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Acoustic Measurements of a Full-Scale Rotor with Four Tip Shapes Vol. 1. Text, Appendix A and Appendix B

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ABS: A full-scale helicopter with four different blade-tip geometries was tested in the 40- by 80-foot wind tunnel at Ames Research Center. Performance, loads, and noise were measured. The four tip shapes tested were rectangular, tapered, swept, and swept-tapered. Noise measurements from that test are presented in the form of tables and plots. The noise data include measurements of the sound pressure level in dB, dBA, and tone-corrected PNdB, for all of the conditions tested. Detailed measurements, 1/3-octave spectra and time-histories for some selected data are included as well as plots of dBA as function of test condition. Some performance measurements are given to aid interpretation of the noise

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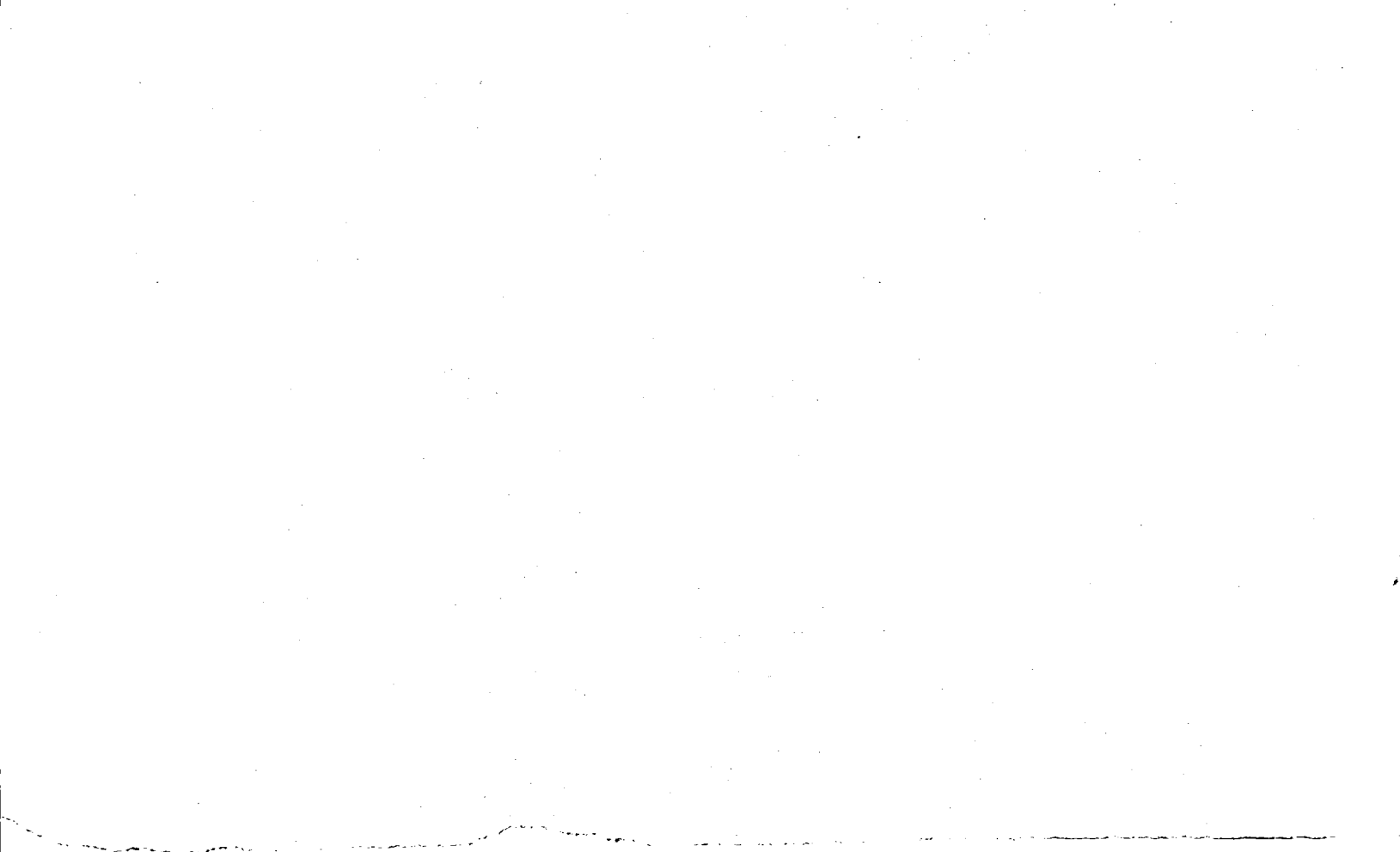

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Acoustic Measurements of a Full-Scale Rotor with Four Tip Shapes Vol. 1. Text, Appendix A and Appendix B

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CONTENTS

ACOUSTIC MEASUREMENTS OF A FULL-SCALE ROTOR WITH FOUR TIP SHAPES

Marianne Mosher

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SUMMARY

A full-scale helicopter with four different blade-tip geometries was tested in the 40- by 80-Foot Wind Tunnel at Ames Research Center. Performance, loads, and noise were measured. The four tip shapes tested were rectangular, tapered, swept, and swept-tapered. This report presents noise measurements from that test in the form of tables and plots. The noise data include measurements of the sound pressure level in dB, dBA, and tone-corrected PNdB, for all of the conditions tested. Also included are the detailed measurements, 1/3-octave spectra and time-histories for some selected data, and plots of dBA as function of test condition. Some performance measurements are included to aid interpretation of the noise data.

SYMBOLS

A	coefficient in background-noise curve fit
B	coefficient in background-noise curve fit
c	speed of sound, m/sec
$\bar{c}$	blade chord, m

dB	sound pressure level, $20\log(P_{rms}/P_{ref})$
dBA	A-weighted sound pressure level, $20\log(P_{rms}/P_{ref})$
dBB	background sound pressure level, $20\log(P_{rms}/P_{ref})$
dBC	sound pressure level corrected for background noise
M_{at}	advancing-tip Mach number, $(1+\mu)M_{tip}$
M_{tip}	rotor rotational Mach number, $\Omega R/c$
N	number of blades
P	rotor power, W
PNdB	tone-corrected perceived noise level
P_{ref}	reference pressure (0.00002 N/m^2)
P_{rms}	root-mean-square sound pressure, N/m^2
R	rotor radius, m
r	distance to microphone from rotor hub, m
rpm	rotor rotational speed, rev/min
S	reference blade area, $N\bar{c}R$, m^2
t	thickness
V	wind-tunnel speed, knots or m/sec
x	distance upstream from rotor center, m
y	distance left from rotor center looking upstream, m
z	distance up from midway between hubs, m

α angle of attack of rotor shaft, deg

δ tab angle deflection, deg

μ rotor advance ratio, $V/\Omega R$

ρ air density, kg/m^2

σ solidity, $S/\pi R^2$

ϕ angle below rotor plane, $\tan^{-1}(-z/r)$, deg

ψ azimuth angle from downstream, $\tan^{-1}(-y/-x)$, deg

Ω rotational speed, rad/sec

INTRODUCTION

The outboard section of a helicopter rotor blade has a significant influence on the aerodynamic and noise characteristics of the rotor system. The noise sources are stronger at the tip of a rotor where the Mach number is high. A change in rotor-blade geometry at the tip of a rotor is expected to produce some change in the aerodynamic and noise characteristics of that rotor.

A full-scale S-76 rotor with four sets of interchangeable tips was tested in the Ames 40- by 80-Foot Wind Tunnel during March of 1977. The four tip geometries tested were rectangular, tapered, swept, and swept-tapered. This report presents a brief description of the rotor, the blade-tip geometries, testing, and analysis, and an extensive listing of the noise measurements from that test.

DESCRIPTION OF MODEL AND TEST

The rotor system tested is shown in figure 1 mounted on the rotor-test apparatus in the 40- by 80-Foot Wind Tunnel. Two electric motors in the rotor-test apparatus powered the rotor. Parameters describing the rotor are listed in table 1 and basic blade geometry is listed in table 2. Descriptions of the model and test are given in references 1 to 5. Figure 2 shows the four tip shapes used. For a more detailed description of the blade geometry see reference 5.

DATA ACQUISITION AND REDUCTION

The acoustic data for this test were acquired using seven 1.3-cm condenser microphones equipped with nose cones to reduce wind-induced noise. Five of these microphones were located upstream of the model, and two were located near the model. The microphone locations are listed in table 3 and shown in figure 3. Signal conditioners were used to control the gain of the acoustic signal and to power the microphones. The acoustic signals were recorded on tape using a 14-track frequency-modulated (FM) tape recorder running at 7 1/2 ips. This gave a bandwidth of 5 kHz. All microphones were calibrated once each day using a 124-dB, 250-Hz signal from a pistonphone. At each data point, a 50-sec sample of acoustic data was recorded for later analysis. In order to ensure a maximum signal-to-noise ratio, the gain of the acoustic signal was adjusted in 10-dB intervals. A schematic of the data-acquisition system is shown in figure 4. Details of data acquisition, along with some results from this test, are given in references 6 to 8.

The acoustic data from this test were analyzed with a minicomputer time-series data system. Figure 5 shows a flowchart of the equipment used for data reduction. Data are digitized at a sample rate of 20 kHz while being played back through a low-pass filter with a cutoff frequency of 10 kHz to prevent aliasing. From the digitized data, the minicomputer generated 1/3-octave spectra from 1-Hz spectra in the range of 10 to 200 Hz, and from 10-Hz spectra in the range of 250 Hz to 10 kHz. The minicomputer also computed dB, dBA, and PNdB from the 1/3-octave spectra and the

first 10 blade passage harmonics from the 1-Hz, narrow-band spectra. The computed acoustic data were then transferred into a computer containing the data base with all of the measured test parameters. Background noise corrections, were made as described in appendix A. Details of this 1/3-octave analysis are given in references 8 through 10.

Time-histories of the acoustic pressures were made to examine the waveform. Triggering with a 1/rev signal and averaging reinforced the periodic components of the waveform and reduced the random components. The acoustic signal was sampled at the rate of 5,120 Hz after being low-pass filtered with a cutoff frequency of 2 kHz. Details of this data processing are given in references 9 and 11.

RESULTS

The acoustic data are listed in appendixes B-F in the form of tables and plots. Each appendix displays a different type of data for each of the four tip shapes. Data are ordered in the appendixes according to tip shape, advancing-tip Mach number (rotational-tip Mach number and wind-tunnel speed), tip-path-plane angle, and rotor-lift coefficient. Tables 4 to 8 list where data are in each appendix B through F respectively. These tables appear at the back of this part of the report and are repeated in each appendix.

A brief listing of performance and acoustic data is given in appendix B for all of the data points in the test. Wherever the data are missing or of questionable quality due to the equipment, acoustic data are given the value 0.

Appendix C contains a more extensive table of performance and acoustic data for a smaller number of data points.

Detailed plots are given for some selected data. Noise measurements from a microphone located 3 rotor radii in front of the rotor and a microphone under the rotor are used. Appendix D contains 1/3-octave plots. Each 1/3-octave plot shows three curves: an uncorrected raw data spectrum, a background-noise spectrum, and a data spectrum corrected for the background noise. By displaying both raw data and data corrected for background noise, the extent to which the background noise contaminates

the data can be observed.

Appendix E contains representative pressure time-histories. The time-histories show a raw waveform for each data point and a waveform from 50 synchronous signals for some of the data. Only some averaged data are shown due to data-acquisition or data-reduction problems.

Noise trends with variations in rotor operating condition are shown for a few microphones. The the sound pressure levels measured in dBA are shown as a function of rotor lift coefficient in appendix F.

CONCLUSIONS

A full-scale modern helicopter was tested in the Ames 40- by 80-Foot Wind Tunnel. Performance, loads, and noise were measured for four tip shapes. The rotor was run through a large range of operating conditions covering wind-tunnel speeds of 30 to 175 knots, tip Mach numbers of 0.550 to 0.700, advance ratios of 0.075 to 0.400, lift coefficients of -0.01 to 0.14, and shaft angles of -10° to 10°. The acoustic data presented in this report cover the tested range for all four tip shapes, matching conditions as closely as possible to allow comparison. Some acoustic data are presented for all test conditions. The more detailed data concentrate on the conditions of normal forward flight; high-speed forward flight, in which high-speed thickness noise is present; and descending flight, in which blade vortex interaction noise is present.

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TABLE 1.-DESCRIPTION OF ROTOR

Item	Quantity
Number of blades	4
Diameter, 2R	13.41 m
Solidity	0.0748
Thickness ratio	0.095
Twist	−10.°

TABLE 2.-DESCRIPTION OF ROTOR BLADE AIRFOIL AND GEOMETRY

Radial station, r/R	Airfoil	Tab	Chord, m
0.182 – 0.189	SC1513–R8	$\delta = -1.66°$ c = 1.27 cm t = 0.127 cm	0.398
0.189 – 0.455	Transition		0.398
0.455 – 0.795	SC1095–R8	$\delta = -2.0°$ c = 1.27 cm t = 0.127 cm	0.398
0.795 – 0.833	Transition		0.398
0.833 – 0.951	SC1095	$\delta = -3.0°$ c = 1.27 cm t = 0.127 cm	0.394
0.951 – 1.000	SC1095	$\delta = -3.0°$ c = 1.27 cm t = 0.102 cm	Root 0.394 Tapered tip 0.237

TABLE 3.-MICROPHONE POSITIONS

Microphone	y, m	z, m	z, m	r, m	r/R	θ, deg	ψ, deg
1	19.8	−0.6	−5.3	20.5	3.06	15	178
2	2.7	−1.9	−3.1	4.5	0.67	44	145
3	19.2	0.0	−4.2	19.7	2.93	12	180
4	18.6	0.6	−2.6	18.8	2.80	8	182
5	19.0	−5.6	−4.2	20.2	3.02	12	164
6	3.5	−3.6	−3.9	6.3	0.95	38	134
7	19.0	5.6	−4.2	20.2	3.02	12	196

TABLE 4.-KEY TO ACOUSTIC DATA TABULATED IN APPENDIX B

Operating condition				Tip planform, page numbers			
μ	M_{tip}	M_{at}	V	Swept-tapered	Swept	Tapered	Rectangular
0.200	0.550	0.660	73	34	--	--	--
.075	.595	.640	30	35	--	--	--
.150	.595	.685	60	36	--	--	--
.200	.600	.720	80	38	59	68	78
.250	.600	.750	100	41	--	--	--
.300	.600	.780	120	43	61	70	80
.375	.600	.825	150	47	63	73	83
.390	.595	.825	160	--	64	--	85
.400	.600	.840	160	49	--	--	--
.250	.650	.815	107	53	--	--	--
.375	.650	.895	164	54	65	--	--
.375	.685	.940	170	56	67	76	--
.250	.700	.875	115	57	--	--	--
.375	.700	.965	175	58	--	77	86

TABLE 5.-KEY TO ACOUSTIC DATA TABULATED IN APPENDIX C

Operating condition				Tip planform, page numbers			
μ	M_{tip}	M_{at}	V	Swept-tapered	Swept	Tapered	Rectangular
0.200	0.550	0.660	73	89	--	--	--
.075	.595	.640	30	--	--	--	--
.150	.595	.685	60	91	--	--	--
.200	.600	.720	80	92	118	131	146
.250	.600	.750	100	97	--	--	--
.300	.600	.780	120	100	121	134	150
.375	.600	.825	150	105	124	139	154
.400	.600	.840	160	107	--	--	--
.250	.650	.815	107	110	--	--	--
.375	.650	.895	164	111	127	142	156
.375	.685	.940	170	114	--	142	--
.250	.700	.875	115	115	--	--	--
.375	.700	.965	175	116	--	144	--

TABLE 6.-KEY TO 1/3-OCTAVE SPECTRA IN APPENDIX D

Operating condition				Tip planform, page numbers			
μ	M_{tip}	M_{at}	V	Swept-tapered	Swept	Tapered	Rectangular
0.200	0.550	0.660	73	--	--	--	--
.075	.595	.640	30	--	--	--	--
.150	.595	.685	60	--	--	--	--
.200	.600	.720	80	160	202	230	260
.250	.600	.750	100	--	--	--	--
.300	.600	.780	120	170	206	238	268
.375	.600	.825	150	178	214	246	274
.400	.600	.840	160	--	--	--	--
.250	.650	.815	107	--	--	--	--
.375	.650	.895	164	186	220	--	278
.375	.685	.940	170	192	226	252	--
.250	.700	.875	115	--	--	--	--
.375	.700	.965	175	198	--	256	--

TABLE 7.-KEY TO TIME-HISTORIES IN APPENDIX E

Operating condition				Tip planform, page numbers			
μ	M_{tip}	M_{at}	V	Swept-tapered	Swept	Tapered	Rectangular
0.200	0.550	0.660	73	--	--	--	--
.075	.595	.640	30	--	--	--	--
.150	.595	.685	60	--	--	--	--
.200	.600	.720	80	286	304	324	344
.250	.600	.750	100	--	--	--	--
.300	.600	.780	120	--	--	--	--
.375	.600	.825	150	290	308	332	352
.400	.600	.840	160	--	--	--	--
.250	.650	.815	107	--	--	--	--
.375	.650	.895	164	296	316	--	354
.375	.685	.940	170	--	--	--	--
.250	.700	.875	115	--	--	--	--
.375	.700	.965	175	300	--	340	--

TABLE 8.-KEY TO GRAPHS OF ACOUSTIC TRENDS IN APPENDIX F

Operating condition				Tip planform, page numbers			
μ	M_{tip}	M_{at}	V	Swept-tapered	Swept	Tapered	Rectangular
0.200	0.550	0.660	73	--	--	--	--
.075	.595	.640	30	--	--	--	--
.150	.595	.685	60	--	--	--	--
.200	.600	.720	80	360	378	396	414
.250	.600	.750	100	--	--	--	--
.300	.600	.780	120	366	384	402	420
.375	.600	.825	150	372	390	408	426
.400	.600	.840	160	--	--	--	--
.250	.650	.815	107	--	--	--	--
.375	.650	.895	164	--	--	--	--
.375	.685	.940	170	--	--	--	--
.250	.700	.875	115	--	--	--	--
.375	.700	.965	175	--	--	--	--

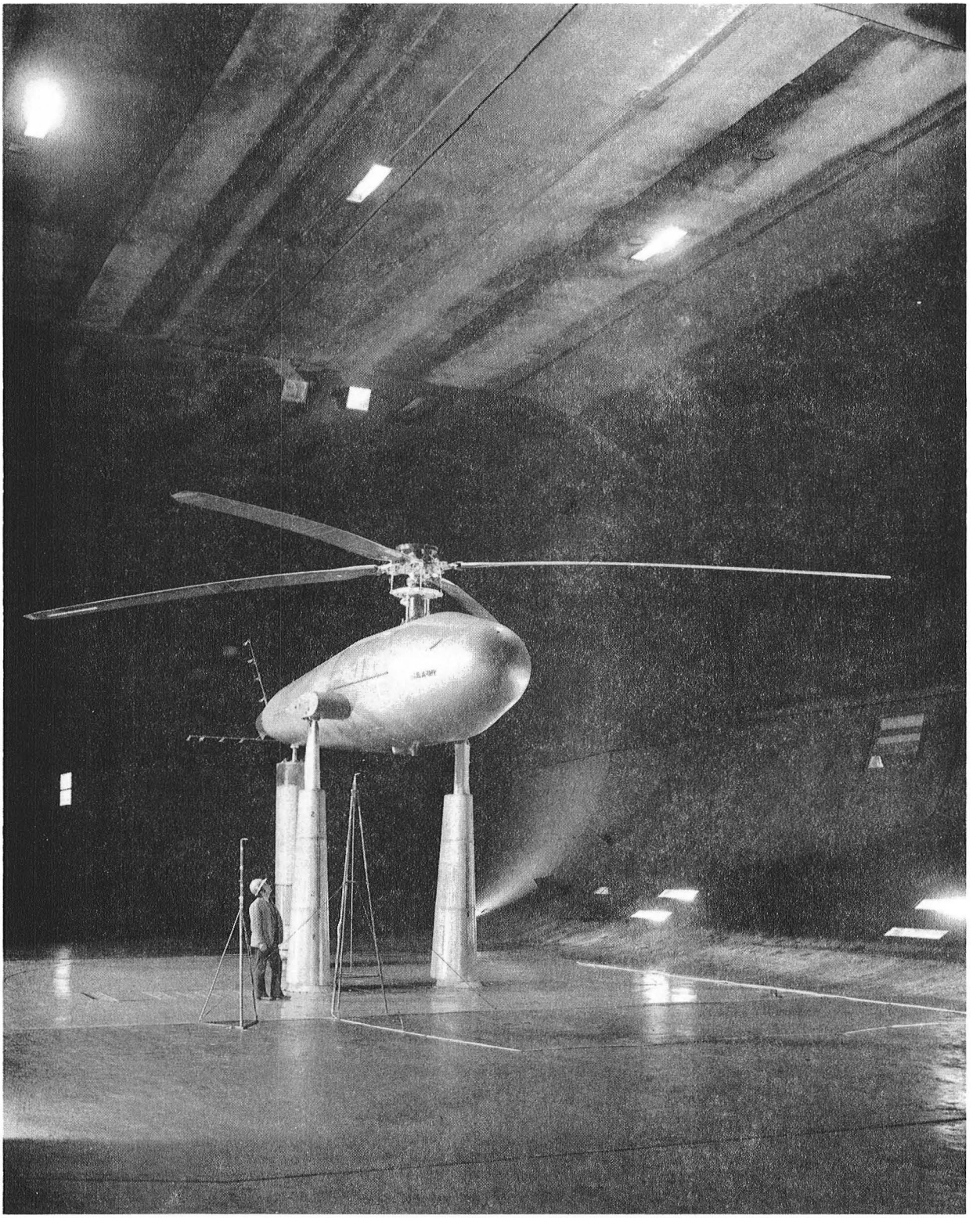

Figure 1. S-76 Rotor in the Ames 40- by 80-Foot Wind Tunnel.

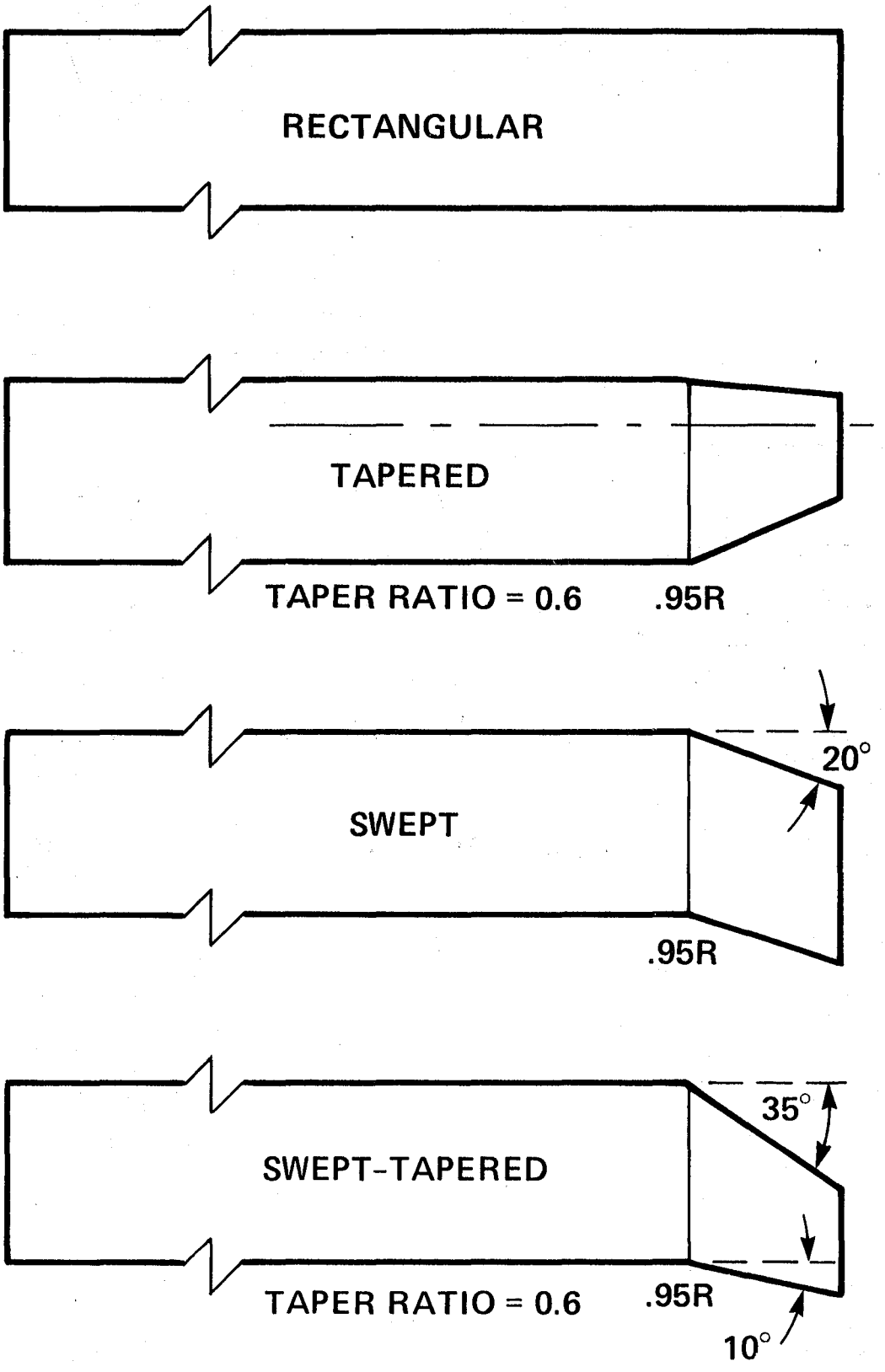

Figure 2. Tip Shapes Tested.

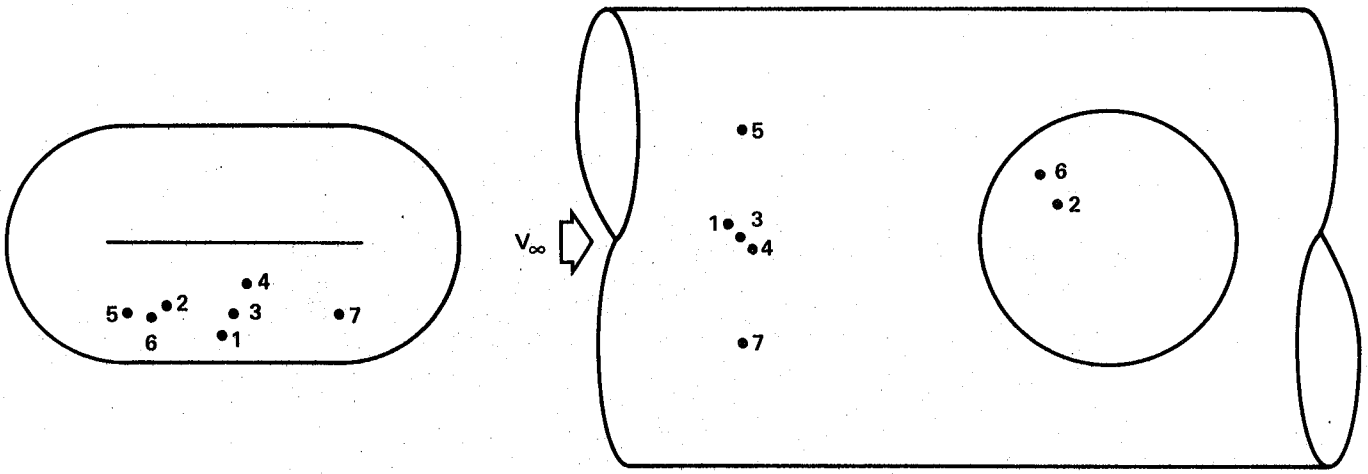

Figure 3. Microphone Locations.

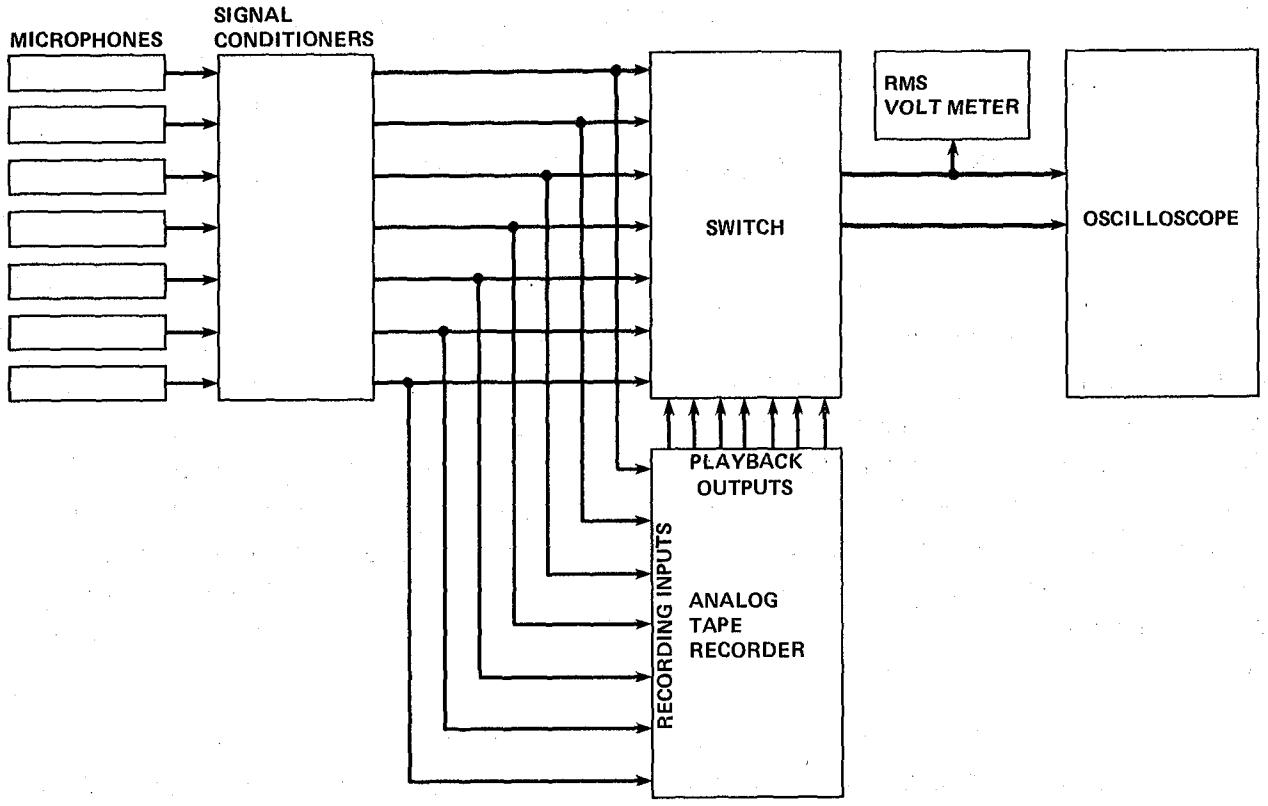

Figure 4. Flow chart of equipment used in acoustic data acquisition.

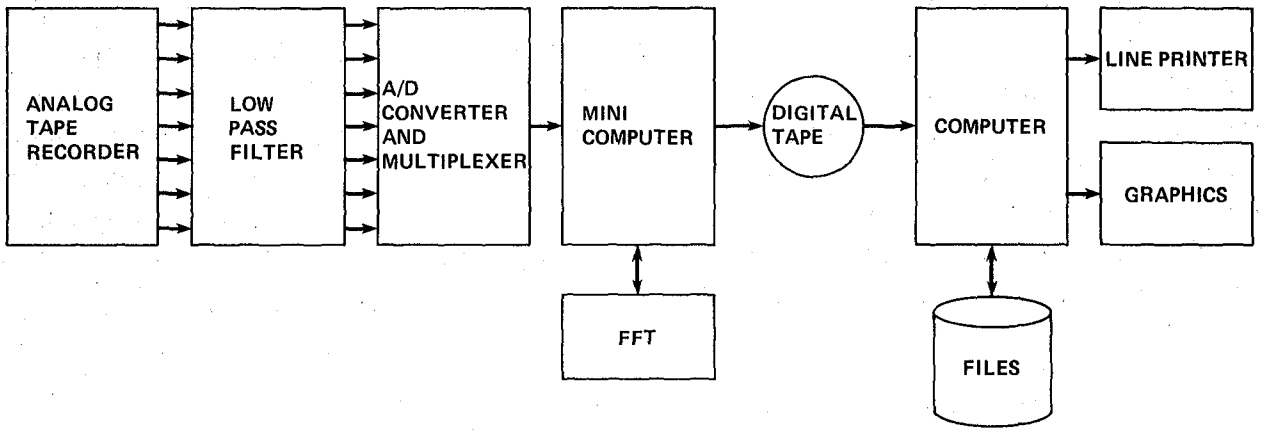

Figure 5. Flow chart of equipment used in acoustic data reduction.

APPENDIX A

BACKGROUND WIND-TUNNEL NOISE CORRECTION

The background noise was determined by a curve fitted to each 1/3-octave band for each microphone and subtracted on a power basis to obtain 1/3-octave spectra corrected for background-noise. The background-noise data were taken from another test described in reference 9. Microphone locations were matched as much as possible between the two tests. This procedure should give adequate background noise because background-noise measurements made on several rotor models over several years in the Ames 40-by 80-Foot Wind Tunnel have been very consistent for microphones located in similar positions.

The curve fit used on the background noise describes the 1/3-octave level as a linear function of the logarithm of the wind-tunnel velocity. This is the correct functional form if the sound pressure is proportional to the velocity raised to a power (equivalent to the Mach number raised to a power in this subsonic wind tunnel). The curve fit is

$$\mathrm{dBB}(i) = \mathrm{A}(i) + \mathrm{B}(i) \cdot \log(\mathrm{V})$$

with A and B solved for in a least squares linear regression. The tables show the coefficients for all seven microphones, i=1,...,7. These averaged background data are a very good match to the actual background noise except at the lowest frequencies at which the wind-tunnel fan harmonics determine the noise. The wind-tunnel fan drive was variable speed so the frequencies of the harmonics, as well as the amplitude, increase as the velocity increases. The poor fit at the lower frequencies will not affect the corrections for rotor noise because the rotor harmonic noise is much louder than the noise of the wind tunnel. The 1/3-octave plots (figs A1 to A7) show the background-noise spectra for several wind-tunnel velocities from 60 to 175 knots for the seven microphones.

The formula used to apply background corrections is

$$\mathrm{dBC}(i) = 10 \cdot \log\left[10^{\frac{\mathrm{dB}(i)}{10}} - 10^{\frac{\mathrm{dBB}(i)}{10}}\right]$$

Figure A8 shows the effect of this correction on a 1/3-octave plot containing raw data, background noise and sound levels with the background noise subtracted.

Table A1. Background Noise Coefficients for Microphones 1 and 2.

BACKGROUND NOISE CURVE FIT
DB = A + B * LOG(V)

1/3 OCTAVE	MICROPHONE 1		MICROPHONE 2	
CENTER FREQUENCY	A	B	A	B
10.0	-28.53	51.60	-10.36	47.44
12.5	-18.17	47.11	-2.94	42.26
16.0	-4.14	44.28	-36.25	61.67
20.0	15.65	36.11	-15.07	53.93
25.0	-26.41	54.79	-27.85	59.30
31.5	-8.49	46.68	-7.38	48.16
40.0	-1.57	45.59	-15.79	53.82
50.0	-48.80	70.10	-16.13	53.97
63.0	-11.75	51.74	-12.11	52.79
80.0	-38.56	66.12	-12.08	54.17
100.0	-14.54	54.89	-8.07	52.92
125.0	3.15	46.63	38.61	30.57
160.0	-21.57	57.29	-16.87	57.45
200.0	-11.77	53.24	-5.46	50.91
250.0	7.41	43.64	-0.85	47.63
315.0	-6.24	50.11	-2.15	48.38
400.0	8.50	42.25	10.26	42.01
500.0	5.91	43.28	10.96	41.48
630.0	26.24	34.21	-0.19	47.20
800.0	-5.01	48.13	-15.23	53.85
1000.0	-21.36	55.70	-23.72	57.68
1250.0	-34.01	61.99	-40.26	65.88
1600.0	-20.11	55.62	-21.58	56.37
2000.0	-31.16	59.06	-22.06	55.63
2500.0	-31.39	58.74	-22.15	55.38
3150.0	-39.02	62.02	-22.43	55.64
4000.0	-40.21	61.99	-18.82	52.89
5000.0	-52.11	68.04	-24.47	56.37
6300.0	-37.51	60.71	-23.34	56.02
8000.0	-32.20	57.80	-18.15	52.73

Table A2. Background Noise Coefficients for Microphones 3 and 4.

BACKGROUND NOISE CURVE FIT
DB = A + B * LOG(V)

1/3 OCTAVE	MICROPHONE 3		MICROPHONE 4	
CENTER FREQUENCY	A	B	A	B
10.0	-28.53	51.60	-28.53	51.60
12.5	-18.17	47.11	-18.17	47.11
16.0	-4.14	44.28	-4.14	44.28
20.0	15.65	36.11	15.65	36.11
25.0	-26.41	54.79	-26.41	54.79
31.5	-8.49	46.68	-8.49	46.68
40.0	-1.57	45.59	-1.57	45.59
50.0	-48.80	70.10	-48.80	70.10
63.0	-11.75	51.74	-11.75	51.74
80.0	-38.56	66.12	-38.56	66.12
100.0	-14.54	54.89	-14.54	54.89
125.0	3.15	46.63	3.15	46.63
160.0	-21.57	57.29	-21.57	57.29
200.0	-11.77	53.24	-11.77	53.24
250.0	7.41	43.64	7.41	43.64
315.0	-6.94	50.11	-6.94	50.11
400.0	8.50	42.25	8.50	42.25
500.0	5.91	43.28	5.91	43.28
630.0	26.24	34.21	26.24	34.21
800.0	-5.01	48.13	-5.01	48.13
1000.0	-21.36	55.70	-21.36	55.70
1250.0	-34.01	61.99	-34.01	61.99
1600.0	-20.11	55.62	-20.11	55.62
2000.0	-31.16	59.06	-31.16	59.06
2500.0	-31.39	58.74	-31.39	58.74
3150.0	-39.02	62.02	-39.02	62.02
4000.0	-40.21	61.99	-40.21	61.99
5000.0	-52.11	68.04	-52.11	68.04
6300.0	-37.51	60.71	-37.51	60.71
8000.0	-32.20	57.80	-32.20	57.80

Table A3. Background Noise Coefficients for Microphones 5 and 6.

BACKGROUND NOISE CURVE FIT
DB = A + B * LOG(V)

1/3 OCTAVE	MICROPHONE 5		MICROPHONE 6	
CENTER FREQUENCY	A	B	A	B
10.0	-7.33	46.34	-10.36	47.44
12.5	11.69	35.79	-2.94	42.26
16.0	36.43	27.16	-36.25	61.67
20.0	-22.32	55.25	-15.07	53.93
25.0	-51.06	69.71	-27.85	59.30
31.5	2.75	43.01	-7.38	48.16
40.0	-5.53	47.47	-15.79	53.82
50.0	-24.90	58.85	-16.13	53.97
63.0	-0.31	46.27	-12.11	52.79
80.0	-42.18	69.26	-12.08	54.17
100.0	-17.27	56.73	-8.07	52.92
125.0	11.68	42.64	30.61	30.57
160.0	-13.19	53.63	-18.87	57.45
200.0	-9.94	52.39	-5.46	50.91
250.0	14.50	40.13	-0.85	47.63
315.0	-9.65	51.50	-2.15	48.38
400.0	17.85	37.82	10.26	42.01
500.0	9.12	41.82	10.96	41.48
630.0	13.12	40.37	-0.19	47.20
800.0	-10.52	51.08	-15.23	53.85
1000.0	-20.35	56.16	-23.72	57.68
1250.0	-31.96	61.01	-40.26	65.88
1600.0	-16.18	53.76	-21.58	56.37
2000.0	-25.98	56.99	-22.06	55.63
2500.0	-33.07	59.83	-22.15	55.38
3150.0	-40.94	63.45	-22.43	55.64
4000.0	-43.29	64.13	-16.82	52.89
5000.0	-43.81	63.57	-24.47	56.37
6300.0	-16.51	50.39	-23.34	56.02
8000.0	-32.68	56.62	-16.15	52.73

Table A4. Background Noise Coefficients for Microphone 7.

BACKGROUND NOISE CURVE FIT
DB = A + B * LOG(V)

1/3 OCTAVE CENTER FREQUENCY	MICROPHONE 7 A	B
10.0	-2.60	41.47
12.5	-19.26	48.03
16.0	9.37	37.20
20.0	-13.74	51.99
25.0	-30.79	58.74
31.5	-3.12	45.05
40.0	-19.02	54.54
50.0	-3.61	47.22
63.0	-7.62	49.87
80.0	-34.12	65.08
100.0	-15.82	56.65
125.0	39.07	30.46
160.0	-22.25	59.08
200.0	-24.23	59.45
250.0	-3.65	49.18
315.0	-12.29	52.95
400.0	10.35	41.67
500.0	7.59	42.86
630.0	47.78	24.68
800.0	-2.25	47.68
1000.0	-23.23	57.87
1250.0	-17.63	54.78
1600.0	-16.25	53.73
2000.0	-22.24	55.39
2500.0	-27.70	57.49
3150.0	-29.40	58.20
4000.0	-26.27	55.67
5000.0	-28.91	56.83
6300.0	-27.57	55.24
8000.0	-21.94	51.94

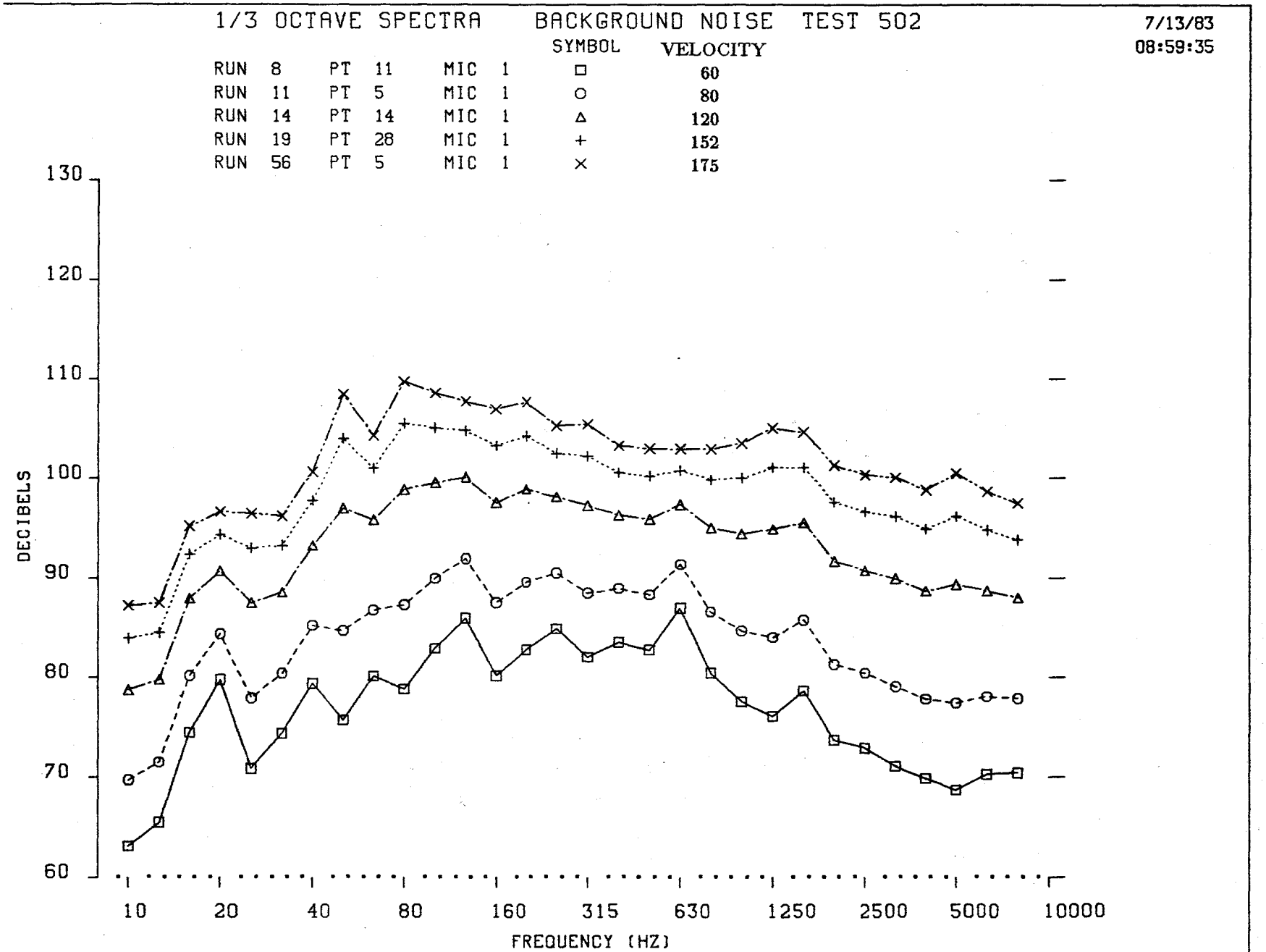

Figure A1. Background noise for microphone 1.

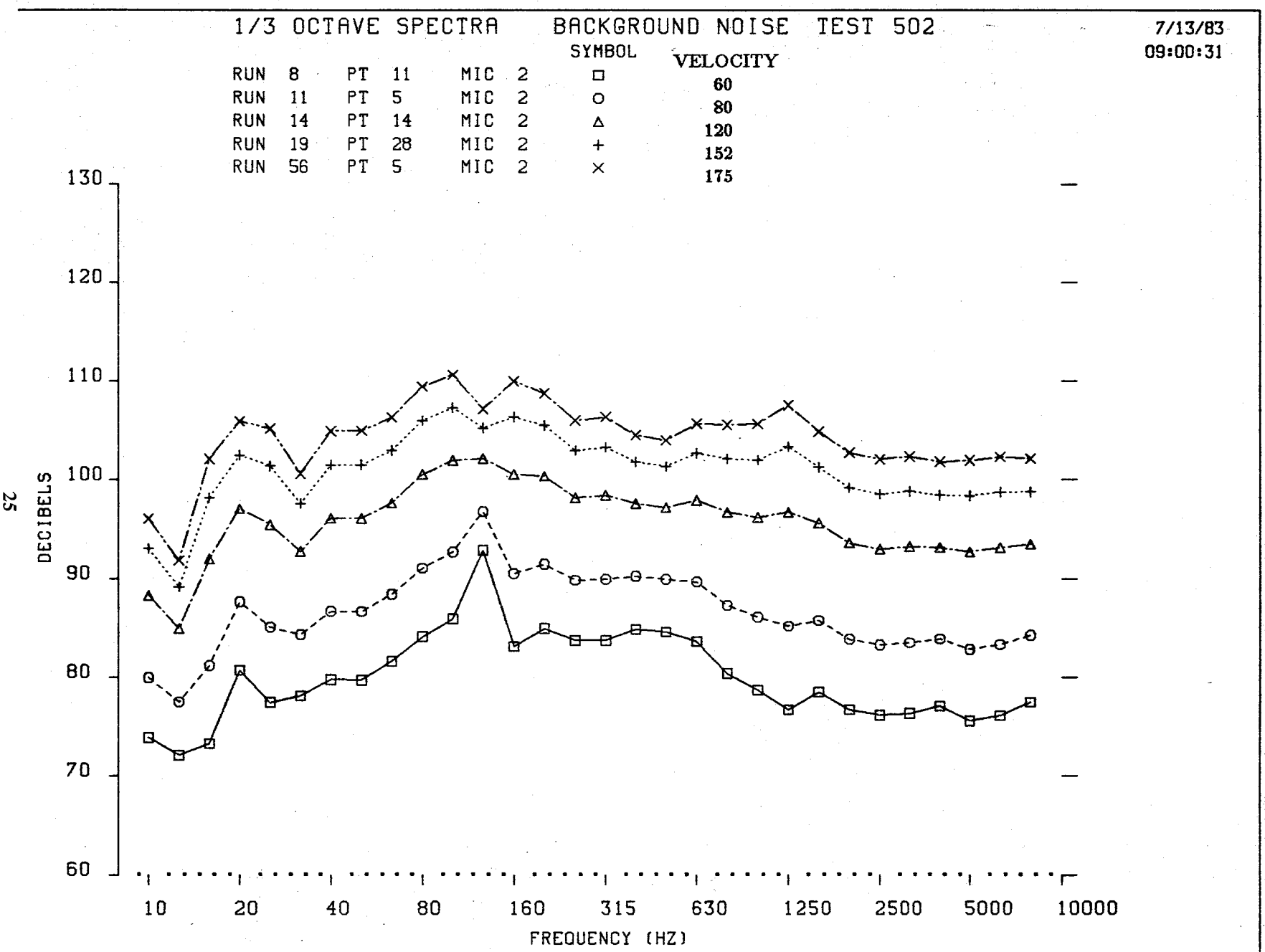

Figure A2. Background noise for microphone 2.

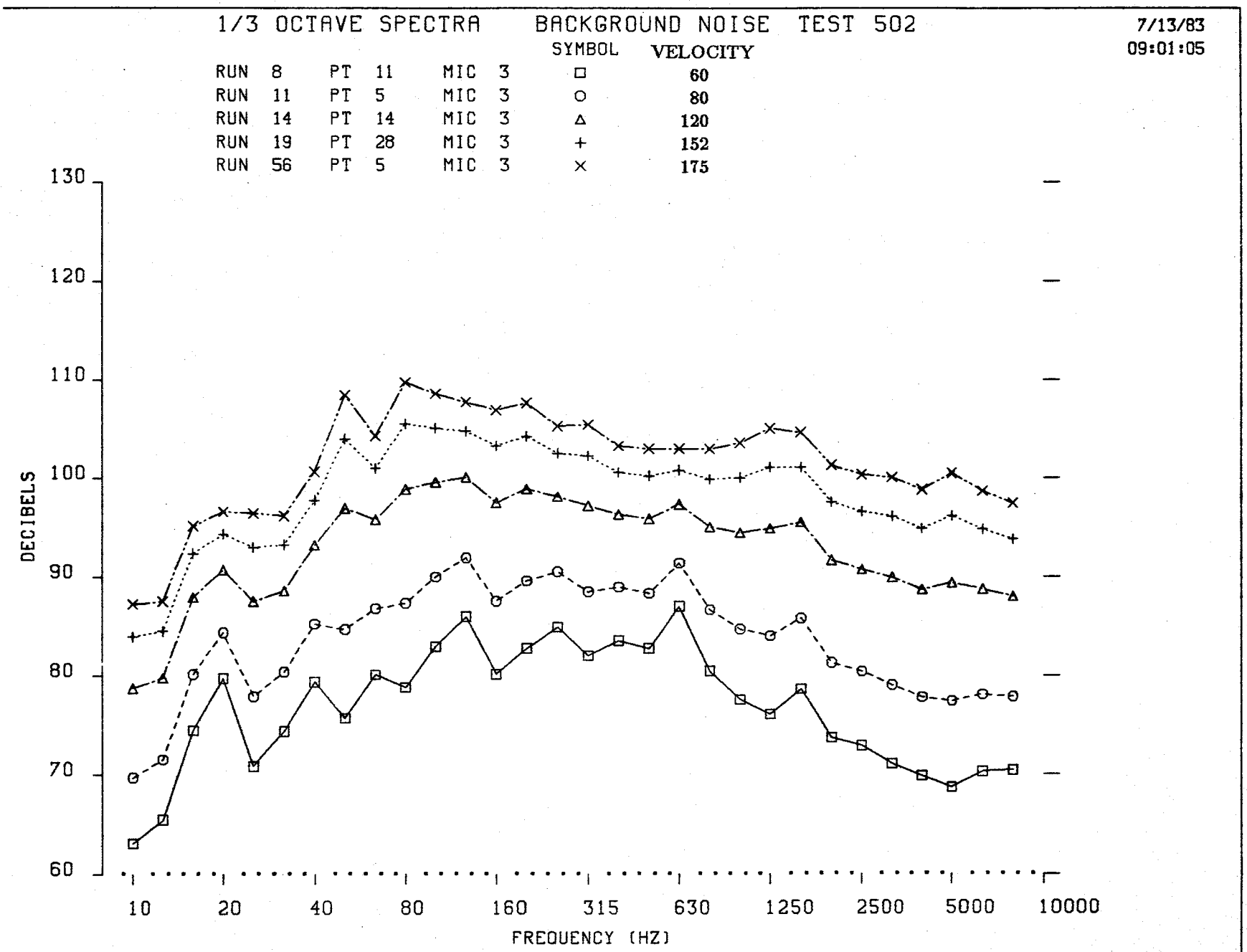

Figure A3. Background noise for microphone 3.

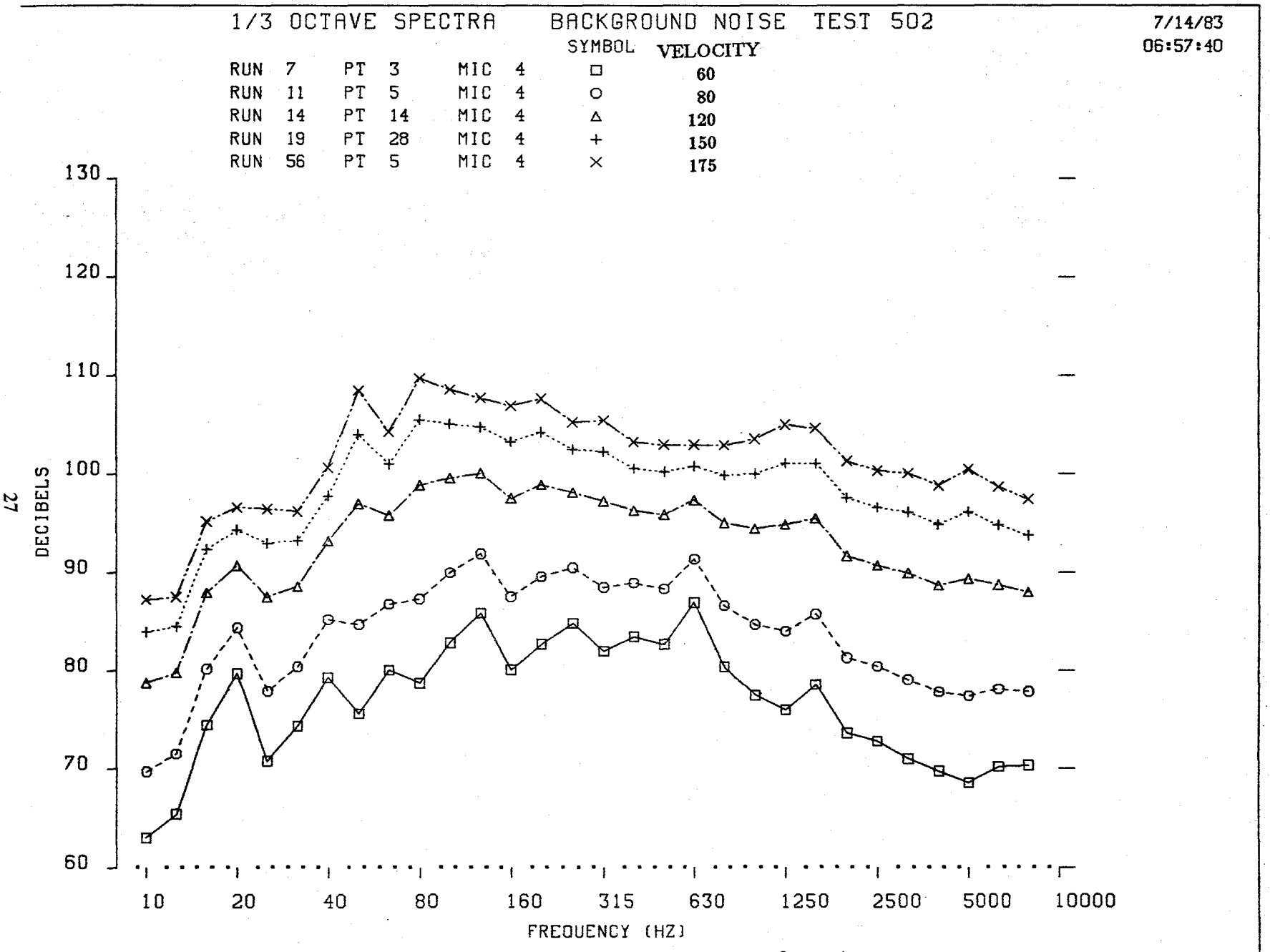

Figure A4. Background noise for microphone 4.

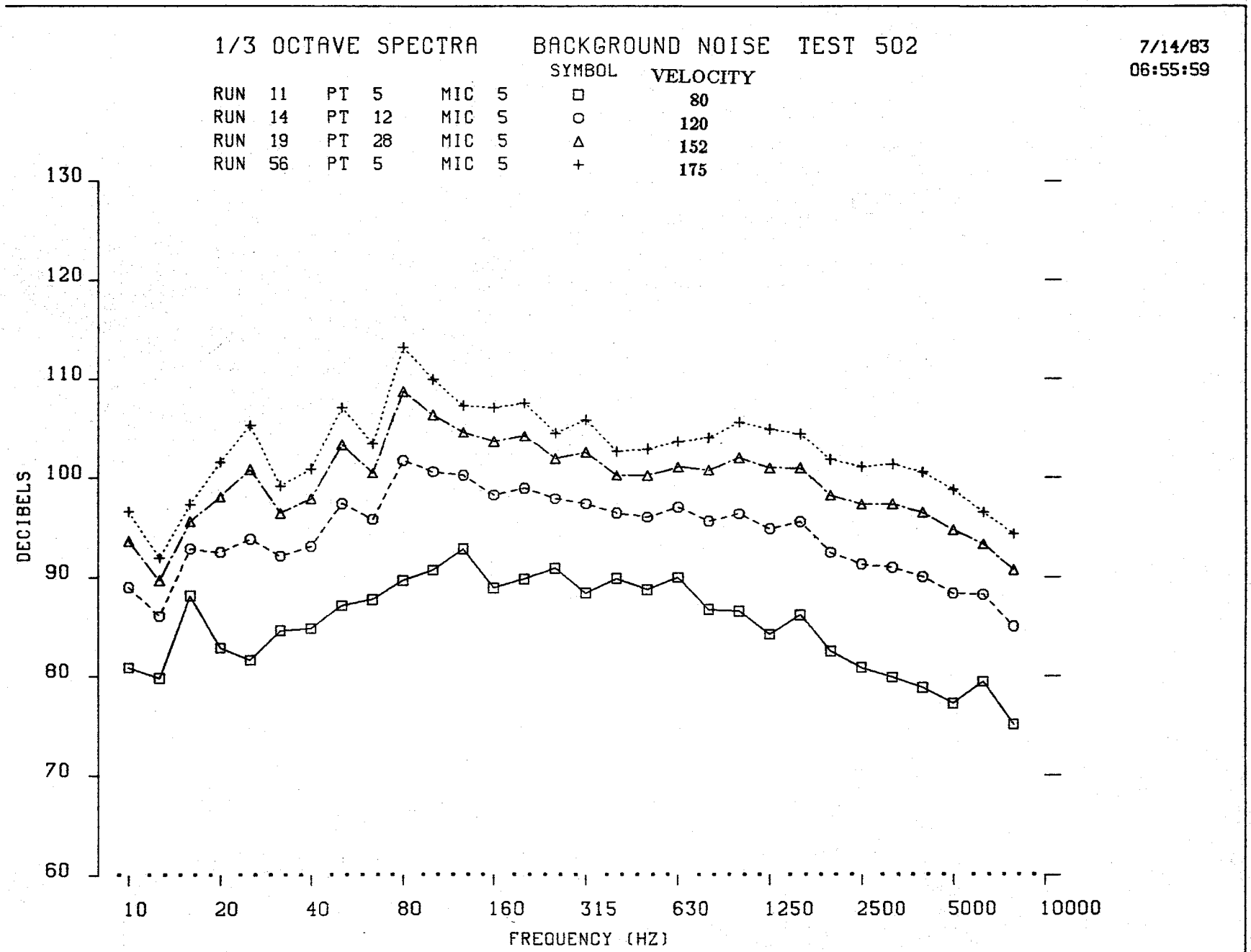

Figure A5. Background noise for microphone 5.

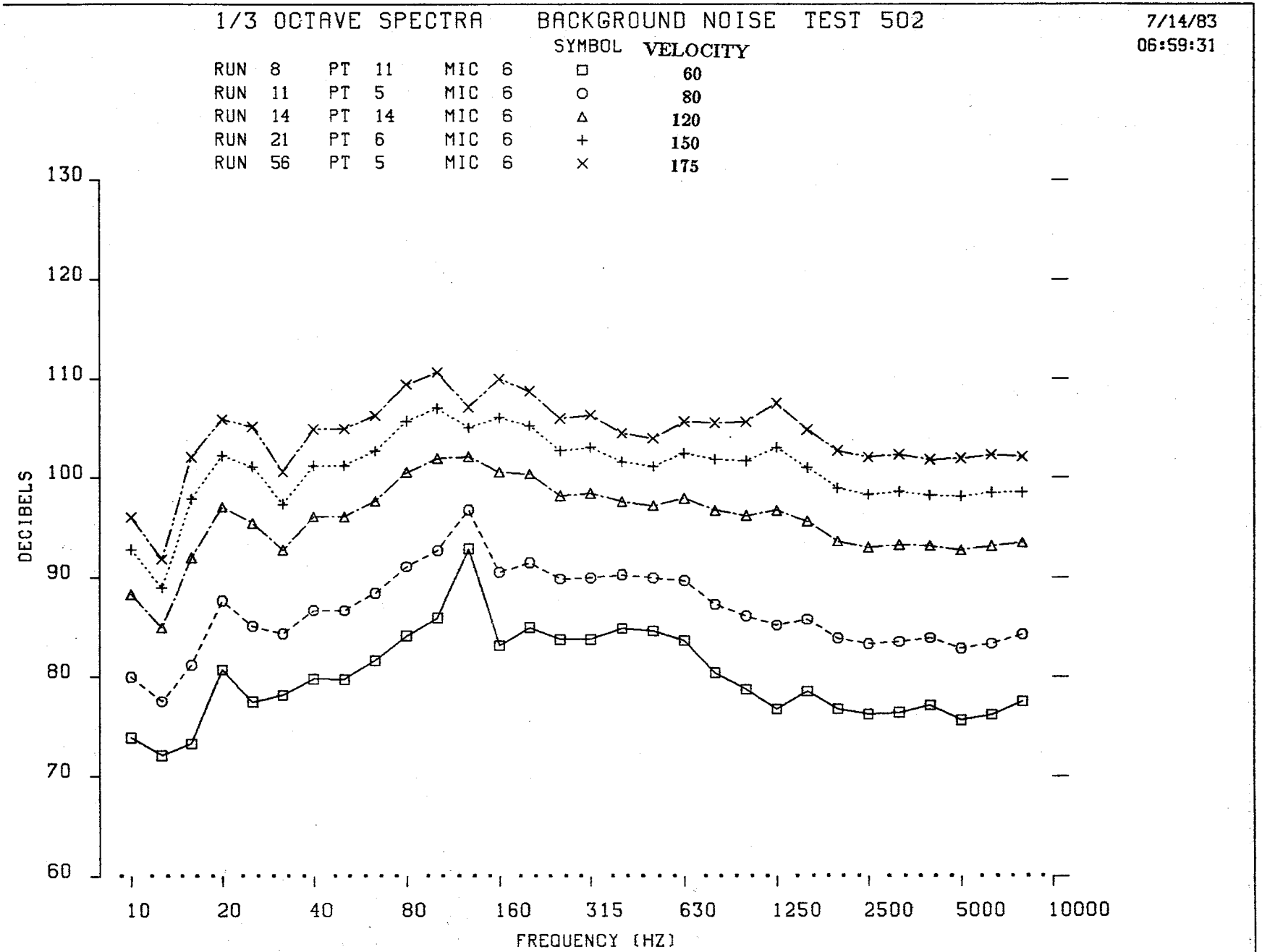

Figure A6. Background noise for microphone 6.

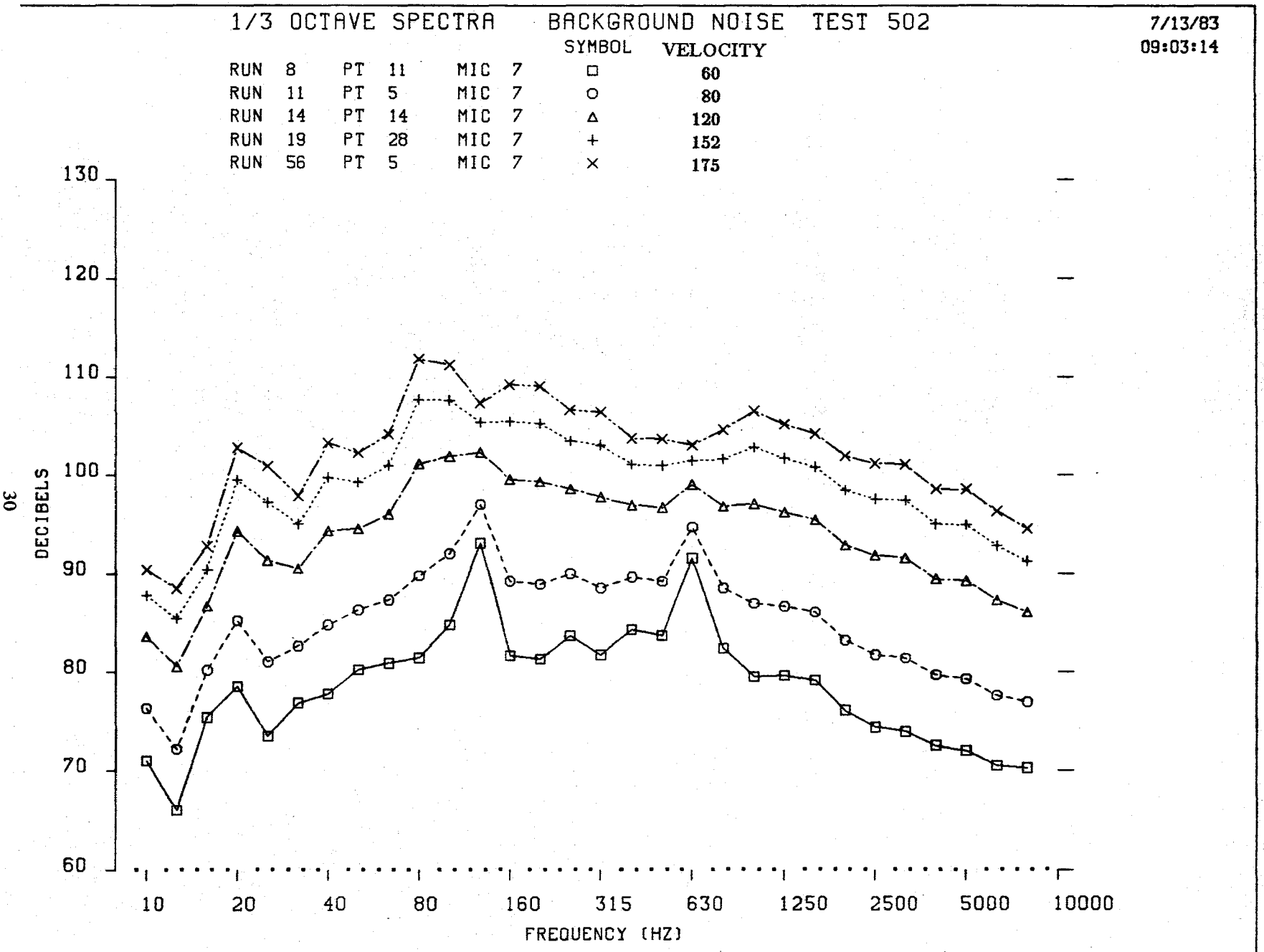

Figure A7. Background noise for microphone 7.

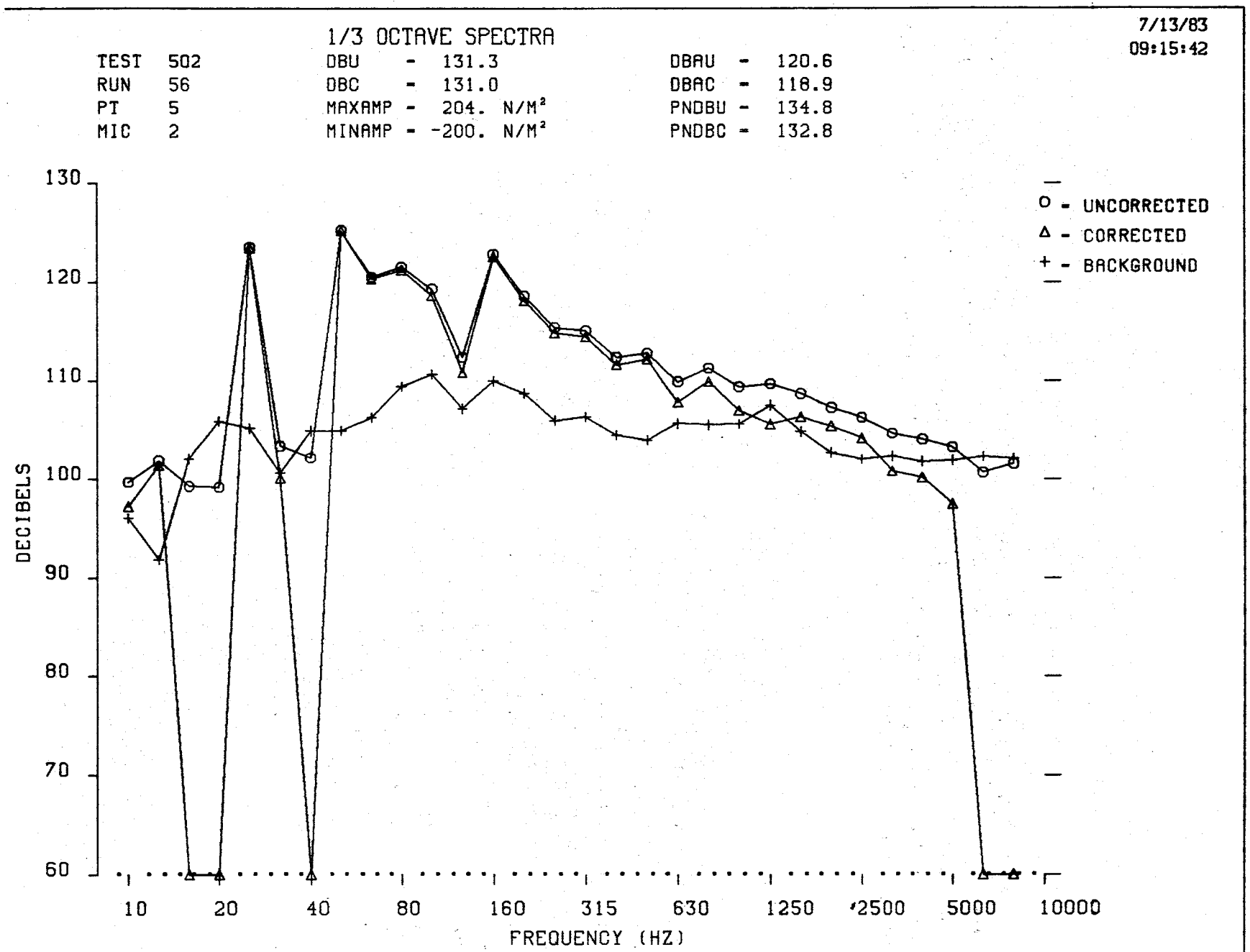

Figure A8. Example of background noise correction.

APPENDIX B

TABULATED ACOUSTIC DATA: ALL DATA POINTS

This appendix provides a brief listing of performance and acoustic data for all of the data points in the test. Wherever the data are missing or of questionable quality due to the equipment, acoustic data are given the value 0. Table 4, which lists the order in which the data are presented, is repeated here for convenience. Symbols used in the listing are defined below.

Symbol	Quantity
ALPHA	angle of shaft from vertical, positive aft, deg
CLR/S	rotor lift coefficient, $\frac{L}{\rho S(\Omega R)^2}$
MAT	advancing-tip Mach number
MIC1	dBA measured at microphone 1; not corrected for background noise
MIC2	dBA measured at microphone 2; not corrected for background noise
MIC3	dBA measured at microphone 3; not corrected for background noise
MIC4	dBA measured at microphone 4; not corrected for background noise
MIC5	dBA measured at microphone 5; not corrected for background noise
MIC6	dBA measured at microphone 6; not corrected for background noise
MIC7	dBA measured at microphone 7; not corrected for background noise
MTIP	rotational tip Mach number
PT	test-point number
RUN	test-run number
V	wind-tunnel velocity, knots
V/OR	advance ratio

TABLE 4.-KEY TO ACOUSTIC DATA TABULATED IN APPENDIX B

Operating condition				Tip planform, page numbers			
μ	M_{tip}	M_{at}	V	Swept-tapered	Swept	Tapered	Rectangular
0.200	0.550	0.660	73	34	--	--	--
.075	.595	.640	30	35	--	--	--
.150	.595	.685	60	36	--	--	--
.200	.600	.720	80	38	59	68	78
.250	.600	.750	100	41	--	--	--
.300	.600	.780	120	43	61	70	80
.375	.600	.825	150	47	63	73	83
.390	.595	.825	160	--	64	--	85
.400	.600	.840	160	49	--	--	--
.250	.650	.815	107	53	--	--	--
.375	.650	.895	164	54	65	--	--
.375	.685	.940	170	56	67	76	--
.250	.700	.875	115	57	--	--	--
.375	.700	.965	175	58	--	77	86

Table B1. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 73.0 MAT= 0.660 MTIP= 0.550 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
12	16	-0.0020	0.0	100.6	104.8	101.7	100.1	103.8	0.0	100.7
12	17	0.0393	0.0	102.1	109.2	102.0	101.7	105.1	0.0	100.8
12	18	0.0593	0.0	103.4	0.0	104.2	102.8	105.5	0.0	0.0
12	19	0.0795	0.0	104.7	0.0	105.4	104.7	0.0	0.0	0.0
12	20	0.1002	0.0	105.9	110.5	108.5	105.3	109.1	0.0	106.0
12	21	0.0504	-2.5	105.9	110.5	108.5	105.3	109.1	0.0	106.0
12	22	0.0709	-2.5	102.0	107.2	105.6	99.5	104.6	0.0	101.0
12	23	0.0919	-2.5	104.0	108.0	103.5	104.4	106.3	0.0	103.1
12	24	0.1116	-2.5	103.8	107.9	105.3	103.1	107.4	0.0	102.7
12	25	0.0418	-5.0	100.2	103.2	101.3	97.7	102.2	0.0	101.0
12	26	0.0632	-5.0	100.6	107.1	100.3	101.4	103.1	128.1	99.9
12	27	0.0841	-5.0	101.0	107.1	101.3	100.7	103.8	0.0	101.1
12	28	0.1038	-5.0	100.5	107.5	101.7	101.0	104.2	0.0	99.9
12	29	0.1211	-5.0	101.7	106.2	102.5	101.3	105.7	0.0	101.3

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 30.0 MAT= 0.640 MTIP= 0.595 V/OR= 0.075

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
61	4	0.0711	0.0	105.8	109.4	106.1	105.8	0.0	110.3	106.5
61	5	0.0713	0.0	104.2	107.7	104.5	103.7	0.0	108.6	105.0
61	8	0.0706	10.0	108.5	110.9	108.1	107.7	0.0	111.3	107.0
61	10	0.0724	0.0	104.7	108.1	104.5	104.4	0.0	108.3	105.0
61	11	0.0706	0.0	103.3	107.1	103.0	103.3	0.0	107.6	104.1
61	12	0.0742	0.0	104.7	108.3	105.0	104.9	0.0	108.8	105.0
61	13	0.0724	0.0	103.8	107.3	104.0	103.3	0.0	108.3	104.5
61	14	0.0711	0.0	103.8	107.3	104.0	103.3	0.0	108.3	104.5
61	15	0.0714	0.0	104.4	108.1	104.3	104.3	0.0	108.7	105.0
61	16	0.0899	0.0	107.2	110.2	107.8	107.4	0.0	111.3	108.2
61	17	0.0521	0.0	104.1	106.9	104.3	102.0	0.0	106.4	102.3
61	18	0.0787	5.0	104.4	107.8	105.2	104.4	0.0	108.0	104.8
61	19	0.0661	-5.0	103.5	107.6	103.5	103.2	0.0	107.3	103.5
61	20	0.0727	0.0	103.5	107.6	103.5	103.2	0.0	107.3	103.5

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 60.0 MAT= 0.685 MTIP= 0.595 V/OR= 0.150

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
7	4	0.0196	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	4	-0.0012	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	5	0.0202	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	6	0.0401	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	7	0.0599	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	8	0.0801	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	9	0.0910	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	10	0.1012	0.0	101.4	105.8	101.1	101.9	102.4	105.6	100.5
8	11	0.1099	0.0	108.6	113.0	108.2	0.0	108.4	112.3	107.7
8	12	0.1206	0.0	110.0	113.7	109.0	0.0	109.6	113.1	107.8
8	13	0.1303	0.0	109.7	113.1	109.3	0.0	110.2	112.3	108.6
8	14	0.1379	0.0	108.6	112.3	108.8	0.0	109.7	112.8	108.4
8	15	0.0334	-2.5	101.7	107.1	101.9	0.0	101.4	105.5	100.4
9	3	0.0218	-5.0	99.8	104.2	100.7	0.0	100.5	104.4	99.0
9	4	0.0409	-5.0	99.3	104.4	102.6	0.0	101.2	104.4	99.5
9	5	0.0541	-5.0	101.7	104.6	101.5	0.0	101.1	103.6	101.7
9	6	0.0708	-5.0	104.6	107.8	102.7	0.0	103.1	104.9	99.1
9	7	0.0862	-5.0	103.6	107.4	102.5	0.0	102.3	106.5	101.4

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 60.0 MAT= 0.685 MTIP= 0.595 V/OR= 0.150

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
9	8	0.0939	-5.0	102.5	107.9	103.9	0.0	113.0	106.4	103.9
9	9	0.0216	-5.0	101.5	103.9	100.0	0.0	100.1	104.5	98.6

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/DR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
10	3	0.0406	-5.0	100.0	107.6	101.3	0.0	0.0	104.4	103.9
10	4	0.0613	-5.0	102.0	108.5	102.1	0.0	0.0	104.9	105.0
10	5	0.0818	-5.0	101.6	108.8	102.9	0.0	0.0	103.8	104.8
10	6	0.0923	-5.0	103.1	108.1	103.1	0.0	0.0	108.6	100.7
10	7	0.1012	-5.0	102.4	107.6	104.9	0.0	0.0	106.2	100.6
10	8	0.1111	-5.0	102.4	107.8	103.6	0.0	0.0	106.3	103.8
10	9	0.1195	-5.0	103.9	108.7	104.5	0.0	0.0	107.0	103.0
10	10	-0.0048	0.0	103.8	107.7	104.4	0.0	0.0	107.4	104.0
10	11	0.0155	0.0	103.3	107.2	103.1	0.0	0.0	107.2	101.8
10	12	0.0373	0.0	104.2	107.8	103.8	0.0	0.0	107.8	104.1
10	13	0.0576	0.0	106.0	0.0	107.1	0.0	0.0	0.0	104.9
10	14	0.0781	0.0	105.4	0.0	106.4	0.0	0.0	0.0	105.2
10	15	0.0981	0.0	108.6	114.7	109.8	0.0	0.0	112.6	0.0
10	16	0.1191	0.0	112.6	0.0	112.6	0.0	0.0	118.2	112.2
10	17	0.0075	-2.5	104.1	107.5	104.5	0.0	0.0	108.1	102.7
10	18	0.0293	-2.5	102.3	106.5	103.4	0.0	0.0	106.6	102.3
10	19	0.0495	-2.5	102.4	109.7	102.9	0.0	0.0	106.9	102.0
10	20	0.0694	-2.5	104.9	110.1	103.8	0.0	0.0	108.2	103.5

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
10	21	0.0894	-2.5	104.6	111.2	105.8	0.0	0.0	107.5	103.9
10	22	0.1091	-2.5	105.8	109.7	106.7	0.0	0.0	109.6	105.5
10	23	0.1193	-2.5	107.2	110.6	107.5	0.0	0.0	0.0	107.4
10	24	0.0532	-7.5	106.0	109.7	102.0	0.0	0.0	103.7	104.2
10	25	0.0749	-7.5	101.0	108.8	0.0	0.0	0.0	106.1	103.1
10	26	0.0939	-7.5	0.0	104.6	0.0	0.0	0.0	107.6	101.7
11	2	0.0538	-7.5	104.3	109.5	103.2	103.2	102.3	106.1	99.8
11	3	0.0751	-7.5	102.0	105.7	103.8	104.7	104.0	106.3	103.8
11	4	0.0950	-7.5	101.7	108.8	102.3	104.5	101.4	105.1	102.4
11	5	0.1043	-7.5	101.2	107.4	102.2	103.8	102.2	106.6	103.2
11	6	0.1140	-7.5	102.9	106.2	104.0	103.9	103.9	107.9	105.0
11	7	0.1217	-7.5	103.5	107.7	104.3	103.0	103.7	107.6	104.5
11	8	0.1264	-7.5	105.6	109.5	106.5	105.6	105.2	109.5	106.5
11	9	0.0297	10.0	100.6	102.9	101.6	100.2	100.7	103.3	101.3
11	10	0.0382	10.0	100.8	103.3	101.4	100.3	101.0	103.5	101.5
11	11	0.0472	10.0	101.0	103.2	101.6	100.6	101.7	103.9	102.4
11	12	0.0696	10.0	101.8	104.7	102.6	101.5	102.6	104.4	102.1
11	13	0.0898	10.0	103.1	105.8	104.1	103.1	103.9	106.1	103.7

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
11	14	0.1113	10.0	105.5	107.1	106.2	105.0	105.4	107.9	105.3
11	15	0.1225	10.0	105.8	108.0	107.0	105.5	108.8	108.5	105.9
26	7	0.0913	-7.5	108.5	110.3	108.8	106.4	0.0	110.5	109.5
26	8	0.0997	-7.5	108.0	110.7	109.2	107.9	0.0	112.2	113.5
63	2	0.0827	-2.9	104.1	107.0	105.2	103.6	0.0	107.4	104.6
63	3	0.0739	-2.9	101.1	105.0	102.0	101.9	0.0	105.4	101.2
63	4	0.0894	-2.9	105.9	109.9	107.0	105.7	0.0	109.9	106.3
63	20	0.0500	-3.8	101.5	104.1	101.9	100.5	0.0	104.2	98.8
63	21	0.0829	-2.9	102.5	107.3	102.9	102.3	0.0	107.5	100.8

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 100.0 MAT= 0.750 MTIP= 0.600 W/DR= 0.250

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
11	19	-0.0019	0.0	106.0	108.8	106.9	106.1	109.1	0.0	105.7
11	20	0.0178	0.0	106.4	108.4	107.1	105.5	108.6	0.0	105.3
11	21	0.0383	0.0	106.6	109.2	107.8	105.6	108.9	0.0	106.5
11	22	0.0581	0.0	108.4	109.7	108.1	107.2	110.2	0.0	106.8
11	23	0.0779	0.0	109.3	111.3	108.9	109.2	112.2	0.0	108.8
11	24	0.0993	0.0	112.2	112.8	112.5	111.1	114.8	0.0	111.2
11	25	0.1175	0.0	114.9	115.9	114.9	114.1	0.0	0.0	0.0
11	26	0.1248	0.0	116.0	117.8	116.1	116.1	119.5	0.0	116.8
11	27	0.0586	-5.0	106.9	109.2	106.1	103.3	107.7	0.0	104.8
11	28	0.0781	-5.0	104.6	109.2	105.0	104.3	107.1	0.0	105.1
12	6	0.0381	0.0	106.6	108.8	107.7	106.1	108.8	0.0	105.9
12	7	0.0791	0.0	110.0	111.2	110.2	108.9	112.1	0.0	109.3
12	8	0.0592	-5.0	105.0	109.2	105.8	105.5	109.0	0.0	104.5
12	9	0.0785	-5.0	106.2	112.1	107.5	106.5	108.7	0.0	0.0
12	10	0.0980	-5.0	106.3	108.6	107.6	105.1	108.2	0.0	104.2
12	11	0.1143	-5.0	106.5	108.1	106.7	105.9	109.0	0.0	105.8
12	12	0.0470	-2.5	106.5	108.1	106.7	105.9	109.0	0.0	105.8
12	13	0.0686	-2.5	106.5	109.9	107.4	105.3	109.3	0.0	107.2

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 100.0 MAT= 0.750 MTIP= 0.600 V/DR= 0.250

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
12	14	0.0884	-2.5	107.5	110.3	107.0	107.3	111.0	0.0	106.9
12	15	0.1073	-2.5	107.8	111.8	108.0	108.2	111.4	0.0	108.9
54	16	0.0578	-5.0	105.2	107.0	105.1	103.5	0.0	106.1	102.9
54	17	0.0774	-5.0	104.8	106.9	105.0	103.5	0.0	106.2	103.6
54	18	0.0982	-5.0	106.0	107.3	106.5	103.9	112.7	106.6	105.0
54	19	0.0830	-5.0	106.0	107.3	106.5	103.9	112.7	106.6	105.0
54	20	0.0794	-5.0	106.0	107.3	106.5	103.9	112.7	106.6	105.0

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
14	3	-0.0033	0.0	112.0	113.3	111.6	109.9	0.0	0.0	108.5
14	4	0.0147	0.0	110.4	111.0	110.7	107.5	0.0	0.0	106.8
14	5	0.0351	0.0	110.4	110.8	110.5	107.7	0.0	0.0	106.5
14	6	0.0532	0.0	110.4	111.6	111.1	107.9	0.0	0.0	106.7
14	7	0.0721	0.0	110.2	112.7	110.4	108.2	0.0	0.0	109.2
14	8	0.0913	0.0	112.3	115.5	113.0	109.6	0.0	114.7	111.4
14	9	0.1080	0.0	112.8	0.0	113.5	111.9	0.0	116.3	113.2
14	10	0.0323	-5.0	108.4	110.3	108.2	105.3	0.0	109.3	105.9
14	11	0.0521	-5.0	107.5	110.3	108.5	105.3	117.7	109.6	106.2
14	12	0.0707	-5.0	107.7	110.8	108.8	105.9	117.5	110.4	106.3
14	13	0.0893	-5.0	107.9	110.3	108.9	105.3	117.3	109.8	105.4
14	14	0.1052	-5.0	108.6	109.3	109.7	105.8	0.0	111.1	105.8
14	15	0.1104	-5.0	112.2	113.8	112.3	108.2	0.0	114.1	108.0
14	16	0.0738	-5.0	108.8	110.2	109.2	105.3	0.0	110.3	106.3
14	17	0.0730	-5.0	109.3	112.1	110.0	107.3	116.9	112.2	108.4
14	18	0.0287	-10.0	107.8	111.0	108.3	0.0	114.4	0.0	106.6
14	19	0.0483	-10.0	107.2	109.8	108.3	105.6	114.0	110.0	108.1
14	20	0.0683	-10.0	108.3	110.3	108.4	105.1	115.4	110.0	107.5

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/DR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
15	3	0.0385	-7.5	109.9	111.2	109.0	106.8	107.1	0.0	108.6
15	4	0.0465	-7.5	108.2	113.3	108.3	105.5	107.9	0.0	106.4
15	5	0.0575	-7.5	107.7	111.3	108.0	105.3	108.0	0.0	106.0
15	6	0.0754	-7.5	107.6	111.2	107.7	104.9	107.9	0.0	105.4
15	7	0.0936	-7.5	108.1	110.1	108.6	104.8	108.0	0.0	106.4
15	8	0.1023	-7.5	108.0	110.2	108.5	105.3	108.6	0.0	105.2
15	9	0.0257	6.0	108.5	109.5	108.9	106.8	107.9	0.0	106.2
15	10	0.0419	6.0	109.1	109.5	109.3	106.8	108.2	0.0	106.4
15	11	0.0614	6.0	109.2	109.8	109.1	107.0	108.7	0.0	106.3
15	12	0.0789	6.0	109.4	109.6	109.2	106.4	108.3	0.0	106.4
15	13	0.0987	6.0	108.7	109.9	108.9	106.9	108.6	0.0	106.7
15	14	0.1165	6.0	109.4	110.4	109.4	108.0	109.3	0.0	107.4
15	15	0.1230	6.0	109.7	111.6	110.2	108.3	109.8	0.0	108.1
22	2	-0.0014	0.0	109.7	111.6	110.2	108.3	109.8	0.0	108.1
22	3	0.0561	-2.5	109.7	110.4	109.2	108.3	0.0	0.0	107.8
22	4	0.0733	-2.5	109.7	112.6	109.3	108.5	0.0	0.0	107.9
22	5	0.0889	-2.5	110.1	112.5	109.4	109.3	0.0	0.0	110.6
22	6	0.0576	-6.5	108.0	110.3	108.4	107.6	0.0	0.0	107.1

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
22	7	0.0748	-6.5	108.5	110.1	108.3	107.2	0.0	0.0	107.6
22	8	0.0748	-6.5	108.9	111.4	108.7	107.8	0.0	0.0	108.0
22	9	0.0901	-6.5	108.6	110.9	109.3	107.3	0.0	0.0	110.0
22	10	0.0610	-10.5	108.7	109.7	109.1	107.8	0.0	0.0	108.2
22	11	0.0599	-10.5	108.9	110.3	108.7	107.7	0.0	0.0	108.0
22	12	0.0759	-10.5	108.0	110.0	108.2	107.2	0.0	0.0	108.0
22	13	0.0781	-10.5	107.8	110.2	109.8	107.3	0.0	0.0	109.1
22	14	0.0924	-10.5	108.0	109.6	108.8	106.9	0.0	0.0	110.1
22	15	0.0608	-11.5	107.9	110.9	108.4	107.4	0.0	0.0	108.0
22	16	0.0771	-11.5	108.2	111.7	108.1	106.6	0.0	0.0	111.2
22	17	0.0922	-11.5	108.9	111.4	108.2	107.0	0.0	0.0	110.7
60	3	0.0702	-2.5	107.3	108.6	107.0	106.5	0.0	109.3	106.2
60	4	0.0689	-2.5	107.6	109.0	107.4	106.7	0.0	109.7	106.0
60	5	0.0565	-2.5	106.8	107.9	106.8	106.2	0.0	109.6	105.6
60	6	0.0812	-2.5	107.8	110.5	107.9	107.2	0.0	110.7	107.0
60	7	0.0684	-2.5	106.8	108.2	107.1	106.0	0.0	109.5	105.9
60	8	0.0680	-2.5	107.4	108.3	107.2	106.6	0.0	109.1	105.8
60	9	0.0692	-2.5	107.4	108.2	106.9	106.5	0.0	109.7	105.8

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/DR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
60	10	0.0957	-2.5	108.5	111.0	108.3	107.8	0.0	110.9	107.5
60	11	0.1080	-2.5	112.0	117.7	111.9	112.0	0.0	115.6	111.6
60	12	0.0420	-2.5	106.9	107.8	106.8	105.5	0.0	109.1	105.5
60	13	0.0689	-2.5	107.2	108.4	107.3	106.2	0.0	109.3	105.5
60	14	0.0570	-3.6	107.1	108.1	107.1	105.5	0.0	108.8	105.5
60	15	0.0788	-0.5	107.8	109.6	108.2	107.1	0.0	109.7	106.8
60	16	0.0680	-2.5	107.2	109.5	107.5	106.2	0.0	108.9	105.4
60	17	0.0687	-2.5	107.0	107.9	107.3	106.1	0.0	109.0	105.6
60	18	0.0685	-2.5	107.5	108.1	107.0	106.2	0.0	109.0	105.8
63	5	0.0522	-6.2	107.2	108.0	106.7	106.1	0.0	108.7	105.4
63	6	0.0807	-4.2	107.1	109.5	107.8	106.5	0.0	109.0	105.9

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
19	23	0.0385	-5.0	112.7	113.3	113.1	111.4	0.0	0.0	111.1
19	24	0.0572	-5.0	113.2	114.0	113.8	111.4	0.0	0.0	111.5
19	25	0.0740	-5.0	113.4	114.4	113.5	111.7	0.0	0.0	112.4
19	26	0.0889	-5.0	113.5	114.0	113.6	112.2	0.0	0.0	113.2
19	27	0.1003	-5.0	116.2	116.7	115.6	113.6	116.3	0.0	116.5
19	28	0.0950	-5.0	114.2	115.8	114.2	112.9	116.0	0.0	115.5
19	29	-0.0053	0.0	115.0	115.9	114.8	114.1	0.0	0.0	113.4
19	30	0.0130	0.0	114.3	114.6	114.6	113.8	0.0	0.0	112.3
19	31	0.0307	0.0	113.8	114.3	114.1	112.5	0.0	0.0	111.6
19	32	0.0461	0.0	113.8	113.7	114.0	112.9	113.2	0.0	111.4
19	33	0.0634	0.0	113.9	114.4	114.1	112.9	0.0	0.0	111.0
19	34	0.0800	0.0	113.8	114.4	114.1	112.9	0.0	0.0	111.0
19	35	0.0954	0.0	113.8	114.4	114.1	112.9	0.0	0.0	111.0
20	6	0.0889	-3.0	112.5	114.9	113.0	111.5	0.0	117.2	115.5
21	3	0.0965	0.0	115.7	117.5	116.5	113.6	0.0	118.9	115.3
21	4	0.1029	0.0	115.7	117.5	115.6	114.3	0.0	119.9	117.6
21	5	0.0506	-10.0	112.8	114.9	114.0	111.4	0.0	116.3	115.0
21	6	0.0670	-10.0	113.5	114.8	114.2	111.4	0.0	115.5	115.9

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/DR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
21	7	0.0825	-10.0	114.4	115.1	114.8	112.1	0.0	117.4	118.5
21	8	0.0759	-10.0	115.1	115.8	115.8	111.5	0.0	116.8	115.7
21	9	0.0328	-10.0	112.4	113.8	113.2	111.7	0.0	115.2	113.7
21	10	0.0753	-10.0	113.3	114.8	114.4	111.9	0.0	116.1	117.3
54	13	0.0770	-4.6	115.4	115.2	115.3	111.2	121.7	116.5	112.0
55	18	0.0717	-5.0	113.4	115.0	113.5	111.3	0.0	116.0	113.0
55	19	0.0799	-5.0	113.5	114.4	113.3	111.6	0.0	115.3	112.0

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 160.0 MAT= 0.840 MTIP= 0.600 V/OR= 0.400

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
17	3	-0.0019	0.0	116.2	116.7	115.9	115.2	0.0	117.9	0.0
17	4	0.0138	0.0	115.8	116.1	115.6	115.1	114.9	117.8	114.4
17	5	0.0315	0.0	115.2	115.4	115.0	114.2	115.0	116.5	113.5
17	6	0.0474	0.0	115.0	114.7	115.2	114.2	114.8	116.6	113.6
17	7	0.0645	0.0	115.4	115.3	115.6	114.2	115.3	117.4	113.0
17	8	0.0806	0.0	115.5	115.8	115.5	114.4	115.3	116.8	114.7
17	9	0.0877	0.0	115.7	116.9	116.1	115.6	0.0	117.9	0.0
17	10	0.0950	0.0	116.2	117.9	116.8	115.9	0.0	118.9	0.0
17	11	0.0382	-5.0	114.7	114.8	115.0	113.4	115.3	116.6	113.3
17	12	0.0563	-5.0	115.2	115.8	115.4	114.3	116.1	116.7	113.4
17	13	0.0719	-5.0	115.2	115.6	115.5	113.6	0.0	117.4	115.8
17	14	0.0780	-5.0	115.8	116.0	116.1	114.9	0.0	118.1	115.0
17	15	0.0849	-5.0	116.1	115.8	116.2	114.2	117.8	119.0	113.4
17	16	0.0923	-5.0	117.3	118.2	116.6	114.6	119.6	119.2	113.6
19	3	0.0366	-5.0	114.4	115.0	113.9	113.1	108.9	117.1	114.3
19	4	0.0523	-5.0	114.5	115.0	114.8	113.8	0.0	117.6	114.8
19	5	0.0901	-5.0	113.5	112.9	115.8	113.6	0.0	118.4	0.0
19	6	0.0699	-5.0	115.6	115.7	115.3	113.3	0.0	118.6	115.4

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 160.0 MAT= 0.840 MTIP= 0.600 V/DR= 0.400

RUN	PT	CLP/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
19	7	0.0777	-5.0	114.7	115.8	114.7	113.8	0.0	117.4	114.1
19	8	0.0769	-5.0	114.6	115.3	115.1	113.1	0.0	117.1	115.7
19	9	0.0974	0.0	116.1	117.6	115.8	114.9	0.0	119.5	0.0
19	10	0.1037	0.0	116.7	117.7	117.1	115.0	0.0	0.0	0.0
19	11	0.0555	-7.5	114.4	115.6	114.5	113.2	0.0	117.0	113.2
19	12	0.0639	-7.5	114.6	115.9	114.6	112.7	0.0	117.0	115.6
19	13	0.0714	-7.5	114.7	115.5	114.6	113.0	0.0	117.7	115.0
19	14	0.0781	-7.5	115.7	117.0	115.2	113.3	115.9	118.4	111.4
19	15	0.0861	-7.5	115.4	117.8	115.4	113.6	117.2	118.8	111.4
19	16	0.0903	-7.5	117.9	118.5	117.4	115.1	120.0	0.0	112.2
19	17	0.0282	6.0	115.6	114.9	115.9	113.6	0.0	0.0	113.8
19	18	0.0427	6.0	115.2	115.0	115.4	113.5	0.0	0.0	113.5
19	19	0.0580	6.0	115.6	114.6	115.2	113.8	0.0	0.0	113.2
19	20	0.0753	6.0	115.0	114.7	114.9	113.8	0.0	0.0	112.6
19	21	0.0894	6.0	114.9	115.2	115.1	113.8	0.0	0.0	112.5
21	11	0.0281	-10.0	113.9	115.4	114.2	112.9	0.0	116.9	114.6
21	12	0.0445	-10.0	114.0	115.5	114.6	112.7	0.0	116.9	115.6
21	13	0.0610	-10.0	114.4	115.5	114.6	112.7	0.0	116.7	116.4

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 160.0 MAT= 0.840 MTIP= 0.600 V/OR= 0.400

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
21	14	0.0686	-10.0	0.0	116.1	114.8	113.0	0.0	117.0	117.1
22	18	0.0614	-9.0	114.2	114.6	115.0	113.0	0.0	0.0	114.6
22	19	0.0756	-9.0	114.8	115.1	115.3	113.0	0.0	0.0	116.6
22	20	0.0650	-9.0	114.3	114.6	114.7	112.7	0.0	0.0	114.4
22	21	0.0680	-9.0	114.6	114.9	114.9	112.6	0.0	0.0	115.3
22	22	0.0554	-7.0	114.7	115.0	115.4	113.7	0.0	0.0	113.8
22	23	0.0741	-7.0	115.0	115.2	115.1	113.0	0.0	0.0	116.1
22	24	0.0709	-7.0	114.8	114.6	114.9	112.9	0.0	0.0	114.5
53	3	0.0728	-4.6	114.9	114.6	114.3	111.2	0.0	116.4	113.1
53	4	0.0741	-4.6	114.3	114.4	114.1	111.3	0.0	115.7	113.2
53	5	0.0606	-4.6	114.3	114.9	114.1	111.1	0.0	116.4	113.7
53	6	0.0883	-4.6	114.5	115.2	114.5	111.5	126.1	116.7	115.8
53	7	0.0764	-4.6	114.0	115.1	114.2	110.8	124.8	115.8	114.6
53	8	0.0740	-4.6	114.2	115.1	114.5	111.5	125.4	116.5	113.4
53	9	0.0760	-4.6	116.2	115.7	115.8	111.5	125.1	116.3	113.9
54	3	0.0753	-4.6	115.0	115.1	114.4	111.6	123.5	116.7	113.0
54	4	0.0892	-4.6	116.2	115.8	116.0	111.8	124.1	117.4	114.1
54	5	0.0614	-4.6	114.4	115.5	114.2	111.4	122.7	116.1	111.9

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 160.0 MAT= 0.840 MTIP= 0.600 V/OR= 0.400

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
54	6	0.0662	-6.6	114.0	115.1	114.0	111.6	122.9	117.1	112.8
54	7	0.0875	-2.6	114.8	115.2	114.5	112.1	123.3	117.0	113.9
54	8	0.0747	-4.6	114.2	115.1	114.1	111.5	122.5	116.8	113.3
54	9	0.0752	-4.6	114.4	114.4	114.2	111.7	123.2	117.0	112.4
54	10	0.0739	-4.6	113.9	113.3	113.5	111.6	121.9	115.9	111.5
54	11	0.0758	-4.6	114.2	114.9	113.9	111.6	122.3	116.6	112.1
54	12	0.0733	-4.6	114.5	115.1	114.0	112.2	122.6	116.7	112.1
63	7	0.0546	-7.6	113.4	113.5	113.8	111.8	0.0	115.6	111.7
63	8	0.0793	-6.3	113.8	113.3	113.8	112.2	0.0	114.8	112.0
63	9	0.0325	-5.0	113.8	113.9	114.0	112.3	0.0	115.5	112.1
63	10	0.0495	-5.0	114.0	113.6	114.0	112.1	0.0	115.8	112.2
63	11	0.0691	-5.0	114.5	114.4	114.2	112.5	0.0	116.2	111.8
63	12	0.0843	-5.0	113.7	113.3	113.8	112.0	0.0	115.6	111.9
63	13	0.0734	-5.0	113.7	113.4	113.7	112.0	0.0	115.3	111.5

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 107.0 MAT= 0.815 MTIP= 0.650 V/OR= 0.250

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
55	9	0.0567	0.0	110.1	111.5	109.4	109.5	117.3	112.6	108.3
55	12	0.0585	-5.0	106.5	107.9	106.9	104.9	114.8	108.1	104.8
55	13	0.0775	-5.0	107.5	107.7	106.9	105.4	115.4	108.8	105.4
55	14	0.0972	-5.0	108.9	109.1	108.8	106.5	115.9	109.6	106.5
55	15	0.0571	0.0	111.2	112.5	110.9	109.4	118.9	113.1	108.5
55	16	0.0776	0.0	111.9	113.3	111.4	109.5	0.0	114.5	109.7
55	17	0.0985	0.0	115.2	116.7	114.0	114.0	0.0	117.9	113.4

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 164.0 MAT= 0.895 MTIP= 0.650 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
21	16	-0.0014	0.0	118.2	118.6	117.8	117.0	0.0	120.0	0.0
21	17	0.0148	0.0	117.1	117.1	117.4	116.5	0.0	118.9	116.2
21	18	0.0313	0.0	117.1	117.1	117.4	116.5	0.0	118.9	116.2
21	19	0.0488	0.0	117.1	117.1	117.4	116.5	0.0	118.9	116.2
21	20	0.0668	0.0	116.1	116.5	116.4	115.9	0.0	118.9	115.5
21	21	0.0836	0.0	116.3	117.0	116.5	115.7	0.0	118.7	116.0
21	22	0.0917	0.0	116.8	117.5	116.9	116.3	0.0	119.1	116.1
21	23	0.0947	0.0	116.8	117.2	116.8	116.6	0.0	119.5	115.9
21	24	0.0402	-5.0	115.7	116.5	116.1	115.2	0.0	118.9	115.1
21	25	0.0600	-5.0	116.6	116.6	116.6	115.5	0.0	118.8	115.3
21	26	0.0766	-5.0	116.7	117.4	116.4	116.2	0.0	119.0	116.0
21	27	0.0846	-5.0	116.4	116.3	116.1	115.9	0.0	118.5	115.9
21	28	0.0914	-5.0	116.7	117.3	116.3	116.9	0.0	118.3	117.8
21	29	0.0935	-5.0	117.3	117.7	116.6	116.9	0.0	0.0	118.1
21	30	0.0503	-5.0	116.3	116.1	116.9	114.6	0.0	0.0	115.9
21	31	0.0523	-5.0	115.0	115.2	115.5	115.1	0.0	0.0	115.3
21	32	0.0509	-10.0	114.6	115.1	115.4	114.2	0.0	0.0	114.1
21	33	0.0598	-10.0	114.6	115.1	115.4	114.2	0.0	0.0	114.1

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 164.0 MAT= 0.895 MTIP= 0.650 V/DR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
21	34	0.0677	-10.0	115.4	115.7	115.9	115.1	0.0	0.0	115.1
21	35	0.0767	-10.0	115.5	115.7	115.9	114.7	0.0	0.0	115.3
21	36	0.0813	-10.0	115.3	115.9	115.9	115.2	0.0	0.0	116.2
21	37	0.0333	-10.0	115.7	115.7	115.8	115.0	0.0	0.0	114.2
55	22	0.0545	-5.0	115.9	115.3	115.6	114.6	123.1	117.5	113.7
55	23	0.0746	-5.0	115.8	115.2	115.4	114.7	123.2	117.5	113.9
55	25	0.0815	-5.0	116.1	115.6	115.1	114.5	123.5	117.7	114.3
55	26	0.0734	-5.0	117.1	117.1	116.6	115.8	123.5	118.5	114.4
55	27	0.0741	-5.0	116.1	115.3	115.7	114.8	124.3	117.1	114.3
63	14	0.0375	-5.0	115.1	114.7	114.6	113.5	0.0	116.3	112.4
63	15	0.0579	-5.0	114.8	114.6	114.3	113.6	0.0	116.6	112.5
63	16	0.0666	-5.0	114.8	114.1	114.5	113.3	0.0	115.7	112.6
63	17	0.0749	-5.0	114.7	114.4	114.7	113.6	0.0	116.1	112.8
63	18	0.0799	-5.0	114.8	114.0	114.8	113.5	0.0	115.9	112.5

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 170.0 MAT= 0.940 MTIP= 0.685 V/DR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
55	28	0.0379	-5.0	122.1	118.3	123.1	0.0	0.0	120.1	121.2
55	29	0.0554	-5.0	0.0	119.3	0.0	0.0	0.0	120.0	122.0
55	30	0.0652	-5.0	122.1	118.7	122.7	0.0	0.0	120.6	121.7
55	31	0.0731	-5.0	122.0	119.1	122.9	0.0	0.0	120.1	122.3
55	32	-0.0026	0.0	100.5	104.5	101.2	100.8	108.9	104.5	100.5
55	33	-0.0012	0.0	101.2	104.6	101.4	101.4	109.2	105.3	101.7
55	34	0.0559	-7.5	0.0	119.1	0.0	0.0	0.0	119.6	0.0
55	35	0.0686	-7.5	124.2	119.8	125.7	0.0	0.0	120.4	0.0
55	36	0.0502	-2.5	122.2	121.0	122.1	0.0	0.0	120.5	121.6
55	37	0.0704	-2.5	122.5	121.0	123.0	0.0	0.0	121.5	122.4
55	38	0.0776	-2.5	122.5	120.5	123.5	0.0	0.0	121.2	122.5
55	39	0.0590	-2.5	121.6	120.7	122.4	0.0	0.0	121.2	122.0
55	40	0.0776	-2.5	122.5	121.3	123.3	0.0	0.0	122.1	123.2
55	41	0.0818	-2.5	121.8	120.3	122.9	0.0	0.0	120.9	122.6

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 115.0 MAT= 0.875 MTIP= 0.700 V/OR= 0.250

RUN	PT	CLP/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
55	3	0.0583	-5.0	110.4	109.4	109.6	108.9	0.0	110.6	107.9
55	4	0.0770	-5.0	110.7	109.6	110.3	108.8	0.0	110.8	108.1
55	5	0.0986	-5.0	113.3	111.4	112.9	110.7	0.0	112.4	109.0
55	6	0.0574	0.0	113.2	113.8	112.8	111.8	0.0	114.9	111.3
55	7	0.0795	0.0	115.6	116.4	115.0	114.2	0.0	117.7	113.6
55	8	0.1000	0.0	120.0	117.5	118.5	116.9	126.8	119.7	116.9

Table B1. continued. Acoustic dBA Measurements for the Swept Tapered Tip Rotor.

SWEPT TAPERED TIP V= 175.0 MAT= 0.965 MTIP= 0.700 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
56	3	0.0530	-5.0	129.3	121.8	130.7	130.6	127.9	121.7	128.7
56	4	0.0707	-5.0	129.6	121.9	130.3	130.9	128.2	121.7	128.3
56	5	0.0783	-5.0	128.7	120.6	130.2	130.9	127.8	121.9	128.6
56	6	0.0831	-5.0	129.5	121.4	130.5	131.2	128.5	122.1	128.1
56	7	0.0617	-5.0	130.1	121.0	130.9	0.0	0.0	122.5	128.5
56	8	0.0494	-2.5	127.1	122.3	128.8	0.0	127.5	123.1	127.7
56	9	0.0658	-2.5	127.9	122.1	129.2	0.0	127.7	123.2	128.4
56	10	0.0832	-2.5	128.0	122.3	129.1	0.0	126.5	123.4	127.8
56	11	0.0879	-2.5	128.5	122.3	129.0	0.0	127.2	124.2	127.4

Table B2. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/DR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
48	4	0.0642	-5.0	100.5	106.0	101.4	102.0	0.0	106.1	102.5
48	5	0.0855	-5.0	101.5	108.8	102.6	101.8	0.0	108.3	100.4
48	6	0.1084	-5.0	103.5	107.8	103.3	105.2	0.0	108.6	102.1
48	7	0.1179	-5.0	103.4	110.6	104.6	104.3	0.0	109.3	103.6
48	8	0.1207	-5.0	104.3	110.1	104.9	105.0	0.0	109.4	104.0
48	9	0.0492	-2.5	101.4	106.1	101.8	101.9	0.0	106.0	101.4
48	10	0.0725	-2.5	102.2	106.8	104.9	102.9	0.0	105.9	101.4
48	11	0.0955	-2.5	103.5	110.0	105.1	104.9	0.0	109.0	102.8
48	12	0.1063	-2.5	105.2	110.5	106.2	106.5	0.0	110.5	105.8
48	13	0.1160	-2.5	107.1	113.0	107.7	108.8	0.0	112.0	107.3
48	14	0.1251	-2.5	110.4	0.0	110.9	110.8	0.0	114.3	112.1
48	15	-0.0046	0.0	98.5	103.3	99.1	99.6	0.0	103.1	98.7
48	16	-0.0032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	17	0.0432	-5.0	101.7	105.7	102.9	102.6	0.0	106.2	99.7
48	18	-0.0072	0.0	105.9	109.1	106.9	104.7	0.0	108.8	102.4
48	19	0.0162	0.0	104.0	106.9	104.9	104.3	0.0	108.0	101.8
48	20	0.0394	0.0	105.0	107.4	104.9	104.0	0.0	108.8	103.6
48	21	0.0611	0.0	105.5	108.3	105.5	104.4	0.0	109.1	103.0

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
48	22	0.0844	0.0	107.4	111.1	107.8	106.8	0.0	110.7	106.7
48	23	0.1059	0.0	112.1	0.0	112.5	113.8	0.0	0.0	111.9
48	24	0.1173	0.0	114.9	0.0	114.7	116.1	0.0	0.0	113.8
48	25	0.1271	0.0	115.8	0.0	116.0	116.0	0.0	0.0	0.0

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
49	3	0.0300	-5.0	107.1	109.0	107.8	106.2	0.0	109.8	105.2
49	4	0.0544	-5.0	106.9	109.0	107.8	105.9	0.0	109.8	104.9
49	5	0.0746	-5.0	107.9	108.6	108.0	106.8	0.0	109.4	105.4
49	6	0.0946	-5.0	107.2	109.8	108.1	106.4	0.0	109.7	106.4
49	7	0.1043	-5.0	107.3	109.6	108.1	106.2	0.0	109.9	105.8
49	8	0.1095	-5.0	109.4	111.4	109.9	107.4	0.0	112.0	106.4
49	9	0.0391	-10.0	106.7	109.4	107.7	105.3	0.0	109.5	105.4
49	10	0.0517	-10.0	106.4	109.3	107.0	106.0	0.0	108.4	105.4
49	11	0.0721	-10.0	106.4	109.4	107.6	105.5	0.0	109.2	106.3
49	12	0.0902	-10.0	108.6	110.1	109.3	105.8	0.0	109.6	105.8
49	13	0.0807	-10.0	106.8	109.0	108.1	105.9	0.0	109.5	106.3
49	14	-0.0072	0.0	109.0	112.7	109.9	108.6	0.0	111.8	107.7
49	15	0.0143	0.0	108.6	110.8	109.0	108.1	0.0	111.2	106.8
49	16	0.0350	0.0	108.3	110.6	108.6	107.3	0.0	111.0	106.6
49	17	0.0551	0.0	108.3	110.7	109.2	107.6	0.0	111.6	107.1
49	18	0.0785	0.0	108.6	111.4	109.4	107.9	0.0	111.6	107.4
49	19	0.0974	0.0	110.7	113.6	111.5	109.8	0.0	113.6	110.5
49	20	0.1077	0.0	111.5	114.5	111.3	109.9	0.0	114.1	110.1

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
49	21	0.1159	0.0	113.7	0.0	114.0	113.2	0.0	117.3	0.0
49	22	-0.0045	0.0	113.7	0.0	114.0	113.2	0.0	117.3	0.0
49	23	-0.0035	0.0	99.7	105.1	101.0	100.2	0.0	104.4	100.8
49	24	0.0434	-5.0	112.9	113.6	113.6	111.5	0.0	115.0	112.7
49	25	0.0505	-5.0	112.1	113.9	113.3	111.1	0.0	115.8	113.5
49	26	0.0808	-5.0	112.8	114.2	113.5	111.3	0.0	114.8	114.3
49	27	0.0895	-5.0	113.1	114.1	113.1	111.0	0.0	115.3	115.0
49	28	0.0965	-5.0	113.1	114.1	113.1	111.0	0.0	115.3	115.0
49	29	0.0429	-10.0	111.8	112.5	112.9	110.4	0.0	114.8	111.7

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
49	24	0.0434	-5.0	112.9	113.6	113.6	111.5	0.0	115.0	112.7
49	25	0.0605	-5.0	112.1	113.9	113.3	111.1	0.0	115.8	113.5
49	26	0.0808	-5.0	112.8	114.2	113.5	111.3	0.0	114.8	114.3
49	27	0.0895	-5.0	113.1	114.1	113.1	111.0	0.0	115.3	115.0
49	28	0.0965	-5.0	113.1	114.1	113.1	111.0	0.0	115.3	115.0
49	29	0.0429	-10.0	111.8	112.5	112.9	110.4	0.0	114.8	111.7
49	30	0.0525	-10.0	112.3	113.5	113.1	110.8	0.0	113.6	113.6
49	31	0.0605	-10.0	111.8	112.2	113.2	110.6	0.0	113.8	114.4
49	32	0.0713	-10.0	111.7	112.7	113.2	110.7	0.0	114.3	114.3
49	33	-0.0068	0.0	113.6	115.8	114.2	113.0	0.0	116.5	115.3
49	34	0.0123	0.0	113.0	114.0	113.5	112.0	0.0	115.4	115.1
49	35	0.0332	0.0	112.7	113.8	113.6	111.6	0.0	116.4	112.3
49	36	0.0502	0.0	112.3	116.0	113.8	111.8	0.0	115.0	112.6
49	37	0.0694	0.0	113.1	113.9	114.0	112.1	0.0	116.0	112.4
49	38	0.0871	0.0	113.0	113.4	114.1	112.0	0.0	114.7	113.3
49	39	0.0950	0.0	113.4	114.6	113.8	111.9	0.0	115.9	114.5
49	40	0.1028	0.0	113.4	115.2	114.5	112.4	0.0	116.2	115.0
51	40	0.0731	-4.6	114.5	113.5	114.6	110.5	113.2	114.2	113.4

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 160.0 MAT= 0.825 MTIP= 0.595 V/OR= 0.390

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
51	25	0.0735	-4.6	113.5	114.6	113.4	110.8	115.9	115.3	114.7
51	26	0.0535	-4.6	114.4	114.1	113.2	110.5	115.4	114.5	115.8
51	27	0.0870	-4.6	113.9	115.3	114.0	111.5	116.2	115.7	115.3
51	28	0.0733	-4.6	115.4	115.2	114.8	110.9	115.8	114.8	114.6
51	29	0.0730	-4.6	113.7	114.0	112.8	110.5	115.5	114.4	114.1
51	30	0.0736	-4.6	113.1	113.2	112.7	110.6	115.1	114.3	114.7
51	31	0.0588	-6.6	113.2	113.6	113.1	110.4	115.8	114.8	114.7
51	32	0.0879	-2.6	115.1	114.9	113.4	111.3	115.5	115.7	115.1
51	33	0.0729	-4.6	113.0	114.0	113.5	110.7	114.7	114.9	114.5
51	34	0.0882	-4.6	115.2	114.8	115.1	110.9	114.9	115.7	115.3
51	35	0.0548	-4.6	112.8	114.2	113.1	110.4	114.7	114.7	113.2
51	36	0.0730	-4.6	113.1	113.0	113.3	111.1	114.6	114.8	114.9
51	37	0.0706	-4.6	114.9	113.8	114.8	110.7	114.3	115.1	114.1
51	38	0.0711	-4.6	113.0	113.8	113.5	110.8	113.9	114.4	114.6
51	39	0.0690	-4.6	113.4	114.3	113.3	111.2	115.4	115.6	114.8

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 164.0 MAT= 0.895 MTIP= 0.650 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
49	43	0.0418	-5.0	115.8	117.0	116.3	115.6	0.0	118.6	115.3
49	44	0.0626	-5.0	116.0	118.0	116.4	115.5	0.0	118.3	115.2
49	45	0.0704	-5.0	116.2	117.2	116.3	116.2	0.0	118.2	115.6
51	3	0.0502	-5.0	117.3	118.8	117.1	116.0	0.0	120.4	115.8
51	4	0.0603	-5.0	125.3	117.9	117.0	116.1	0.0	120.2	115.8
51	5	0.0692	-5.0	117.0	117.4	116.8	115.6	0.0	120.1	115.8
51	6	0.0778	-5.0	119.2	117.7	119.0	115.2	0.0	120.1	115.8
51	7	0.0883	-5.0	118.1	118.3	117.8	116.6	0.0	120.2	115.6
51	8	0.0906	-5.0	117.4	117.7	116.9	116.4	0.0	120.0	115.9
51	9	0.0328	-10.0	117.3	115.5	116.7	114.1	0.0	117.8	113.8
51	10	0.0430	-10.0	115.9	115.0	116.3	114.6	0.0	118.1	114.6
51	11	0.0526	-10.0	116.9	115.7	116.8	113.7	0.0	117.5	114.3
51	12	0.0623	-10.0	117.8	115.2	116.5	115.1	0.0	118.1	114.8
51	13	0.0671	-10.0	117.0	114.8	116.9	113.9	0.0	117.5	114.7
51	14	-0.0039	0.0	118.4	119.2	118.0	117.2	0.0	120.0	117.6
51	15	0.0100	0.0	117.4	117.9	117.3	116.3	0.0	119.0	116.6
51	16	0.0306	0.0	117.7	117.3	117.3	116.7	0.0	118.4	116.2
51	17	0.0491	0.0	118.2	117.1	117.9	116.0	0.0	118.4	115.3

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 164.0 MAT= 0.895 MTIP= 0.650 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
51	18	0.0591	0.0	118.2	117.1	117.9	116.0	0.0	118.3	115.5
51	19	0.0685	0.0	117.4	116.4	117.0	116.2	0.0	117.9	115.8
51	20	0.0781	0.0	117.2	116.7	117.0	115.2	0.0	118.1	115.5
51	21	0.0861	0.0	117.2	116.6	116.7	115.5	0.0	118.4	115.9
51	22	0.0939	0.0	118.9	117.5	117.6	115.3	0.0	118.3	115.5
59	5	0.0546	-5.0	117.1	117.7	116.6	116.0	0.0	119.4	114.4
59	6	0.0748	-5.0	117.1	118.2	116.5	115.4	0.0	119.8	115.2
59	7	0.0933	-5.0	117.4	118.4	117.4	116.6	0.0	119.9	115.7

Table B2. continued. Acoustic dBA Measurements for the Swept Tip Rotor.

SWEPT TIP V= 170.0 MAT= 0.940 MTIP= 0.685 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
59	8	0.0464	-5.0	0.0	119.6	0.0	0.0	0.0	119.7	0.0
59	9	0.0651	-5.0	0.0	120.3	0.0	0.0	0.0	120.4	0.0
59	10	0.0764	-5.0	0.0	120.4	0.0	0.0	0.0	120.9	0.0
59	11	0.0568	-5.0	0.0	120.0	0.0	0.0	0.0	120.0	0.0
59	12	0.0513	-2.5	123.6	121.0	124.5	0.0	0.0	121.4	0.0
59	13	0.0609	-2.5	0.0	120.3	123.5	0.0	0.0	121.7	0.0
59	14	0.0692	-2.5	0.0	120.5	0.0	0.0	0.0	120.7	0.0
59	15	0.0811	-2.5	123.3	120.4	123.8	0.0	0.0	121.1	0.0
59	16	0.0520	-7.5	0.0	119.1	0.0	0.0	0.0	120.1	0.0
59	17	0.0711	-7.5	0.0	119.6	0.0	0.0	0.0	120.8	0.0
59	18	0.0770	-7.5	0.0	119.0	0.0	0.0	0.0	121.3	0.0

Table B3. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
23	3	-0.0091	0.0	106.6	109.7	107.2	106.6	108.4	110.5	110.1
23	4	0.0129	0.0	107.4	107.8	107.5	105.5	107.2	109.6	109.9
23	5	0.0349	0.0	106.0	108.2	105.8	106.0	107.8	109.4	106.7
23	6	0.0584	0.0	108.1	108.4	108.0	106.3	0.0	109.3	106.7
23	7	0.0808	0.0	108.8	112.0	108.9	107.8	0.0	112.0	107.6
23	8	0.1037	0.0	111.3	116.8	111.2	112.1	0.0	114.6	112.1
23	9	0.1149	0.0	114.4	0.0	114.6	114.9	114.5	117.5	114.1
23	10	0.1253	0.0	117.0	0.0	117.0	117.1	117.1	119.5	116.8
23	11	0.1344	0.0	119.5	0.0	118.9	120.0	119.5	0.0	0.0
23	12	0.1374	0.0	120.9	122.5	0.0	120.7	0.0	123.5	0.0
23	13	0.0266	-2.5	106.2	107.7	106.2	104.4	109.2	107.6	105.4
23	14	0.0485	-2.5	105.1	108.5	105.5	103.6	0.0	108.0	103.2
23	15	0.0731	-2.5	105.6	111.4	106.3	104.5	0.0	108.4	104.3
23	16	0.0955	-2.5	108.4	112.0	107.3	107.8	0.0	110.4	107.2
23	17	0.1172	-2.5	107.7	113.2	107.9	108.9	0.0	111.7	111.4
23	18	0.1263	-2.5	112.7	0.0	112.4	112.4	0.0	115.3	113.7
23	19	0.1288	-2.5	116.4	0.0	115.2	115.5	0.0	0.0	116.9
23	20	-0.0043	0.0	116.4	0.0	115.2	115.5	0.0	0.0	116.9

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
23	21	-0.0050	0.0	102.1	105.5	102.2	102.3	0.0	105.9	101.5
23	22	0.0423	-5.0	104.7	107.3	104.3	102.8	0.0	106.5	102.7
23	23	0.0647	-5.0	105.4	107.7	104.3	103.0	0.0	108.6	105.7
23	24	0.0878	-5.0	104.3	107.7	103.3	107.2	0.0	109.1	107.8
23	25	0.1094	-5.0	104.9	110.0	104.3	105.8	0.0	110.6	109.8
23	26	0.1182	-5.0	106.9	112.1	106.1	105.4	0.0	110.8	110.1
23	27	0.1248	-5.0	110.4	112.7	109.9	107.9	0.0	111.9	112.3
23	28	0.0256	10.0	107.5	105.5	107.3	104.1	112.2	108.8	108.9
23	29	0.0468	10.0	107.3	106.1	107.2	104.0	110.1	109.2	108.4
23	30	0.0683	10.0	109.1	107.2	108.8	105.0	114.0	109.3	109.0
23	31	0.0907	10.0	109.0	108.1	108.7	106.3	112.0	110.6	109.2
23	32	0.1141	10.0	109.3	109.6	109.1	107.0	114.0	112.6	110.2
23	33	0.1362	10.0	110.5	109.8	110.0	108.1	114.5	112.5	111.0
23	34	0.1454	10.0	108.9	110.4	109.1	107.9	113.5	111.4	109.7

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
24	3	0.0013	0.0	112.1	112.6	111.5	110.5	0.0	114.7	113.1
24	4	0.0108	0.0	110.9	111.8	111.2	110.1	0.0	113.8	111.3
24	5	0.0327	0.0	110.8	111.0	110.3	108.9	0.0	112.1	110.6
24	6	0.0538	0.0	110.2	111.3	110.2	109.1	0.0	111.9	108.5
24	7	0.0751	0.0	109.9	111.6	110.5	109.5	0.0	112.1	108.8
24	8	0.0969	0.0	111.1	113.0	111.2	110.1	0.0	113.9	111.0
24	9	0.1055	0.0	113.3	116.0	112.6	112.5	0.0	115.8	114.2
24	10	0.1148	0.0	114.9	118.0	115.5	115.1	0.0	117.6	0.0
24	11	0.1208	0.0	118.3	120.6	117.6	117.2	0.0	120.2	119.4
24	12	0.0271	7.5	112.6	111.7	112.4	110.0	0.0	114.5	111.5
24	13	0.0463	7.5	112.1	111.5	111.4	109.8	0.0	113.5	110.7
24	14	0.0667	7.5	112.2	111.7	111.9	109.8	0.0	113.7	110.7
24	15	0.0859	7.5	111.0	111.1	111.3	109.3	0.0	112.5	110.3
24	16	0.1066	7.5	111.3	110.9	111.3	109.5	0.0	112.9	109.4
24	17	0.1156	7.5	111.1	111.9	111.2	109.7	0.0	112.7	109.3
24	18	0.1231	7.5	110.9	112.4	111.1	109.7	0.0	112.8	109.5
25	3	0.0505	-5.0	108.0	109.0	108.6	107.4	0.0	110.3	106.3
25	4	0.0729	-5.0	107.6	108.8	109.4	107.2	0.0	111.6	107.1

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/DR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
25	5	0.0921	-5.0	107.8	109.8	110.0	106.9	0.0	111.6	110.2
25	6	0.1014	-5.0	108.4	110.8	109.2	106.9	0.0	113.2	110.6
25	7	0.1050	-5.0	109.2	111.9	110.4	108.2	0.0	114.3	113.6
25	8	0.0504	-10.0	108.3	112.2	109.1	106.0	0.0	110.7	109.1
25	9	0.0611	-10.0	107.3	110.8	108.2	106.3	0.0	110.4	109.5
25	10	0.0710	-10.0	107.6	112.2	108.3	105.7	0.0	110.7	110.5
25	11	0.0812	-10.0	108.5	112.3	108.3	106.1	0.0	111.2	110.0
26	3	0.0836	-5.0	108.4	110.4	108.6	106.1	0.0	110.1	108.7
26	4	0.0495	-7.5	107.9	112.5	108.0	108.8	0.0	109.1	107.4
26	5	0.0610	-7.5	107.7	112.0	108.8	106.3	0.0	109.1	107.6
26	6	0.0816	-7.5	108.7	109.7	108.7	107.1	0.0	110.7	109.7
26	7	0.0913	-7.5	108.5	110.3	108.8	106.4	0.0	110.5	109.5
26	8	0.0997	-7.5	108.0	110.7	109.2	107.9	0.0	112.2	113.5
26	9	0.1046	-7.5	110.1	114.4	111.1	108.6	0.0	115.1	116.9
28	3	0.0652	-2.5	108.1	108.1	108.8	107.0	0.0	110.6	111.1
28	4	0.0692	-2.5	108.1	108.1	108.8	107.0	0.0	110.6	111.1
28	5	0.0568	-2.5	107.2	109.0	108.4	107.4	0.0	110.0	110.6
28	6	0.0805	-2.5	108.7	110.2	108.7	107.3	0.0	110.6	109.8

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
28	7	0.0686	-2.5	108.8	110.1	109.3	108.9	0.0	109.8	110.4
28	8	0.0680	-2.5	108.2	109.8	108.2	106.7	0.0	111.0	109.6
28	9	0.0693	-2.5	107.7	110.2	108.1	106.0	0.0	111.3	110.4
28	12	0.0659	-2.5	107.9	109.6	107.5	105.6	0.0	111.0	109.4
28	13	0.0553	-4.5	108.3	108.3	108.7	106.3	0.0	110.1	110.3
28	14	0.0797	-0.5	108.6	109.9	108.7	107.1	0.0	109.9	108.7

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLP/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
25	12	-0.0084	0.0	115.8	117.2	116.5	114.5	0.0	118.9	116.1
25	13	0.0102	0.0	116.4	116.4	116.7	113.1	0.0	117.3	114.9
25	14	0.0298	0.0	114.9	114.2	115.0	112.9	0.0	116.5	114.3
25	15	0.0490	0.0	114.8	114.0	115.0	112.9	0.0	117.2	113.7
25	16	0.0675	0.0	114.8	114.3	115.2	113.2	0.0	116.6	114.4
25	17	0.0849	0.0	114.4	114.5	115.0	112.9	0.0	116.3	113.7
25	18	0.0933	0.0	114.9	114.8	114.9	112.9	0.0	116.9	115.2
25	19	0.1009	0.0	114.9	115.2	115.5	113.7	0.0	118.3	115.9
26	10	0.0496	-5.0	114.0	115.8	114.6	112.4	0.0	116.1	112.9
26	11	0.0588	-5.0	113.8	115.6	114.7	112.0	0.0	116.4	113.4
26	12	0.0774	-5.0	114.4	124.9	114.9	111.8	0.0	117.2	114.1
26	13	0.0871	-5.0	114.5	116.5	114.8	112.3	0.0	117.4	117.3
26	14	0.0423	-10.0	113.1	113.5	114.4	111.8	0.0	115.6	113.7
26	15	0.0524	-10.0	114.1	114.1	115.1	112.1	0.0	116.6	112.7
26	16	0.0604	-10.0	113.9	114.3	114.4	111.5	0.0	117.7	114.0
26	17	0.0707	-10.0	115.3	115.1	115.4	112.3	0.0	117.5	116.5
26	18	-0.0031	0.0	100.9	105.0	101.9	102.0	0.0	105.5	102.1
26	19	0.0757	-10.0	114.1	114.6	114.9	111.3	0.0	117.1	115.1

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
26	20	0.0244	6.0	114.8	114.9	115.5	112.8	0.0	117.6	114.4
26	21	0.0430	6.0	114.5	114.2	114.8	112.6	0.0	116.4	114.5
26	22	0.0516	6.0	114.1	114.1	114.7	112.2	0.0	116.2	114.0
26	23	0.0609	6.0	114.0	113.9	114.6	112.4	0.0	116.0	113.0
26	24	0.0692	6.0	114.3	114.1	114.6	112.2	0.0	116.2	113.6
26	25	0.0769	6.0	114.0	113.6	114.7	112.3	0.0	116.0	113.0
26	26	0.0849	6.0	113.7	114.3	114.4	112.0	0.0	115.8	112.1
30	10	0.0699	-4.2	113.1	114.8	113.5	111.2	0.0	115.7	117.6
30	11	0.0702	-4.2	114.2	115.2	114.5	111.5	0.0	115.6	117.5
30	12	0.0564	-4.2	113.7	113.9	113.8	111.2	0.0	116.0	115.0
30	13	0.0870	-4.2	114.0	115.6	113.9	111.9	0.0	116.4	116.5
30	14	0.0724	-4.2	114.3	116.2	114.0	111.8	0.0	116.7	116.8
30	15	0.0707	-4.2	113.5	114.8	113.8	111.2	0.0	115.5	117.6
30	16	0.0716	-4.2	115.1	115.5	114.5	112.0	0.0	116.3	116.1
30	17	0.0983	-4.2	114.9	116.5	115.3	113.2	0.0	117.2	118.7
30	18	0.0385	-4.2	113.2	114.8	113.6	111.5	0.0	115.1	115.6
30	19	0.0849	-2.2	113.2	114.8	113.6	111.5	0.0	115.1	115.6
30	20	0.0533	-6.2	114.0	115.0	114.4	112.4	0.0	117.9	116.4

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
30	21	0.0723	-4.2	114.7	114.6	114.9	112.4	0.0	118.4	117.6
30	22	0.0734	-4.2	114.6	114.9	115.0	112.9	0.0	118.7	117.4
30	23	0.0717	-4.2	115.5	116.1	115.1	112.1	0.0	118.3	116.7
30	24	0.0723	-4.2	114.8	116.1	114.8	112.1	0.0	117.7	117.2
30	25	0.0723	-4.2	114.5	115.7	113.9	112.4	0.0	117.7	116.8
30	26	0.0711	-4.2	114.3	116.1	115.1	112.6	0.0	118.1	117.6
32	3	0.0232	6.0	114.7	114.7	115.2	113.3	111.8	117.5	115.0
32	4	0.0410	6.0	116.0	115.5	116.1	113.0	111.4	117.2	113.9
32	5	0.0520	6.0	114.1	114.4	114.9	113.0	111.0	116.8	114.0

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 170.0 MAT= 0.940 MTIP= 0.685 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
57	8	0.0383	-5.0	114.1	114.4	114.9	113.0	111.0	116.8	114.0
58	3	0.0384	-5.0	0.0	118.4	0.0	0.0	0.0	119.9	0.0
58	4	0.0574	-5.0	0.0	118.9	0.0	0.0	0.0	119.8	0.0
58	5	0.0696	-5.0	123.8	118.2	125.2	126.6	0.0	119.3	124.0
58	6	0.0778	-5.0	122.0	118.2	123.7	125.0	0.0	119.4	123.1
58	7	0.0817	-5.0	122.8	118.2	124.1	125.5	132.9	119.0	122.7
58	8	0.0514	-2.5	121.7	120.4	123.4	125.3	133.9	120.6	122.9
58	9	0.0605	-2.5	121.7	119.5	122.8	125.0	0.0	120.1	123.6
58	11	0.0706	-2.5	120.2	119.6	120.6	122.8	131.2	119.9	120.9
58	12	0.0780	-2.5	121.1	119.4	121.9	124.6	132.6	119.8	122.1
58	15	0.0536	-7.5	124.8	117.5	126.9	126.7	0.0	118.7	124.8
58	16	0.0691	-7.5	124.1	118.0	126.0	126.1	0.0	118.9	124.1

Table B3. continued. Acoustic dBA Measurements for the Tapered Tip Rotor.

TAPERED TIP V= 175.0 MAT= 0.965 MTIP= 0.700 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
58	17	0.0478	-7.5	130.6	119.2	132.1	131.0	0.0	121.2	129.7
58	18	0.0700	-7.5	130.0	119.3	130.7	130.2	0.0	121.3	129.9
58	19	0.0560	-5.0	130.2	120.8	131.1	131.2	0.0	122.1	129.3
58	20	0.0658	-5.0	129.7	121.5	131.0	131.0	0.0	121.6	129.0
58	21	0.0762	-5.0	130.6	122.2	131.1	131.4	0.0	123.7	129.1
58	22	0.0846	-5.0	129.3	121.5	130.5	130.5	0.0	122.9	129.0
58	23	0.0522	-2.5	129.0	0.0	129.5	130.5	0.0	123.9	128.5
58	24	0.0686	-2.5	129.2	124.0	130.0	130.7	0.0	123.0	128.8
58	26	0.0783	-2.5	127.9	122.7	129.0	130.6	0.0	123.1	128.0

Table B4. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
39	3	0.0270	-2.5	102.7	105.8	103.0	102.5	0.0	106.7	102.8
39	4	0.0498	-2.5	102.2	106.6	102.6	102.4	0.0	106.2	102.3
39	5	0.0737	-2.5	104.5	109.2	104.9	104.1	0.0	107.5	102.9
39	6	0.0953	-2.5	104.8	110.9	104.2	106.4	0.0	109.7	104.7
39	7	0.1075	-2.5	104.5	111.3	105.8	106.7	0.0	109.6	106.0
39	8	0.1174	-2.5	105.8	111.8	106.6	107.2	0.0	110.4	107.2
39	9	0.0409	-5.0	100.6	106.7	102.5	102.3	0.0	105.0	102.3
39	10	0.0634	-5.0	101.3	108.4	102.7	104.8	0.0	105.8	100.7
39	11	0.0891	-5.0	103.9	105.8	102.4	103.9	0.0	107.1	104.8
39	12	0.1099	-5.0	105.4	107.7	105.3	105.3	0.0	108.4	104.2
39	13	0.1176	-5.0	104.1	110.9	105.1	105.1	0.0	109.7	107.2
39	14	-0.0055	0.0	101.0	105.8	101.9	102.1	0.0	105.6	101.6
39	15	-0.0102	0.0	104.7	108.7	105.2	104.3	0.0	109.6	106.6
39	16	0.0109	0.0	104.0	106.3	104.3	103.6	0.0	107.0	103.5
39	17	0.0347	0.0	104.3	108.4	104.4	104.0	0.0	108.5	104.1
39	18	0.0586	0.0	104.4	108.1	104.7	104.8	0.0	108.1	103.7
39	19	0.0798	0.0	107.5	112.5	108.4	108.0	0.0	111.7	105.9
39	20	0.1050	0.0	111.3	0.0	112.4	112.9	0.0	116.7	111.8

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 80.0 MAT= 0.720 MTIP= 0.600 V/OR= 0.200

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
39	21	0.1152	0.0	113.6	0.0	113.7	115.0	0.0	118.7	114.0
39	22	0.1248	0.0	115.8	0.0	116.7	116.4	0.0	0.0	114.8
39	23	0.0465	10.0	105.8	105.5	106.3	103.5	0.0	107.8	101.2
39	24	0.0688	10.0	105.9	105.7	106.0	104.0	0.0	107.9	102.5
39	25	0.0902	10.0	106.3	107.0	106.6	104.9	0.0	108.5	103.6
39	26	0.1131	10.0	108.2	109.4	108.3	106.9	0.0	112.0	104.9
39	27	0.1370	10.0	109.4	109.7	109.7	108.9	0.0	112.0	106.6
39	28	0.1449	10.0	107.8	110.6	108.1	108.1	0.0	110.9	107.5
39	29	0.0248	10.0	104.0	104.7	104.7	102.7	0.0	107.0	101.8

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/OR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
40	3	0.0293	-5.0	108.0	109.9	108.5	106.7	0.0	111.0	105.7
40	4	0.0498	-5.0	107.7	108.9	108.8	107.1	0.0	110.5	105.8
40	5	0.0717	-5.0	107.1	110.0	108.5	106.8	0.0	110.4	105.8
40	6	0.0910	-5.0	107.3	112.0	108.4	106.8	0.0	110.5	106.4
40	7	0.1001	-5.0	108.0	112.3	109.4	107.4	0.0	111.8	106.9
40	8	0.1074	-5.0	108.9	112.5	109.9	108.7	0.0	112.6	109.2
40	9	0.0263	-10.0	106.9	110.0	108.0	105.9	0.0	110.8	105.4
40	10	0.0481	-10.0	106.9	111.3	108.2	106.8	0.0	110.1	105.9
40	11	0.0695	-10.0	106.7	110.2	107.9	105.9	0.0	110.1	106.3
40	12	0.0887	-10.0	107.7	110.7	107.9	106.7	0.0	110.9	107.1
40	13	0.0984	-10.0	107.5	111.4	109.1	107.4	0.0	111.8	106.2
40	14	-0.0103	0.0	110.6	113.2	111.0	109.9	0.0	113.8	109.8
40	15	0.0115	0.0	109.5	112.0	110.2	109.3	0.0	112.7	108.0
40	16	0.0350	0.0	108.9	110.8	109.5	108.6	0.0	111.7	107.3
40	17	0.0550	0.0	109.1	111.3	109.7	108.6	0.0	112.5	108.8
40	18	0.0764	0.0	109.5	112.1	109.8	109.1	0.0	112.2	108.8
40	19	0.0951	0.0	111.3	113.7	111.3	110.2	0.0	114.8	109.8
40	20	0.1143	0.0	114.1	116.3	114.5	114.3	0.0	116.2	0.0

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/DR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
40	21	0.1207	0.0	116.5	119.1	117.0	115.9	0.0	118.8	115.8
41	3	0.0196	6.0	105.6	108.9	106.5	105.1	0.0	109.4	107.6
41	4	0.0422	6.0	108.8	110.5	109.3	108.6	0.0	112.1	107.5
41	5	0.0628	6.0	108.7	110.4	109.2	108.2	0.0	111.6	107.4
41	6	0.0819	6.0	109.0	110.4	109.5	108.2	0.0	111.9	107.5
41	7	0.1043	6.0	108.6	110.2	109.0	108.1	0.0	111.4	107.6
41	8	0.1128	6.0	108.8	110.7	109.5	108.6	0.0	111.6	108.2
41	9	0.1202	6.0	109.3	111.5	109.9	109.8	0.0	112.2	109.0
42	3	0.0696	-2.5	108.8	110.3	108.7	107.7	0.0	111.2	106.4
42	4	0.0690	-2.5	108.5	109.9	108.4	107.1	0.0	111.2	106.6
42	5	0.0575	-2.5	108.1	109.6	107.6	107.3	0.0	110.3	106.6
42	6	0.0849	-2.5	108.8	111.5	109.1	107.9	0.0	111.2	108.4
42	7	0.0702	-2.5	107.8	110.1	108.3	107.1	0.0	110.9	108.1
42	8	0.0692	-2.5	107.2	109.8	108.8	106.7	0.0	110.0	106.5
42	9	0.0706	-2.5	108.2	109.5	108.4	107.4	0.0	111.0	108.0
42	10	0.1003	-2.5	109.6	113.2	110.7	110.0	0.0	113.1	108.4
42	11	0.0360	-2.5	107.3	109.4	108.0	106.8	0.0	110.6	108.0
42	12	0.0694	-2.5	107.2	109.7	108.7	107.6	0.0	111.3	108.2

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 120.0 MAT= 0.780 MTIP= 0.600 V/DR= 0.300

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
42	13	0.1002	-2.5	109.0	113.7	109.5	109.1	0.0	112.9	109.3
42	14	0.0385	-2.5	107.2	108.7	108.1	107.8	0.0	111.2	106.9
42	15	0.0695	-2.5	107.2	109.5	108.9	107.9	0.0	111.5	108.2
42	16	0.0574	-4.5	107.2	108.4	108.3	107.3	0.0	109.9	106.1
42	17	0.0806	-0.5	108.4	110.9	108.8	108.1	0.0	110.8	107.1
42	18	0.0690	-2.5	107.5	110.5	108.1	107.1	0.0	110.8	106.5
42	19	0.0694	-2.5	107.9	110.9	108.4	107.0	0.0	110.4	106.5
42	20	0.0692	-2.5	107.8	110.4	108.2	106.8	0.0	111.7	107.0
42	21	0.0686	-2.5	107.5	110.3	108.4	106.7	0.0	110.0	107.6

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
41	10	0.0505	-5.0	113.0	115.0	113.7	112.1	0.0	115.1	110.9
41	11	0.0508	-5.0	112.9	115.2	113.6	112.1	0.0	115.8	111.3
41	12	0.0620	-5.0	112.6	114.9	113.8	111.6	0.0	115.8	110.6
41	13	0.0801	-5.0	112.3	114.5	113.9	112.1	0.0	115.7	110.9
41	14	0.0877	-5.0	113.2	115.5	114.3	112.0	0.0	116.4	111.2
41	15	0.0946	-5.0	113.2	114.5	114.8	112.5	0.0	117.3	112.0
41	16	0.0320	-10.0	111.7	113.3	112.9	110.9	0.0	115.1	110.6
41	17	0.0553	-10.0	112.4	113.4	113.6	111.2	0.0	115.9	110.3
41	18	0.0720	-10.0	112.9	112.9	113.5	111.2	0.0	115.3	110.5
41	19	0.0760	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	20	-0.0112	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	21	0.0104	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	22	0.0280	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	23	0.0494	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	24	0.0678	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	25	0.0864	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	26	0.0958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	27	0.1023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 150.0 MAT= 0.825 MTIP= 0.600 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
41	28	0.1056	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	24	0.0249	6.0	113.5	114.1	114.4	112.6	0.0	116.7	111.5
42	25	0.0437	6.0	113.4	114.0	114.6	112.2	0.0	116.4	111.3
42	26	0.0620	6.0	113.1	113.9	114.5	112.3	0.0	115.6	111.4
42	27	0.0785	6.0	112.8	114.0	113.9	112.2	0.0	116.1	111.5
42	28	0.0876	6.0	112.8	114.0	114.5	112.0	0.0	115.7	111.3
42	29	0.0967	6.0	112.7	113.8	113.9	112.1	0.0	115.7	111.1
42	30	0.0988	6.0	112.3	113.9	113.8	112.3	0.0	115.9	111.5
45	12	0.0741	-4.6	113.1	116.9	113.5	111.2	124.2	115.1	109.9

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 155.0 MAT= 0.825 MTIP= 0.595 V/DR= 0.390

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
43	3	0.0737	-4.6	115.2	117.8	115.8	113.3	124.6	118.9	111.1
43	4	0.0727	-4.6	115.6	117.6	115.7	113.0	124.4	118.8	110.6
43	5	0.0558	-4.6	115.1	116.7	114.6	112.9	123.5	117.9	110.4
43	6	0.0867	-4.6	115.6	117.6	115.6	113.4	123.9	118.6	111.6
43	7	0.0717	-4.6	115.5	118.6	115.5	113.0	123.4	118.5	111.0
43	8	0.0704	-4.6	115.2	117.5	115.2	113.0	123.4	117.8	110.8
43	9	0.0718	-4.6	115.2	118.2	115.4	113.4	123.5	117.5	110.5
43	10	0.0870	-4.6	114.9	117.9	115.0	113.1	123.5	117.3	111.3
43	11	0.0556	-4.6	114.3	118.0	114.7	112.8	123.2	116.3	110.7
43	12	0.0706	-4.6	114.3	117.8	114.5	112.8	122.4	116.6	110.6
45	3	0.0719	-4.6	0.0	116.5	114.3	112.1	113.9	115.9	110.8
45	4	0.0580	-5.6	113.6	116.2	113.7	111.4	112.8	115.0	110.5
45	6	0.0733	-4.6	113.7	115.3	113.9	112.7	113.9	115.2	111.0
45	7	0.0710	-4.6	113.8	115.0	114.0	111.8	0.0	116.0	111.5
45	8	0.0870	-2.6	114.6	117.2	114.6	112.4	0.0	116.5	111.5
45	9	0.0728	-4.6	114.2	116.4	113.9	111.5	0.0	115.5	116.9
45	10	0.0698	-4.6	114.1	117.2	114.3	112.1	0.0	116.5	110.9
45	11	0.0719	-4.6	114.1	117.0	113.9	111.7	0.0	115.4	110.8

Table B4. continued. Acoustic dBA Measurements for the Rectangular Tip Rotor.

RECTANGULAR TIP V= 175.0 MAT= 0.965 MTIP= 0.700 V/OR= 0.375

RUN	PT	CLR/S	ALPHA	MIC1	MIC2	MIC3	MIC4	MIC5	MIC6	MIC7
46	3	0.0411	-5.0	117.8	118.6	117.0	115.9	121.2	119.2	114.3
46	4	0.0615	-5.0	117.3	119.2	116.9	116.0	120.9	118.9	114.4
46	5	0.0703	-5.0	116.7	118.5	116.5	116.0	120.8	119.2	113.9
46	6	0.0784	-5.0	118.2	118.5	117.6	116.2	120.5	118.6	114.5
46	7	0.0890	-5.0	116.8	118.3	116.4	115.6	120.4	118.8	114.4
46	8	0.0920	-5.0	116.9	118.4	116.4	115.4	120.4	118.9	114.8
46	9	0.0333	-10.0	115.8	114.6	115.3	114.5	119.3	116.3	112.6
46	10	0.0439	-10.0	116.8	114.8	116.8	114.4	119.1	116.4	112.3
46	11	0.0528	-10.0	115.8	114.3	115.4	114.1	118.6	115.9	112.5
46	12	0.0732	-10.0	116.8	115.0	116.5	114.5	118.7	116.4	112.5
46	13	0.0820	-10.0	117.3	115.5	116.8	114.7	118.8	116.9	113.5
46	14	-0.0126	0.0	118.6	119.3	117.7	117.2	121.8	119.7	116.3
46	15	0.0077	0.0	117.9	118.0	117.3	116.5	121.4	118.8	116.1
46	16	0.0275	0.0	118.3	117.5	117.9	116.8	121.2	118.5	115.0
46	17	0.0451	0.0	116.8	116.4	117.0	116.9	121.4	118.0	114.7
46	18	0.0530	0.0	118.1	117.3	117.9	116.6	121.6	118.3	114.4
46	19	0.0521	0.0	117.5	116.6	117.6	116.2	121.6	118.1	114.8
46	20	0.0721	0.0	117.5	116.1	116.4	116.1	121.5	118.3	114.9

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16. Abstract

A full-scale helicopter with four different blade-tip geometries was tested in the 40- by 80-Foot Wind Tunnel at Ames Research Center. Performance, loads, and noise were measured. The four tip shapes tested were rectangular, tapered, swept, and swept-tapered. This report presents noise measurements from that test in the form of tables and plots. The noise data include measurements of the sound pressure level in dB, dBA, and tone-corrected PNdB, for all of the conditions tested. Also included are the detailed measurements, 1/3-octave spectra and time-histories for some selected data, and plots of dBA as function of test condition. Some performance measurements are included to aid interpretation of the noise data.

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