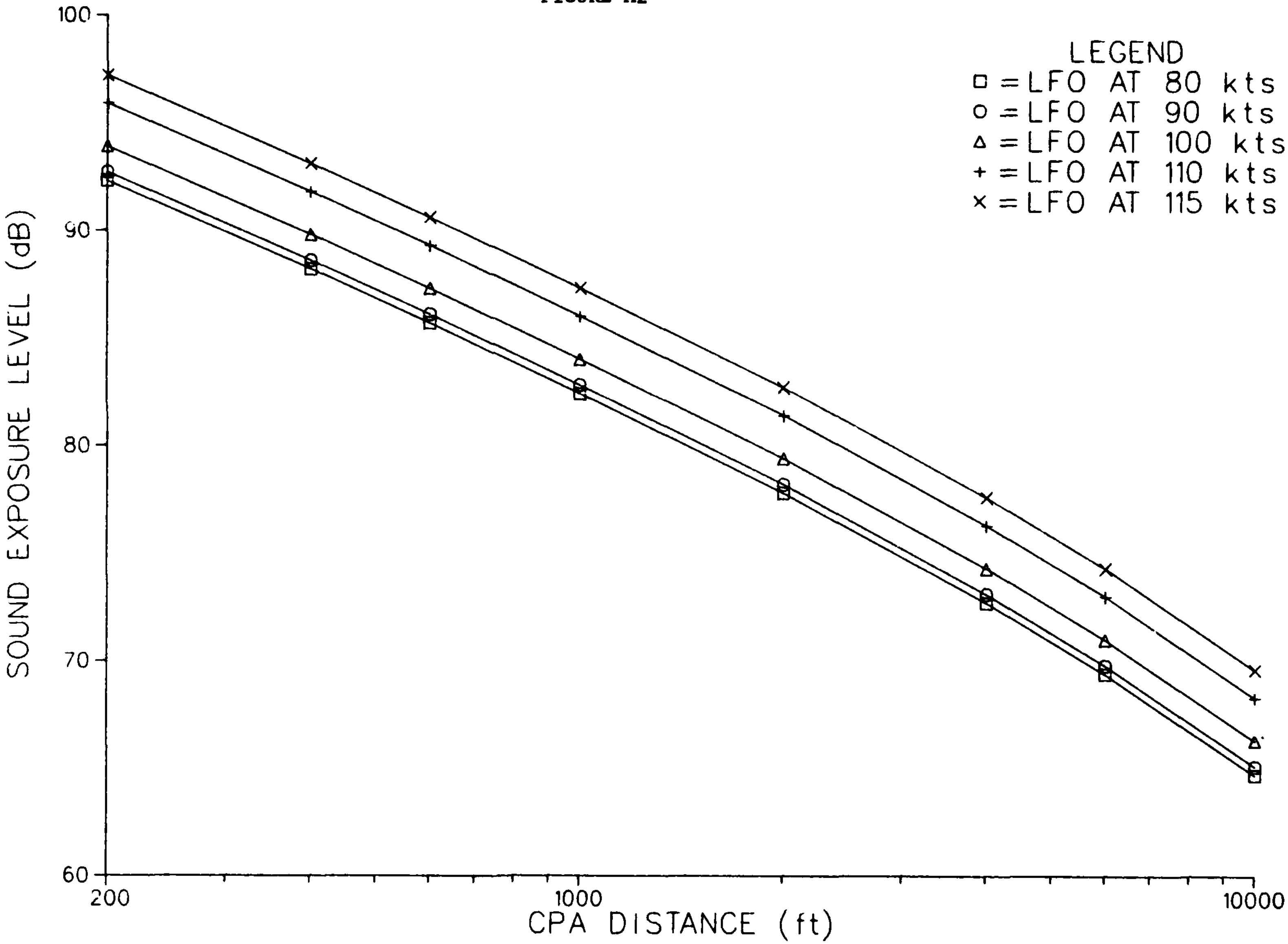


TABLE: A3

BELL 212 HOVER DATA TABLE

Military Designation: UH-1N

CPA Distance (FT)	A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
	Maximum A-Weighted Sound Level, L_{AM}		
200	93.1	96.1	98.1
400	86.3	89.3	91.8
600	81.5	84.5	88.0
1000	74.1	77.1	83.0
2000	64.7	67.7	76.2
4000	55.7	58.7	68.5
6000	50.6	53.6	63.6
10000	43.7	46.7	56.7
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX B

SIKORSKY S-61 DATA TABLE

TABLES

FIGURE

TABLE: B1

SIKORSKY S-61 TAKEOFF/APPROACH DATA TABLE

Military Designation: SH-3A

CPA Distance (FT)	Takeoff SEL (dB)	Approach SEL (dB)
200	97.5	96.6
400	93.0	92.3
600	90.2	89.8
1000	86.4	86.4
2000	80.4	81.3
4000	72.3	75.5
6000	67.5	71.7
10000	60.6	66.3

Takeoff Notes

Vy (Speed for best rate of climb) = 74 kts

BRC (Best rate of climb) = 1100 feet per minute (fpm)

Climb Angle (degrees) = 8.4°

Climb Gradient (Run/Rise) = 6.8

Takeoff Weight = 19,000 lbs

Approach Notes

Vy (Speed for best rate of climb) = 74 kts

Approach Angle (degrees) = 6°

SIKORSKY S-61 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE B1

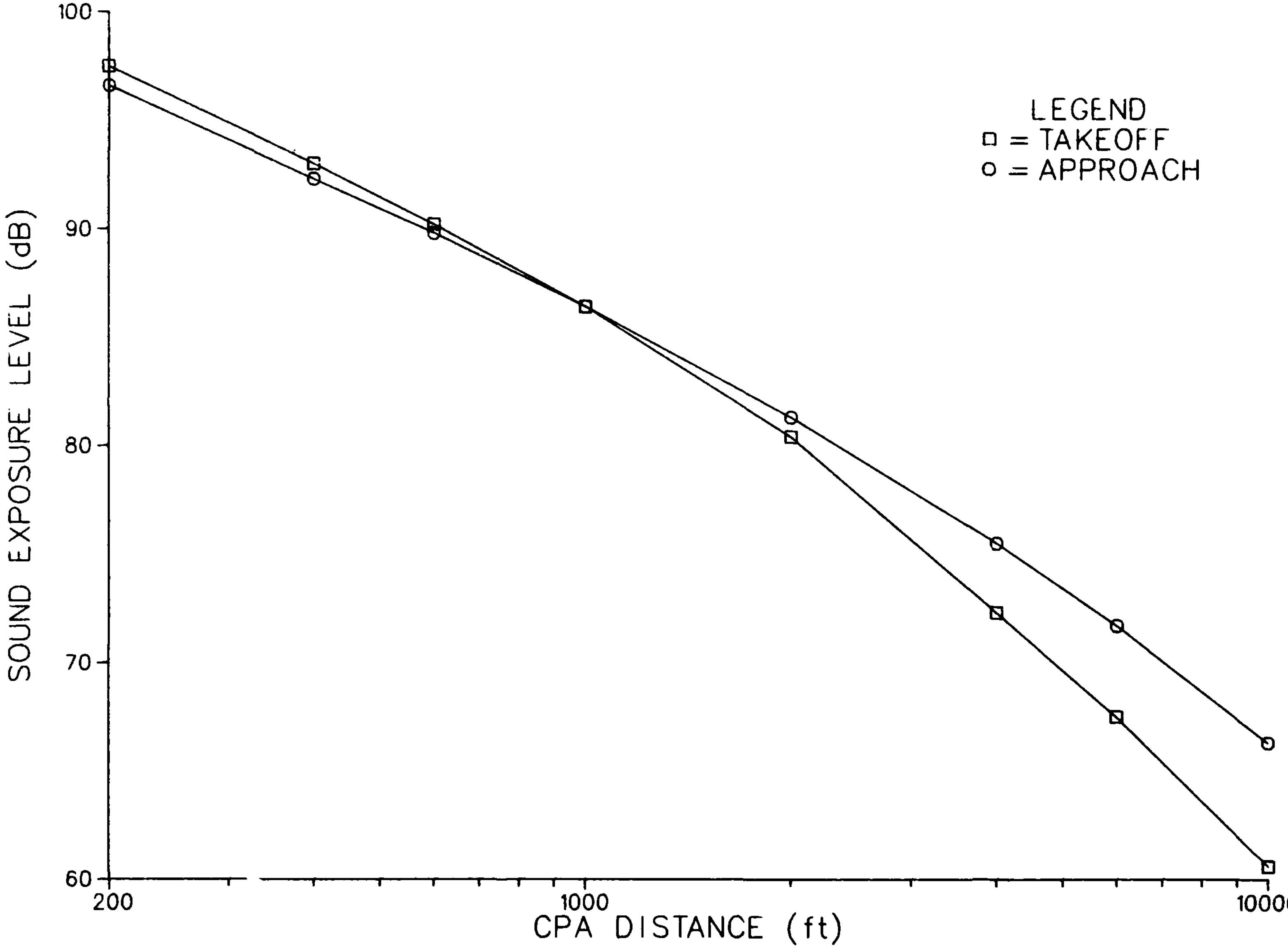


TABLE: B2

SIKORSKY S-61 LEVEL FLYOVER DATA TABLE

Military Designation: SH-3A

CPA Distance (FT)	V= 60 kts SEL (dB)	V= 80 kts SEL (dB)	V= 100 kts SEL (dB)	V= 120 kts SEL (dB)	V= 130 kts SEL (dB)
200	92.6	91.9	91.6	92.7	94.9
400	88.6	87.6	87.3	88.4	90.6
600	85.9	84.9	84.6	85.7	87.9
1000	82.2	81.2	80.9	82.0	84.2
2000	76.6	75.6	75.3	76.4	78.6
4000	70.0	69.0	68.7	69.8	72.0
6000	65.6	64.6	64.3	65.4	76.6
10000	59.5	58.5	58.2	59.3	61.5

SIKORSKY S–61 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE B2

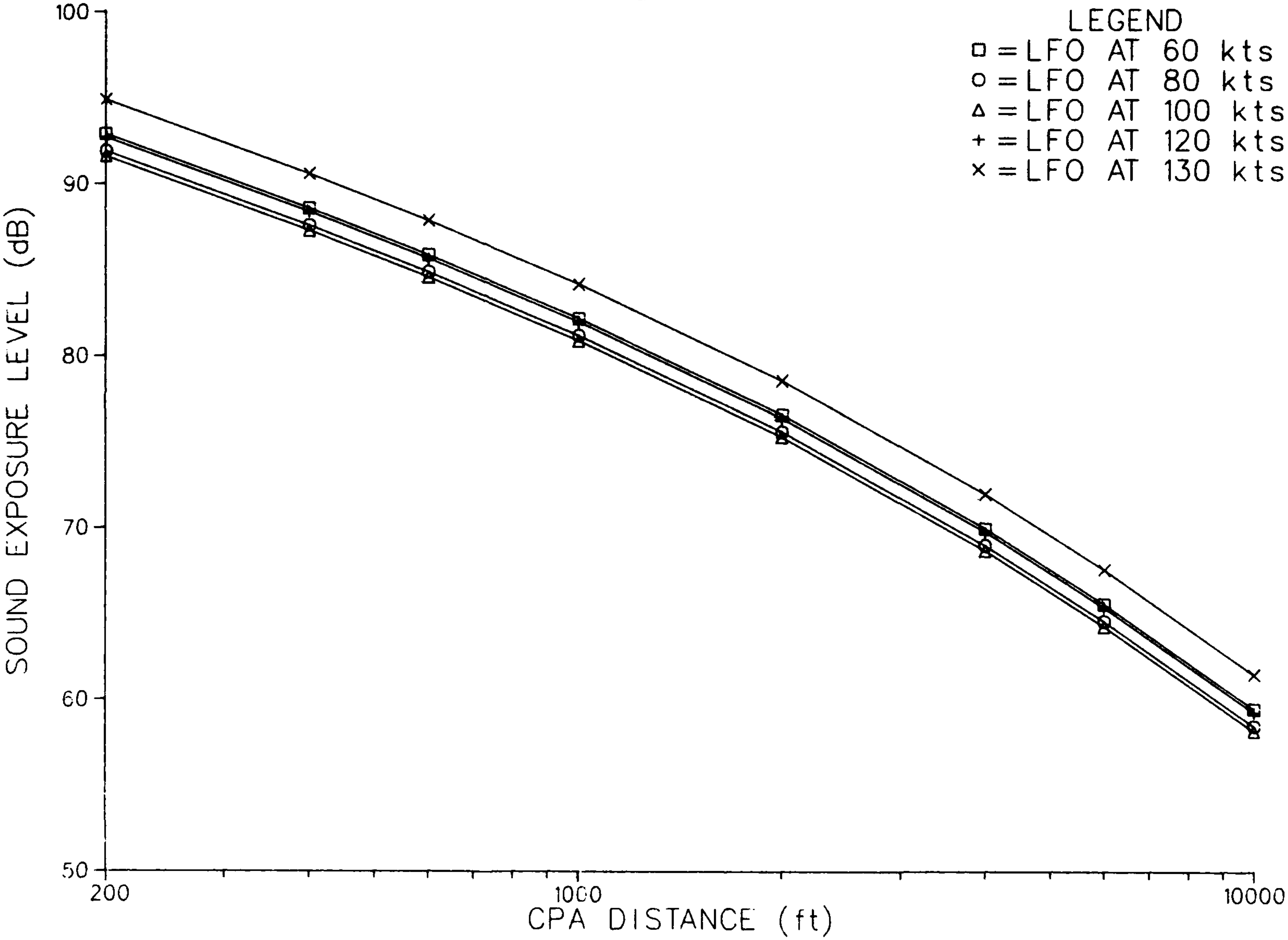


TABLE: B3

SIKORSKY S-61 HOVER DATA TABLE

Military Designation: SH-3A

CPA Distance (FT)	A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
	Maximum A-Weighted Sound Level, L_{AM}		
200	95.2	98.2	100.2
400	88.3	91.3	93.8
600	83.4	86.4	89.9
1000	75.9	78.9	84.9
2000	66	69.0	77.5
4000	56.5	59.5	69.3
6000	50.9	53.9	63.9
10000	43.5	46.5	56.5
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application to the engine shielding algorithm.

APPENDIX C

SIKORSKY S-64 NOISE CURVE DATA

TABLE: C1

SIKORSKY S-64 TAKEOFF/APPROACH DATA TABLE

Military Designation: CH-54B

CPA Distance (FT)	Takeoff SEL (dB)	Approach SEL (dB)
200	99.2	103
400	95.1	98.9
600	92.6	96.4
1000	89.4	93.2
2000	84.7	88.5
4000	79.6	83.4
6000	76.4	80.2
10000	71.9	75.7

Takeoff Notes

Vy (Speed for best rate of climb) = 60 kts

BRC (Best rate of climb) = 1330 feet per minute (fpm)

Climb Angle (degrees)= 12.6°

Climb Gradient (Run/Rise)= 4.5

Takeoff Weight = 42,000 lbs

Approach Notes

Vy (Speed for best rate of climb) = 60 kts

Approach Angle (degrees) = 6°

SIKORSKY S-64 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE C1

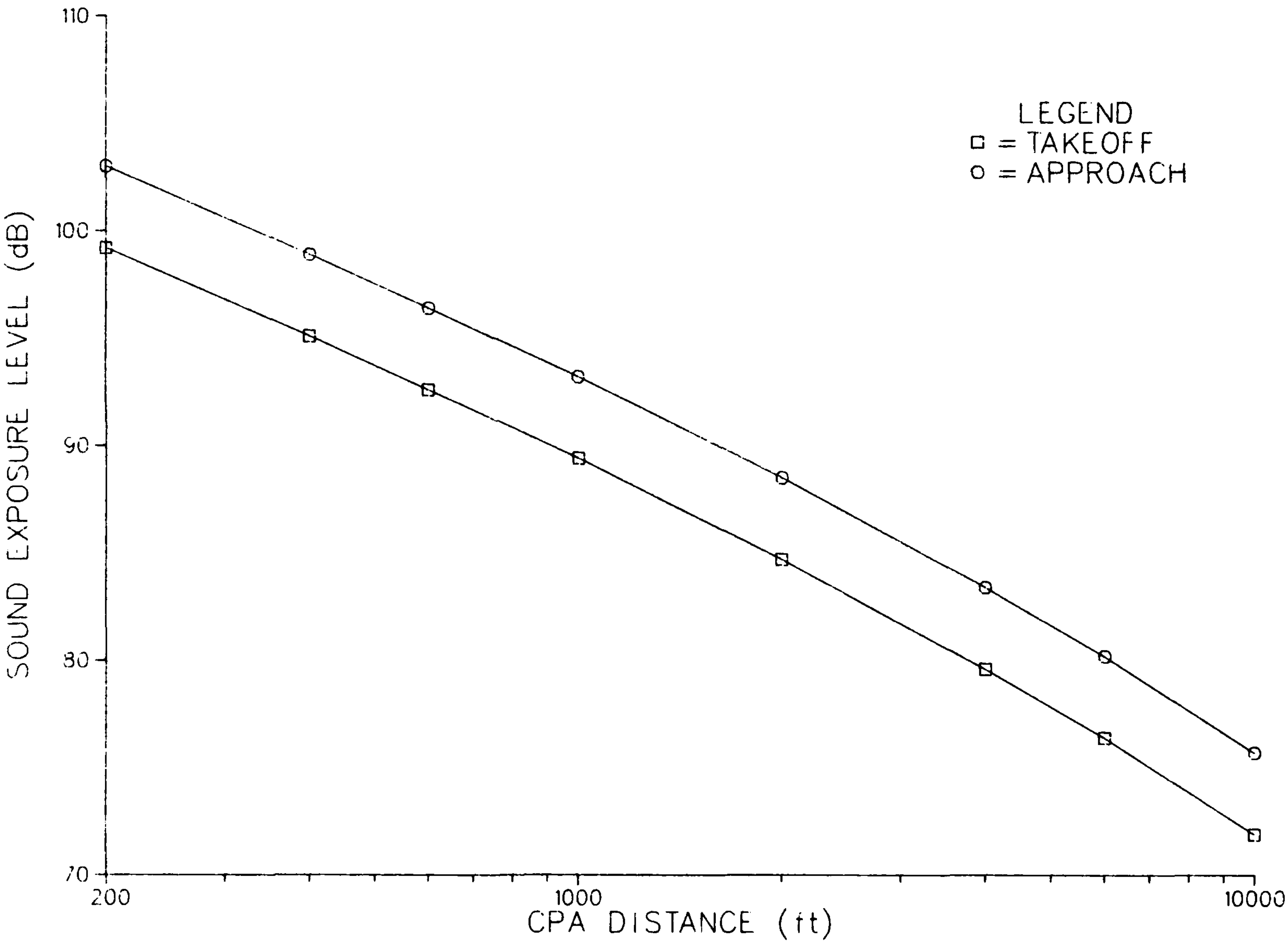


TABLE: C2

SIKORSKY S-64 LEVEL FLYOVER DATA TABLE

Military Designation: CH-54B

CPA Distance (FT)	V= 60 kts SEL (dB)	V= 75 kts SEL (dB)	V= 85 kts SEL (dB)	V= 95 kts SEL (dB)	V= 105 kts SEL (dB)
200	99.9	98.5	98.5	99.5	100.6
400	95.7	94.3	94.3	95.3	96.4
600	93.2	91.8	91.8	92.8	93.9
1000	89.8	88.4	88.4	89.4	90.5
2000	84.9	83.5	83.5	84.5	85.6
4000	79.4	78.0	78.0	79	80.1
6000	75.9	74.5	74.5	75.5	76.6
10000	70.9	69.5	69.5	70.5	71.5

SIKORSKY S-64 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE C2

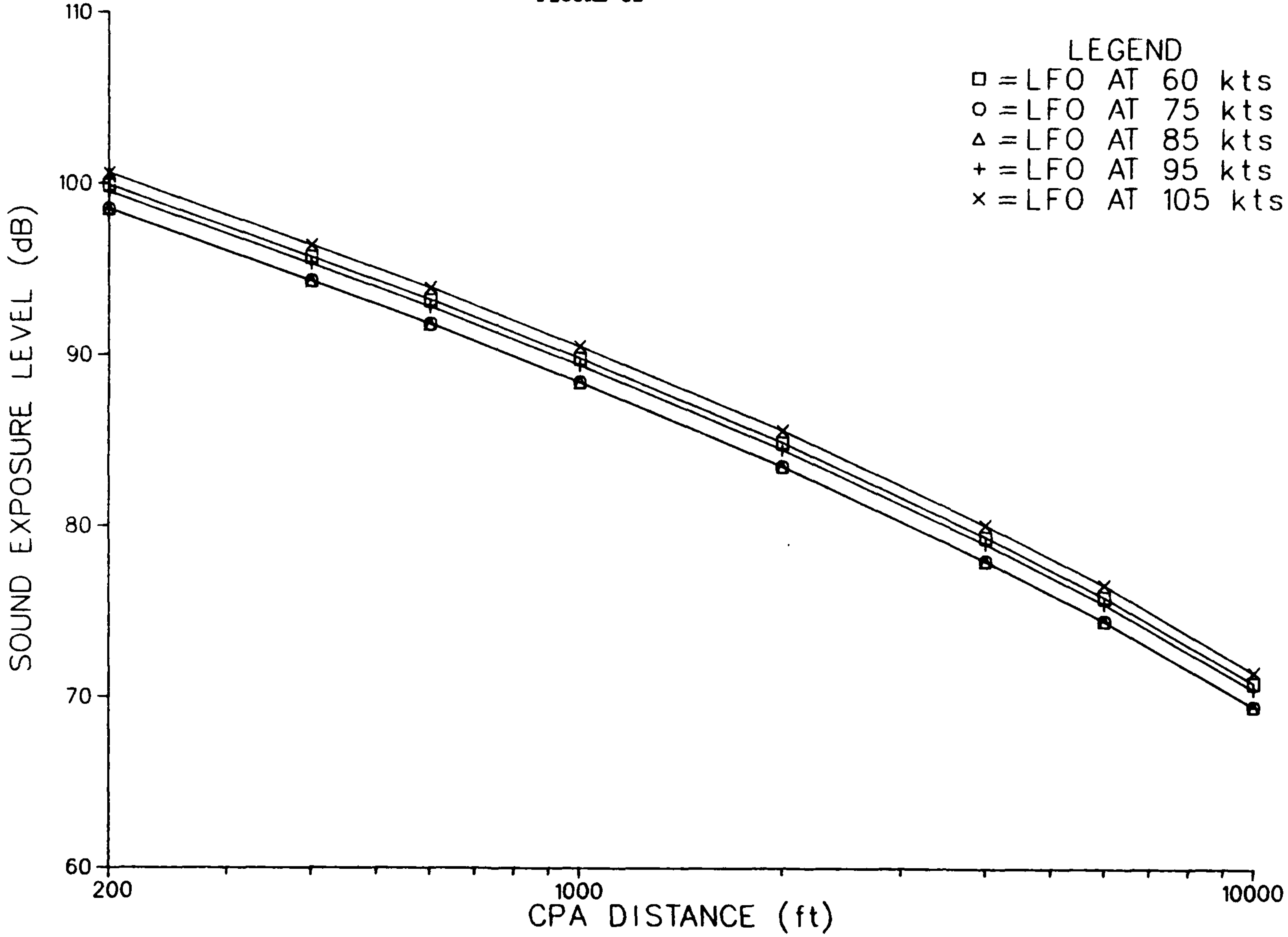


TABLE: C3

SIKORSKY S-64 HOVER DATA TABLE

Military Designation: CH-54B

CPA Distance (FT)	A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
	Maximum A-Weighted Sound Level, L_{AM}		
200	94.8	97.8	99.8
400	87.9	90.9	93.4
600	83	86.0	89.5
1000	75.5	78.5	84.5
2000	65.6	68.6	77.1
4000	56.3	59.3	69.1
6000	50.9	53.9	63.9
10000	43.7	46.7	56.7
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX D

BOEING VERTOL CH-47C

TABLE: D1

BOEING VERTOL CH-47C TAKEOFF/APPROACH DATA TABLE

Military Designation: CH-47C

CPA Distance (FT)	Takeoff SEL (dB)	Approach SEL (dB)
200	105.1	108.9
400	101.0	104.8
600	98.6	102.4
1000	95.4	99.2
2000	90.8	94.6
4000	85.7	89.5
6000	82.2	86.0
10000	77.3	81.1

Takeoff Notes

Vy (Speed for best rate of climb) = 60 kts

BRC (Best rate of climb) = 1380 feet per minute (fpm)

Climb Angle (degrees) = 13.1°

Climb Gradient (Run/Rise) = 4.3

Takeoff Weight = 45,000 lbs

Approach Notes

Vy (Speed for best rate of climb) = 60 kts

Approach Angle (degrees) = 6°

CH-47C NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE D1

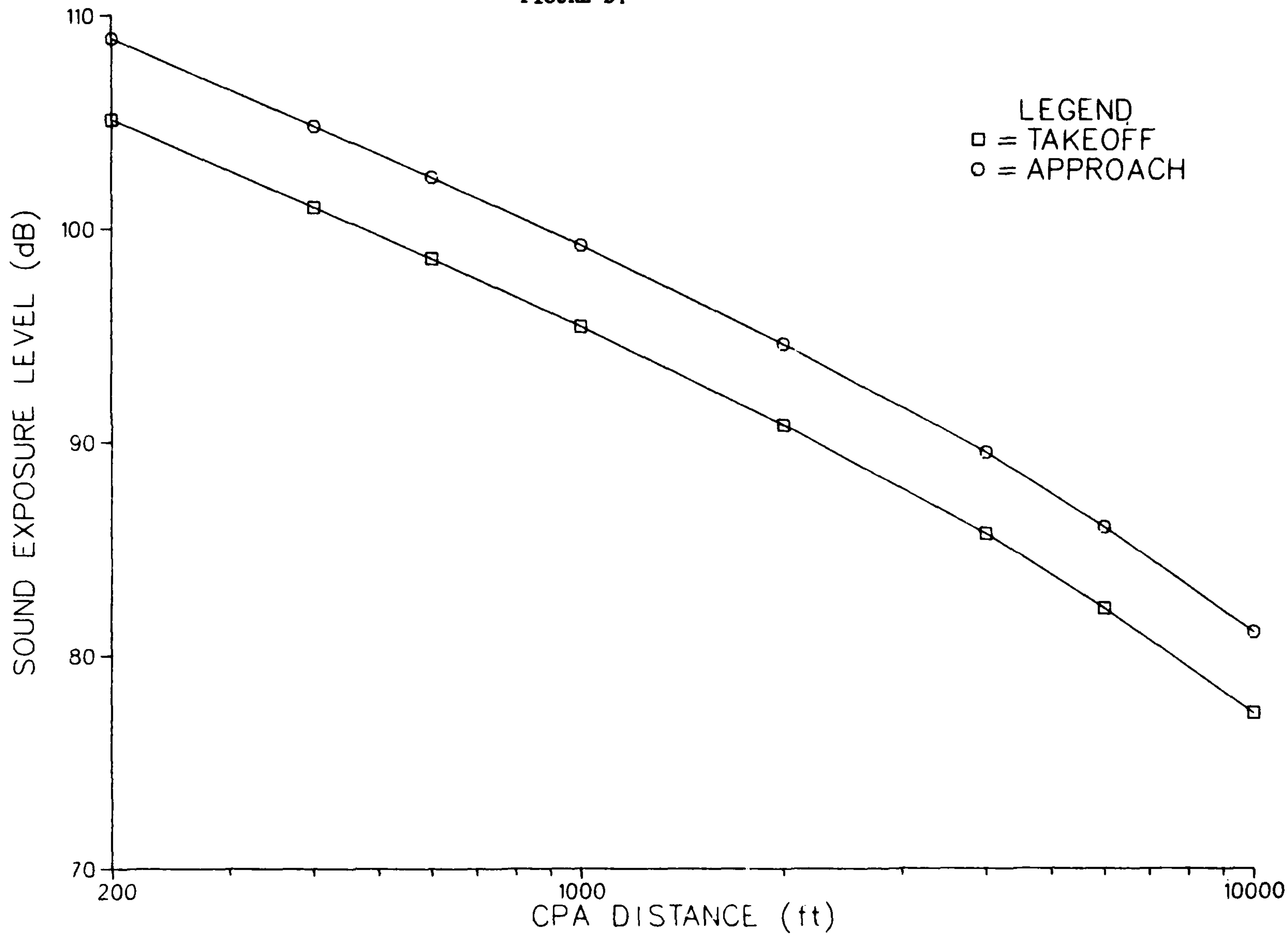


TABLE: D2

BOEING VERTOL CH-47C LEVEL FLYOVER DATA TABLE

Military Designation: CH-47C

CPA Distance (FT)	V= 60 kts SEL (dB)	V= 80 kts SEL (dB)	V= 100 kts SEL (dB)	V= 120 Kts SEL (dB)	V= 140 kts SEL (dB)	V= 150 kts SEL (dB)
200	106.8	102.9	102.3	103.6	107.7	110.9
400	102.7	98.8	98.2	99.5	103.6	106.8
600	100.3	96.8	95.8	97.1	101.2	104.4
1000	97.2	93.3	92.7	94.0	98.1	101.3
2000	92.7	88.8	88.2	89.5	93.6	96.8
4000	87.7	83.8	83.2	84.5	88.6	91.8
6000	84.5	80.6	80.0	81.3	85.4	88.6
10000	80.0	76.1	75.5	76.8	80.9	84.1

CH-47C NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE D2

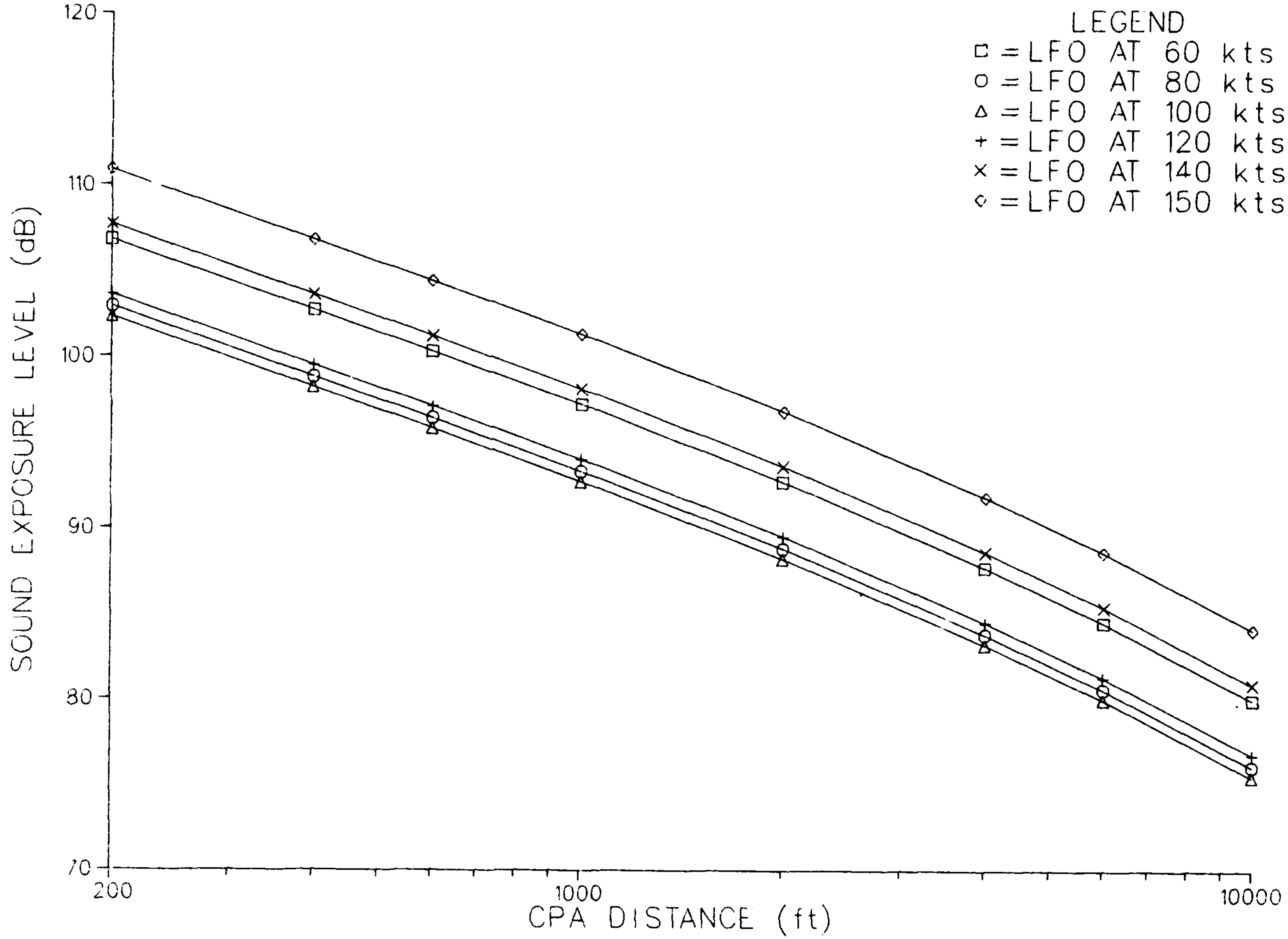


TABLE: D3

BOEING VERTOL CH-47C HOVER DATA TABLE

Military Designation: CH-47C

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	96.6	99.6	101.6
400	89.9	92.9	95.4
600	85.1	88.1	91.6
1000	77.8	80.8	86.8
2000	68.4	71.4	79.9
4000	59.7	62.7	72.5
6000	54.8	57.8	67.8
10000	48.3	51.4	61.4
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX E

HUGHES 500C

TABLE

FIGURE

TABLE: E1

HUGHES 500C TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	Takeoff SEL (dB)	Approach SEL (dB)
200	87.3	93.2
400	83.2	89.1
600	80.7	86.5
1000	77.4	83.2
2000	72.5	78.2
4000	67.6	72.4
6000	63.7	68.3
10000	58.0	62.4

Takeoff Notes

Vy (Speed for best rate of climb) = 50 kts

BRC (Best rate of climb) = 1440 feet per minute (fpm)

Climb Angle (degrees) = 16.5°

Climb Gradient (Run/Rise) = 3.4

Takeoff Weight = 2,550 lbs

Approach Notes

Vy (Speed for best rate of climb) = 50 kts

Approach Angle (degrees) = 6°

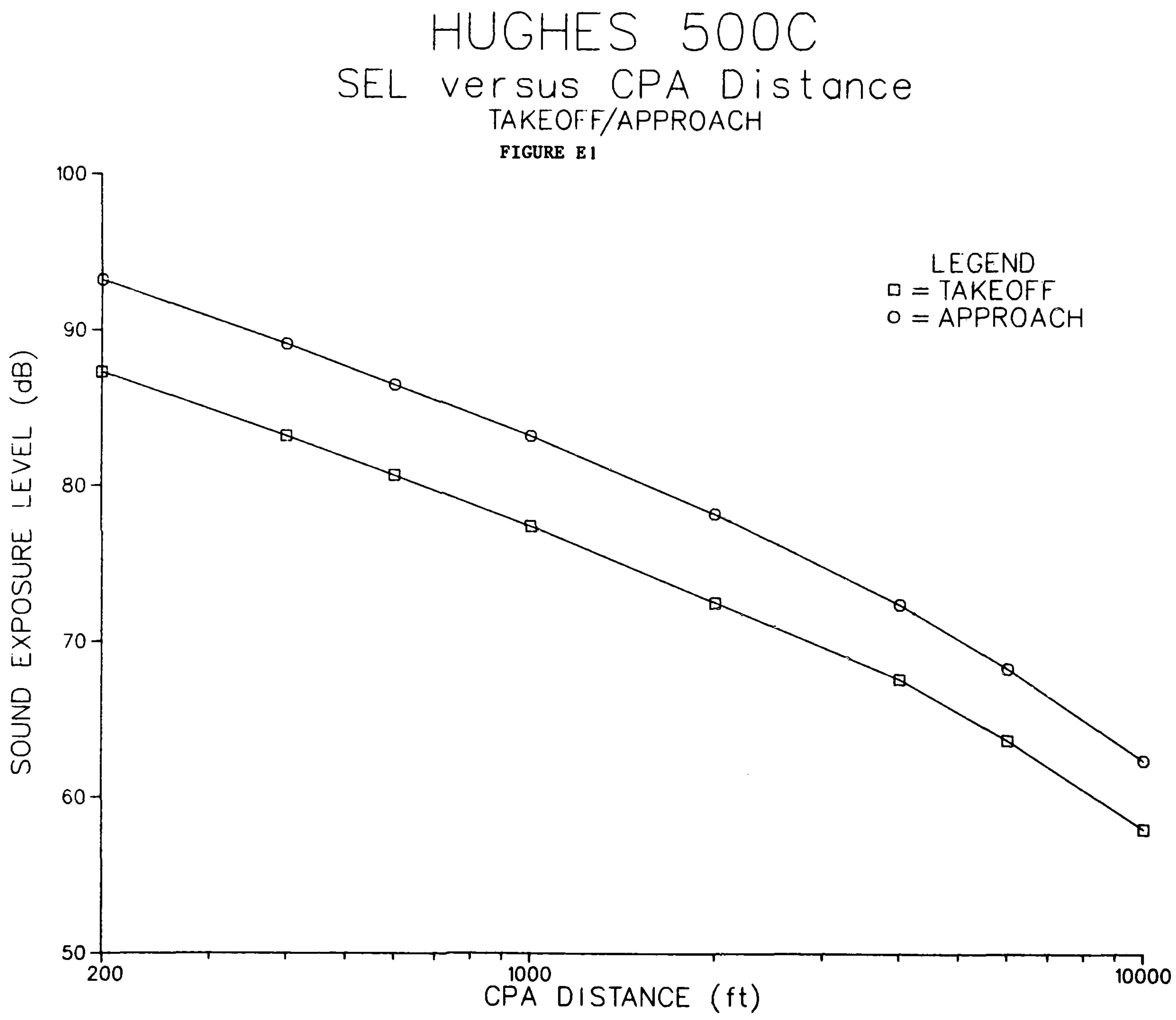

HUGHES 500C
SEL versus CPA Distance
TAKEOFF/APPROACH
LEGEND
□ = TAKEOFF
○ = APPROACH
SOUND EXPOSURE LEVEL (dB)
100
90
80
70
60
50
200
1000
10000
CPA DISTANCE (ft)

FIGURE E1

TABLE: E2

HUGHES 500C LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 60 kts SEL (dB)	V= 80 kts SEL (dB)	V= 100 kts SEL (dB)	V= 120 kts SEL (dB)	V= 130 kts SEL (dB)
200	89.1	88.0	87.5	88.6	90.7
400	84.8	83.7	83.2	84.3	86.4
600	82.2	81.1	80.6	81.7	83.8
1000	78.7	77.6	77.1	78.2	80.3
2000	73.4	72.3	71.8	72.9	75.0
4000	68.0	66.9	66.4	67.5	69.6
6000	64.0	62.9	62.4	63.5	65.6
10000	58.4	57.3	56.8	57.9	60.0

HUGHES 500C NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE E2

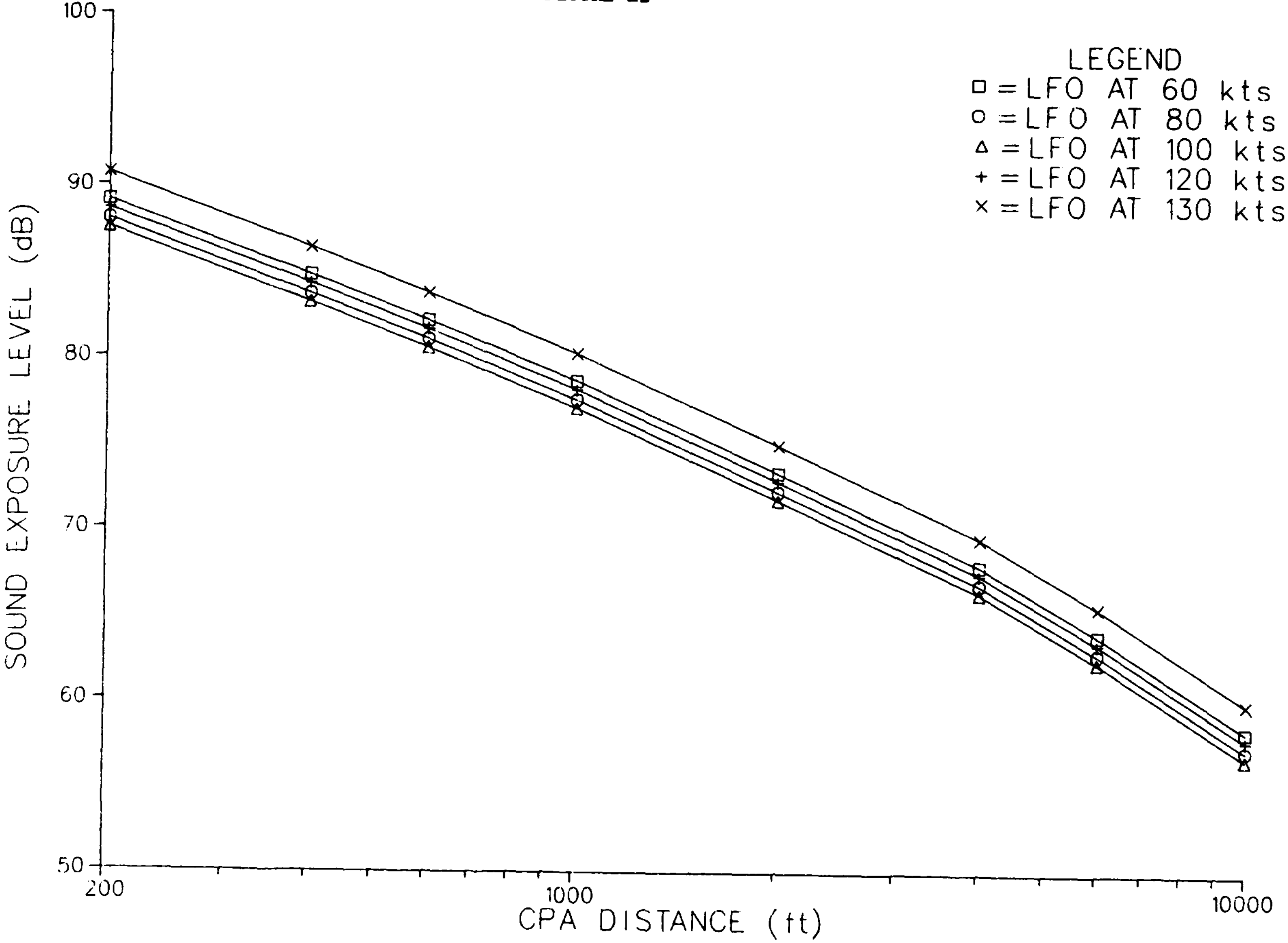


TABLE: E3

HUGHES 500C HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	86.8	89.8	91.8
400	80.0	83.0	85.5
600	75.2	78.2	81.7
1000	67.6	70.6	76.6
2000	57.8	60.8	69.5
4000	48.1	51.1	60.9
6000	42.4	45.4	55.4
10000	34.6	37.6	47.6
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX F

BOELKOW BO-105

TABLE

FIGURE

TABLE: F1

BOELKOW BO-105 TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	90.6	97.3
400	86.3	93.2
600	83.7	90.6
1000	80.2	87.3
2000	75.0	82.3
4000	69.7	76.4
6000	65.8	72.5
10000	60.3	66.6

Takeoff Notes

Vy (Speed for best rate of climb) = 70 kts

BRC (Best rate of climb) = 1700 feet per minute (fpm)

Climb Angle (degrees) = 16.2°

Climb Gradient (Run/Rise) = 3.4

Takeoff Weight = 5,070 lbs

Approach Notes

Vy (Speed for best rate of climb) = 70 kts

Approach Angle (degrees) = 6°

BOELKOW BO-105 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE F1

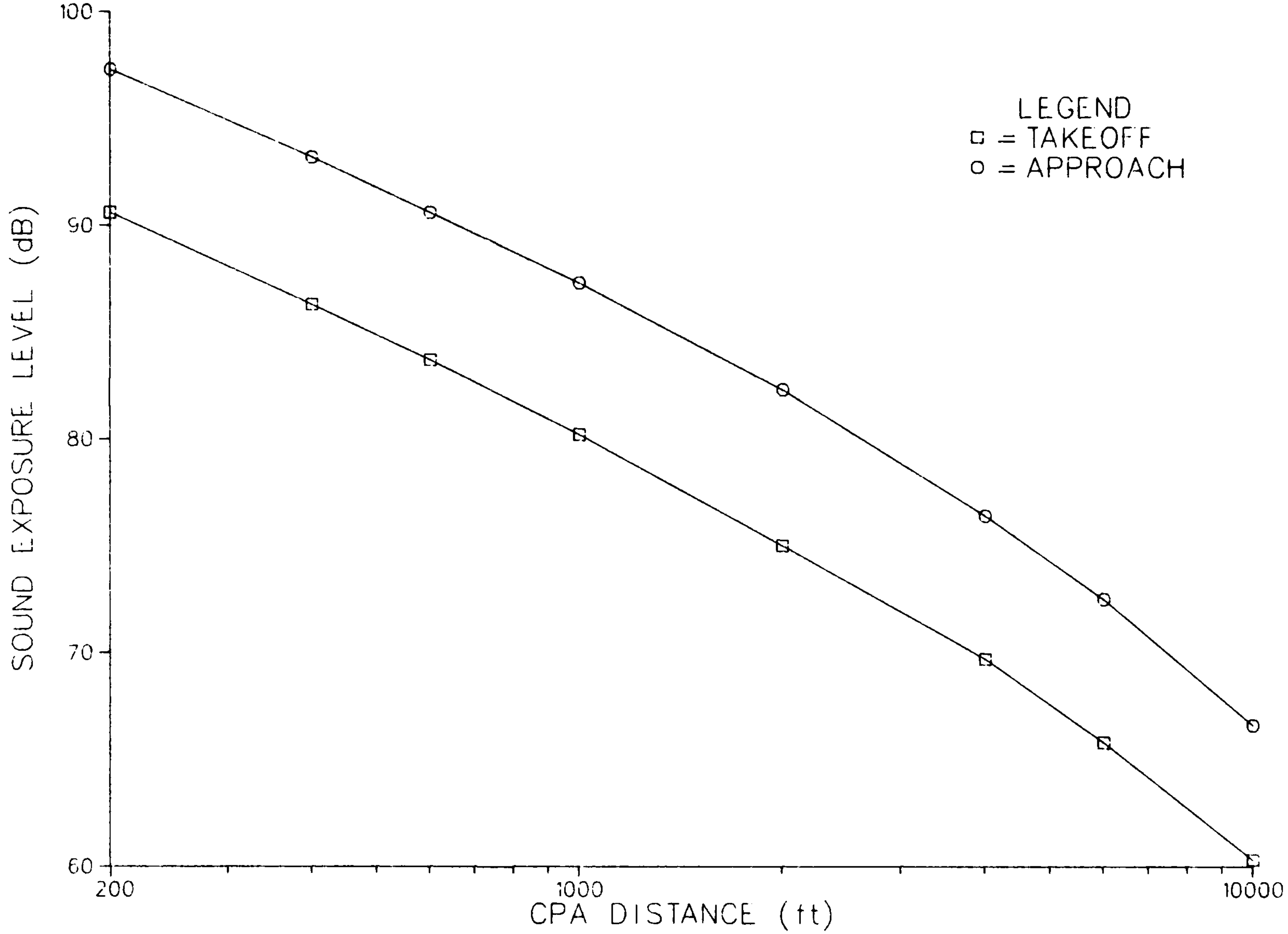


TABLE: F2

BOELKOW BO-105 LEVEL FLYOVER DATA TABLE

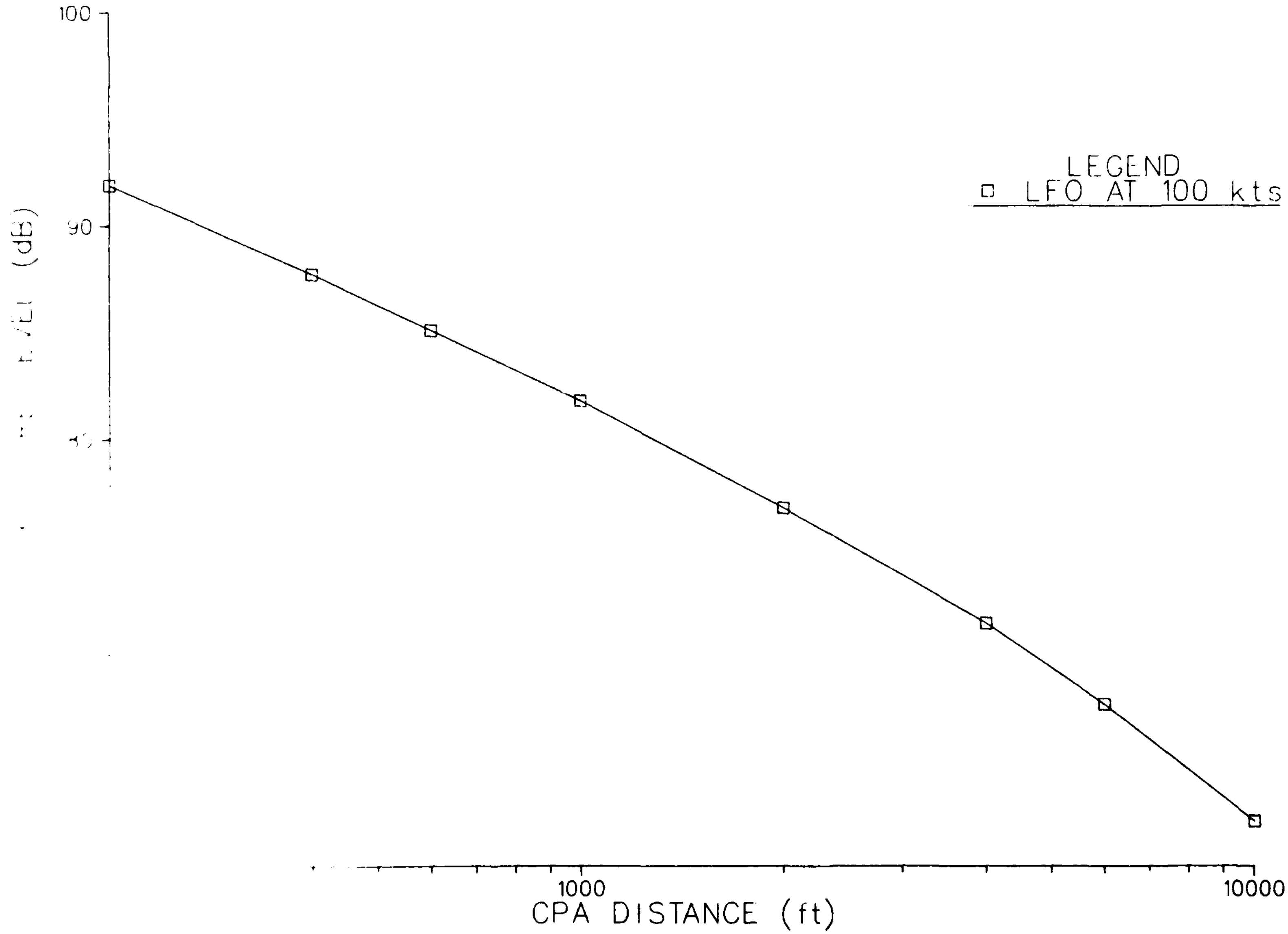
CPA Distance (FT)	V= 100 kts SEL (dB)
200	91.9
400	87.7
600	85.1
1000	81.8
2000	76.8
4000	71.4
6000	67.6
10000	62.1

BOELKOW BO-105 NOISE CURVE

SEL versus CPA Distance

LEVEL FLYOVER

FIGURE F2



AD-A123 467 HELICOPTER NOISE EXPOSURE CURVES FOR USE IN ENVIRONMENTAL IMPACT ASSESSMENT(U) FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE OF ENVIR. 2/2

UNCLASSIFIED J S NEWMAN ET AL. NOV 82 DOT/FAA/EE-82-16 F/G 20/1 NL

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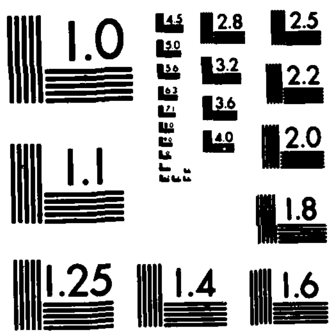


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE: F3

BOELKOW BO-105 HOVER DATA TABLE

Military Designation:

	Maximum A-Weighted Sound Level, L_{AM}		
CPA Distance (FT)	A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	86.7	89.7	91.7
400	79.8	82.8	85.3
600	75.0	78.0	81.5
1000	67.5	70.5	76.5
2000	57.9	60.9	69.4
4000	48.7	51.7	61.5
6000	43.5	46.5	56.5
10000	36.6	39.6	49.6
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX G

BELL 47G

TABLE

FIGURE

TABLE: G1

BELL 47G TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	87.9	91.7
400	83.7	87.5
600	81.1	84.9
1000	77.7	81.5
2000	72.6	76.4
4000	66.9	70.7
6000	63.2	67.0
10000	58.0	61.8

Takeoff Notes

Vy (Speed for best rate of climb) = 52.1 kts

BRC (Best rate of climb) = 800 feet per minute (fpm)

Climb Angle (degrees) = 8.7°

Climb Gradient (Run/Rise) = 6.5

Takeoff Weight = 2,950 lbs

Approach Notes

Vy (Speed for best rate of climb) - 52.1 kts

Approach Angle (degrees) = 6°

BELL 47G NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE G1

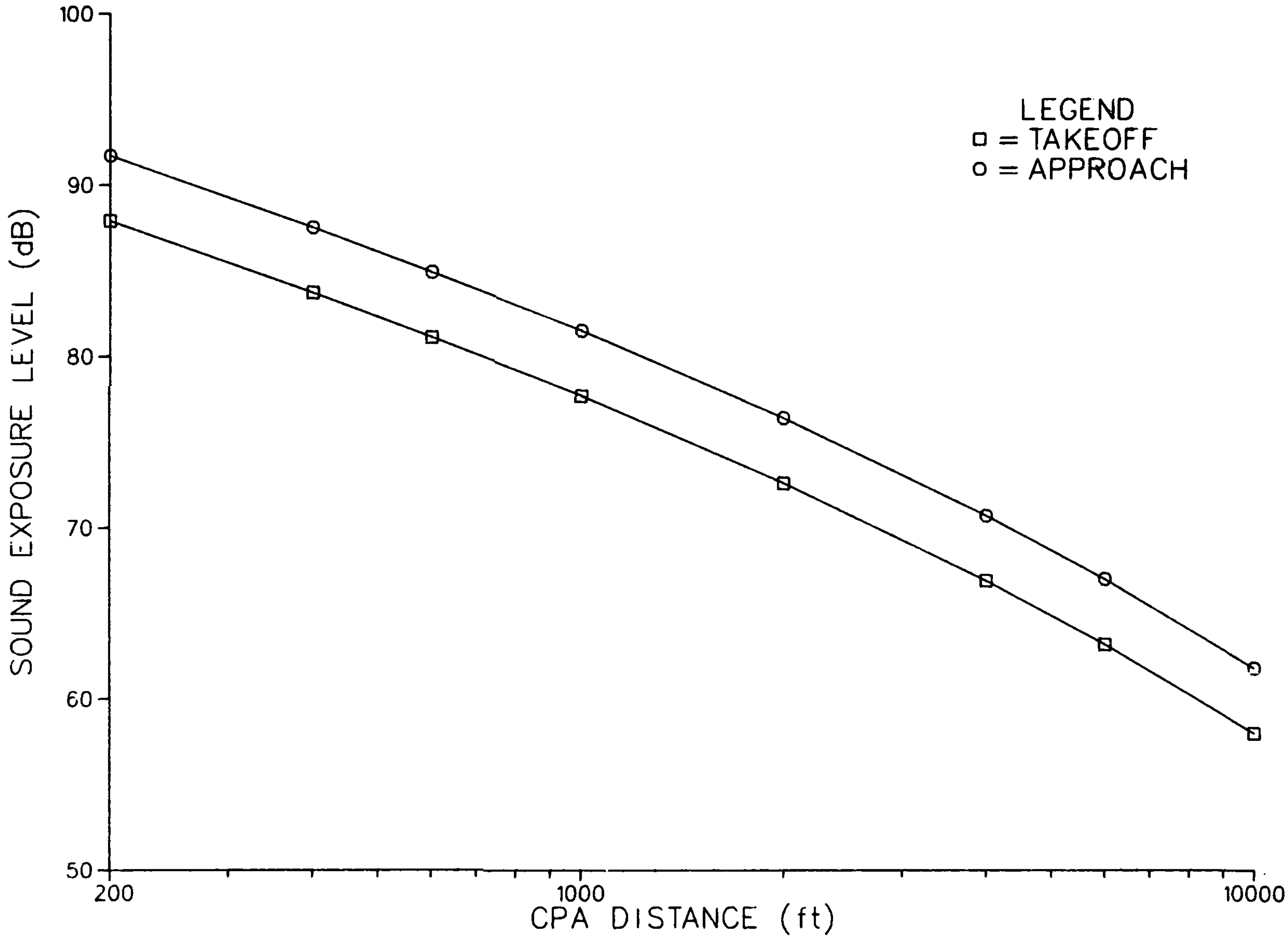


TABLE: G2

BELL 47G LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 50 kts SEL (dB)	V= 55 kts SEL (dB)	V= 65.2 kts SEL (dB)	V= 75 kts SEL (dB)
200	87.1	88.5	88.9	88.5
400	82.7	84.1	84.5	84.1
600	79.9	81.3	81.7	81.3
1000	76.2	77.6	78.0	77.6
2000	70.5	71.9	72.3	71.9
4000	64.1	65.5	65.9	65.5
6000	60.1	61.5	61.9	61.5
10000	54.6	56.0	56.4	56.0

BELL 47G NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE G2

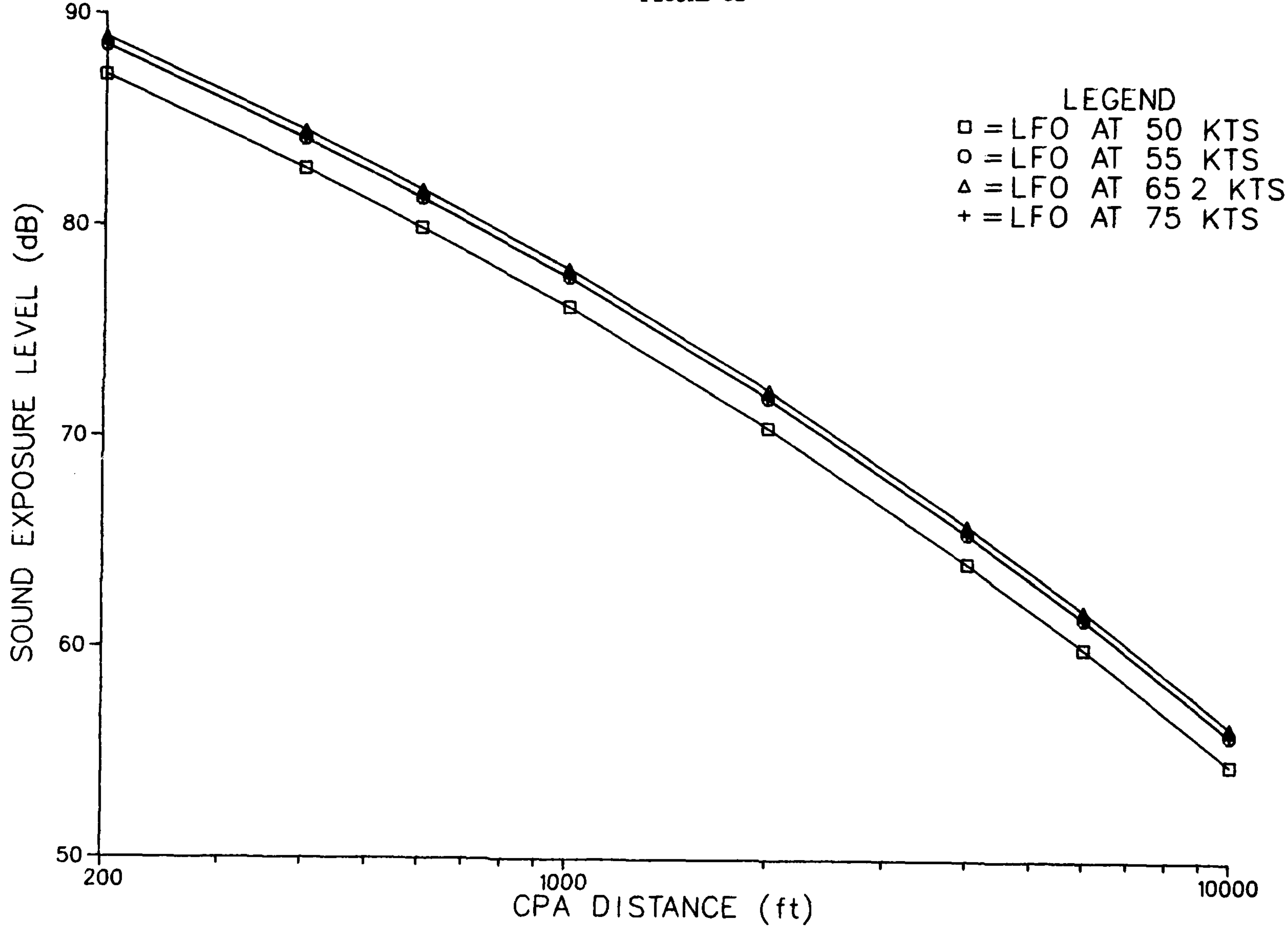


TABLE: G3

BELL 47G HOVER DATA TABLE

CPA Distance (FT)	A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
	Maximum A-Weighted Sound Level, L_{AM}		
200	83.8	86.8	88.8
400	77.0	80.0	82.5
600	72.3	75.3	78.8
1000	65.0	68.0	74.0
2000	55.5	58.5	67.0
4000	46.7	49.7	59.5
6000	41.6	44.6	54.6
10000	34.7	37.7	47.7
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX H

PUMA SA-330J

TABLE

FIGURE

TABLE: H1

PUMA SA-330J TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	96.0	96.6
400	91.6	92.5
600	88.8	89.9
1000	85.1	86.7
2000	79.3	82.0
4000	71.8	76.7
6000	67.1	73.4
10000	60.4	68.7

Takeoff Notes

Vy (Speed for best rate of climb) = 70 kts

BRC (Best rate of climb) = 1175 feet per minute (fpm)

Climb Angle (degrees) = 7.6°

Climb Gradient (Run/Rise) = 7.5

Takeoff Weight = 15,532 lbs

Approach Notes

Vy (Speed for best rate of climb) = 70 kts

Approach Angle (degrees) = 6°

PUMA SA-330J NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE H1

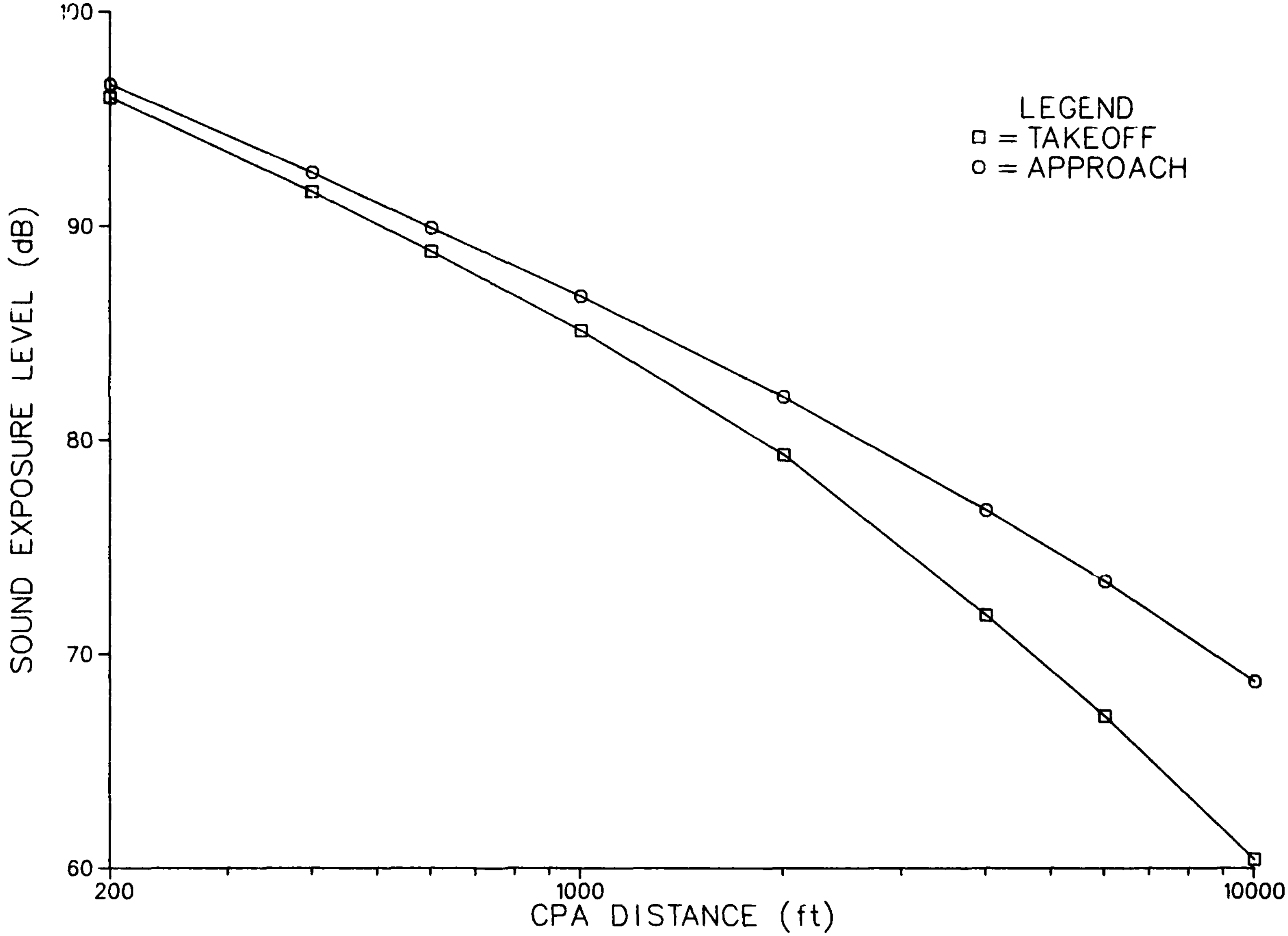


TABLE: H2

PUMA SA-330J LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 112 kts SEL (dB)
200	94.9
400	90.6
600	87.9
1000	84.2
2000	78.5
4000	72.2
6000	67.4
10000	60.4

PUMA SA-330J NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVER

FIGURE H2

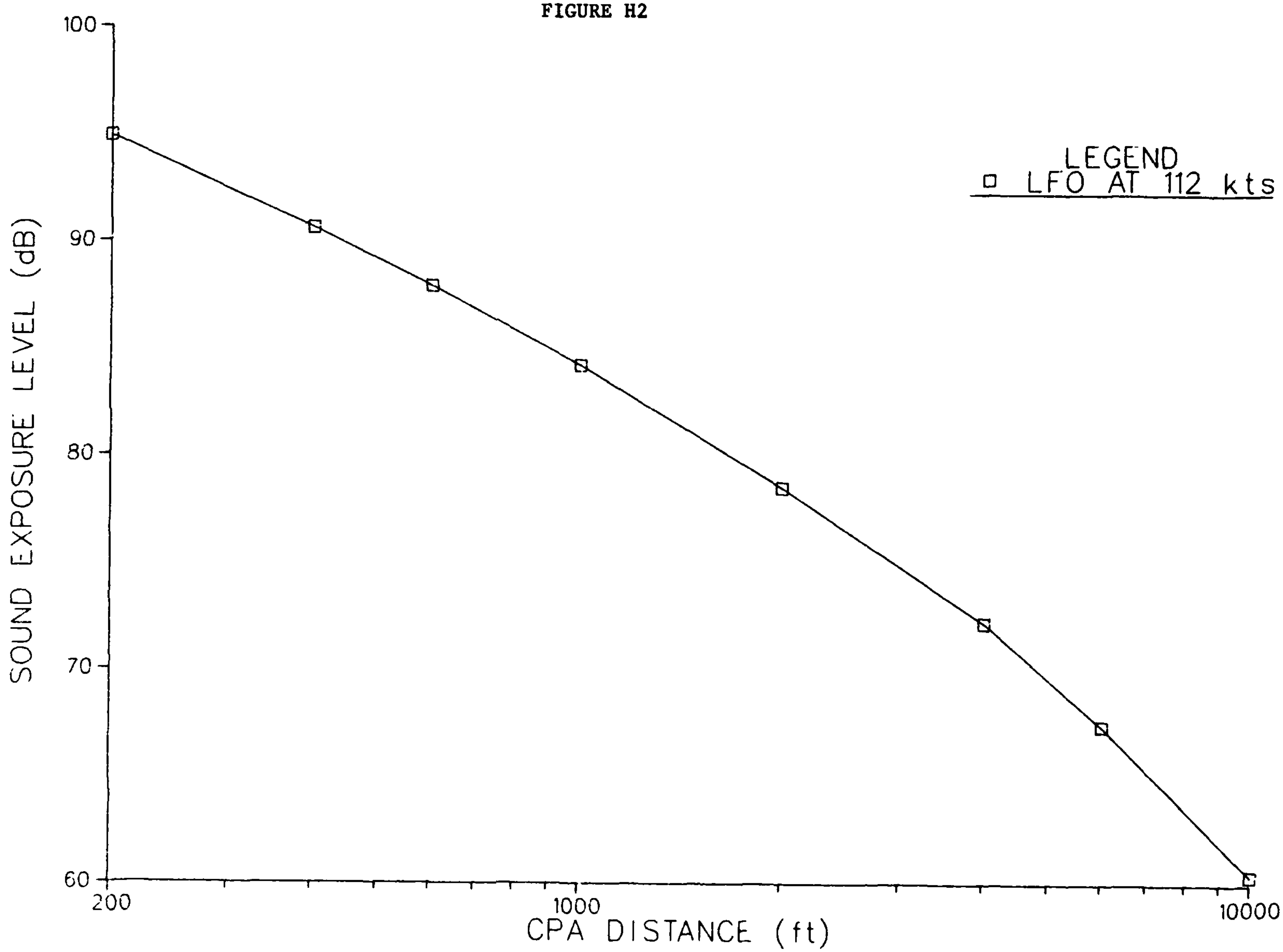


TABLE: H3

PUMA SA-330J HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} — A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	90.3	93.6	95.6
400	83.4	86.4	88.9
600	78.6	81.6	85.1
1000	71.1	74.1	80.1
2000	61.5	64.5	73.0
4000	52.3	55.3	65.1
6000	47.1	50.1	60.1
10000	40.2	43.2	53.2
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX I

BELL 206L

TABLE

FIGURE

TABLE: I1

BELL 206L TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	89.2	89.3
400	84.9	85.2
600	82.3	82.7
1000	78.7	79.4
2000	73.4	74.7
4000	67.9	69.4
6000	63.9	65.7
10000	58.3	60.4

Takeoff Notes

Vy (Speed for best rate of climb) = 52 kts

BRC (Best rate of climb) = 1380 feet per minute (fpm)

Climb Angle (degrees) = 15.2°

Climb Gradient (Run/Rise) = 3.7

Takeoff Weight = 4,000 lbs

Approach Notes

Vy (Speed for best rate of climb) = 52 kts

Approach Angle (degrees) = 6°

BELL 206L NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE I1

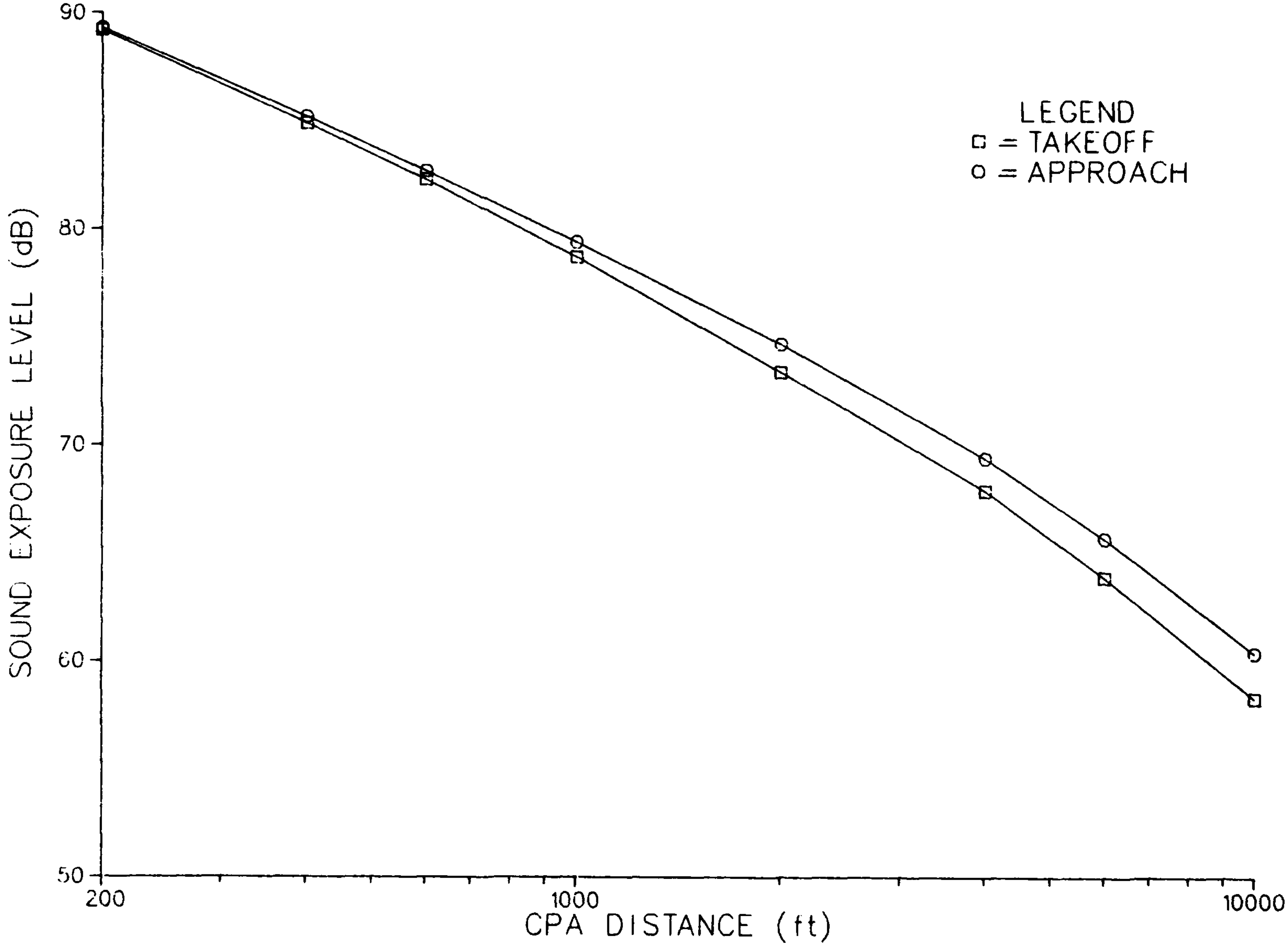
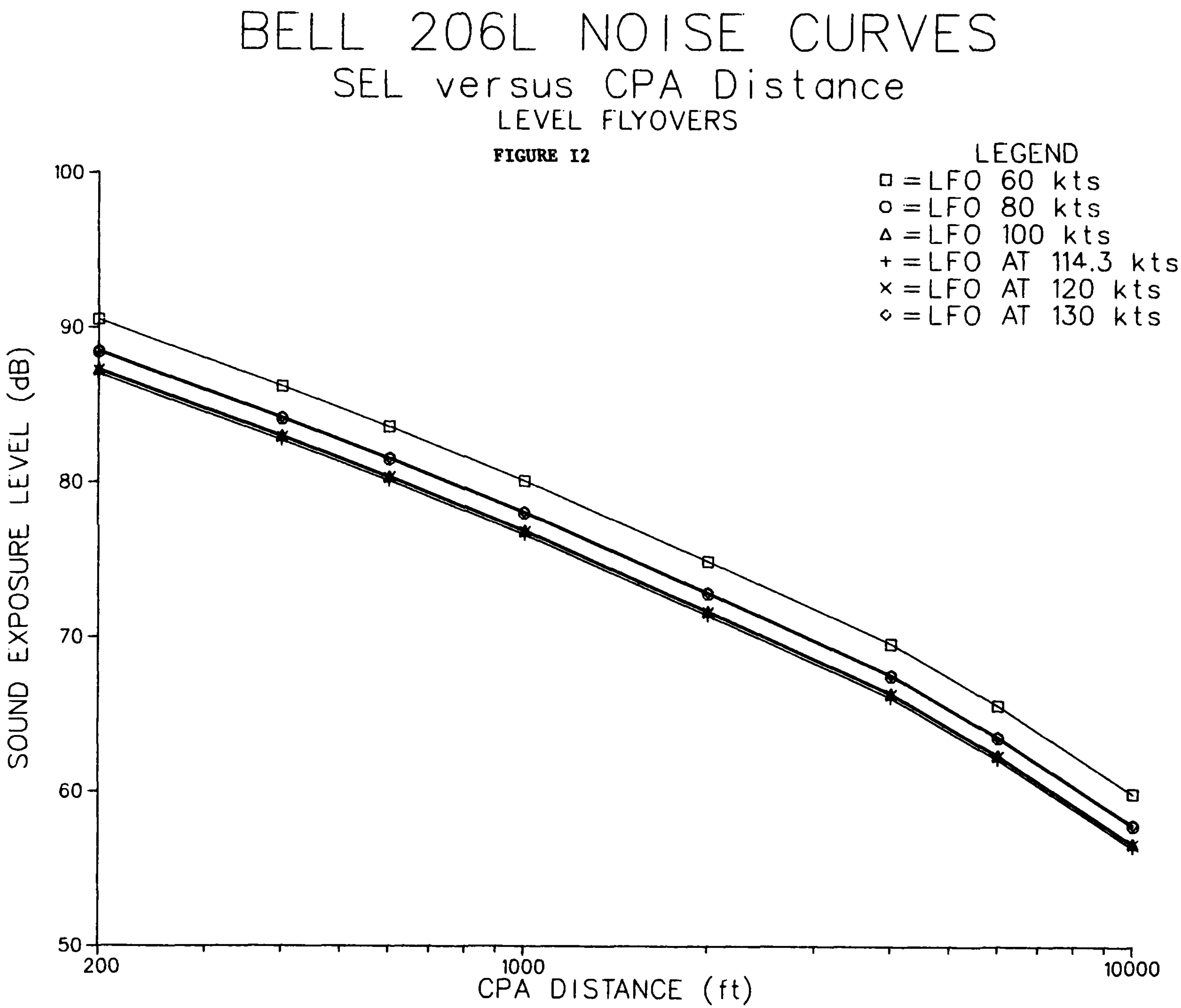


TABLE: I2

BELL 206L LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 60 kts SEL (dB)	V= 80 kts SEL (dB)	V= 100 kts SEL (dB)	V= 114.3 kts SEL (dB)	V= 120 kts SEL (dB)	V= 130 kts SEL (dB)
200	90.5	88.4	87.3	87	87.2	88.5
400	86.2	84.1	83.0	82.7	82.9	84.2
600	83.6	81.5	80.4	80.1	80.3	81.6
1000	80.1	78.0	76.9	76.6	76.8	78.1
2000	74.9	72.8	71.7	71.4	71.6	72.9
4000	69.6	67.5	66.4	66.1	66.3	67.6
6000	65.6	63.5	62.4	62.1	62.3	63.6
10000	59.9	57.8	56.7	56.4	56.6	57.9



BELL 206L NOISE CURVES
SEL versus CPA Distance
LEVEL FLYOVERS
LEGEND
□ = LFO 60 kts
○ = LFO 80 kts
△ = LFO 100 kts
+ = LFO AT 114.3 kts
× = LFO AT 120 kts
◇ = LFO AT 130 kts
SOUND EXPOSURE LEVEL (dB)
100
90
80
70
60
50
200
1000
10000
CPA DISTANCE (ft)

FIGURE I2

TABLE: I3

BELL 206L HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	85.0	88.0	90
400	78.2	81.2	83.7
600	73.5	76.5	80.0
1000	66.1	69.1	75.1
2000	56.5	59.5	68.0
4000	47.4	50.4	60.2
6000	42.1	45.1	55.1
10000	35	38.0	48.0
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX J

AUGUSTA A109

TABLES

FIGURES

TABLE: J1

AUGUSTA A109 TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	93.0	99.8
400	88.6	95.6
600	85.9	93.1
1000	82.3	89.7
2000	76.8	84.7
4000	70.5	78.8
6000	66.3	74.7
10000	60.3	68.4

Takeoff Notes

Vy (Speed for best rate of climb) = 60 kts

BRC (Best rate of climb) = 1450 feet per minute (fpm)

Climb Angle (degrees) = 13.7°

Climb Gradient (Run/Rise) = 4.1

Takeoff Weight = 5,730 lbs

Approach Notes

Vy (Speed for best rate of climb) = 60 kts

Approach Angle (degrees) = 6°

A109 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE J1

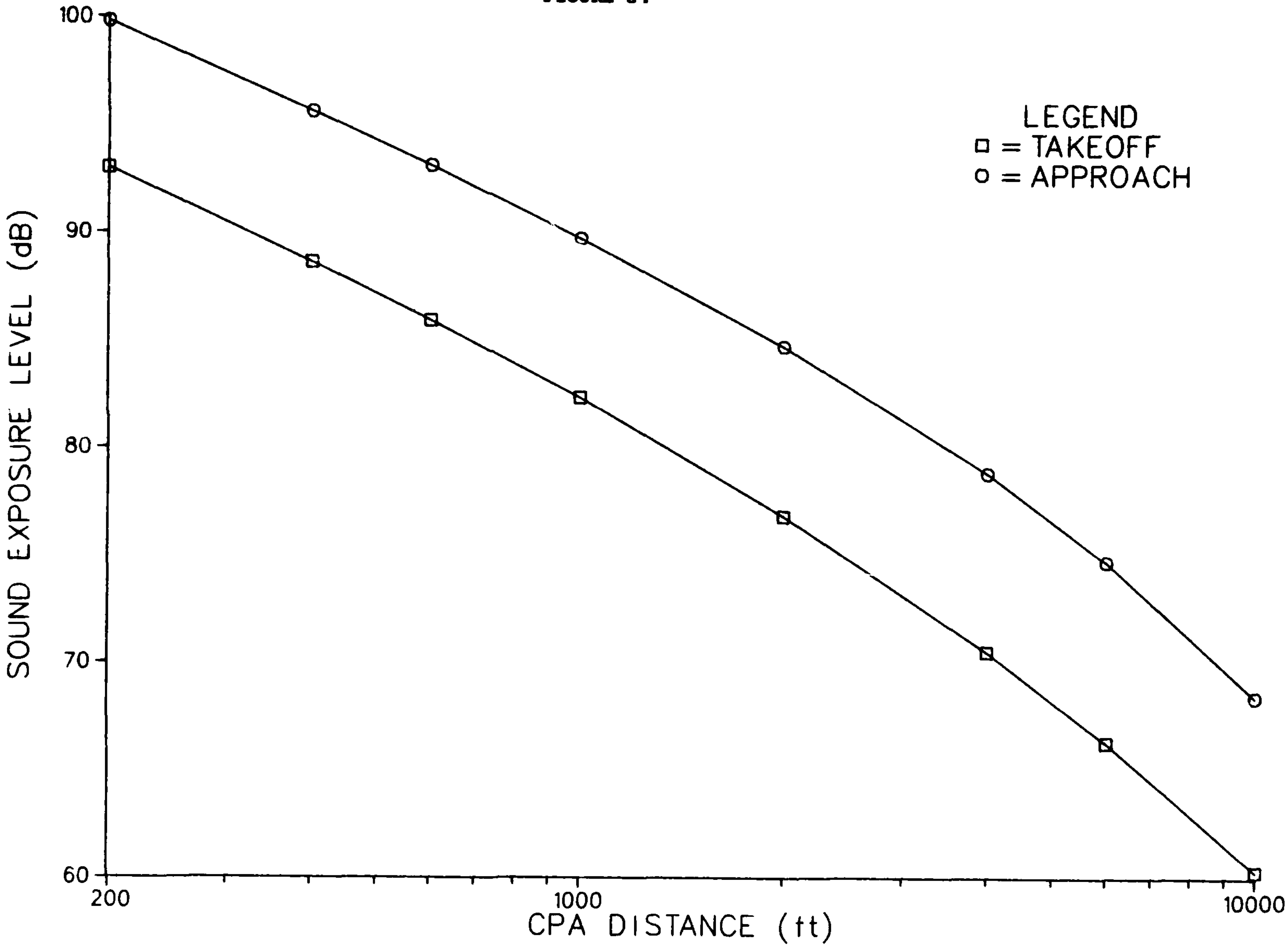


TABLE: J2

AUGUSTA A109 LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 87 kts SEL (dB)	V= 102 kts SEL (dB)	V= 116 kts SEL (dB)	V= 130 kts SEL (dB)	V= 145 kts SEL (dB)
200	91.9	92.6	93.8	94.8	97.2
400	87.7	88.4	89.6	90.6	93.0
600	85.2	85.9	87.1	88.1	90.5
1000	81.9	82.6	83.7	84.8	87.1
2000	77.1	77.7	78.8	79.9	82.1
4000	71.6	72.9	73.9	74.3	77.0
6000	68.0	69.3	70.2	71.0	73.1
10000	62.7	63.9	64.8	65.2	67.3

A109 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE J2

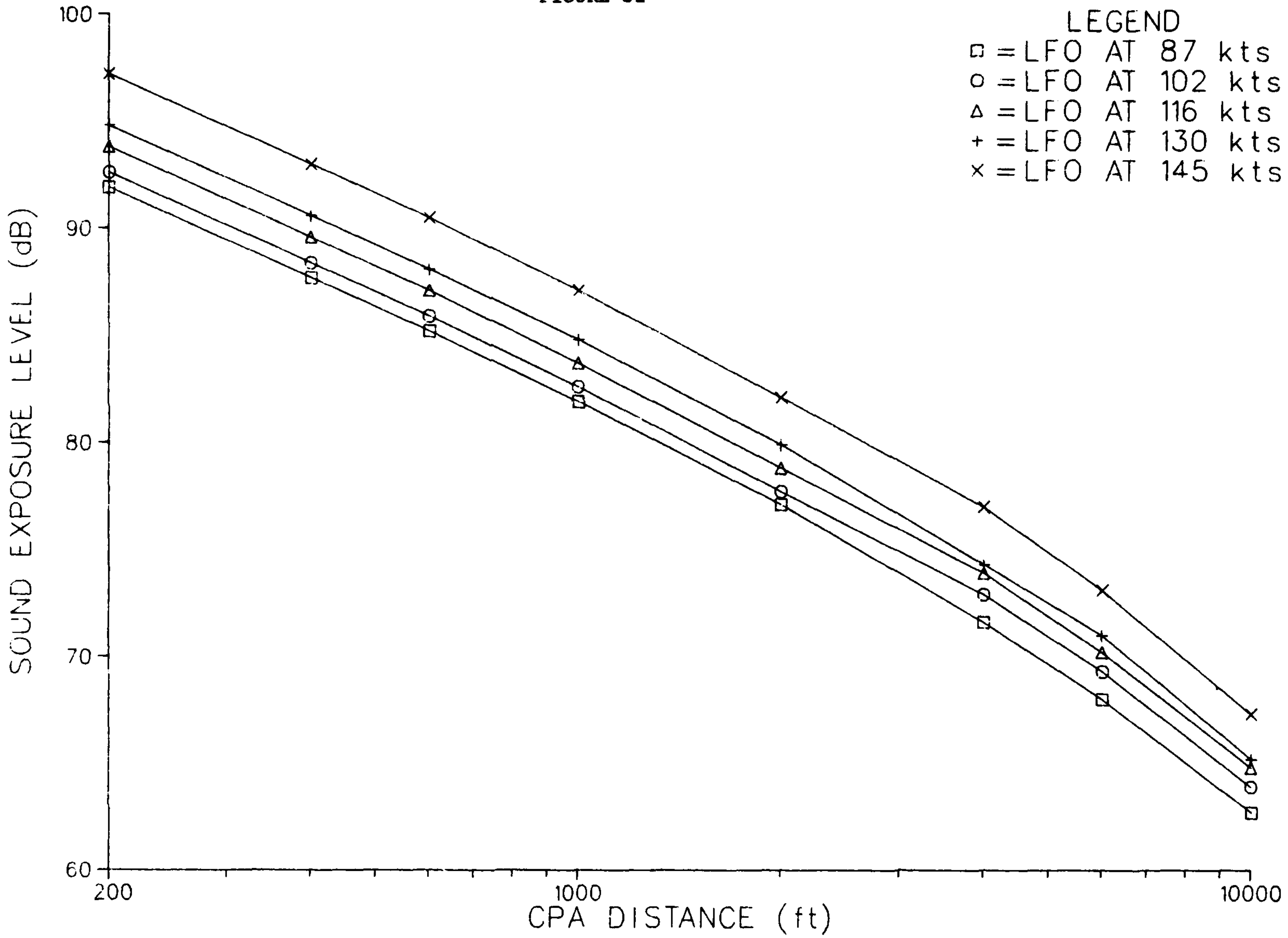


TABLE: J3

AUGUSTA A109 HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	87.1	90.1	92.1
400	80.2	83.2	85.7
600	75.4	78.4	81.9
1000	67.9	70.9	76.9
2000	58.3	61.3	69.8
4000	49.1	52.1	61.9
6000	43.9	46.9	56.9
10000	37.0	40.0	50.0
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX K

GAZELLE SA-341G

TABLE

FIGURE

TABLE: K1

GAZELLE SA-341G TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	89.5	91.9
400	85.0	87.7
600	82.1	85.2
1000	78.1	81.8
2000	72.0	76.7
4000	64.7	70.9
6000	59.8	66.9
10000	52.6	61.3

Takeoff Notes

Vy (Speed for best rate of climb) = 65 kts

BRC (Best rate of climb) = 1378 feet per minute (fpm)

Climb Angle (degrees) = 12.1°

Climb Gradient (Run/Rise) = 4.7

Takeoff Weight = 3,970 lbs

Approach Notes

Vy (Speed for best rate of climb) = 65 kts

Approach Angle (degrees) = 6°

GAZELLE SA-341G NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE K1

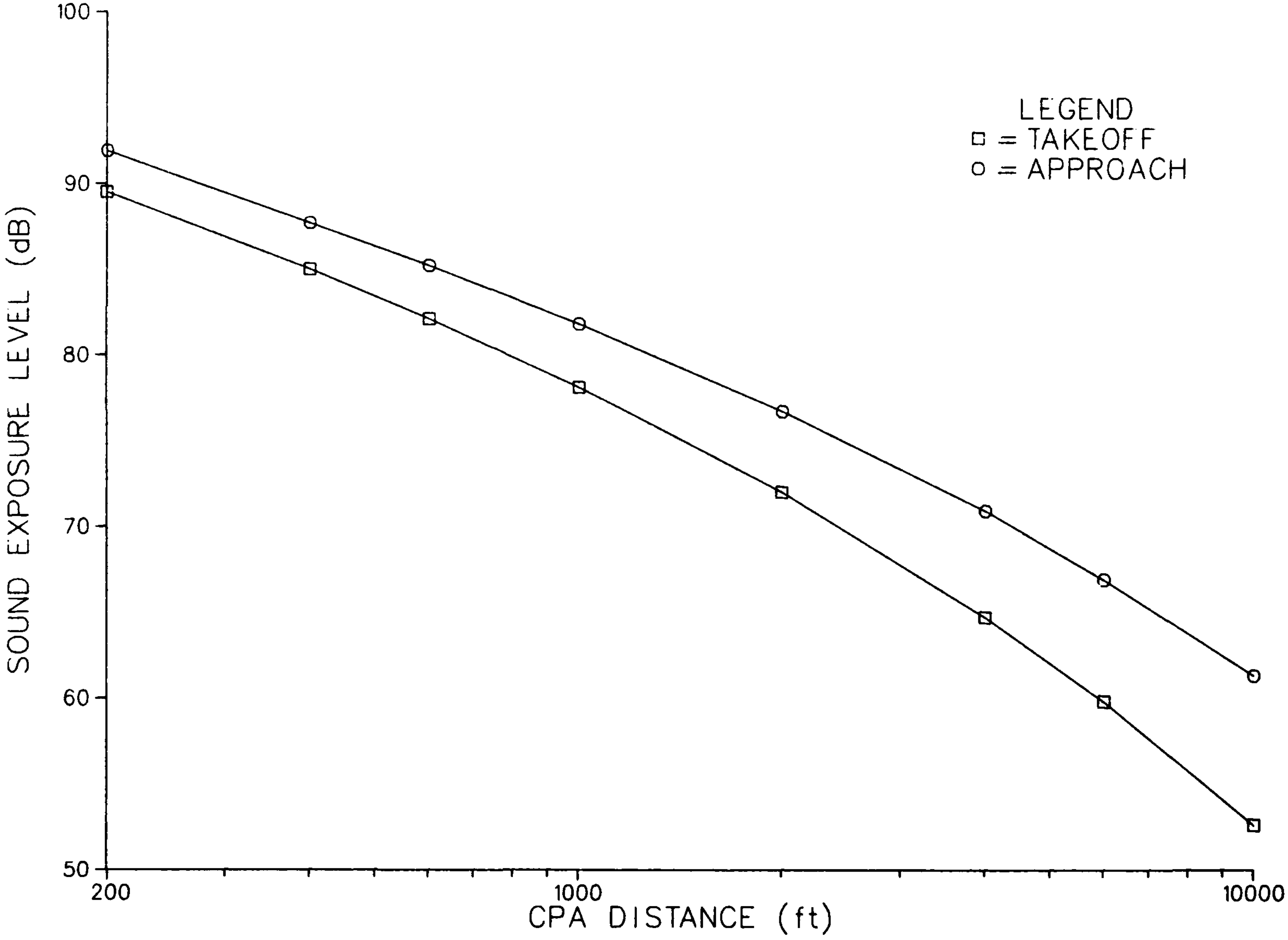


TABLE: K2

GAZELLE SA-341G LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 147 kts SEL (dB)
200	88.7
400	84.1
600	81.3
1000	77.3
2000	71.1
4000	64.2
6000	59.1
10000	52.0

GAZELLE SA-341G NOISE CURVE

SEL versus CPA Distance

LEVEL FLYOVER

FIGURE K2

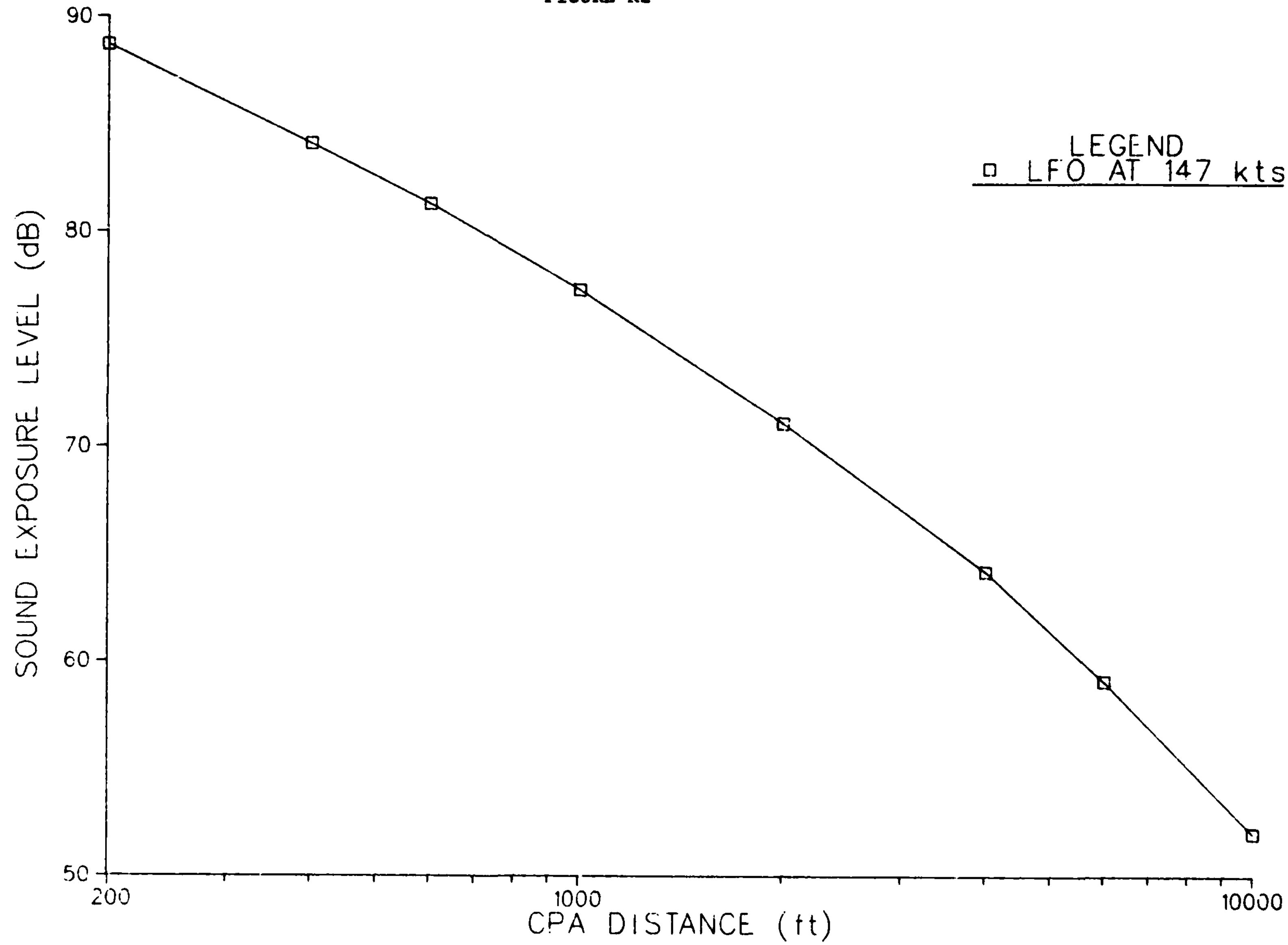


TABLE: K3

GAZELLE SA-341G HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	85.8	88.8	90.8
400	78.9	81.9	84.4
600	74.1	77.1	80.6
1000	66.6	69.6	75.6
2000	57.0	60.0	68.5
4000	47.8	50.8	60.6
6000	42.6	45.6	55.6
10000	38.7	41.7	51.7
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX L

HUGHES 300C

TABLE

FIGURE

TABLE: L1

HUGHES 300C TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	89.0	92.8
400	84.8	88.6
600	82.3	86.1
1000	78.9	82.7
2000	73.9	77.7
4000	68.1	71.9
6000	64.1	67.9
10000	58.2	62.0

Takeoff Notes

Vy (Speed for best rate of climb) = 52.1 kts

BRC (Best rate of climb) = 750 feet per minute (fpm)

Climb Angle (degrees) = 8.2°

Climb Gradient (Run/Rise) = 7.0

Takeoff Weight = 1,900 lbs

Approach Notes

Vy (Speed for best rate of climb) = 52.1 kts

Approach Angle (degrees) = 6°

HUGHES 300C NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE L1

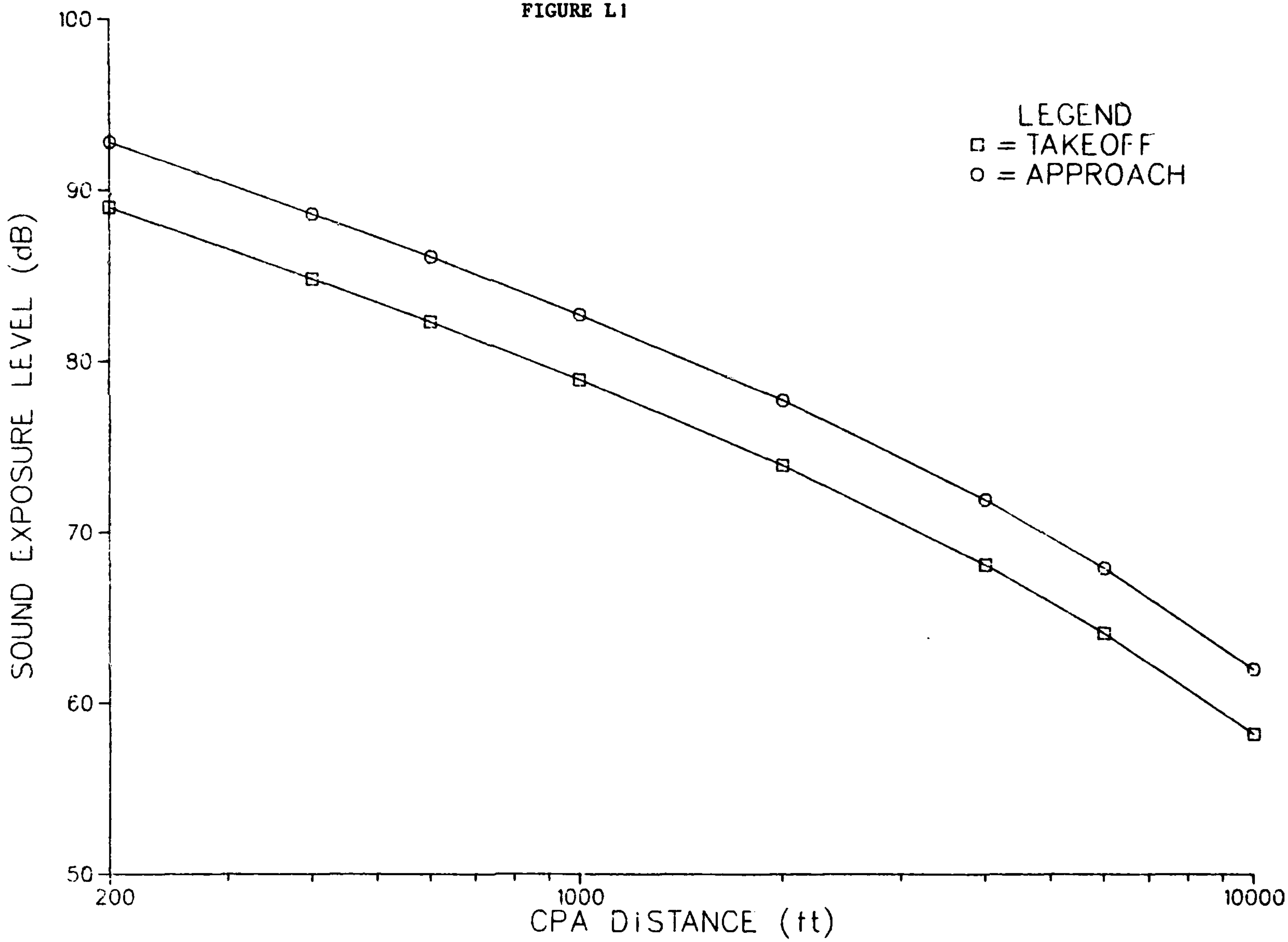


TABLE: L2

HUGHES 300C LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 50 kts SEL (dB)	V= 60 kts SEL (dB)	V= 66 kts SEL (dB)	V= 70 kts SEL (dB)	V= 80 kts SEL (dB)
200	81.7	81.6	81.3	80.7	80.7
400	77.3	77.2	76.9	76.3	76.3
600	74.6	74.5	74.2	73.6	73.6
1000	70.8	70.8	70.5	69.9	69.9
2000	65.4	65.3	65.0	64.4	64.4
4000	59.1	59.[illegible]	58.7	58.1	58.1
6000	55.0	54.9	54.6	54.0	54.0
10000	49.3	49.2	48.9	48.3	48.3

HUGHES 300C NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE L2

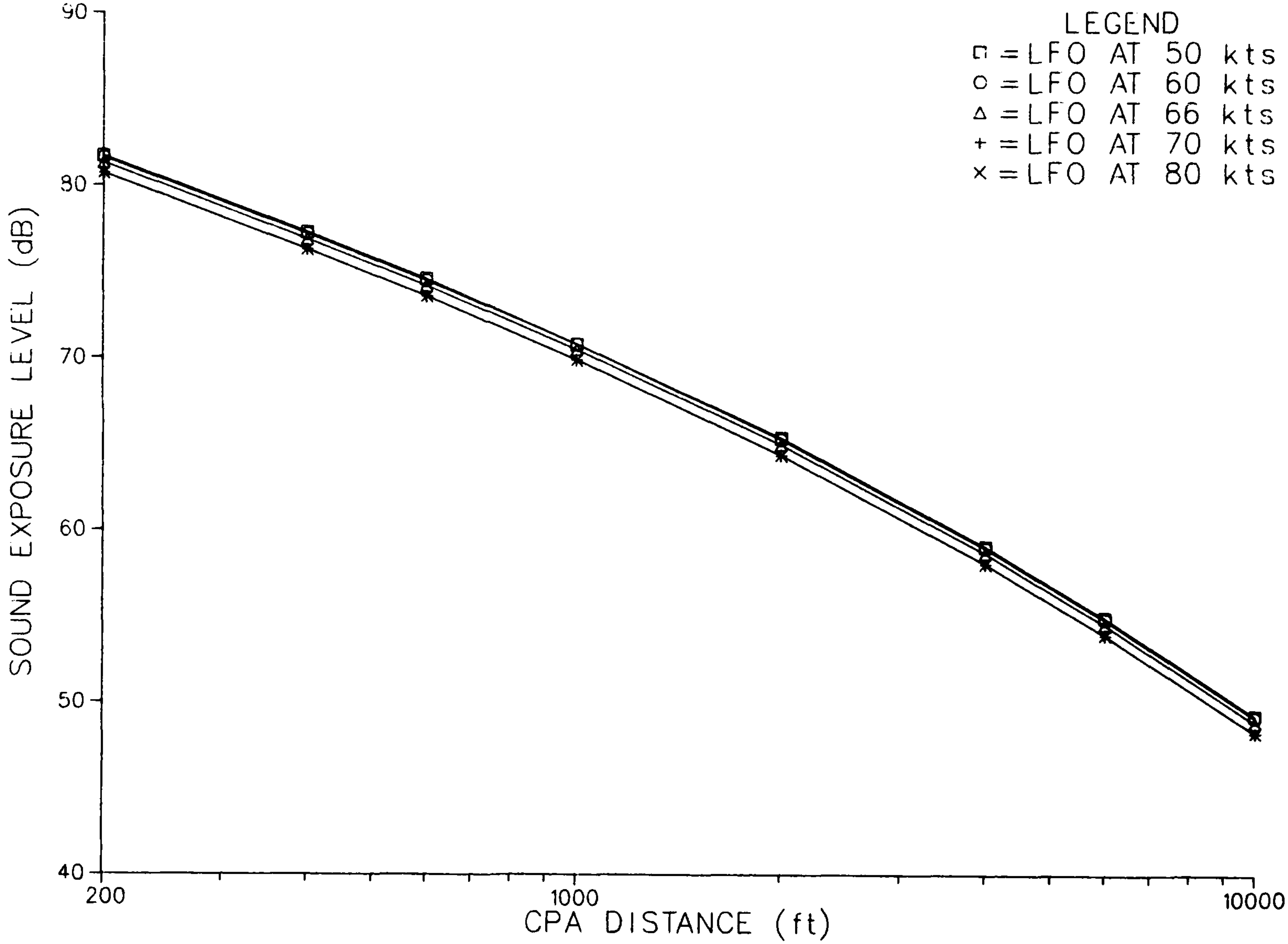


TABLE: L3

HUGHES 300C HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	81.1	84.1	86.1
400	74.2	77.2	79.7
600	69.3	72.3	75.8
1000	61.7	64.7	70.7
2000	51.7	54.7	63.2
4000	42.1	45.1	54.9
6000	36.6	39.6	49.6
10000	29.1	32.1	42.1
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.

2. Excess ground attenuation (EGA) has been applied to Columns A and B.

3. EGA has not been applied in Column C.

4. Engine shielding has not been applied in any case nor have data been ajusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX M

SIKORSKY CH-53

TABLE

FIGURE

TABLE: M1

SIKORSKY CH-53 TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKOEFF SEL (dB)	APPROACH SEL (dB)
200	97.3	99.0
400	93.0	94.9
600	90.5	92.4
1000	87.0	89.1
2000	81.8	84.4
4000	76.2	79.2
6000	72.1	75.7
10000	66.2	70.9

Takeoff Notes

Vy (Speed for best rate of climb) = 76 kts

BRC (Best rate of climb) = 1800 feet per minute (fpm)

Climb Angle (degrees) = 13.5°

Climb Gradient (Run/Rise) = 4.2

Takeoff Weight = 37,000 lbs

Approach Notes

Vy (Speed for best rate of climb) - 76 kts

Approach Angle (degrees) = 6°

SIKORSKY CH-53 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE M1

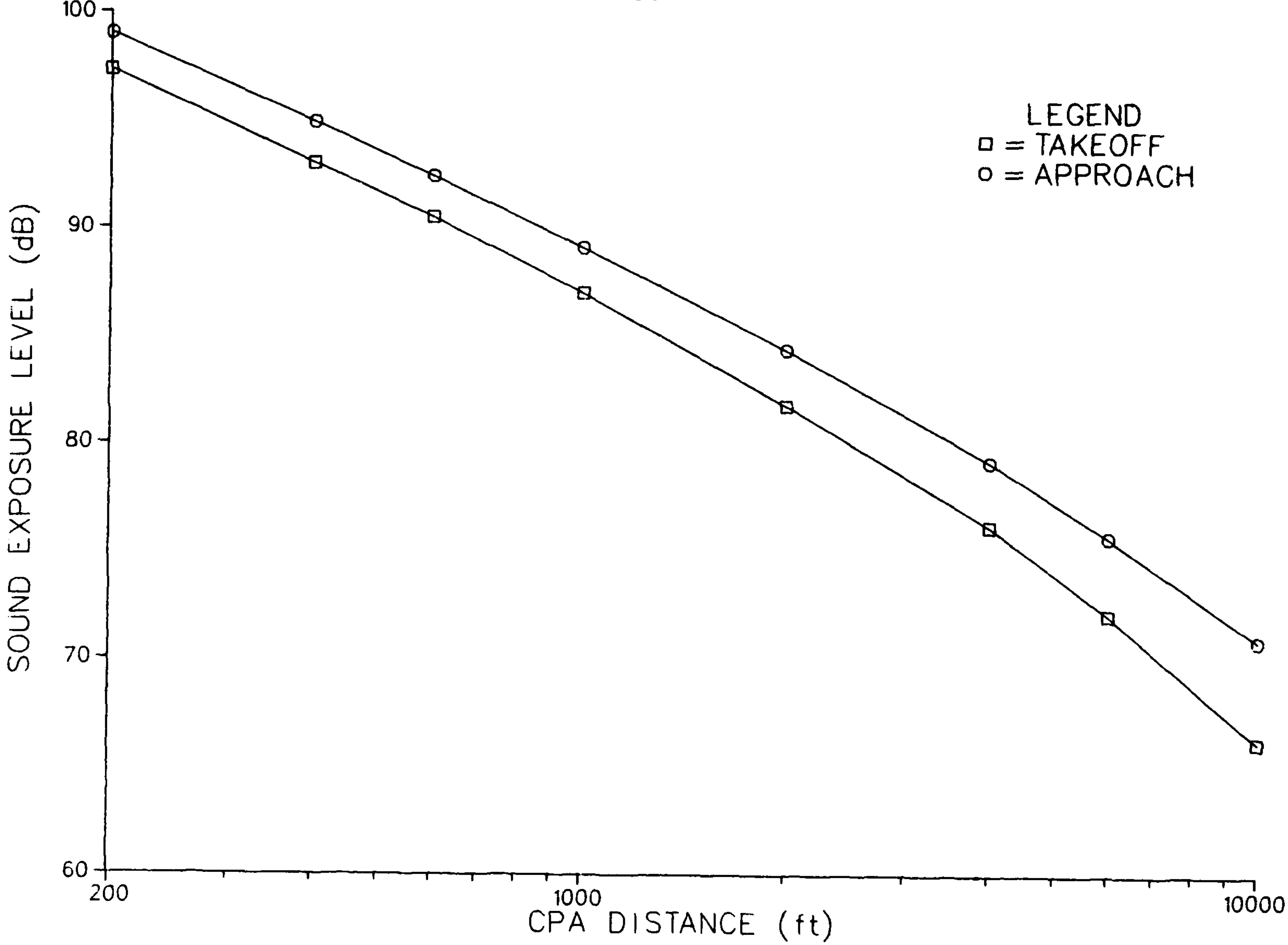


TABLE: M2

SIKORSKY CH-53 LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 100 kts SEL (dB)	V= 120 kts SEL (dB)	V- 140 kts SEL (dB)	V= 150 kts SEL (dB)
200	94.9	95.9	97.1	97.9
400	90.6	91.6	92.8	93.6
600	88.0	89.0	90.2	91.0
1000	84.5	85.5	86.7	87.5
2000	79.3	80.3	81.5	82.3
4000	73.8	74.8	76.0	76.8
6000	69.7	70.7	71.9	72.7
10000	63.9	64.9	66.1	66.9

SIKORSKY CH-53 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE M2

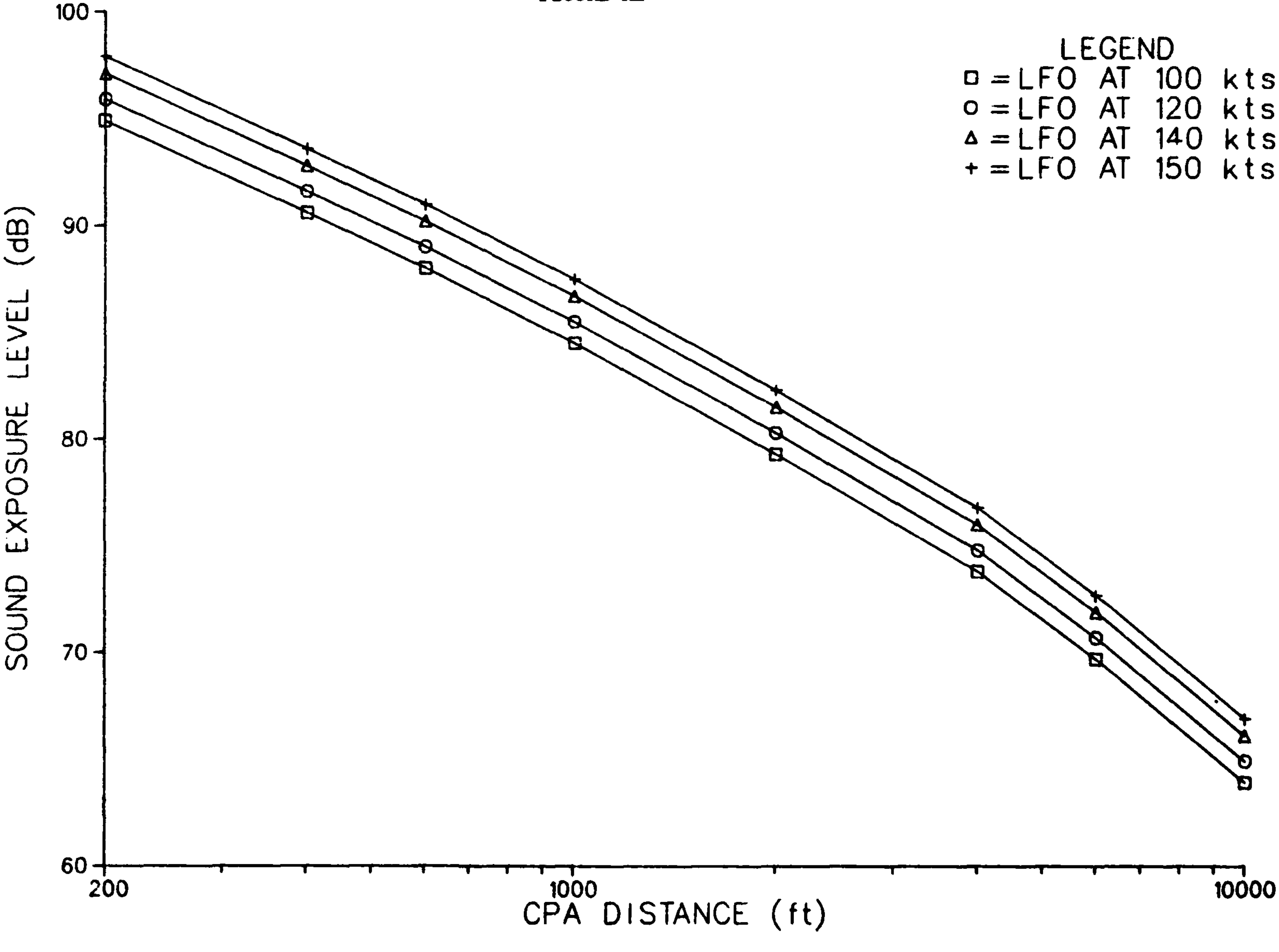


TABLE: M3

SIKORSKY CH-53 HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	93.2	96.2	98.2
400	86.3	89.3	91.8
600	81.5	84.5	88.0
1000	74.0	77.0	83.0
2000	64.4	67.4	75.9
4000	55.2	58.2	68.0
6000	50.0	53.0	63.0
10000	43.1	46.1	56.1
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX N

SIKORSKY S-70

TABLE: N1

SIKORSKY S-70 TAKEOFF/APPROACH DATA TABLE

Military Designation: UH-60A

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	91.4	98.2
400	86.9	94.1
600	84.1	91.7
1000	80.4	88.5
2000	74.9	83.9
4000	69.3	78.9
6000	65.6	75.7
10000	60.6	71.2

Takeoff Notes

Vy (Speed for best rate of climb) - 80 kts

BRC (Best rate of climb) = 1950 feet per minute (fpm)

Climb Angle (degrees) = 13.9°

Climb Gradient (Run/Rise)= 4.0

Takeoff Weight = 20,250 lbs

Approach Notes

Vy (Speed for best rate of climb) = 80 kts

Approach Angle (degrees) = 6°

SIKORSKY S-70 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE N1

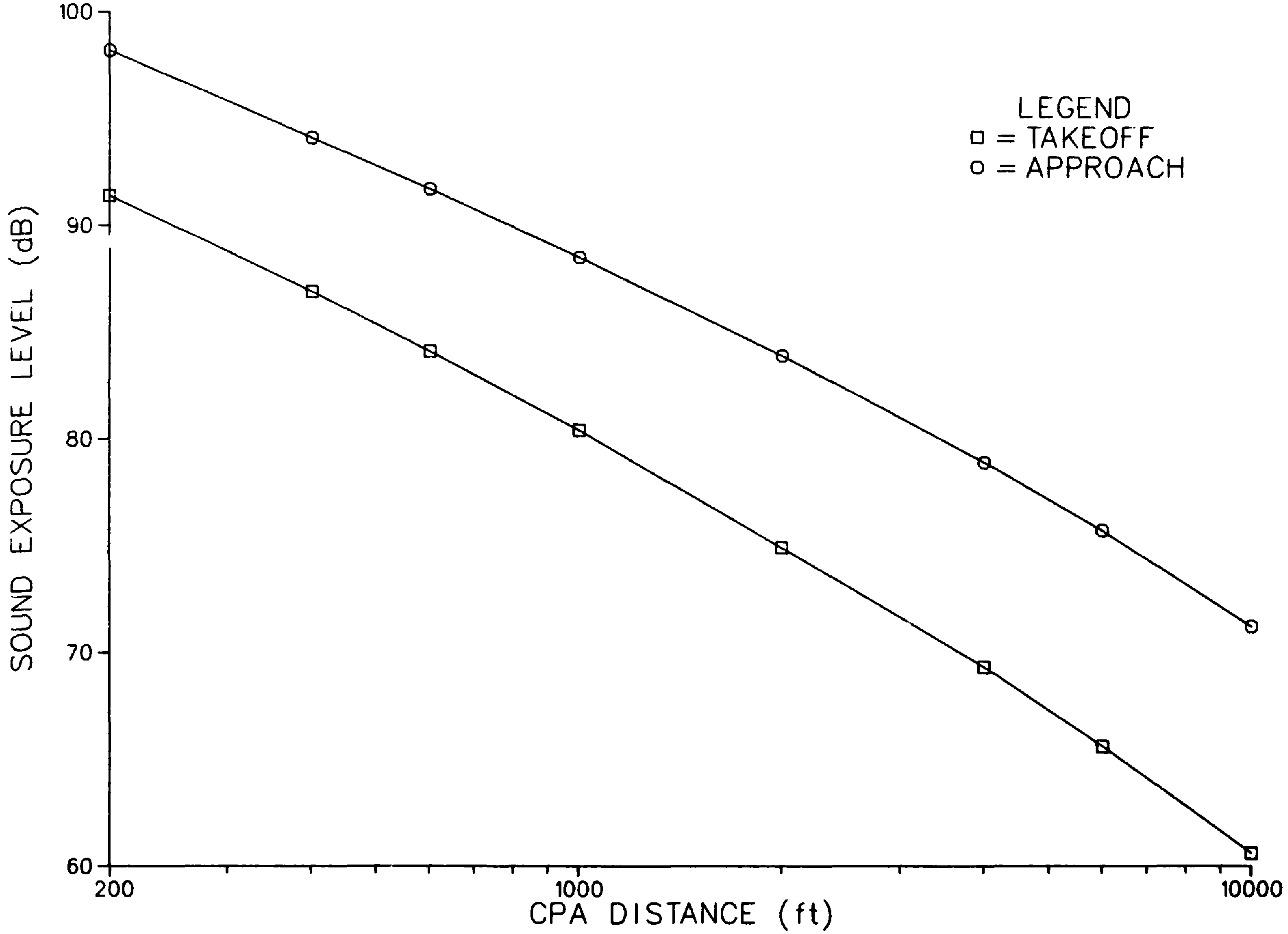


TABLE: N2

SIKORSKY S-70 LEVEL FLYOVER DATA TABLE

Military Designation: UH-60A

CPA Distance (FT)	V= 100 kts SEL (dB)	V= 115 kts SEL (dB)	V= 132 kts SEL (dB)	V= 152 kts SEL (dB)	V= 165 kts SEL (dB)
200	93.0	95.8	97.0	97.7	99.3
400	88.5	91.3	92.8	93.5	95.1
600	85.8	88.6	90.2	91.0	92.6
1000	82.0	84.8	86.7	87.7	89.2
2000	76.3	79.1	81.4	82.8	84.3
4000	70.3	73.1	75.9	78.0	79.3
6000	65.8	68.6	71.9	74.3	75.5
10000	59.5	62.4	66.1	69.1	70.1

SIKORSKY S-70 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE N2

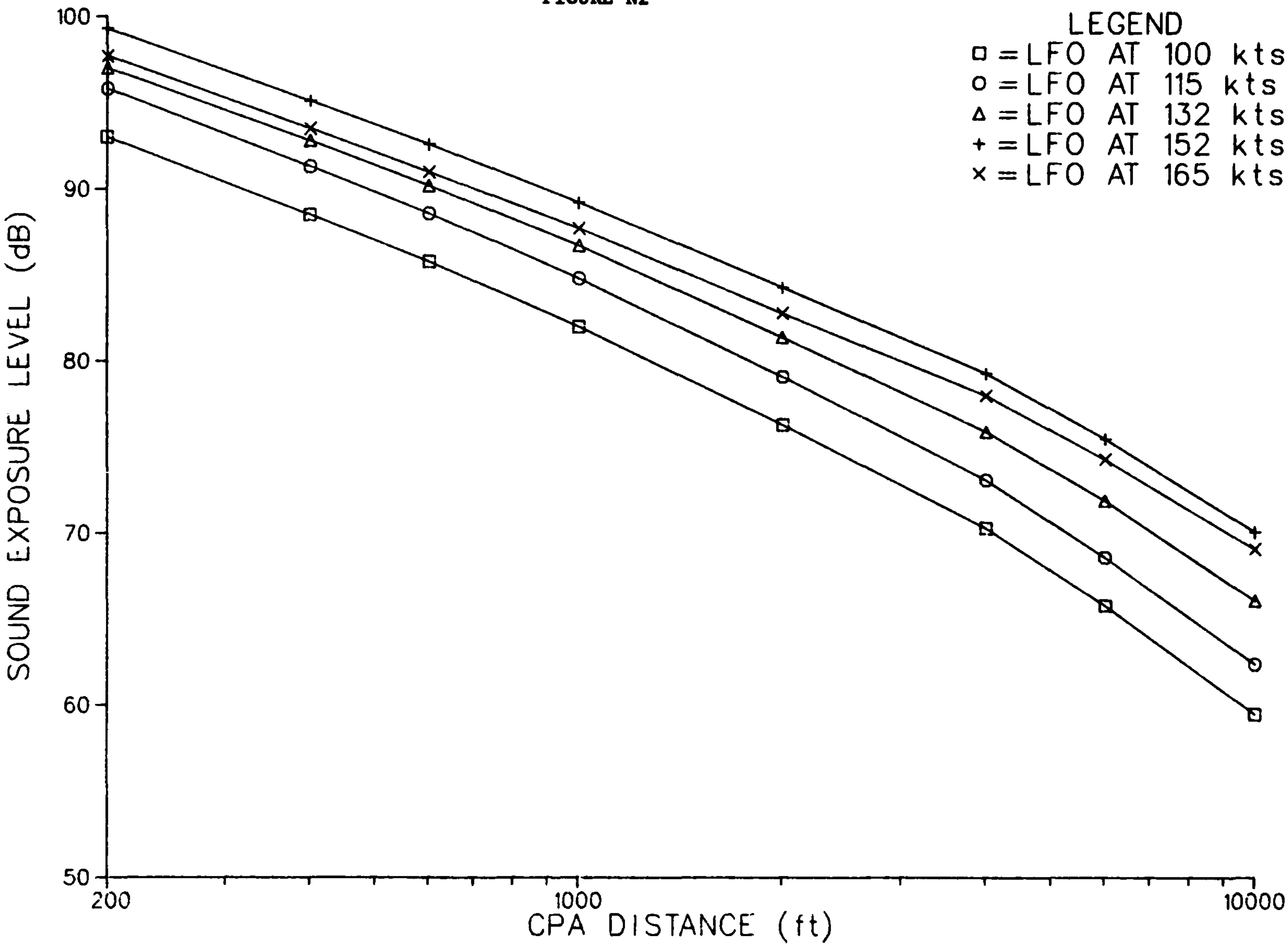


TABLE: N3

SIKORSKY S-70 HOVER DATA TABLE

Military Designation: UH-60A

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
200	91.2	94.2	96.2
400	84.3	87.3	89.8
600	79.5	82.5	86.0
1000	72.0	75.0	81.0
2000	62.4	65.4	73.9
4000	53.2	56.2	66.0
6000	48.0	51.0	61.0
10000	41.1	44.1	54.1
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.

APPENDIX O

SIKORSKY S76-100% RPM

TABLE

FIGURE

TABLE: 01

SIKORSKY S76-100% Takeoff/Approach Data Table

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	94.9	95.6
400	90.1	91.5
600	87.3	89.0
1000	83.8	85.8
2000	78.9	81.0
4000	74.1	75.6
6000	71.3	72.1
10000	67.8	68.3

Takeoff Notes

Vy (Speed for best rate of climb) = 74 kts

BRC (Best rate of climb) = 1350 feet per minute (fpm)

Climb Angle (degrees) = 10.3°

Climb Gradient (Run/Rise) = 5.5

Takeoff Weight = 10,000 lbs

Approach Notes

Vy (Speed for best rate of climb) = 74 kts

Approach Angle (degrees) = 6°

SIKORSKY S-76 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE 01

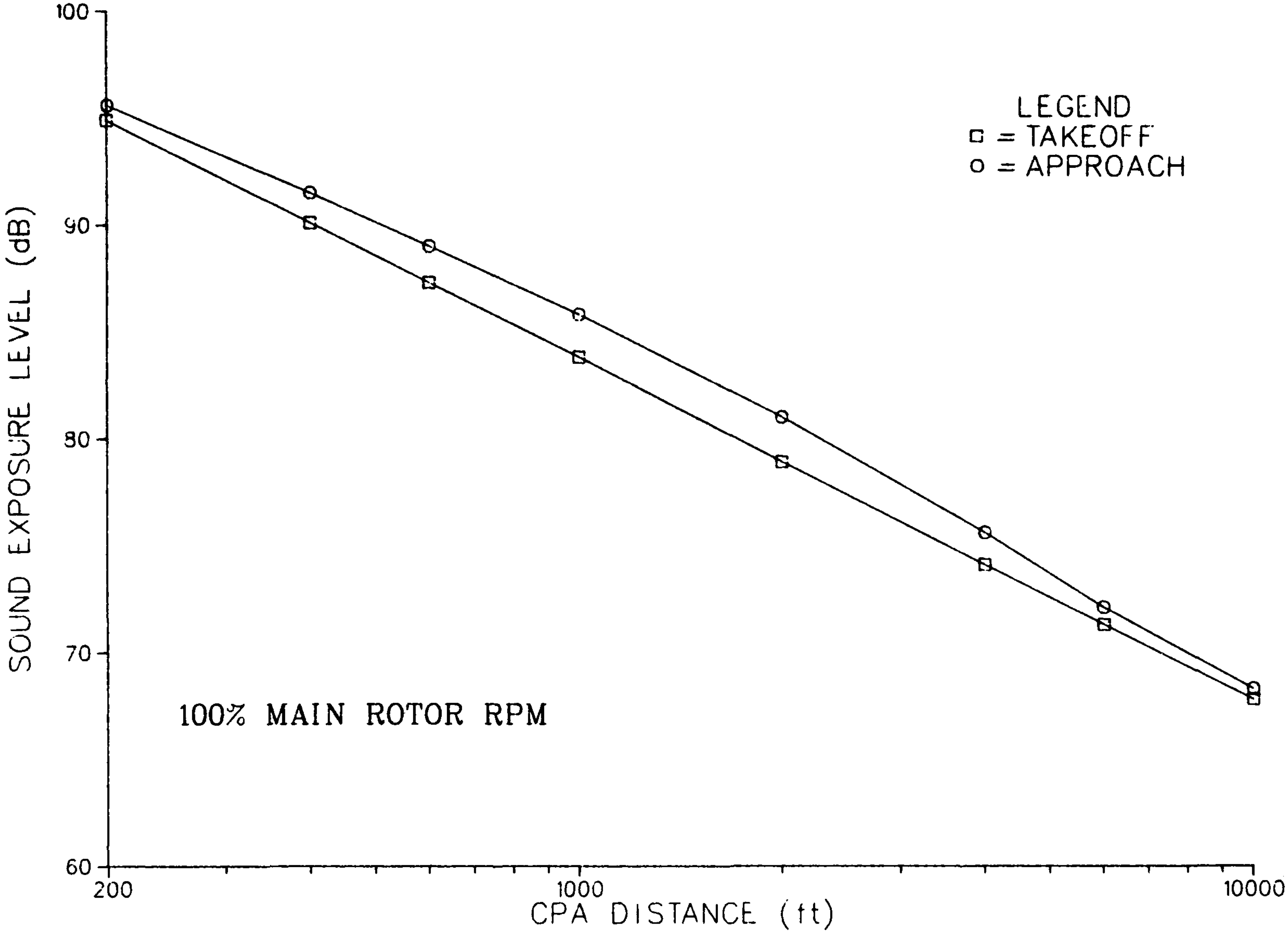


TABLE: 02

SIKORSKY S76-100% RPM LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 93 kts SEL (dB)	V= 109 kts SEL (dB)	V= 124 kts SEL (dB)	V= 140 kts SEL (dB)	V= 155 kts SEL (dB)
200	89.8	89.7	90.3	91.5	93.3
400	87.1	87.0	87.6	88.8	90.6
600	85.5	85.2	86.0	87.2	89.0
1000	82.6	82.5	83.1	84.3	86.1
2000	76.6	76.5	77.1	78.3	80.1
4000	70.5	70.5	71.0	72.3	74.0
6000	67.0	66.9	67.5	68.8	70.5
10000	62.6	62.5	63.1	64.3	66.1

SIKORSKY S-76 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE 02

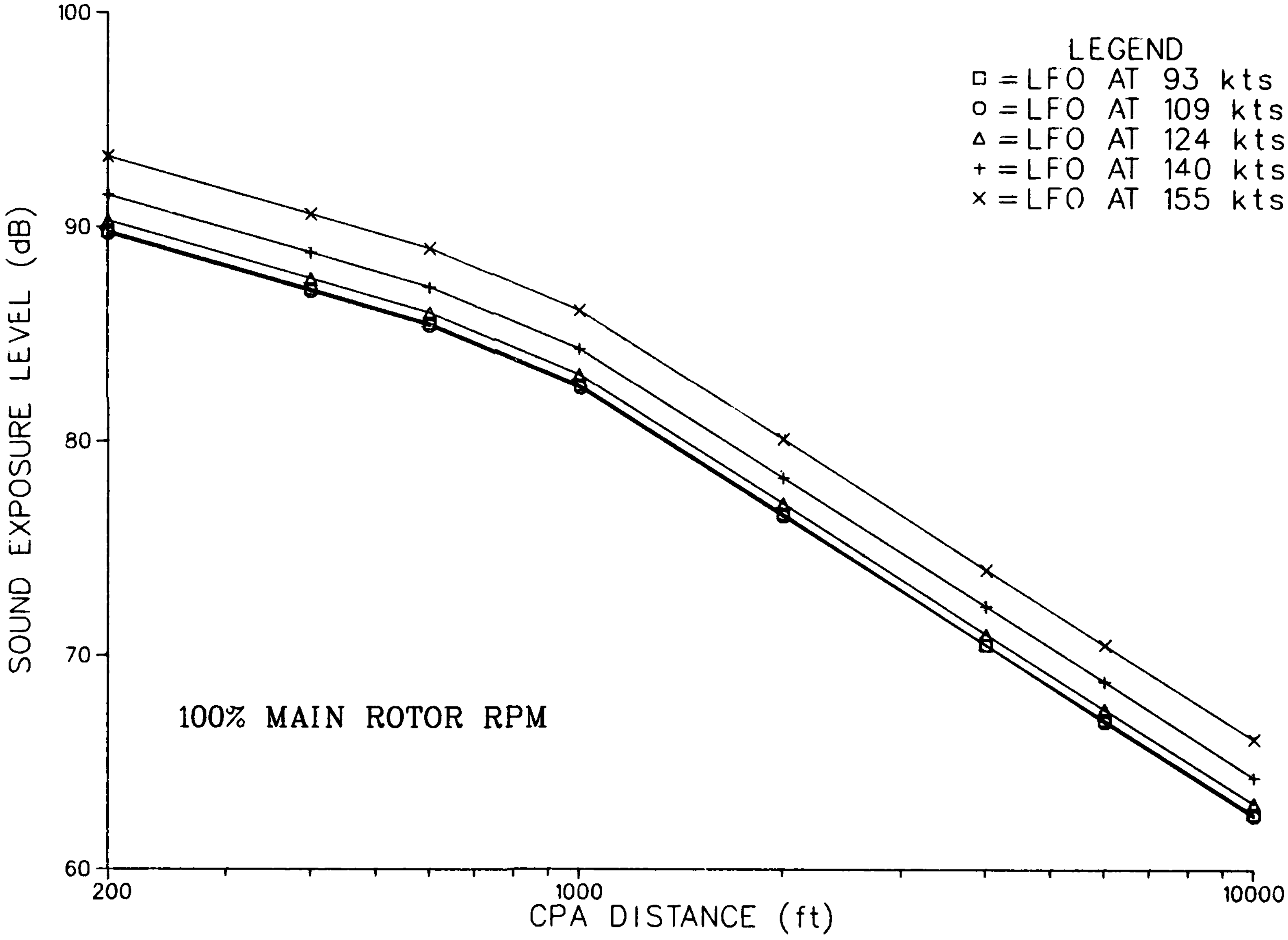


TABLE: 03

SIKORSKY S76-100% HOVER DATA TABLE

CPA Distance (FT)	A Ground-to-Ground	B Low Angle OGE Hover	C Air-to-Ground OGE Hover Direct Climb
	Maximum A-Weighted Sound Level, L_{AM}		
200	85.0	88.0	90.0
400	78.3	81.3	83.8
600	73.6	76.6	80.1
1000	66.4	69.4	75.4
2000	57.2	60.2	68.7
4000	48.8	51.8	61.6
6000	44.2	47.2	57.2
10000	38.1	41.1	51.1
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.
5. S-76 data derived from data provided by Sikorsky.

APPENDIX P

SIKORSKY S76-107% RPM

TABLE

FIGURE

TABLE: P1

SIKORSKY S76-107% RPM TAKEOFF/APPROACH DATA TABLE

CPA Distance (FT)	TAKEOFF SEL (dB)	APPROACH SEL (dB)
200	94.9	98.2
400	90.1	94.0
600	87.3	91.5
1000	83.8	88.4
2000	78.9	84.2
4000	74.1	80.0
6000	71.3	77.5
10000	67.8	74.4

Takeoff Notes

Vy (Speed for best rate of climb) = 74 kts

BRC (Best rate of climb) = 1240 feet per minute (fpm)

Climb Angle (degrees) = 9.5°

Climb Gradient (Run/Rise) = 6

Takeoff Weight = 10,000 lbs

Approach Notes

Vy (Speed for best rate of climb) = 74 kts

Approach Angle (degrees) = 6°

SIKORSKY S-76 NOISE CURVES

SEL versus CPA Distance

TAKEOFF/APPROACH

FIGURE P1

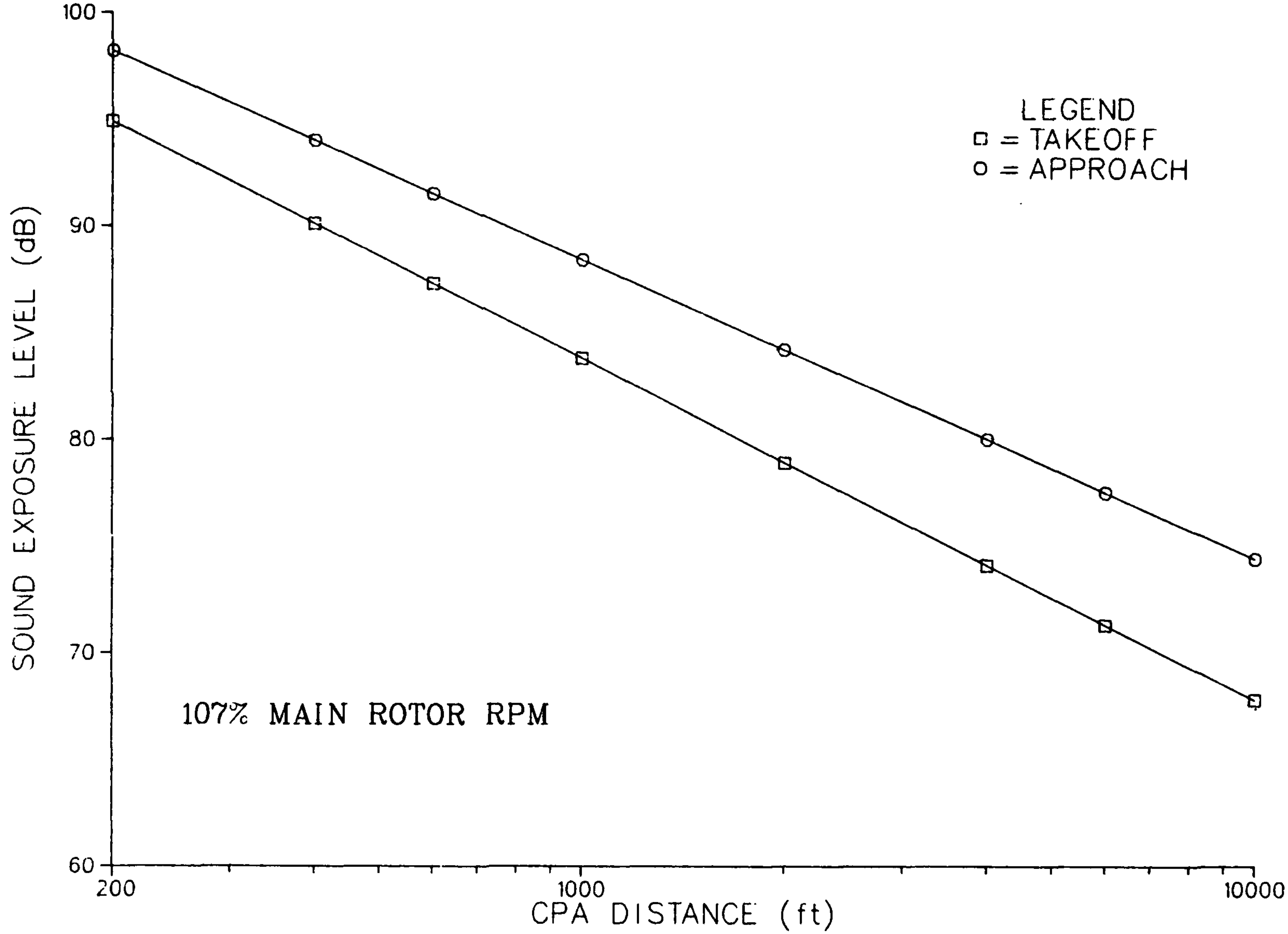


TABLE: P2

SIKORSKY S76-107% LEVEL FLYOVER DATA TABLE

CPA Distance (FT)	V= 93 kts SEL (dB)	V= 109 kts SEL (dB)	V= 124 kts SEL (dB)	V= 140 kts SEL (dB)	V= 155 kts SEL (dB)
200	93.4	93.4	94.1	95.6	97.7
400	89.2	89.2	89.9	91.4	93.4
600	86.8	86.8	87.5	88.9	91.0
1000	83.4	83.4	84.1	85.6	87.6
2000	78.3	78.3	79.0	80.5	82.5
4000	73.2	73.2	73.9	75.3	77.4
6000	70.2	70.2	70.9	72.3	74.4
10000	66.4	66.4	67.1	68.6	70.6

SIKORSKY S-76 NOISE CURVES

SEL versus CPA Distance

LEVEL FLYOVERS

FIGURE P2

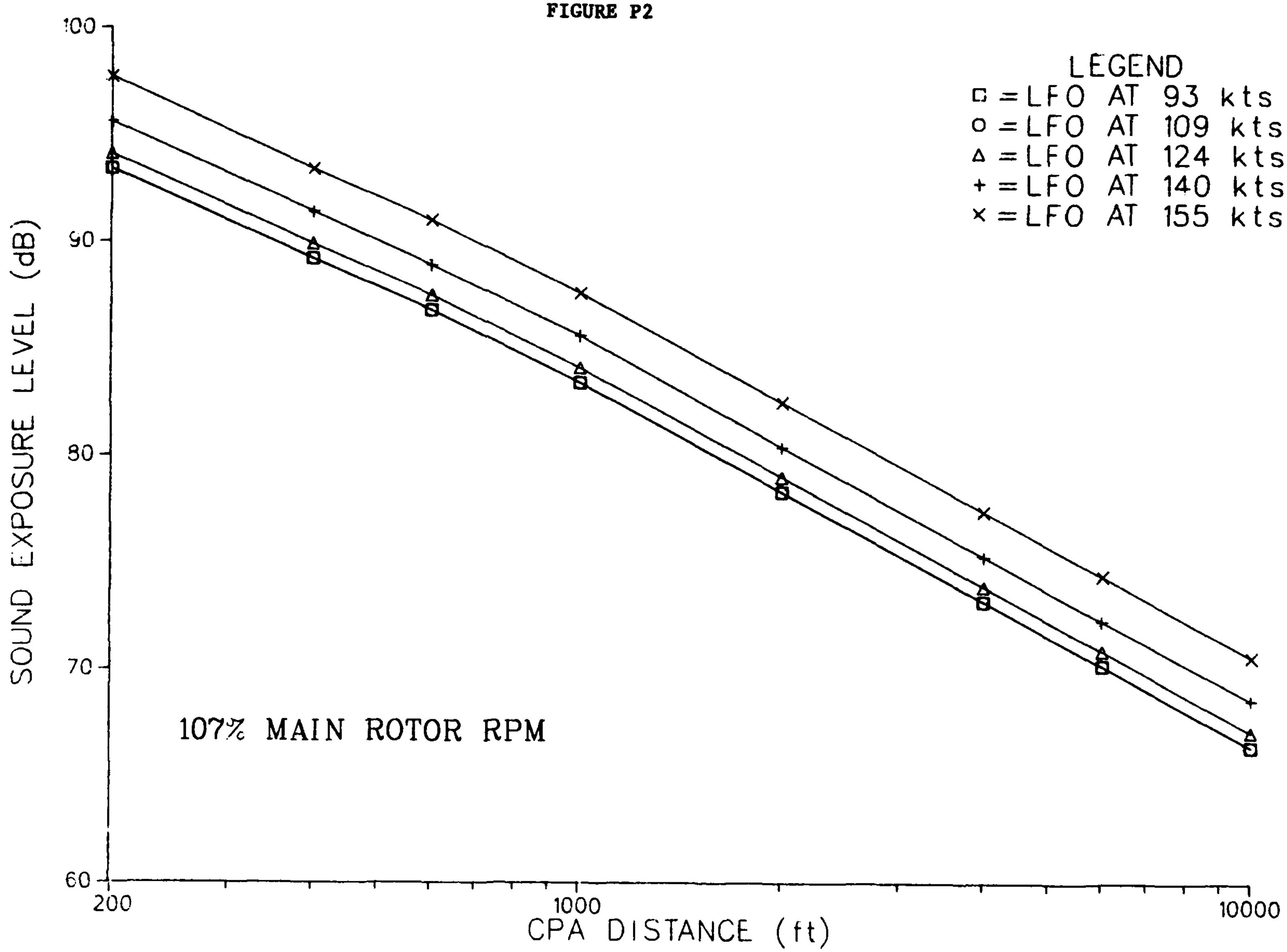


TABLE: P3

SIKORSKY S76-107% HOVER DATA TABLE

CPA Distance (FT)	Maximum A-Weighted Sound Level, L_{AM} — A: Ground-to-Ground	B: Low Angle OGE Hover	C: Air-to-Ground OGE Hover Direct Climb
200	85.0	88.0	90.0
400	78.3	81.3	83.8
600	73.6	76.6	80.1
1000	66.4	69.4	75.4
2000	57.2	60.2	68.7
4000	48.8	51.8	61.6
6000	44.2	47.2	57.2
10000	38.1	41.1	51.1
APPLICATION	Stationary Hover Hover Taxi	Stationary Hover Hover Taxi	Direct Climb

NOTES:

1. See Section 4 for application details.
2. Excess ground attenuation (EGA) has been applied to Columns A and B.
3. EGA has not been applied in Column C.
4. Engine shielding has not been applied in any case nor have data been adjusted to compensate for computer model arbitrary application of the engine shielding algorithm.
5. S-76 data derived from data provided by Sikorsky.

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