

AD-A046 585

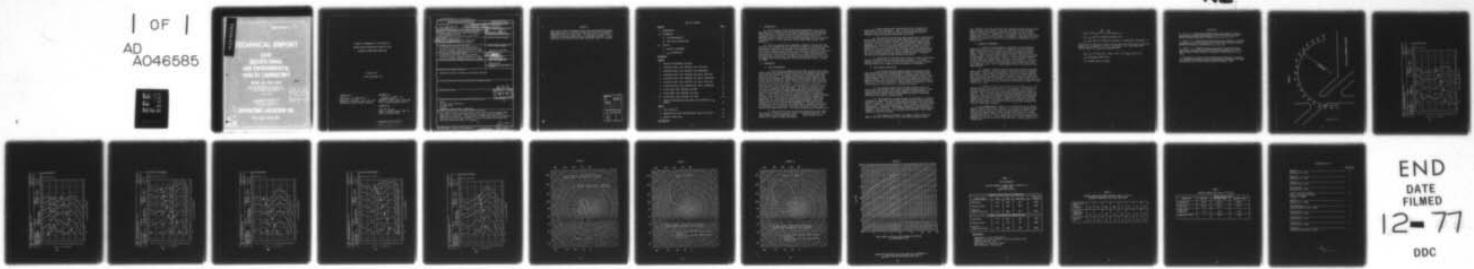
AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LAB --ETC F/G 20/1
ACOUSTIC PERFORMANCE OF THE A/M32A-52 EXHAUST MUFFLER (MODIFIED--ETC(U))
OCT 77 N A FARINACCI

UNCLASSIFIED

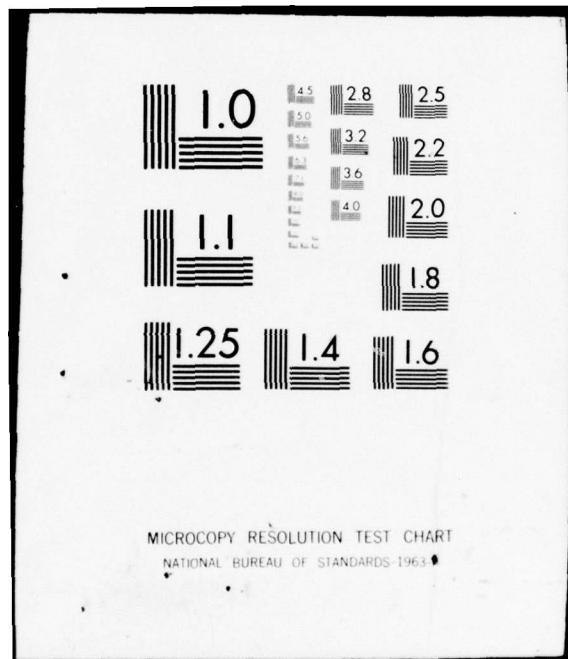
OEHL-OLAA-77-5

NL

| OF |
AD
A046585



END
DATE
FILMED
12-77
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963

AD A046585

Report Number

77-5

TECHNICAL REPORT USAF OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY

BROOKS AFB, TEXAS 78235

ACOUSTIC PERFORMANCE OF THE A/M32A-52
EXHAUST MUFFLER (MODIFIED) DURING KC-135A
AIRCRAFT GROUND RUNUP OPERATION

October 1977

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DDC LIBRARY
NOV 21 1977
FBI - SAN ANTONIO
FBI - SAN ANTONIO

OPERATING LOCATION AA

KELLY AFB, TEXAS 78241

Ref. No. /
AMC FILE COPY

ACOUSTIC PERFORMANCE OF THE A/M32A-52
EXHAUST MUFFLER (MODIFIED) DURING KC-135A
AIRCRAFT GROUND RUNUP OPERATION

October 1977

OL AA USAF OEHL 77-5

PREPARED BY:

Nicholas A. Farinacci
NICHOLAS A. FARINACCI, Capt, USAF, BSC
Consulting Bioenvironmental Engineer

REVIEWED BY:

Shelton R. Birch
SHELTON R. BIRCH, Major, USAF, BSC
Chief, Bioenvironmental Engr Div

APPROVED BY:

Gale D. Taylor
GALE D. TAYLOR, Colonel, USAF, VC
Chief, OL AA USAF OEHL

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER OL AA USAF OEHL-77-5	2. GOVT ACCESSION NO. (14) OEHL-01 MA-77-5	3. RECEIPT DATE & CATALOG NUMBER <i>Jan</i>
4. TITLE (and Subtitle) ACOUSTIC PERFORMANCE OF THE A/M32A-52 EXHAUST MUFFLER (MODIFIED) DURING KC-T35A AIRCRAFT GROUND RUNUP OPERATION.	5. TYPE OF REPORT & PERIOD COVERED TECHNICAL REPORT	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) NICHOLAS A. FARINACCI Capt, USAF, BSC Consulting Bioenvironmental Engineer	8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS OL AA USAF Occupational and Environmental Health Laboratory, Aerospace Medical Division, Air Force Systems Command, Kelly AFB TX 78241	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Special Project 77-4	
11. CONTROLLING OFFICE NAME AND ADDRESS OL AA USAF Occupational and Environmental Health Laboratory, Aerospace Medical Division, Air Force Systems Command, Kelly AFB TX 78241	12. REPORT DATE (11) Oct 1977	13. NUMBER OF PAGES (12) 24 p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASSIFICATION (of this report) UNCLASSIFIED	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES DDC RPG-111111 NOV 21 1977 A		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Noise Aircraft noise suppressors Aircraft noise KC-135A A/M32A-52 Exhaust Muffler (Modified)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report presents processed acoustic data acquired during ground runup operations on a KC-135A aircraft with and without a modified A/M32A-52 engine noise suppressor. The data show a significant reduction in acoustic power levels at high power settings. A short discussion for determining day-night equivalent levels is included.		

ABSTRACT

This report presents processed acoustic data acquired during ground runup operations on a KC-135A aircraft with and without a modified A/M32A-52 engine noise suppressor. The data show a significant reduction in acoustic power levels at high power settings. A short discussion for determining day-night equivalent levels is included.

DISSEMINATION	
NTIS	White Section <input checked="" type="checkbox"/>
DOC	Buff Section <input type="checkbox"/>
UNANNOUNCED <input type="checkbox"/>	
JUSTIFICATION.....	
BY	
DISTRIBUTION/AVAILABILITY CODES	
DIST.	AVAIL. and/or SPECIAL
A	

TABLE OF CONTENTS

<u>SECTION</u>		<u>PAGE</u>
I. INTRODUCTION		1
II. METHODOLOGY		1
A. FIELD MEASUREMENTS		1
B. DATA ANALYSIS/PROCESSING		2
III. RESULTS		3
A. ACOUSTIC PERFORMANCE		3
B. L_{dn} DETERMINATION		3
<u>REFERENCES</u>		<u>5</u>
<u>FIGURES</u>		
1 FAR-FIELD MEASUREMENT LOCATIONS		6
2 A-WEIGHTED EQUAL LEVEL CONTOURS, 80%, FREE FLOW		7
3 A-WEIGHTED EQUAL LEVEL CONTOURS, 80%, SUPPRESSED		8
4 A-WEIGHTED EQUAL LEVEL CONTOURS, MIL (DRY), FREE FLOW		9
5 A-WEIGHTED EQUAL LEVEL CONTOURS, MIL (DRY), SUPPRESSED		10
6 A-WEIGHTED EQUAL LEVEL CONTOURS, MIL (WET), FREE FLOW		11
7 A-WEIGHTED EQUAL LEVEL CONTOURS, MIL (WET), SUPPRESSED		12
8 85 dBA EQUAL LEVEL CONTOURS, 80% RPM		13
9 85 dBA EQUAL LEVEL CONTOURS, MIL (DRY)		14
10 85 dBA EQUAL LEVEL CONTOURS, MIL (WET)		15
11 CHART FOR CONVERTING 85 dBA EQUAL LEVEL CONTOURS TO L_{dn} VALUES		16
<u>TABLES</u>		
1 TEST CONDITIONS		17
2 MAXIMUM OCTAVE BAND SOUND PRESSURE LEVELS AT 250 FEET		18
3 ACOUSTIC POWER LEVEL		19
<u>DISTRIBUTION</u>		

I. INTRODUCTION:

A. At the request of the National Guard Bureau/DEM a joint effort was conducted by personnel from OL AA USAF Occupational and Environmental Health Laboratory, Kelly AFB TX and 6570 Aerospace Medical Research Laboratory/BBE, Wright-Patterson AFB OH to acquire acoustic data on the A/M32A-52 Muffler, Exhaust, Aircraft Ground Runup (Modified) for evaluating the effectiveness of this suppressor during single engine ground runup operations.

B. This is a portable type suppressor, originally designed for use by Tactical Air Command (TAC) on the J57-P-21 engines, and has been modified according to specifications developed by the US Navy for use with their F-8 aircraft, which also use the J57. The modification consists of replacing the original colander with one fabricated of 1/4-inch cold-rolled steel, perforated with 1/4-inch diameter holes so as to remove approximately 30% of the colander surface area. The modification drawings are on file at the 126 Aerial Refueling Wing (ANG)/MA, O'Hare International Airport, Chicago IL 60666.

II. METHODOLOGY:

A. FIELD MEASUREMENTS:

1. Far-field noise produced by a KC-135A aircraft during single engine ground runup operations with and without the suppressor was acquired at 19 locations spaced at 10 degree intervals on a 100 meter (328 feet) semicircle (Figure 1). The center of the semicircle was located on the ground directly beneath the intersection of the aircraft centerline and a plane passing through the exhaust nozzle of the muffler when installed on the inboard engine (#3 engine). The exhaust plane of this same engine was used for un suppressed operation. The aircraft was situated on a black-top apron, while measurement locations were over concrete surfaces; a few (0 to 20 degrees) were over grass. The radius of the semicircle was such to assure that the measurements would be in the acoustic far-field where the sound wave fronts spherically diverge and the noise source is considered a point source. In the far-field, the radiation pattern is well formed, allowing extrapolation of data to greater distances from the source when accounting for geometric dispersion, atmospheric absorption, etc. There were no sound reflecting surfaces within 1000 feet of the aircraft except for ground support equipment, which were positioned so as not to disturb the measurements. The semicircle was oriented such that the nose of the aircraft was at 0 degrees and the tail at 180 degrees, and was placed on the same side of the aircraft (right side) as the engine under test. The aircraft heading was 260 degrees true.

2. Only one side of the aircraft was measured since the radiation pattern is laterally symmetric about the aircraft centerline. Two teams covered the measurement locations, each taking one-half of the semicircle in order to speed data acquisition.

3. Several engine power settings were used to compare the effectiveness of the suppressor. Table 1 lists the engine operating conditions for each power setting used and the average surface meteorological conditions present during data acquisition.

4. The acoustic data were recorded sequentially at each measurement location by the two teams over their respective halves of the semi-circle using modified NAGRA IV portable battery-operated magnetic tape recorders. The Brue & Kjaer (B & K) Type 4133 one-half inch condenser microphone was used with B & K Type 2619 microphone preamplifier and air foam windscreens. Each microphone was mounted on a pole and vertically scanned at a uniform rate from 2 feet to .10 feet above the ground during the 10 second sampling period in order to smooth out interactions between the direct radiated sound and the ground reflected sound. Throughout the scan the microphone was kept pointed at the source.

5. Background noise samples were recorded so these interferences could be eliminated from the test data during analysis. All ground support equipment was turned off during the test and individual sampling was done around local airport activity to minimize interferences.

B. DATA ANALYSIS/PROCESSING:

1. At the 6570 Aerospace Medical Research Laboratory, Biodynamic Environments Branch, Wright-Patterson AFB OH, the recording-playback-analysis system was calibrated over a frequency range of one-third octave bands centered from 25 to 20,000 Hz and corrected to effect a flat system response. These corrections included the response of the microphone and windscreens, accounting for the incidence (perpendicular) of the sound on the microphone diaphragm. Random incidence corrections (instead of perpendicular) were applied to the background samples.

2. The recorded acoustic data was analyzed into one-third octave band sound pressure levels over this same frequency range. These raw data were then processed by digital computer at the Aeronautical Systems Division Computer Center, Wright-Patterson AFB OH, to provide calculated noise data as discussed below.

3. The propagation of sound through the atmosphere is strongly influenced by temperature and relative humidity and to a lesser extent by barometric pressure. Therefore, the data were corrected from field meteorology to standard day meteorology (59°F, 70% rel humidity, and 29.92 in Hg bar pressure). Standard day meteorology represents the average weather conditions found worldwide. The resulting normalized data can be directly compared at the same distance to normalized data obtained at other power settings or from other sources.

4. The accuracy of the data is at least \pm 2 dB in the 25 to 5000 Hz one-third octave bands, and \pm 3 dB, 6300 to 20,000 Hz bands.

III. RESULTS: The final processed data represent expected average levels based on standard day weather. Data were not taken at the 180 degree position during the two unsuppressed military power runs due to high exhaust flow velocity. Usually this is unimportant since the levels are approximately 20 dB less than those at 170 degrees. Other data were either deleted or corrected to account for the proximity of background or electronic noise.

A. ACOUSTIC PERFORMANCE:

1. Table 2, which presents a comparison of this suppressor performance with Grade III residuals in accordance with MIL-N-83155B (USAF) at 250 feet, military power (dry), and at standard day meteorology, indicates that this suppressor does not meet Grade III specifications. However, acoustic power levels allow for a comparison which may be more useful. They are given in Table 3. Notice that the suppressor is not effective at lower exhaust flow rates such as 80% RPM. But at military power the acoustic power reduction is significant, on the order of 19 dB (re 10^{-12} watt) for military power (dry) at which most engine trim operations occur. This is approximately 1/83 of the original sound power emitted.

2. Figures 2 through 7 show extrapolated far-field A-weighted equal level contours of expected average levels calculated for standard day weather. The contours, presented as a function of angle around and far-field distance (in meters) from the aircraft, are in 5 dB steps with every 10 dB step lined in and labeled. Figures 8 through 10 show the 85 dBA butterfly contours for the 80%, military (dry), and military (wet) runs respectively. For brevity only one-half of the butterfly is shown; distance scaling is in feet.

3. Notice in Figure 8 the reversal of the contours, i.e., the suppressed engine being louder from 0 to 110 degrees. An examination of the 80% suppressed raw data indicates a reinforcement of the levels in the upper one-third octave bands, especially those centered on 2000 and 4000 Hz. This is possibly caused by resonances generated by having the suppressor connected, the suppressor not being designed for maximum performance at low exhaust flow rates. Regardless of the cause, the phenomenon appears only in the lower settings (or is masked in the higher ones) and its impact on the contours is very minimal when compared with those at higher power settings.

B. L_{dn} DETERMINATION: Figure 11 is a chart which can be used to convert these 85 dBA butterfly contours to L_{dn} values for daytime (0700 - 2200 hrs) ground runups only, given the total number of similar engine runups during daytime only, and the average runup duration in seconds. For nighttime (2200 - 0700 hrs) runups only, add 10 dB to the L_{dn} value obtained from the chart. Thus a comparison of the relative impact of the daytime and nighttime operations can be obtained. Total L_{dn} may be calculated from:

$$L_{dn} = 10 \log_{10} \left(10^{\frac{L_d}{10}} + 10^{\frac{L_n}{10}} \right), \text{ where eq. 1}$$

L_d = L_{dn} value for daytime operations, and

L_n = L_{dn} value for nighttime operations, as determined from Figure 11.

Besides being a function of runup duration and time of day that the operation occurs, L_{dn} is dependent on level. Accordingly, if a level other than 85 dBA is used, the L_{dn} may be computed from:

$$L_{dn} = L_A + 10 \log_{10} (N_d + 10N_n) - 49.4 + 10 \log_{10} D, \text{ where eq. 2}$$

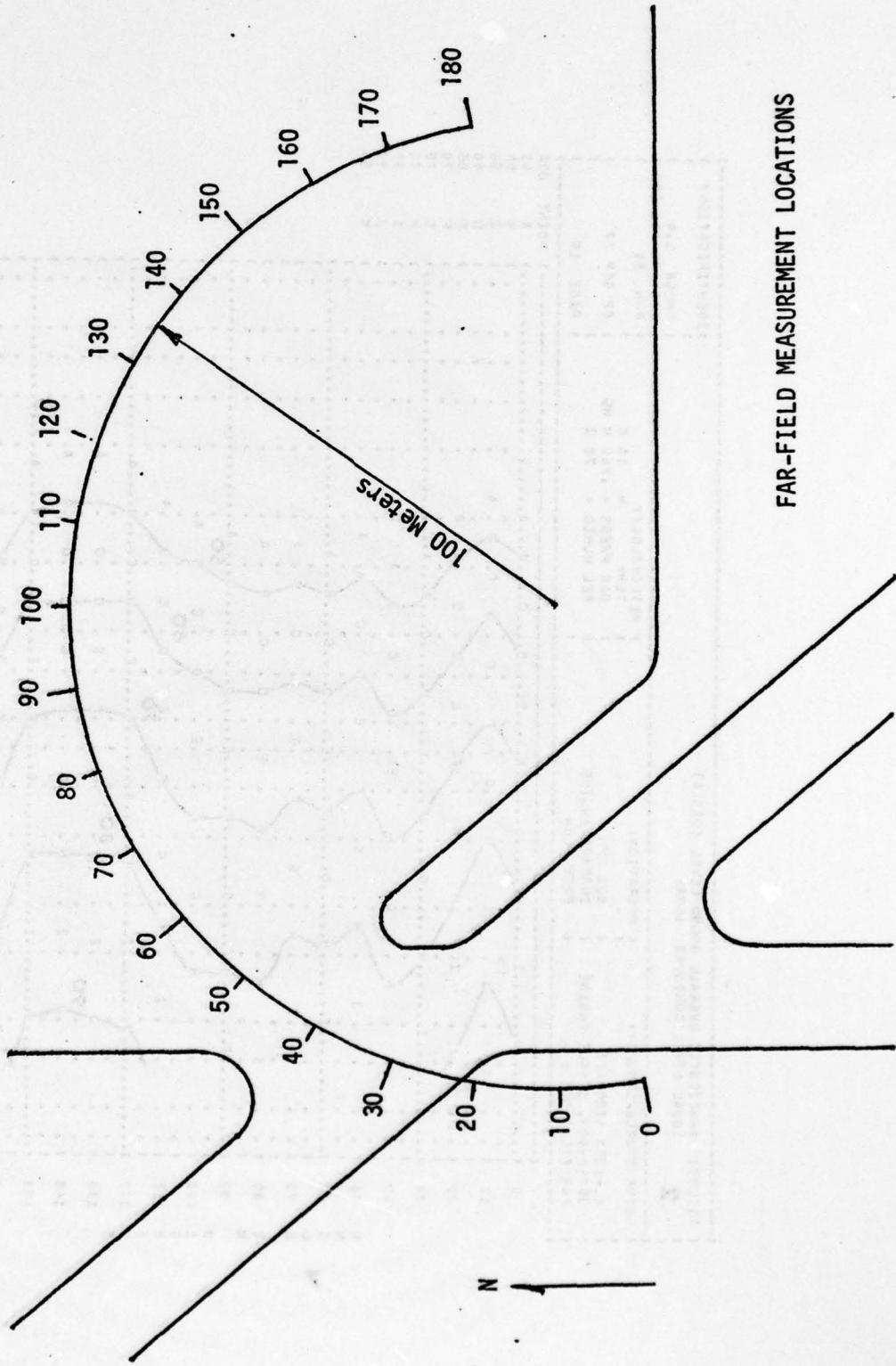
L_A = A-weighted sound level,

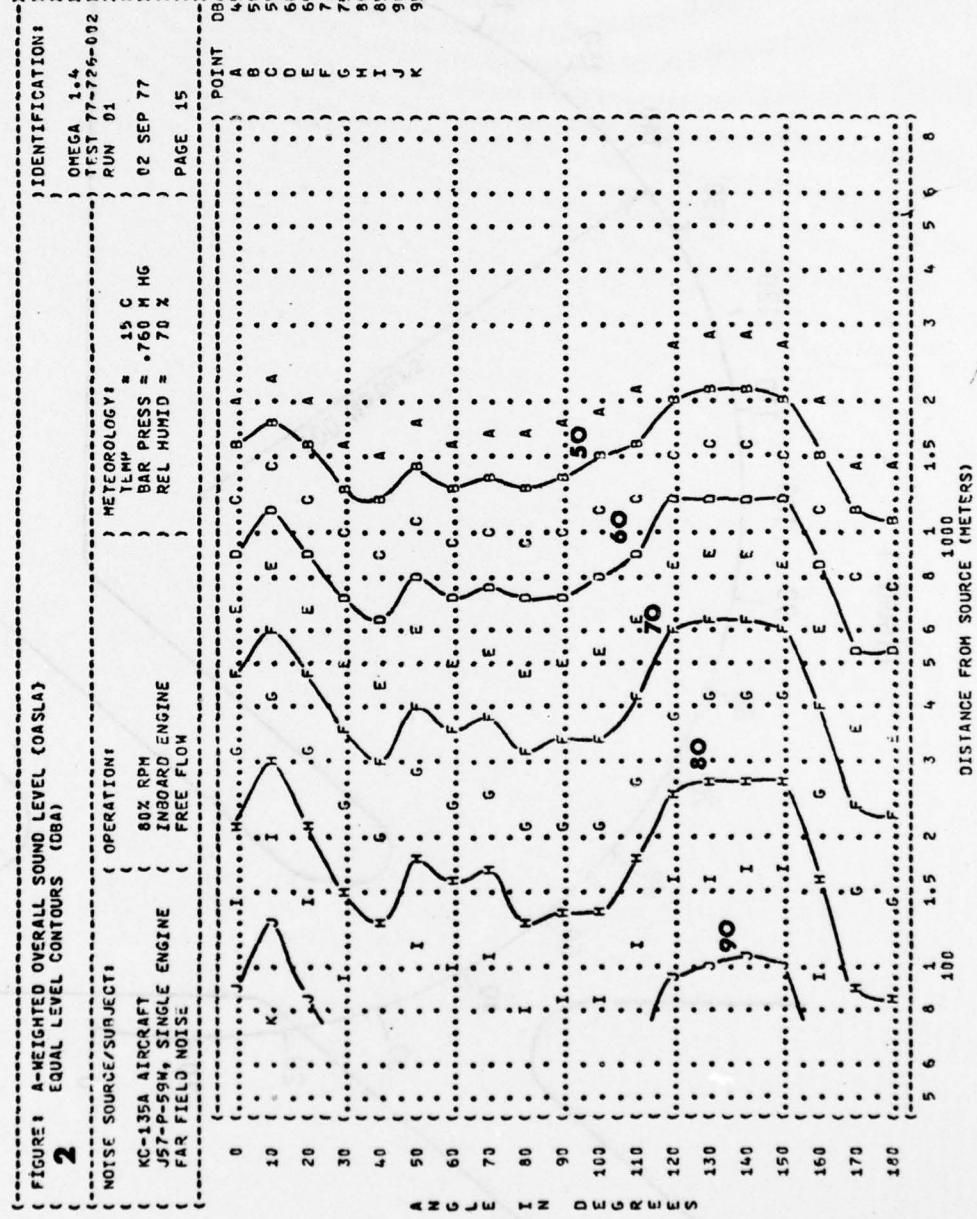
D = average runup in seconds.

REFERENCES

1. Cole, J.N., USAF Bioenvironmental Noise Data Handbook, Volume 1: Organization, Content and Application, AMRL-TR-75-50(1), Aerospace Medical Research Laboratory, Wright-Patterson AFB OH, 1975.
2. Powell, R.G., USAF Bioenvironmental Noise Data Handbook, Volume 83: C-135A Near and Far-Field Noise, AMRL-TR-75-50(83), Aerospace Medical Research Laboratory, Wright-Patterson AFB OH, 1976.
3. Bishop, D.E., Community Noise Exposure Resulting From Aircraft Operations: Application Guide for Predictive Procedure, AMRL-TR-73-105, Aerospace Medical Research Laboratory, Wright-Patterson AFB OH, 1974.
4. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, EPA Report No. 550/9-74-004, US Environmental Protection Agency, 1974.

FIGURE 1





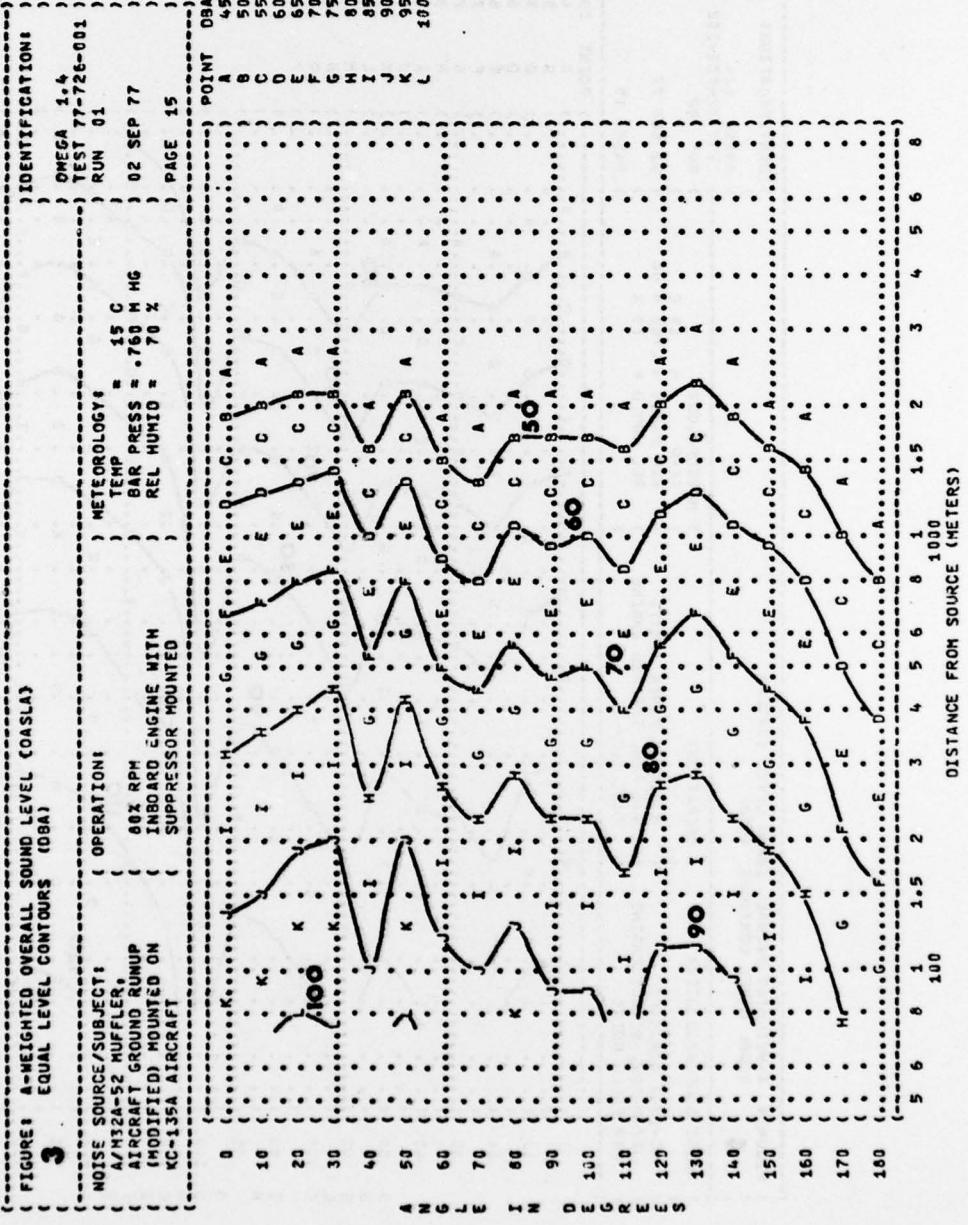


FIGURE 4
A-WEIGHTED OVERALL SOUND LEVEL (DBA)
EQUAL LEVEL CONTOURS

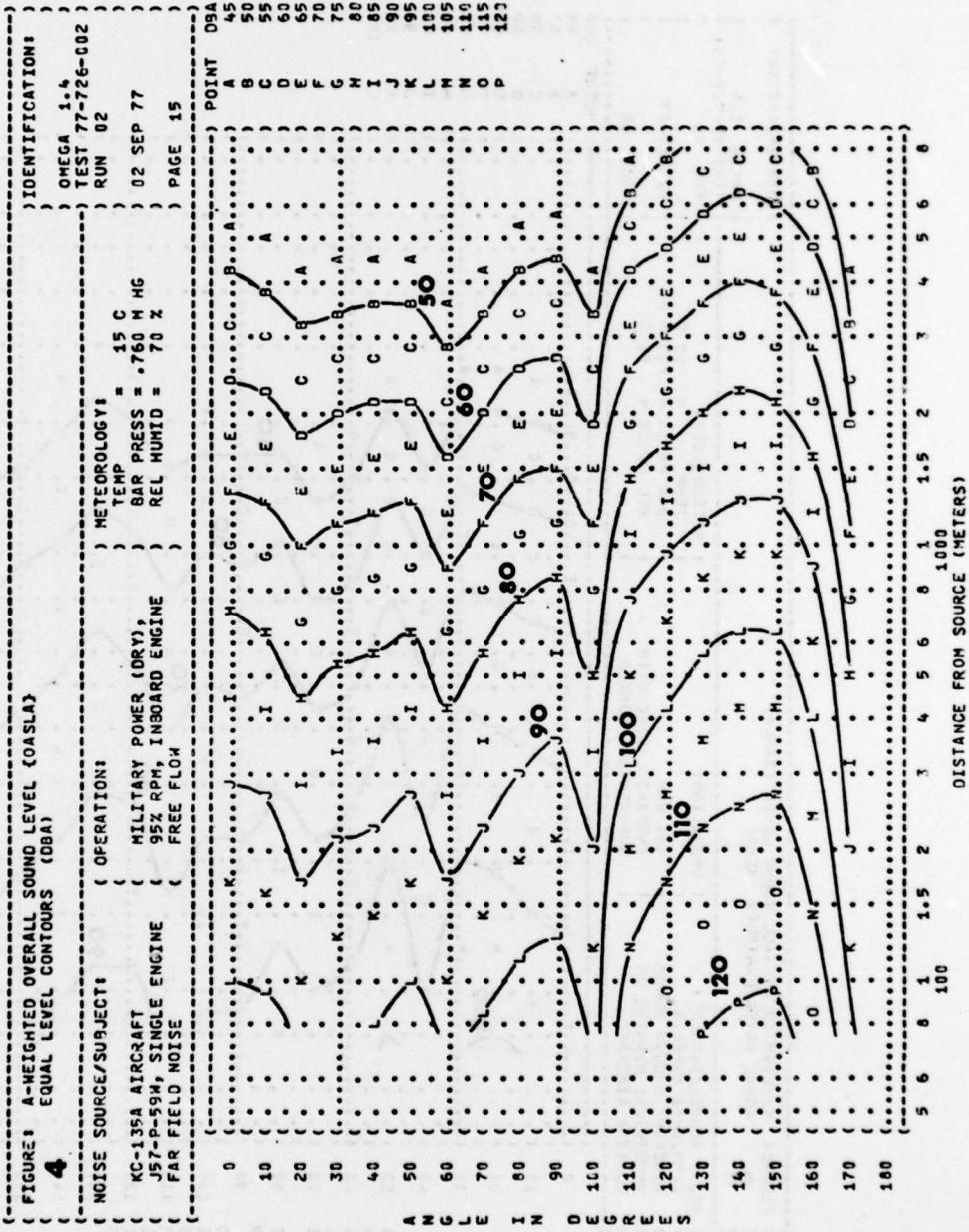


FIGURE 1 A-WEIGHTED OVERALL SOUND LEVEL (OASLA)
EQUAL LEVEL CONTOURS (OBA)

A-WEIGHTED OVERALL SOUND LEVEL

NOISE SOURCE/SUBJECT:
A/MJ2A-52 MUFFLER,
AIRCRAFT GROUND RUN
(MODIFIED) HUNTED
XC-14124-A-10000

NOISE SOURCE/SUBJECT! OPERATION!

NOISE SOURCE/SUBJECT:	OPERATIONS
A/M32-52 MUFFLER,	MILITARY POWER (DRY),
AIRCRAFT GROUND RUNUP	667 RPM. TURBOPROP ENGINE
(MODIFIED) MOUNTED ON	
THE AIRCRAFT	

NOISE SOURCE/SUBJECT:	OPERATION:	METEOROLOGY:
A/M32-52 MUFFLER, AIRCRAFT GROUND RUNUP (IMPROVED) MOUNTED ON MILITARY POWER (DRY), 662 RPM. TURBINE ENGINE	MILITARY POWER (DRY), 662 RPM. TURBINE ENGINE	TEMP = 15 C BAR. PRESS = .760 M H REL. HUMID. = 70 %

NOISE SOURCE/SUBJECT:	OPERATION:	METEOROLOGY:	RUN
A/M321-52 MUFFLER, AIRCRAFT GROUND RUNUP (MODIFIED) MOUNTED ON IMPROVED TIRE	MILITARY POWER (DRY), 667 RPM. TRANSMISSION MOUNTED ON IMPROVED TIRE	TEMP = 15 C BAR PRESS = .760 HG REL HUMID = 70%	02 SEP 77

NOISE SOURCE/SUBJECT:	OPERATION:	METEOROLOGY:
A/M32-52 MUFFLER AIRCRAFT GROUND RUNUP (IMPROVED) MOUNTED ON T-33A/PD FIGHTER	MILITARY POWER (DRY), 96.2 RPM.	TEMP = 15 C BAR PRESS = .760 Hg REL HUMID = 70 %
		RUN 02 02 SEP 77

NOISE SOURCE/SUBJECT: A/M32-52 MUFFLER, AIRCRAFT GROUND RUNUP (IMPROVED) MOUNTED ON TEST SITE //CD-CU1

OPERATION:		METEOROLOGY:	RUN 02
(MILITARY POWER (DRY), 967 RPM, TURBOPROP ENGINES)	(REFL HUMD = .70 %)	TEMP = 15 C ATM PRESS = .760 HG	02 SEP 77

THE JOURNAL OF CLIMATE VOL. 15, NO. 10, OCTOBER 2002

NO. & S/N. MOUNT	WITH SURFACE COIN MOUNTED	PAUL 13	
		POINT	OBA
0	J.....I.....H.....G.....F.....E.....D.....C.....B.....A.....	A	45

The diagram shows a triangular lattice structure with points labeled A through T. The points are arranged in a hexagonal close-packed pattern. Point A is at the top vertex. Points B and C are on the top edge, with B to the left of A and C to the right. Points D and E are on the second row from the top, with D below B and E below C. Points F and G are on the third row from the top, with F below D and G below E. Points H and I are on the fourth row from the top, with H below F and I below G. Points J, K, and L are on the fifth row from the top, with J below H, K below I, and L below G. Points M and N are on the sixth row from the top, with M below K and N below L. Point O is located above point F. Point P is located above point G. Point Q is located above point H.

170
180

FIGURE: A-WEIGHTED OVERALL SOUND LEVEL CONTOURS (DBA)

6
 NOISE SOURCE/SUBJECT: KC-135A AIRCRAFT
 J57-P-59H, SINGLE ENGINE
 FAR FIELD NOISE
 OPERATION: MILITARY POWER (MET),
 96% RPM, INBOARD ENGINE
 FREE FLOW
 METEOROLOGY: TEMP = 15 C
 BAR PRESS = .760 HG
 REL HUMID = 70 %
 TEST 77-726-002
 RUN 03
 02 SEP 77
 PAGE 15

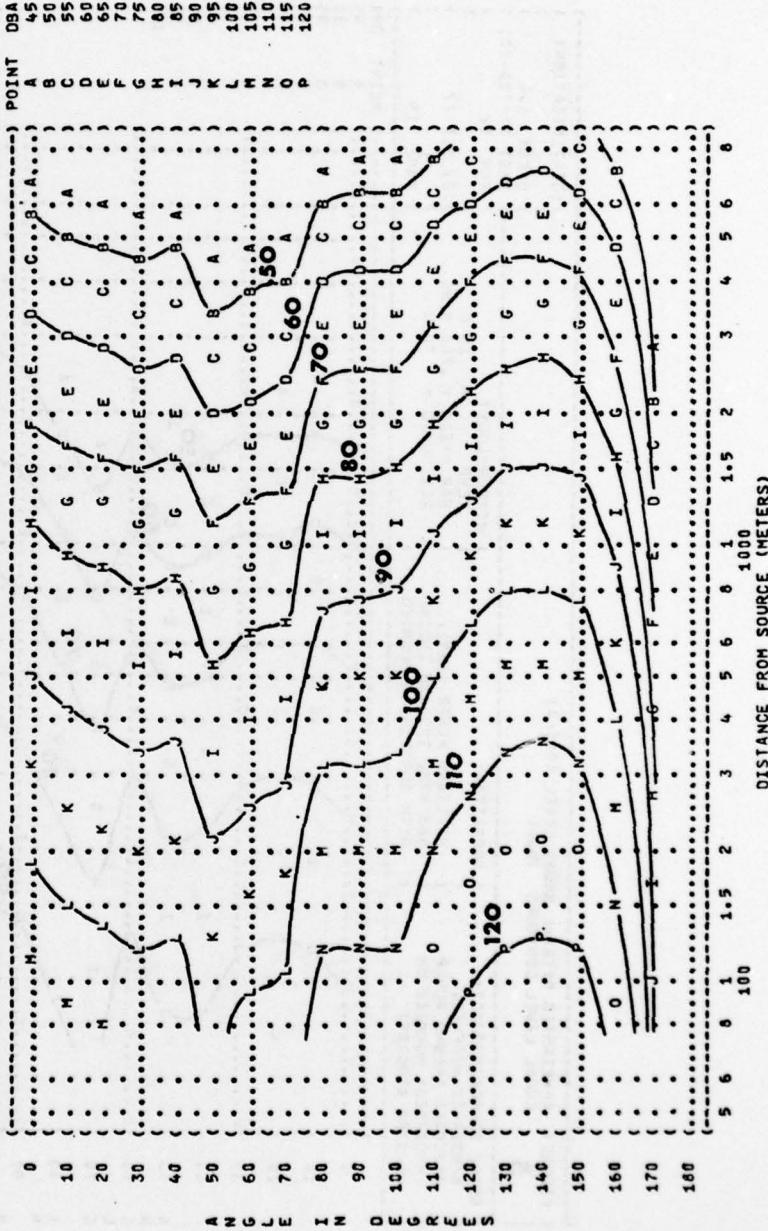


FIGURE 1
A-WEIGHTED OVERALL SOUND LEVEL (DBA)
EQUAL LEVEL CONTOURS

7

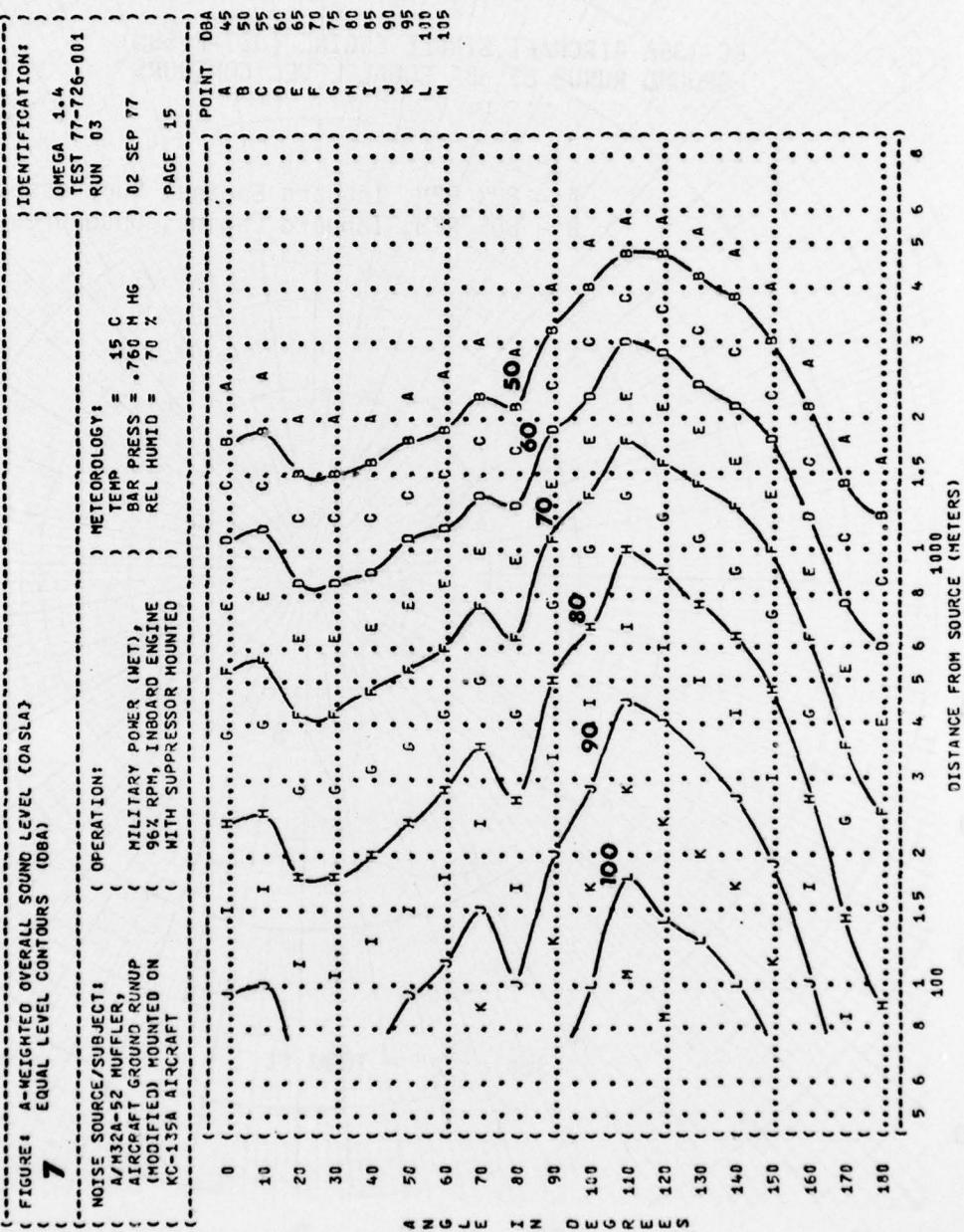


FIGURE 8

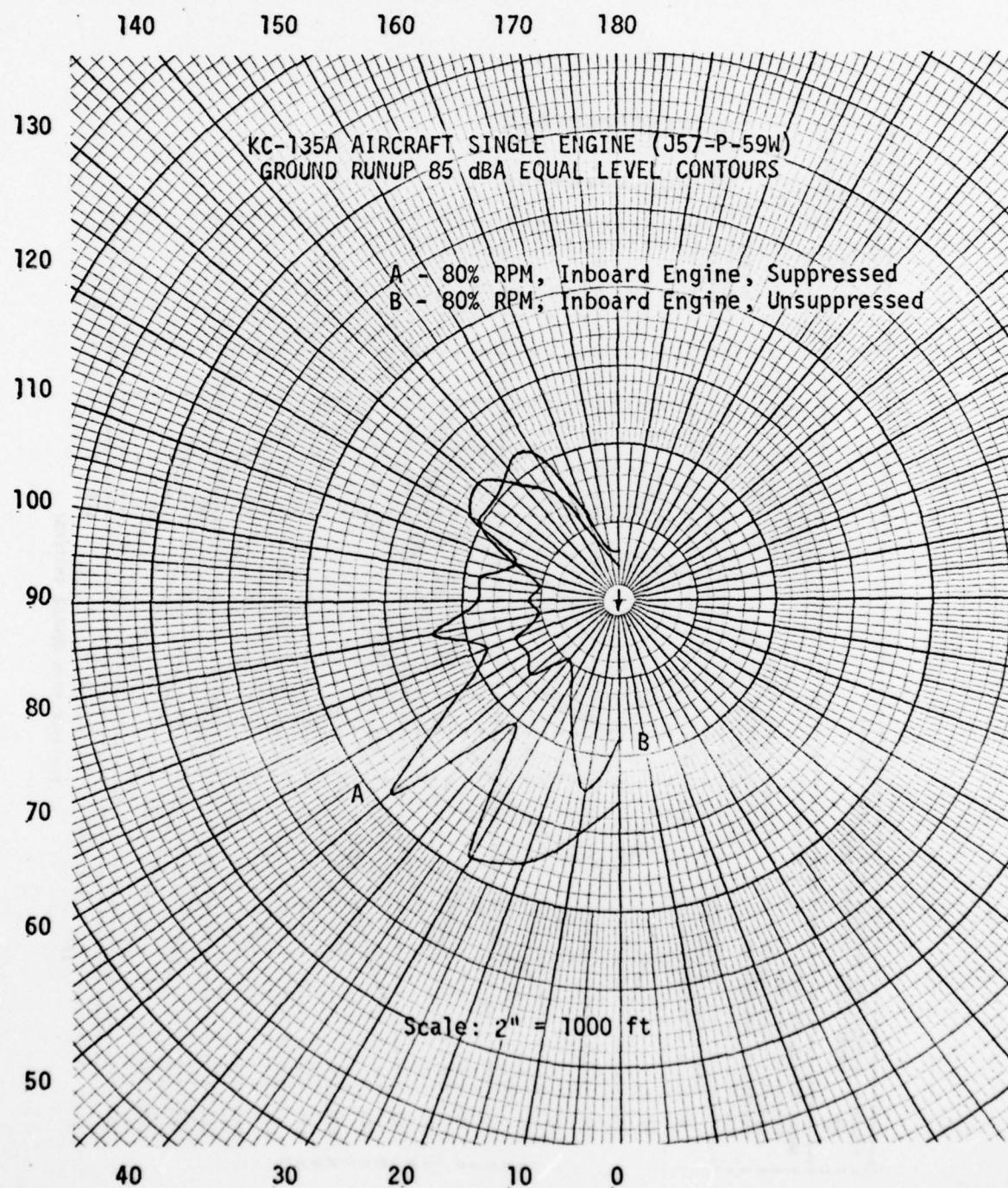


FIGURE 9

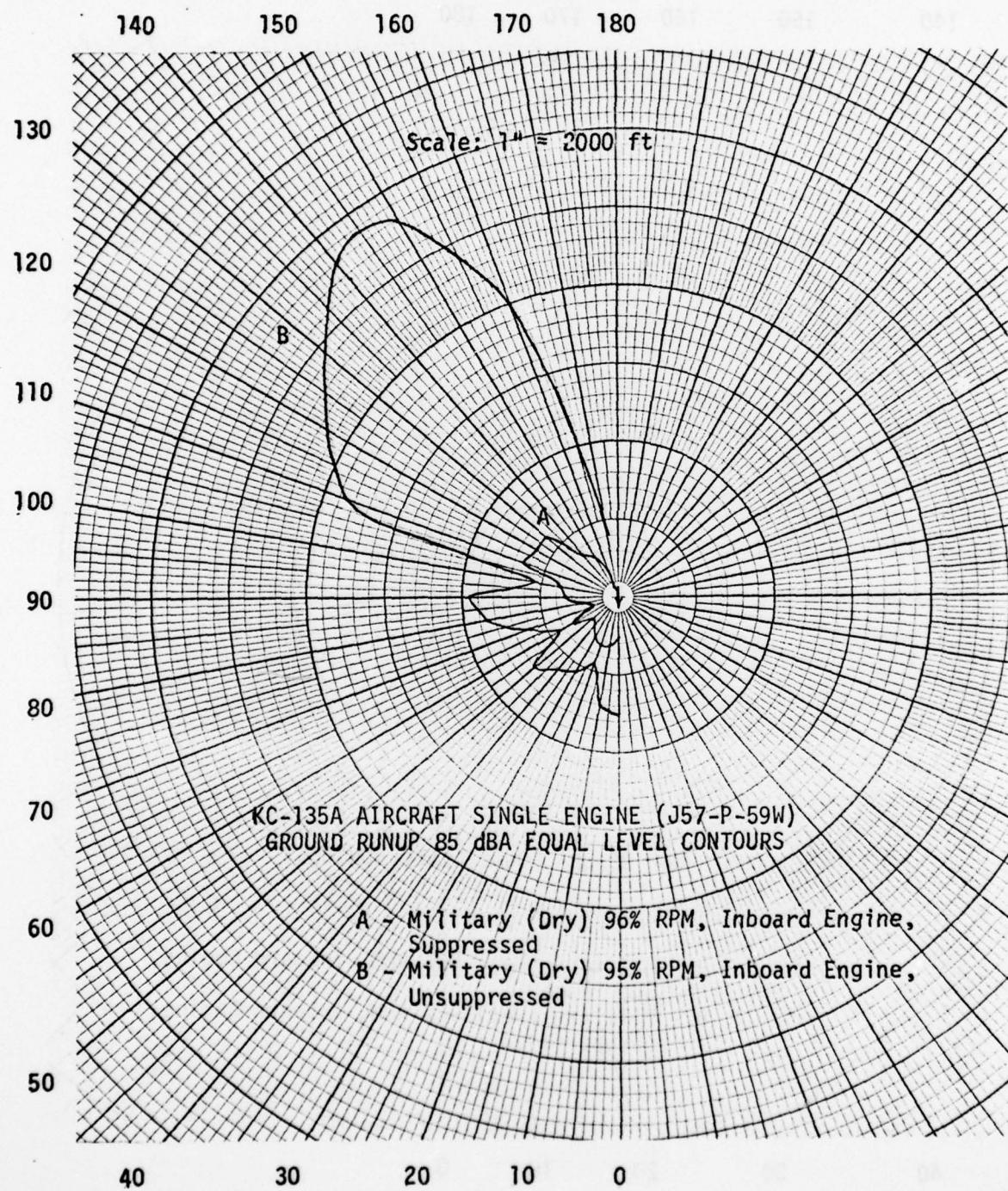


FIGURE 10

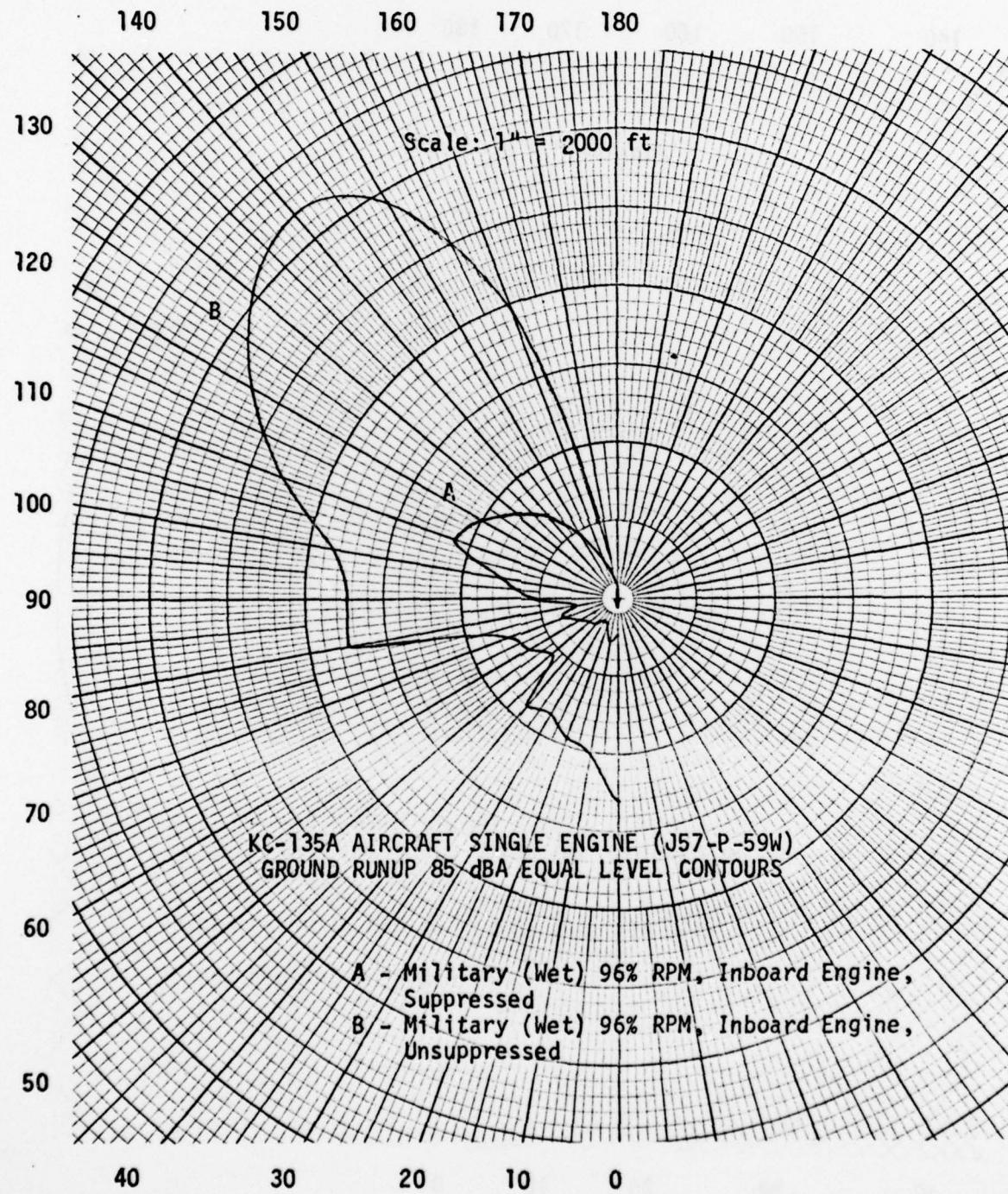


FIGURE 11

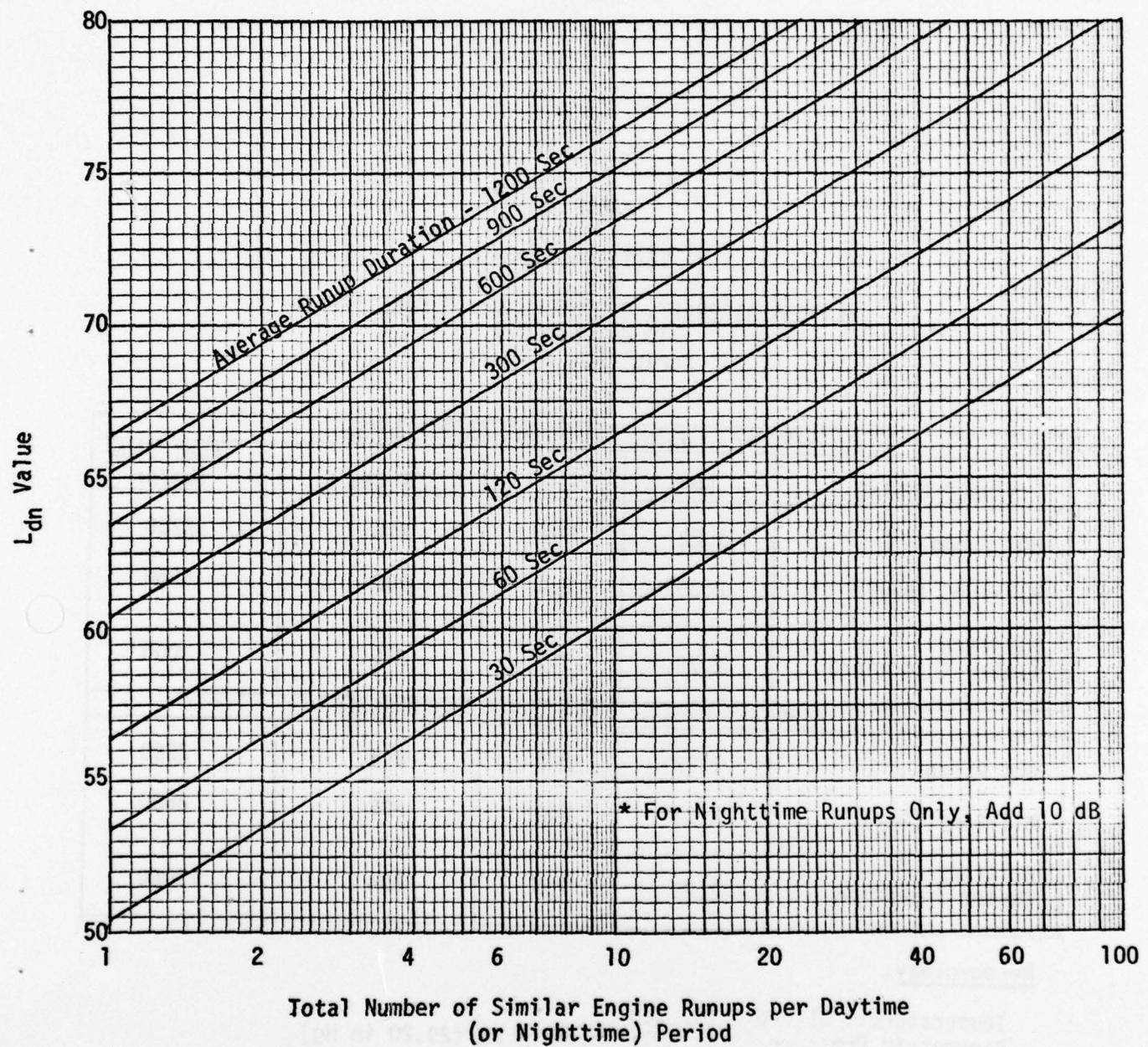


CHART FOR CONVERTING THE 85 dBA EQUAL LEVEL CONTOURS TO
 L_{dn} VALUES FOR DAYTIME GROUND RUNUPS ONLY *

TABLE 1
TEST CONDITIONS

KC-135A AIRCRAFT, GROUND RUNUP, O'HARE IAP IL
10 August 1977
Serial No. 61-0271A

AIRCRAFT ENGINE OPERATION (SUPPRESSED)				
SINGLE ENGINE	EPR	RPM	EGT deg C	Fuel Flow lbs/hr
80% Runup	1.22	80%	315	2200
Military (Dry)	2.35	96%	608	8550
Military (Water Injection)	2.79	96%	615	13000
AIRCRAFT ENGINE OPERATION (UNSUPPRESSED)				
80% Runup	1.27	80%	345	2350
Military (Dry)	2.34	95%	605	8600
Military (Water Injection)	2.79	96%	624	13000

Meteorology:

Temperature: 31 deg C (87 deg F)
 Barometric Pressure (Station): 0.742 m Hg (29.20 in Hg)
 Relative Humidity: 52%
 Wind Speed: 5.2 m/sec (10 knots)
 Wind Direction: 270 deg True

TABLE 2

MAXIMUM OCTAVE BAND SOUND PRESSURE LEVELS AT 250 FT,
STANDARD METEOROLOGY, MILITARY POWER (DRY)

Octave Band Center Frequency	63	125	250	500	1K	2K	4K	8K
Grade III Suppressor Residuals	97	97	96	95	92	91	91	92
Measured SPL	97	100	102	99	97	93	90	83

TABLE 3
ACOUSTIC POWER LEVEL (dB re 10^{-12} Watt)

OPERATION	ENGINE POWER SETTING		
	80% RPM	MILITARY (DRY)	MILITARY (WET)
Unsuppressed	141.9	165.9	169.6
Suppressed	142.0	146.7	152.1
Power Level Reduction	-0.1	19.2	17.5
Reduction Factor	-	1/83	1/56

DISTRIBUTION LIST

	<u>Nr of Cys</u>
NGB/DEM----- Washington DC 20314	7
SAF/MIQ----- Washington DC 20330	1
AFSC/SG----- Andrews AFB DC 20331	1
HQ USAF/SGPA----- Washington DC 20314	1
126 Air Refueling Wing/MA----- O'Hare International Airport Chicago IL 60666	5
AMD/RDF----- Brooks AFB TX 78235	1
6570 AMRL/BBE----- Wright-Patterson AFB OH 45433	1
USAF OEHL/CC----- Brooks AFB TX 78235	1
CINCSAC/SGPA----- Offutt AFB NE 68113	1
AFPRES/SGP----- Robins AFB GA 31093	1
ASD/ENECP----- Wright-Patterson AFB OH 45433	1