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A COMPARISON OF TWO INDEPENDENT MEASUREMENTS AND ANALYSES OF JET AIRCRAFT FLYOVER NOISE

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16. Abstract

This study takes advantage of a special situation in which flyover noise measurements were made simultaneously by two groups. The measurements were made close to one another for the same flyover conditions and with similar measurement procedures, but with different acoustic equipment and personnel. Each group also independently processed the data in accordance with FAR 36 procedures, including corrections to reference meteorological, performance, and flight-path conditions. Measured and corrected data, from 24 controlled flyovers processed by both groups, are compared and the differences in the results obtained by the two groups are discussed. It is observed that the average value of the difference between the groups' measured acoustic descriptors (PNL, PNLTM, and EPNL) was ≤0.8 dB; the average difference for the corrected descriptors (PNL, PNLTM, and EPNL) was ≤1.5 dB. Causes of the differences were found to be mainly related to different spectrum extrapolation and preemphasis techniques used by the two groups.

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CONTENTS

Page

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SUMMARY

In this study, advantage was taken of a special situation in which flyover noise measurements were made simultaneously by two groups. The measurements were made close to one another for the same flyover conditions and with similar measurement procedures, but with different acoustic equipment and personnel. Each group also independently processed the data in accordance with FAR 36 procedures, including corrections to reference meteorological, performance, and flight-path conditions. This report describes the data measurement and analysis equipment and procedures used by one of the groups. The measured and corrected results, from 24 controlled flyovers processed by both groups are compared and the differences in the results obtained by the two groups are discussed. It was found that the average value of the difference between the measured acoustic descriptors (PNL, PNLTM, and EPNL) for the groups was ≦0.8 dB; the average difference for the corrected descriptors (PNL, PNLTM, and EPNL) was ≦1.5 dB. The kind of difference observed for the measured descriptors should be expected for field measurements but may be approaching the total system accuracy of the measurement and analysis apparatus. The differences observed for the corrected descriptors were found to be mainly related to different spectrum extrapolation and preemphasis techniques used by the groups. This difference probably cannot be reduced unless more rigidly defined data acquisition and processing procedures are adopted.

INTRODUCTION

There is a continuing concern about the variability observed in aircraft flyover noise measurement and analyses performed by different organizations. Very few data are published, however, which are definitive enough to identify the causes of such variability. References 1 and 2 are notable exceptions. The data reported in reference 1 were from tests in which eight organizations measured and analyzed the noise from the same airplane flyovers using their own equipment, personnel, and procedures. Comparison of the results showed that large differences existed between the measured and corrected descriptors for the various organizations.

In an attempt to identify the sources of organizational variations attributable to analysis apparatus and procedure differences, the SAE A-21 Committee, Instrument and Analysis Subcommittee, prepared a test tape consisting of three flyover noise recordings. This tape was distributed to 13 organizations with instructions to analyze the data according to the procedures of FAR 36 (ref. 3). Also distributed to each organization were tabulated one-third-octave band spectra; these tables served to eliminate organizational variation due to differences in analysis hardware. The participating organizations were not required to correct the data to reference meteorological, performance, or flight-path conditions. The results of this statistical study (ref. 2) indicated that the effective perceived noise level (EPNL) calculation procedures caused a large part of the variation among organizations, even when corrections to reference conditions were not made. The two standard deviation variation values for the EPNL values computed from the taped data ranged from ±0.6 EPNdB to ±1.4 EPNdB whereas for the tabulated data these values ranged from ±0.3 EPNdB to ±0.4 EPNdB.

In this study, advantage is taken of a special situation in the NASA Refan Program (refs. 4 to 8) in which two groups simultaneously made flyover noise measurements close to one another and used the same flyover conditions and similar measurement procedures, but with different acoustic measurement equipment, personnel, and analysis procedures. After the noise measurements, the data were also independently corrected (to reference meteorological, performance, and flight-path conditions) by each group according to the procedures specified in FAR 36.

The purpose of this paper is to compare measurement and analysis results obtained by the two groups. Differences in both measured and corrected data are discussed and, where possible, the causes of the differences are identified. The results are based on data reported in reference 7 and an extension of data reported in reference 8. To supplement the discussion, descriptions of the measurement and analysis apparatus and procedures are also provided. In writing this report, reader familiarity with FAR 36 was assumed.

SYMBOLS

The data presented herein are in the International System of Units (SI) with the equivalent values given in the U.S. Customary Units. Calculations were made in the U.S. Customary Units.

A aircraft altitude, m (ft)

b_a distance of closest aircraft approach to projection of microphone position on actual ground path, m (ft)

b_r	distance of closest aircraft approach to projection of microphone position on reference ground path, m (ft)
c	speed of sound, m/sec (ft/sec)
D	duration factor, EPNdB, see equation (1)
d	duration of significant PNLT time history, sec
EPNL	effective perceived noise level, EPNdB
F_n	static thrust per engine (power setting), N (lbf)
L	lateral deviation of microphone from ground path, m (ft)
L_A,dB(A)	A-weighted sound pressure level, dB
OASPL	overall sound pressure level, dB
PNL	perceived noise level, PNdB
PNLM	maximum perceived noise level, PNdB
PNLT	tone-corrected perceived noise level, PNdB
R	slant range, distance from microphone to airplane at time PNLTM spectrum was emitted, m (ft)
SPL	sound pressure level (Re 2×10^{-5} N/m^2), dB
s	standard deviation
t_o	time aircraft is overhead the projection of microphone position on ground path, sec
t_m	time for which PNLTM is received, sec
V	aircraft flight-path speed, m/sec (ft/sec)
$\bar{x}$	mean value

α_a angle between actual flight path, aircraft position on that flight path when PNLTM spectrum is emitted, and actual microphone position, deg

α_i atmospheric sound absorption coefficient for ith one-third-octave band, dB/100 m (dB/1000 ft)

α_r angle between reference flight path, aircraft position on that path when PNLTM spectrum is emitted, and reference microphone position, deg

γ flight-path angle, deg

Δ difference in sound pressure levels, dB or EPNdB

Δ_a actual distance of closest approach, m (ft)

Δ_r reference distance of closest approach, m (ft)

Δ_s speed correction, EPNdB

Δ_2 duration correction, EPNdB

δ ratio of atmospheric pressure at airplane flight altitude to standard atmospheric pressure

Subscripts:

a actual (measured)

av average

c corrected

i ith one-third-octave band

m measured (actual)

r reference

Abbreviations:

ADDS	Airborne Digital Data System
FAR 36	Federal Aviation Regulation, Part 36
FM	frequency modulated
Group A	NASA Langley Research Center
Group B	Douglas Aircraft Company
ILS	Instrument Landing System
IRIG	Interrange Instrumentation Group
MALT	Mobile Automatic Laser Tracking System
MART	Mobile Atmospheric Recording Tower
Mic	microphone
NBS	National Bureau of Standards
SAE	Society of Automotive Engineers

DATA ACQUISITION APPARATUS[1]

This section describes the airplane, tracking, performance, meteorological, and acoustic apparatus used in this study. With the exception of the acoustic apparatus and airplanes, all the other measurement systems were operated and maintained by group B, the data being made available to group A as appropriate for this study. Both groups operated their own acoustic apparatus and one of the test airplanes was flown cooperatively by group B and U.S. Air Force personnel.

[1]Certain commercial equipment and materials are identified in this paper in order to adequately specify the experimental procedures. In no case does such identification imply recommendation or endorsement of the product by NASA, nor does it imply that the equipment or materials are necessarily the best available for the purpose.

Airplanes

The two test airplanes used for most of this study are shown in figure 1. The primary difference between the two airplanes is that one (fig. 1(a)) was equipped with Pratt & Whitney JT8D-109 (refanned) engines with acoustically treated nacelles. The other (fig. 1(b)) was equipped with JT8D-9 engines with minimally acoustically treated (hardwall) nacelles. This second airplane was supplied by and flown with the cooperation of the U.S. Air Force Military Airlift Command, Scott Air Force Base, Illinois. As will be discussed in the section "Flight Test Procedures," these two airplanes served as the controlled noise sources. In addition, the landing approach noise from commercial air traffic into Yuma International Airport was measured as part of an initial study to verify test procedures.

Tracking Apparatus

Airplane tracking data were obtained with the Mobile Automatic Laser Tracking System (MALT). As described in reference 7, "MALT uses an auto-track, monopulse optical-radar, with a multipower laser as the ranging-beam energy source. [It] is self-contained in a small truck, uses a portable power source, and can acquire, track, and record the position of a retroreflector-equipped airplane. Tracking range is up to 18 288 m (60 000 ft) with elevation coverage of -0.09 to +0.79 rad (-5° to $+45^{\circ}$), and azimuth coverage of ±2.09 rad ($\pm 120^{\circ}$). Line of sight permitting, microphone locations were also determined from the MALT van, thereby, eliminating the need of a transit survey. All space positioning data (and time codes) were recorded on magnetic tape in a digital format for subsequent computer processing."

"Certain of the landing approach flyovers were made with flight test paths other than that of the Yuma airport ILS. To help the pilot maintain the required glideslope, a pulsed light visual landing aid (PLVLA) consisting of a portable light system was used."

Performance Apparatus

Airplane performance data were measured by an Airborne Digital Data System (ADDS) and a cockpit camera focused on the pilot instrument panel. As described in reference 7, "the ADDS is designed to monitor the aircraft and engine operating parameters by means of an airborne integrating data system, a telemetry microwave link, and a ground data center. [It] provided real-time monitoring aboard the aircraft and a magnetic tape recording for subsequent processing."

Meteorological Apparatus

Measurements of the temperature and relative humidity 10 m (33 ft) above the surface were also made by group B with their Mobile Atmospheric Recording Tower (MART) (ref. 7). These two parameters were output by MART on time-calibrated paper. Vertical temperature, humidity, and wind profiles were obtained from balloon soundings of upper air weather before, during, and after the flyover noise tests. Continuous analog recordings of temperature, relative humidity, and air turbulence were also measured by an instrumented light airplane before and during the flyover noise tests. (See ref. 7.)

Acoustic Measurement Apparatus

The acoustic data acquisition system used by group A consisted of the microphones, cables, signal conditioning, and recording equipment suitable to obtain flyover noise data in accordance with FAR 36. A data acquisition system block diagram for a typical microphone channel is shown in figure 2. Principal system components are pressure microphones with accessory windscreens and preamplifiers, variable-gain amplifiers, and an FM tape recorder. An oscillograph was used for in-field data verification and to establish optimum recording levels. The microphones were configured with the standard grid cap, and Bruel and Kjaer Model UA0237 windscreen. To accommodate 457-m (1500 ft) signal cables, Bruel and Kjaer Model 2804 power supplies with a factory-installed integral line driver were used. The tape recorder was operated at 76.2 cm/sec (30 in./sec) (IRIG Intermediate Band FM) with an IRIG B time code signal recorded simultaneously with the microphone data in all cases. The time code, necessary to maintain correlation between the tracking and acoustic data, was synchronized between groups to within ±0.25 second. Further system specifications are presented in the "Laboratory System Calibration" section.

Observed Differences in Group A and Group B Acoustic Apparatus

The acoustic apparatus used by both groups differed primarily in two areas. (1) By using a Bruel and Kjaer Model 141 remote microphone power supply, group B drove much longer cables than group A (a maximum length of 3048 m (10 000 ft) for group B compared with a maximum length of 457 m (1500 ft) for group A). (2) Before the microphone signal was recorded on magnetic tape, group B used a nonuniform, positive-gain filter network to increase the signal-to-noise ratio (preemphasize) of the high acoustic frequencies.

DATA ACQUISITION PROCEDURES

This section describes the flight test and data acquisition procedures that were generally followed by both measurement groups.

Flight Test Procedures

The measurements described in this paper were made between January 24, 1975 and March 4, 1975. During this period, the noise from approximately 127 flyovers was measured by both groups. Of these 127 noise measurements, 48 were used for the analysis included in this paper. Table I presents the test matrix for these 48 noise measurements. As can be seen, the measurements fall into two major categories: (1) uncontrolled (no tracking, performance, or meteorological data were recorded) landing approaches of commercial air traffic and (2) controlled take-offs and landing approaches of the refan and hardwall airplanes.

The four uncontrolled landing approaches were necessary so that both groups could familiarize themselves with the joint calibration and measurement procedures described in the "Field System Calibration" section. Brief analyses were also performed on these data by both groups so that an indication of the intergroup agreement of measurement and analysis results could be obtained prior to the controlled flyover noise measurements.

Most of the data in this study were obtained from the remaining 44 controlled flyover noise measurements. As indicated in table I, these flyovers were divided into five groups: take-off correction, cutback correction, take-off with cutback, landing approach correction, and 50° flap landing approach.

The take-off correction flyovers were made over a range of thrust settings, airspeed being maintained as nearly constant as possible. Various flap angles and climb gradients were used as required to maintain a constant airspeed. These correction runs were performed only to determine the relative variation of EPNL with thrust and not to determine absolute levels.

The cutback correction flyovers were used to insure that engine "spool-down" had occurred prior to recording the 10-dB down point on the PNLT time history (see the "Duration Factor" section). No other analyses were performed on these data.

The take-off with cutback flyovers, with the test aircraft flying a profile consisting of a full-power take-off followed by a noise-abatement power cutback after an altitude of 305 m (1000 ft) was attained, were used to insure that valid FAR 36 reference levels were obtained.

As was done for take-off, landing approach correction flyovers were flown to determine the relative variation of EPNL with thrust. The 50° flap landing approaches defined the FAR 36 reference EPNL levels for the test aircraft flying a conventional 3° glide slope.

For the purposes of this study, the type of airplane (hardwall or refan) was not considered a primary variable. The names hardwall and refan are retained only to aid in run identification on various tables in this paper and to maintain the commonality between the data reported here and in references 7 and 8.

Laboratory System Calibration

Prior to the field noise measurement program, extensive calibration and testing were conducted to verify proper system operation and to document system performance. All system components for each data channel were individually calibrated in accordance with the manufacturers' recommended procedures. General calibration laboratory policies and procedures were as recommended in reference 9. All test measurements were made with instruments whose calibrations are traceable to the NBS. To determine microphone frequency response, an electrostatic calibration was performed by use of a Bruel and Kjaer Model 4142 microphone calibration apparatus. Microphone sensitivity was determined by using a Bruel and Kjaer Model 4220 pistonphone.

Components were assembled and the critical parameters of frequency response, distortion, linearity, and noise floor were documented. System level test results are summarized in table II. A typical microphone channel frequency response is shown in figure 3.

Field System Calibration

The following calibrations were performed in the field by group A for each microphone channel each test day for all the flyover noise measurements:

(1) Total channel sensitivity was determined by using Bruel and Kjaer Model 4220 pistonphone. The calibration signal of 124 dB at 250 Hz was recorded on magnetic tape and the barometric pressure was noted in the tape log.

(2) An oscillator signal was applied at the preamplifier input and a channel frequency response sweep from 20 Hz to 20 KHz was recorded on magnetic tape.

(3) A pink noise signal from a General Radio Model 1382 random noise generator was applied to the preamplifier input and recorded on magnetic tape as a frequency response reference for subsequent data reduction.

(4) The pistonphone was checked daily against a reference microphone.

At the conclusion of the test day, calibrations (1), (3), and (4) were repeated.

For the uncontrolled flyover noise measurements only, the two measurement groups exchanged pistonphone calibrators and recorded their output on magnetic tape. Pink noise and pure tone calibrations (at the center frequency of each octave band from 50 Hz to 10 kHz) were also recorded simultaneously by both groups. For the controlled source noise measurements, only the pistonphone exchange and simultaneous pink noise calibrations were routinely included in each test day pre- and post-calibrations.

Noise Measurement Sites

Figure 4 shows the measurement sites used in this study and in references 7 and 8. Both groups made noise measurements at location C5 for the uncontrolled flyovers and at locations C6 and C10 for the controlled take-off and landing approaches, respectively. Data measured at the remaining sites are reported in reference 7 only. A microphone array, similar to the one shown in figure 5, was used at locations C5, C6, and C10. Both groups' microphones were placed on 1.2-m (4 ft) stands along the extended center line of the runway. The microphone diaphragms were oriented for grazing incidence.

DATA ANALYSIS APPARATUS

A block diagram of the data analysis apparatus is shown in figure 6. Recorded flyover noise analog data and IRIG B time code are played back through a multichannel (one-third-octave band) root-mean-square (rms) detector and time code generator, respectively. The outputs (one-third-octave band spectra and time code) from these instruments are sampled every 1/2 second by a digital computer. This computer, acting as the executive, compiles the spectral and time code information in a predefined format onto digital magnetic tape. Based on operator instructions, the computer also issues commands for the rms detector to begin and cease sampling and for the playback recorder to stop. This system meets the requirements of Proposed SAE Aerospace Recommended Practice 1264, Airplane Flyover Analysis System Used for Effective Perceived Noise Level Computations, described in reference 10.

Flyover noise descriptors, such as EPNL, are computed by the EPNL software shown in figure 6. The methodology used in these computations and the test results provided by them are described in detail in the following sections.

DATA ANALYSIS PROCEDURES

This section is intended to provide insight into the methods of group A for analyzing flyover noise data subsequent to the preliminary data analysis. In this analysis, FAR 36 was used as a guide and was strictly adhered to in areas where it was explicit. However, several areas of FAR 36 are interpretive in nature. For the most part, it is these interpretive areas that are described in this section.

In this and following sections, the terms measured and corrected are frequently used. In the context of this paper, measured refers to descriptors computed from test day flyover noise measurements. Corrected refers to computed descriptors that have been corrected from the actual test day meteorological, performance, and flight-path conditions to a reference set of such conditions. The reference meteorological conditions used were 25° C (77° F) and 70-percent relative humidity, as specified in FAR 36. The reference performance and flight-path conditions were determined by group B and made available as required. The measured and corrected acoustic descriptors referred to in this report are as follows:

Measured	Corrected
Duration factor	Atmospheric correction
Tone correction	Duration factor correction
dB(A)	Speed correction
OASPL	Thrust correction
PNL	Tone correction
PNLTM	dB(A)
EPNL	OASPL
	PNL
	PNLTM
	EPNL

Overview of Analysis Procedure

Analysis of flyover noise data according to FAR 36 may be thought of in terms of two EPNL values associated with two sets of corrections. As represented in figure 7, after the acquisition of the digital one-third-octave band time history tape (discussed in the "Data Analysis Apparatus" section in conjunction with fig. 6), a set of corrections is applied to each one-third-octave band spectrum for each 1/2 second of the flyover noise time history. These corrections adjust the measured spectra for recording and analysis system irregularities, excessive ambient noise levels at the test site, spectrum irregularities attributable to ground reflections, and system dynamic response. These corrected spectra are then used to compute the PNLT time history from which the measured EPNL is computed.

In order to insure uniformity in evaluating EPNL values, FAR 36 requires the measured EPNL to be corrected to reference atmospheric, performance, and flight-path conditions. These corrections are computed from the PNLTM spectrum, the airplane thrust or weight, and the airplane speed and flight-path geometry. As shown in figure 7, these corrections are then added to the measured EPNL to obtain the corrected EPNL. The following sections present detailed information on each of the corrections used.

Corrections Made for Each 1/2 Second of Flyover Noise Data

The corrections discussed in this section were applied to the digital one-third-octave band measured time history prior to computing the measured EPNL.

System corrections.- The following system corrections were made:

(1) Microphone response

(2) Windscreen

(3) Free field

(4) Pink noise

(5) Barometric pressure

Correction (1) was determined by a laboratory electrostatic microphone correction prior to the test. Corrections (2) and (3) were obtained from manufacturers' data and are shown in figure 8. Correction (4) was determined from daily system pre- or post-calibrations. Correction (5) was determined from manufacturers' charts and measurements of the barometric pressure made prior to each series of test runs. Table III shows typical values for corrections (1) to (5).

Ambient noise correction.- When the flyover noise SPL in any one-third-octave band was within 5 to 10 dB of the ambient noise levels, the ambient noise was subtracted from the flyover noise on a power basis. The sound pressure level of this difference replaced the original level. If the flyover noise levels in a one-third-octave band were 5 dB or closer to the ambient level, the level in that band was unchanged. These ambient-corrected one-third-octave band levels were then used in the PNL and PNLT calculations with the exception that the bands whose levels were 5 dB or closer to the ambient were omitted from the PNL (but retained for the PNLT) calculation of the measured flyover noise. As will be discussed under the section "Atmospheric absorption correction," an extrapolation procedure was used to adjust the levels in these bands for calculation of the corrected PNL, PNLT, and EPNL.

Dynamic response.- In order to insure that the analysis system dynamic response was compatible with FAR 36, a moving 1.5-second linear average was applied to the levels in each one-third-octave band. To do this, three consecutive 0.5-second bands were averaged on a power basis. The center value was replaced by the average, the first 0.5-second spectrum was dropped, and the original center value was averaged with the next two 0.5-second spectra. This procedure was repeated for the entire flyover.

Pseudotone correction.- To avoid calculating erroneous tone corrections because of ground reflections (pseudotones), tone corrections were not computed for one-third-octave bands up to and including the 630-Hz band. This frequency limit was chosen to be compatible with ground-board microphone studies which showed ground reflections to be the cause of the spectral irregularities below 630 Hz.

Computation of Measured EPNL

By reference again to figure 7 the measured one-third-octave band spectra, with the appropriate corrections included, are next used to compute the PNLT time history. From this time history, the value of the PNLTM is retained and the duration factor D and measured EPNL are computed as described in the following sections.

Duration factor.- The time period d used to calculate the duration factor D was the interval, rounded to the nearest second, during which the criterion PNLTM - PNLT $\leqq$ 10 PNdB was satisfied. For the case of a two-peak PNLT time history, the duration time was taken from the first point that met the criterion to the last point which met the criterion, rounded to the nearest second. FAR 36 states that when PNLTM - 10 PNdB $\leqq$ 90 PNdB, "the value of d may be taken as the time interval [to the nearest whole second] between the initial and final times for which PNLT(k) equals 90 PNdB." However, the 90 PNdB restriction was not used in this analysis since it is now accepted practice, approved by the FAA, to remove that limitation.

The duration factor is given mathematically by FAR 36 as

$$D = 10 \log \left[\sum_{k=0}^{2d} \log^{-1} \frac{\mathrm{PNLT}(k)}{10} \right] - \mathrm{PNLTM} - 13 \tag{1}$$

Measured EPNL.- The measured EPNL is computed from the sum of PNLTM and D,

$$\mathrm{EPNL} = \mathrm{PNLTM} + D \tag{2}$$

or by substituting equation (1) into equation (2)

$$\mathrm{EPNL} = 10 \log \left[\sum_{k=0}^{2d} \log^{-1} \frac{\mathrm{PNLT}(k)}{10} \right] - 13 \tag{3}$$

Corrections Based on PNLTM Spectrum, Airplane Performance, and Flight-Path Geometry

This section outlines the corrections which were necessary to compute the corrected EPNL from the measured EPNL value.

Flight-path corrections.- Flight-path data (flight-path angle, altitude over the microphone, lateral flight-path deviation, flight-path speed, and time over the microphone) provided by group B were used to geometrically calculate the actual and reference slant ranges at the time the PNLTM spectrum was emitted and the actual and reference distances of closest approach. This section describes the method used to calculate the slant ranges $(R_a$ and $R_r)$ and distances of closest approach $(\Delta_a$ and $\Delta_r)$.

Figure 9 shows a general test situation where the actual and reference flight paths and measurement positions are known. It is assumed that the values of A_a, A_r, L_a, L_r, V, t_m, t_o, γ_a, γ_r, and c are known. It is also assumed that the aircraft sound propagates in a straight line (that is, refraction effects are ignored). The problem, then, is to compute the actual and reference slant ranges $(R_a$ and R_r, respectively$)$ and distances of closest approach $(\Delta_a$ and Δ_r, respectively$)$ at the time the PNLTM spectrum was emitted. It can be shown that

$$R_a = \sqrt{\left(L_a^2 + f^2\right) + \left(A_a + f \tan \gamma_a\right)^2} \tag{4}$$

where f is the distance shown in figure 9, as determined by the appropriate root of the quadratic equation,

$$f^2 + f \frac{2A_a \tan \gamma_a + \dfrac{2\left(t_m - t_o\right)V \cos \gamma_a}{k^2 \cos^2 \gamma_a}}{1 + \tan^2 \gamma_a - \dfrac{1}{k^2 \cos^2 \gamma_a}} + \frac{L_a^2 + A_a^2 - \dfrac{\left(t_m - t_o\right)^2 V^2 \cos^2 \gamma_a}{k^2 \cos^2 \gamma_a}}{1 + \tan^2 \gamma_a - \dfrac{1}{k^2 \cos^2 \gamma_a}} = 0 \tag{5}$$

and where $k = V/c$.

After the actual slant range has been computed, Δ_r, Δ_a, and R_r may be computed as follows:

$$\Delta_r = \sqrt{b_r^2 + L_r^2} \tag{6}$$

where

$$b_r = A_r \cos \gamma_r \tag{7}$$

Similarly,

$$\Delta_a = \sqrt{b_a^2 + L_a^2} \tag{8}$$

where

$$b_a = A_a \cos \gamma_a \tag{9}$$

The assumption is now made that α_a (in this case the angle between the measurement position, the aircraft position when PNLTM was emitted, and the aircraft flight path) is the same for both the actual and reference measurement conditions. Thus,

$$\alpha_a = \alpha_r = \sin^{-1}\left(\frac{\Delta_a}{R_a}\right) \tag{10}$$

so that

$$R_r = \frac{\Delta_r}{\sin \alpha_r} = \left(\frac{\Delta_r}{\Delta_a}\right) R_a \tag{11}$$

These values of R_a, R_r, Δ_a, and Δ_r were then used in the atmospheric absorption correction, duration factor correction, and speed correction calculations.

Duration factor correction.- Duration factor corrections were applied to the EPNL values whenever the actual and reference take-off or landing approach flight paths differed. The correction term Δ_2 was calculated as follows:

$$\Delta_2 = -10 \log \frac{\Delta_a}{\Delta_r} \tag{12}$$

and was added algebraically to the EPNL calculated from the measured acoustic data. The section entitled "Flight-path corrections" describes how the actual and reference distances of closest approach $\left(\Delta_a \text{ and } \Delta_r, \text{ respectively}\right)$ are calculated.

Speed correction.- The following relationship (ref. 11) was used to correct the EPNL levels for differences between the actual and reference aircraft path speeds:

$$\Delta_s = 10 \log \frac{V_a}{V_r} \tag{13}$$

Atmospheric absorption correction.- The acoustic spectrum at the time of PNLTM was corrected to the reference conditions of 25° C (77° F) and 70-percent relative humidity based on meteorological data obtained at 10 m (33 ft). This was to account for differences in atmospheric sound absorption from the actual to reference meteorological conditions. The procedure was to correct each one-third-octave band according to the following equation (from FAR 36):

$$SPL_{i,c} = SPL_{i,a} + \left(\alpha_{i,a} - \alpha_{i,r}\right)R_a + \alpha_{i,r}\left(R_a - R_r\right) + 20 \log \frac{R_a}{R_r} \tag{14}$$

where the $SPL_{i,a}$ and $SPL_{i,c}$ are the actual and corrected sound pressure levels, respectively, in the ith one-third-octave band. The first correction term accounts for the effects of change in atmospheric sound absorption for the entire actual propagation path (slant range) R_a. The coefficients $\alpha_{i,a}$ and $\alpha_{i,r}$ are the sound absorption coefficients for the actual and reference atmospheric conditions, respectively, for the ith one-third-octave band. These absorption coefficients were computed by the method of reference 12. The second correction term accounts for the excess, or shortage, of atmospheric absorption on the change in the path from the actual to the reference slant range R_r. The third correction term accounts for the effects of the inverse square law when correcting from the actual to the reference slant range.

In these analyses the atmospheric absorption corrections were broken down into path and weather corrections. The sum of all the atmospheric absorption and inverse square law corrections of equation (14) on a PNLT basis was termed the "atmospheric absorption correction." From the atmospheric absorption corrected PNLT was subtracted the contribution of the $\left(\alpha_{i,a} - \alpha_{i,r}\right)R_a$ (weather correction) term. The result of this subtraction was termed the "path correction."

Because preemphasis networks were not used in measuring the flyover noise, the atmospheric absorption corrected PNLTM spectra were allowed to roll off at a rate of 2 dB per one-third-octave band (as specified in ref. 13 for jet noise spectra) beginning with the first one-third-octave band (in the uncorrected spectrum) after the spectrum peak which fell to within 5 dB of the ambient level. This extrapolation procedure was used not only to avoid the calculation of erroneous tone corrections caused by large atmospheric absorption corrections being applied to ambient spectrum levels, but also to provide the best engineering estimates of the corrected PNL, PNLT, and EPNL.

Performance corrections.- After all the previously mentioned corrections were made to each flyover noise measurement, the EPNL values for the take-off correction and 50° flap landing approach correction flyovers were plotted against normalized thrust as shown in figures 10 to 13. By use of these curves and knowledge of the reference thrust, the EPNL values for take-off with cutback and 50° flap landing approach were corrected for the difference between the actual and reference thrust.

In this study it was assumed that corrections for thrust and gross weight were equivalent since, everything else being equal, thrust and gross weight would vary directly. Therefore, no gross weight corrections were made.

Observed Differences Between Group A and Group B Data Analysis Procedures

The analysis procedures followed by Groups A and B were found to be very similar. There were, however, two areas in which the groups' procedures differed: (1) Group B analyzed a much larger number of flyovers than group A. The group A analysis consisted of the 48 uncontrolled and controlled flyovers indicated in table I, whereas group B analyzed at least 100 controlled refan flyovers and approximately 40 controlled hardwall flyovers in addition to the four uncontrolled flyovers. (2) As described in the "Atmospheric absorption correction" section, group A extrapolated the corrected PNLTM spectrum (at a rate of 6 dB per octave) over the one-third-octave bands where the measured signal to ambient noise ratio was ≦5 dB. The group B procedure was to truncate the corrected PNLTM spectrum beginning with the first band where the measured signal-to-noise ratio was ≦5 dB. The difference between the truncation and extrapolation procedures is illustrated in figure 14. The effect of the extrapolation and truncation procedures on corrected acoustic descriptors such as PNLTM and EPNL is described in the section "Results and Discussion."

RESULTS AND DISCUSSION

This section describes the results of measurements and analyses of the noise from the uncontrolled (commercial landing approaches) and controlled (refan and hardwall aircraft) sources. The intent in reporting these results is not to indicate correct or incorrect procedures, but rather to show the differences in the results of the two participating groups and to indicate the probable causes of the differences. The reader is reminded that in this and following sections, the terms <u>measured</u> and <u>corrected</u> are frequently used. In the context of this paper, <u>measured</u> refers to descriptors computed from test day flyover noise measurements. <u>Corrected</u> refers to computed descriptors that have been corrected from the <u>actual</u> test day meteorological, performance, and flight-path conditions to a <u>reference</u> set of such conditions. The reference meteorological conditions used were 25° C (77° F) and 70-percent relative humidity, as specified in FAR 36. The reference performance and flight-path conditions were determined by group B and made available as required. The measured and corrected acoustic descriptors referred to in this report are listed in the section "Data Analysis Procedures."

Uncontrolled Source Noise Measurements

To compare the group A and group B noise measurement capabilities prior to making the controlled source noise measurements, the data from the four uncontrolled source flyovers (see table I) were analyzed in three ways:

(a) Analyses of both group A and group B data tapes by group B by using group B calibrations

(b) Analyses of group A data tapes by group A and group B by using group B calibrations

(c) Analyses of group A data tapes by group A by using both group A and group B calibrations

The results of these analyses for run 5 (performed on all four microphones deployed) and a comparison of one-third-octave band spectra at the time of PNLM are presented in tables IV to VII. The analyses included pink noise, slow response, windscreen, and microphone electrostatic response corrections. No flight-path, performance, or weather corrections are included in the data of tables IV to VII and the results shown should not be interpreted as landing-approach certification numbers. The level differences shown in these tables are typical of all four flyovers, with the exception that the signs varied so that there was no obvious system sensitivity bias.

Table IV presents a comparison of the group A and group B measured noise levels as analyzed by group B ((a) analyses). The Δ column contains values of the numerical differences between averages of the group A and group B measurements, respectively.

Table V presents a comparison of group A and group B analyses of group A data tapes ((b) analyses), in order to provide a direct comparison of analysis procedures.

Table VI presents a comparison of the results obtained by using both group A and group B calibrations ((c) analysis). Except for sign differences, the values shown in the Δ columns of tables V and VI are similar to those in table IV.

Table VII presents a comparison of group A-measured PNLM one-third-octave band spectra as analyzed by groups A and B along with difference of the average SPL values obtained by each group. With the exception of the 50-, 63-, 125-, and 200-Hz bands, the one-third-octave band levels differ by less than 1 dB. The cause of the large level differences in the four low-frequency bands is not known, particularly the 4.3-dB difference in the 200-Hz band. Fortunately, the effect of these low-frequency differences on the calculated descriptors (for example, EPNL) was negligible.

Based on these results, the measured values obtained by both groups seem to be similar. It should be remembered that the small differences observed include contributions from equipment, procedural, and operator errors associated with each group.

These results demonstrate that the differences in flyover noise level measurements among organizations can be made small if the proper techniques and care are used.

As will be shown in the next section, the good agreement between the groups' measured levels was also exhibited for the controlled source noise measurements, with one exception. The measured levels for the five hardwall 50° flap landing approach and approach correction flyovers showed that a systematic difference of approximately 2 dB existed. An investigation of this difference provided no indication of the cause.

Controlled Source Noise Measurements

Between January 28 and March 4, 1975, the noise from at least 82 refan and 41 hardwall flyovers was measured coincidentally by both groups. Of these 123 controlled flyovers, the 44 shown in table I were analyzed by group A. Tables VIII to X present a summary of the group A results. Tables VIII and X present the results for the refan airplane and table IX for the hardwall airplane. The results are presented in SI Units in the (a) part of each table and in U.S. Customary Units in the (b) part. Shown in the tables are values of the reference and actual conditions as well as the uncorrected (measured) and corrected noise levels. The thrust correction curves for take-off and landing approach for each aircraft are shown in figures 10 to 13. These curves were plotted from the thrust-correction and landing-approach-correction data in tables VIII and IX by using the method of least squares in conjunction with either linear or quadratic curve-fitting techniques.

Comparison of Group A and Group B Results

As stated earlier, group B analyzed approximately 140 of the controlled source noise flyovers. Comparison of the group A and group B results analyzed by both groups showed that there were 24 controlled flyovers processed by both groups: eight take-offs with cutback, six take-off corrections, seven 50° flap landing approaches, and three landing-approach corrections. In order to compare the group A and group B results, tables XI and XII were prepared. Table XI is a tabulation of 13 of the group A and group B descriptors for each of the 24 controlled flyovers (see table I) processed by both groups. Included are values for the duration factor, duration factor correction, speed correction, thrust correction, atmospheric correction (that is, weather plus path), tone correction, tone band, measured and corrected PNL, measured and corrected PNLT, and measured and corrected EPNL.

Table XII presents the mean and standard deviation of the difference between the group A and group B descriptors. The acoustic descriptors in this table are divided into four groups. The first group contains the means and standard deviations for all the corrections used to compute the corrected PNLTM and EPNL values. The second group contains similar values for the measured and corrected PNL values; the third group for the measured and corrected PNLTM; and the fourth group for the measured and corrected EPNL. The means and standard deviations are computed for each of the four flight conditions listed in table XI as well as for the total sample population. In entering this table, it is easiest to identify trends by studying the values for the total sample population. Variations from condition to condition can then be examined by studying the appropriate columns. Most of the following discussion is based on trends observed in the total population, by use of results from specific conditions as necessary to support observations.

In studying the total population data, it is clear that even in the worst case the mean and standard deviations are small ($\bar{x} \leqq 1.46$ dB; $s \leqq 1.47$ dB). It is also apparent that for all but one descriptor, the values of the group A descriptors were probably greater than the values of group B descriptors (that is, $\bar{x} \geqq 0$). Furthermore, for nearly every descriptor, the $s \geqq \bar{x}$. This may be an indication that the limits of accuracy of the measurement apparatus and procedures (acoustic, performance, and tracking) have been reached.

Correction descriptors.- If the correction descriptors are considered first, except for the atmospheric and tone corrections $\bar{x} \leqq 0.20$ dB and $s \leqq 0.43$ dB, the large s for the tone correction seems to have been caused by the take-off correction data. Specifically, table XI shows that only one run (run 54) out of six showed a nonzero difference in group A and group B tone correction values; however, since it was the only flyover of the six from the refan airplane it was included in the results as a warning of a possible problem.

The causes for the larger (compared with the other values) values of $\bar{x}$ and s for the atmospheric correction are more complicated to explain. First of all, it has already been stated (see "Uncontrolled Source Noise Measurements") that for an unknown reason there was a systematic difference of approximately 2 dB between the group A and group B hardwall 50° flap landing approach and approach correction measurements; therefore, the total population $\bar{x}$ and s is biased because of measurement problems. That measurement difference may then be the cause of the relatively large value of $\bar{x}$ (0.72 dB).

But, what of the atmospheric correction values of $\bar{x}$ and s for the other three conditions? The large values of $\bar{x}$ and s for the take-off with cutback and take-off correction conditions seem to be caused by the difference in the way the two groups treated their corrected spectra in the high-frequency bands where the acoustic signal to ambient noise ratio is ≤5 dB. As stated in the section "Observed Differences Between Group A and Group B Data Analysis Procedures," group A extrapolated the spectrum, whereas group B truncated it. Tables XIII and XIV demonstrate the differences obtained in the corrected PNL by applying these two procedures to all the group A take-off with cutback and take-off correction PNLTM spectra. (For take-off flyovers the tone correction almost always equals zero because the acoustic spectrum is jet noise dominated. This result can be verified by the data in tables VIII to X. Thus, the PNL usually equals PNLT for these runs.) In addition to the two PNL values for each run, the time that the spectrum was recorded and the bands that were either extrapolated or truncated are also tabulated. Table XIV presents the values of $\bar{x}$ and s for the difference between the PNL values computed from spectra corrected by using group A and group B procedures. For all conditions, $1.84 \text{ dB} \leqq \bar{x} \leqq 1.90 \text{ dB}$ and $0.50 \text{ dB} \leqq s \leqq 0.53 \text{ dB}$.

These mean values are somewhat larger than those indicated in table XII ($\bar{x} = 1.31$ dB for take-off with cutback and $\bar{x} = -0.77$ dB for take-off correction). However, direct comparison of the mean values in tables XII and XIV should be done with caution. Table XIV shows only the difference between the PNL values computed for extrapolated and truncated spectra. The difference in this case will always be positive. However, the sign and magnitude of the atmospheric absorption correction will vary depending on the relative differences between the measured and corrected PNLTM spectra. Figure 15 illustrates how such variation occurs. For the four generalized spectra shown, the PNLT for the truncated corrected spectrum will always be greater than the PNLT for the lower measured spectrum (positive atmospheric absorption correction) and less than the value for the upper measured spectrum (negative atmospheric absorption correction). The PNLT for the extrapolated spectrum will always be greater than the PNLT for the lower measured spectrum but may be either less than or greater than the PNLT for the upper measured spectrum, depending on the value of the contribution to the PNLT from the extrapolated bands.

The values in table XIV, then, should serve only to identify the cause of the large average difference between the atmospheric absorption corrections of the two groups for the take-off with cutback and take-off correction conditions; they should not be expected to agree in magnitude with the values in table XII.

It should be obvious at this point that the atmospheric absorption correction differences for the refan 50° flap landing approach were very small ($\bar{x} = 0.20$ dB; $s = 0.39$ dB) This should be expected since spectrum extrapolation is not needed for landing approach data with high ratios of signal to noise. These landing approach data are, in fact, further confirmation of the extrapolation effect.

Measured and corrected PNL.- By looking first at the total population $\bar{x}$ and s, an important observation can be made; the corrected values ($\bar{x} = 1.16$ dB; $s = 1.47$ dB) are notably larger than the measured values ($\bar{x} = 0.78$ dB; $s = 0.77$ dB). This difference between corrected and measured values seems to result from similar trends in the take-off with cutback and take-off correction conditions. The cause of the difference is again attributed to the extrapolation and truncation procedures. The difference is minimized for the refan landing approach. For reasons previously discussed, the hardwall landing approach data are excluded from consideration.

Measured and corrected PNLTM.- The observations made in the previous section apply equally well here. Only the values of $\bar{x}$ and s have changed.

Measured and corrected EPNL.- Again the total population $\bar{x}$ and s for the corrected EPNL are significantly larger than those for the measured EPNL in all cases. This difference seems to be generated mainly by the take-off with cutback data if the hardwall landing approach data are not considered. The cause of the difference cannot be attributed only to the extrapolation procedure but must be considered to be due to contributions from all the other correction differences listed in table XII.

Effect of preemphasis.- As was discussed earlier (see "Observed Differences in Group A and Group B Acoustics Apparatus"), the group B measurement systems used preemphasis. The effect of preemphasis on the PNL data can be shown from tables XV and XVI.

Table XV is a tabulation of the PNL computed from measured group A and group B spectra. (Measured spectra were used because the group A and group B corrected PNLTM spectra occasionally occurred at different times. The results should be similar for both cases, however.) Shown are the measurement times, the group A PNL, the group B PNL computed with and without the preemphasis bands, and the group B preemphasis bands. Table XVI presents the values of $\bar{x}$ and s of the difference between the group A and the two group B PNL values. The values of $\bar{x}$ and s for the total population show that when preemphasis bands are included in the group B PNL, $\bar{x} = 0.41$ dB and $s = 1.02$ dB. However, when the same bands are used to compute both the group A and group B PNL values, $\bar{x} = -0.09$ dB and $s = 1.06$ dB. The first $\bar{x}$ suggests that the group A measured PNL values were generally about 0.4 PNdB less than the measured group B PNL values, whereas the second value of $\bar{x}$ suggests that the difference is caused by the preemphasis bands. The large s values indicate a rather wide variation in the PNL values.

The effect of preemphasis, of course, is minimized to about 8 kHz for landing approach data where the signal-to-noise ratio is large. Thus, the data shown in table XVI should only be considered applicable to the take-off with cutback and take-off correction conditions.

CONCLUDING REMARKS

Noise measurements were made and data were processed for 123 controlled flyovers in general accordance with FAR 36 procedures by two independent groups. The measurements, conducted as part of the NASA Refan Program, allowed the two groups to make coincidental noise measurements for the same flyover conditions, but with different acoustic equipment, personnel, and analysis procedures. The measurement procedures, however, were similar.

Of the 123 flyovers measured, 24 were analyzed by both groups. These flyovers consisted of eight take-offs with cutback, six take-off corrections, seven 50° flap landing approaches, and three landing approach corrections. Tabulations of the mean difference between the acoustic descriptors for the two groups showed that the computations of PNL, PNLTM, and EPNL based on measured data agreed within average values of 0.8 PNdB, 0.8 PNdB, and 0.7 EPNdB, respectively. Similar tabulations for the corrected PNL, PNLTM, and EPNL showed agreement to within average values of 1.2 PNdB, 1.2 PNdB, and 1.5 EPNdB, respectively. The standard deviations of the difference of the values obtained by the two groups for these descriptors ranged from $0.6 \text{ dB} \leqq s \leqq 0.8 \text{ dB}$ and $1.1 \text{ dB} \leqq s \leqq 1.5 \text{ dB}$ for the measured and corrected descriptors, respectively.

The mean values $\bar{x}$ of the difference between the correction descriptors for the two groups (for example, duration factor correction, speed correction, thrust correction, atmospheric correction, and tone correction) were in the range, $-0.1 \text{ dB} \leqq \bar{x} \leqq 0.4 \text{ dB}$. The largest difference was associated with the atmospheric correction.

The differences between the values obtained by the two groups for their atmospheric corrections and corrected PNL, PNLTM, and EPNL were found to be caused mainly by different methods for treating the sound pressure levels in the high-frequency bands of the corrected PNLTM spectrum. One group extrapolated these levels and the other truncated the spectrum. This difference in procedure had a strong impact on take-off noise data where it was found to cause a 1.9-PNdB mean difference in corrected PNLTM. The landing-approach data were not affected by this problem.

A second, although less important cause of the differences in the descriptor values was the absence of preemphasis filters in the acoustic apparatus of one group. The absence of preemphasis was found to result in about a 0.4-dB difference in the measured PNL calculations.

The approximately 0.8-dB difference between the measured descriptors for the two groups should be considered state of the art for field acoustic measurements. This value may be approaching the accuracy of acoustic data measurement and analysis apparatus. The larger differences (1.2 to 1.5 dB) between the corrected descriptors for the two groups cannot be reduced until more rigidly defined data acquisition and processing procedures are used by both groups.

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TABLE I.- TEST MATRIX FOR FLYOVERS ANALYZED BY GROUP A

Condition	Date	Run (a)	Aircraft	Configuration				
				Gear	Flaps, deg	Slats	Gross mass, kg	
							Reference	Actual
Uncontrolled landing approach	1/24/75	2	Commercial	----	---	--------	------	------
		4		----	---	--------	------	------
		5		----	---	--------	------	------
		6		----	---	--------	------	------
Controlled take-off correction	2/2/75	54	Refan	Up	0	Extended	48 989	48 766
		56						47 899
		60						46 308
		61						45 901
		62						45 452
	3/3/75	37	Hardwall					48 939
		38						48 175
		43						45 860
		45						44 544
		47						44 136
Controlled cutback correction	3/3/75	21	Refan	Up	0	Extended	48 989	42 862
		22						42 321
		23						41 913
		39	Hardwall					47 858
		40						47 216
		41						46 808
		42						46 359
Controlled take-off with cutback	1/29/75	12	Refan	Up	0	Extended	48 989	47 450
		19						44 004
	3/3/75	17R						47 675
		18R						46 951
		22R						44 911
		29	Hardwall					48 766
		31						47 400
		36						44 820
Controlled landing approach correction	1/31/75	33	Refan	Down	50	--------	44 906	41 187
		35				--------		39 962
		37				--------		39 509
	2/1/75	39				--------		------
		40				--------		------
		41				--------		------
		51				--------		------
	2/26/75	3	Hardwall			--------		46 585
		4				--------		45 950
		11				--------		42 276
		12				--------		41 822
		13				--------		41 368
Controlled landing approach	1/31/75	27	Refan	Down	50	--------	44 906	44 634
		28				--------		43 682
		32				--------		41 595
		1R				--------		48 127
		6R				--------		45 314
		5	Hardwall			--------		45 451
		10	Hardwall			--------		42 729

[a]Circled numbers indicate runs processed by both group A and group B.

TABLE II.- SUMMARY OF GROUP A SYSTEM LEVEL TEST RESULTS

Test	Procedure	Test results
Frequency response* (45 Hz to 11.2 kHz)	Apply oscillator signal at preamplifier input. Record system frequency response through tape recorder output.	±0.5 dB
Distortion	Apply signal at microphone using acoustic calibrator. Check system distortion through tape recorder output.	<1 percent
Linearity	Apply oscillator signal at preamplifier input. Check system linearity at tape recorder output over expected range settings of variable-gain amplifier.	±1.0 percent of full-scale tape recorder deviation
Dynamic range	Short circuit preamplifier input and monitor system noise level at tape recorder output.	45 to 50 dB

*With respect to the calibration signal at 250 Hz.

TABLE III.- TYPICAL GROUP A SYSTEM CORRECTION VALUES

One-third-octave-band center frequency, Hz	Correction and value, dB				
	Windscreen*	Free field*	Mic response	Pink noise	Barometric pressure
50	0	0	0	-0.04	0.2
63	0	0	0	-.02	.2
80	0	0	0	-.33	.2
100	0	0	0	-.69	.2
125	0	0	0	.55	.2
160	0	0	0	-.14	.2
200	0	0	0	-.47	.2
250	0	0	0	0	.2
315	0	0	0	.22	.2
400	0	0	0	.11	.2
500	-.10	.10	0	.12	.2
630	-.10	.10	0	0	.2
800	-.10	.10	-.10	.60	.2
1 000	-.13	.10	-.10	.27	.2
1 250	-.29	.11	-.10	-.05	.2
1 600	-.49	.13	-.10	-.10	.2
2 000	-.66	.15	-.10	.16	.2
2 500	-.84	.17	-.10	-.26	.2
3 150	-.80	.19	-.10	-.51	.2
4 000	-.23	.21	-.10	.01	.2
5 000	.46	.23	-.10	-.31	.2
6 300	.47	.25	-.15	.54	.2
8 000	.27	.27	-.25	.32	.2
10 000	.99	.33	-.45	.56	.2

*For 90° incidence.

TABLE IV.- COMPARISON OF FLYOVER NOISE LEVELS FROM UNCONTROLLED SOURCE MEASURED BY GROUPS A AND B AND AS ANALYZED* BY GROUP B

	Group A measurements		Group B measurements		Δ
	Mic 3	Mic 4	Mic 2	Mic 5	$(\text{Group A})_{av} - (\text{Group B})_{av}$
Maximum L_A	95.7	95.4	95.4	95.8	-0.1
PNLM	110.3	109.8	109.8	110.4	-.1
PNLTM	111.5	111.3	110.4	111.4	.5
Tone correction	1.2	1.5	1.2	1.0	.3
Duration factor	-6.4	-6.0	-5.8	-6.3	-.2
EPNL	105.1	105.3	104.6	105.1	.4

*Using group B pistonphone and pink noise calibrations; includes pink noise, slow response, windscreen, and microphone response corrections.

TABLE V.- COMPARISON OF FLYOVER NOISE LEVELS FROM UNCONTROLLED SOURCE AS MEASURED BY GROUP A AND AS ANALYZED* BY BOTH GROUP A AND GROUP B

	Group A analysis		Group B analysis		Δ
	Mic 3	Mic 4	Mic 3	Mic 4	$\overline{(\text{Group A})_{av}} - \overline{(\text{Group B})_{av}}$
Maximum L_A	95.7	95.3	95.7	95.4	-0.1
PNLM	110.4	109.9	110.3	109.8	.1
PNLTM	111.8	111.1	111.5	111.3	.1
Tone correction	1.4	1.2	1.2	1.5	-.1
Duration factor	-7.1	-6.5	-6.4	-6.0	-.6
EPNL	104.7	104.6	105.1	105.3	-.6

*Using group B pistonphone and pink noise calibrations; includes pink noise, slow response windscreen, and microphone response corrections.

TABLE VI.- COMPARISON OF FLYOVER NOISE LEVELS FROM UNCONTROLLED SOURCE AS MEASURED AND ANALYZED* BY GROUP A USING BOTH GROUP A AND GROUP B CALIBRATIONS

	Group A calibrations		Group B calibrations		Δ
	Mic 3	Mic 4	Mic 3	Mic 4	$(\text{Group A})_{av} - (\text{Group B})_{av}$
Maximum L_A	96.0	95.3	95.7	95.3	0.2
PNLM	110.7	110.0	110.4	109.9	.2
PNLTM	112.0	111.6	111.8	111.1	.4
Tone correction	1.3	1.6	1.4	1.2	.2
Duration factor	-6.8	-6.6	-7.1	-6.5	.1
EPNL	105.2	105.0	104.7	104.6	.5

*Includes pink noise, slow response, windscreen, and microphone response corrections.

TABLE VII.- COMPARISON OF TYPICAL FLYOVER NOISE SPECTRA FROM UNCONTROLLED SOURCE AS MEASURED BY GROUP A AND ANALYZED* BY GROUPS A AND B AT TIME OF PNLM

One-third-octave-band center frequency, Hz	Mic 3, dB		Mic 4, dB		Δ, dB
	B	A	B	A	$B_{av} - A_{av}$
50	74.0	71.9	74.9	73.5	1.8
63	---	72.0	73.0	69.2	-2.4
80	72.2	72.2	72.8	72.5	.2
100	82.2	82.6	83.5	83.8	-.4
125	86.2	84.8	86.5	85.7	-1.1
160	88.5	87.8	88.3	87.2	.9
200	87.1	83.4	87.8	82.9	4.3
250	86.0	86.2	85.8	86.0	-.2
315	89.2	88.8	89.3	89.9	-.1
400	86.0	85.8	86.4	86.2	.2
500	86.0	85.6	87.1	85.8	.8
630	85.7	85.7	86.5	85.3	.6
800	84.8	84.8	85.3	85.3	.5
1 000	83.3	83.2	83.6	83.1	.3
1 250	83.4	83.5	83.1	83.1	-.0
1 600	83.0	82.9	81.9	81.8	.1
2 000	82.7	82.6	81.7	81.8	.0
2 500	84.2	84.2	83.2	83.4	-.1
3 150	87.5	88.1	86.3	87.1	-.7
4 000	83.9	84.1	83.2	83.4	-.2
5 000	79.7	80.2	78.9	79.7	-.6
6 300	77.8	77.0	76.7	77.1	.2
8 000	75.7	75.8	74.8	75.7	-.5
10 000	71.1	72.1	70.9	71.8	-1.0

*Using group B pistonphone and pink noise calibrations; includes pink noise, slow response, windscreen, and microphone response corrections.

TABLE VIII.- SUMMARY OF REFAN I DATA ANALYSES

(a) SI Units

	Take-off correction					Cutback correction		
RUN NUMBER	54	56	60	61	62	21	22	23
OVERHEAD TIME	9:46: 6.2	10: 1:26.6	10:30:10.7	10:36:51.8	10:47:12.1	11:33:48.3	11:42:10.4	11:49:25.2
TIME OF PNLTM	9:46:14.5	10: 1:29.5	10:30:14.0	10:36:55.5	10:47:16.0	11:33:54.0	11:42:16.0	11:49:32.5
REFERENCE CONDITIONS								
ALTITUDE, M	753.5	753.5	753.5	753.5	753.5	684.3	684.3	684.3
LATERAL DISPLACEMENT, M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	8.8	8.8	8.8	8.8	8.8	4.7	4.7	4.7
CLOSEST APPROACH, M	744.5	744.5	744.5	744.5	744.5	681.9	681.9	681.9
PATH SPEED, M/SEC	92.8	92.8	92.8	92.8	92.8	92.5	92.5	92.5
NORMALIZED THRUST, N	61787.2	61787.2	61787.2	61787.2	61787.2	42038.0	42038.0	42038.0
SLANT RANGE, M	1042.2	775.6	782.7	794.8	797.3	767.0	781.6	859.5
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, M	645.3	630.0	656.1	650.5	674.9	731.4	674.6	667.2
LATERAL DISPLACEMENT, M	3.5	-62.5	46.8	-3.4	18.9	-34.1	-22.8	5.4
PATH ANGLE, DEG.	8.9	8.4	8.0	7.5	7.7	6.1	6.2	5.6
CLOSEST APPROACH, M	637.5	626.4	651.4	645.0	669.0	728.1	671.1	664.0
PATH SPEED, M/SEC	92.5	92.7	93.2	93.0	92.3	90.3	90.8	91.8
NORMALIZED THRUST, N	60764.1	57054.5	53829.7	49777.6	47873.8	40717.0	39734.0	40347.8
SLANT RANGE, M	892.4	652.5	684.8	688.5	716.4	818.9	769.1	836.9
TEMPERATURE, DEG. CENT.	12.9	13.4	14.1	14.7	15.1	13.6	13.7	13.8
RELATIVE HUMIDITY, PERCENT	42.5	44.8	43.6	39.6	39.7	27.5	27.4	25.8
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-.9	-1.1	-.8	-.1	-1.2	.1	-1.9	-.8
TONE BAND, KHZ	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	100.4	98.2	96.0	93.6	93.4	86.8	89.6	89.1
EPNL, EPNDB	99.5	97.1	95.2	93.4	92.1	86.9	87.7	88.4
OASPL, DB	94.7	93.2	91.9	89.5	89.7	84.2	86.7	87.0
DBA, DB	86.7	87.5	85.4	82.5	82.4	76.3	79.4	77.9
CORRECTED LEVELS								
TONE BAND, KHZ	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WEATHER CORRECTION, EPNDB	.7	.8	.8	1.0	.9	2.1	2.2	3.4
PATH CORRECTION, EPNDB	-1.8	-2.1	-1.6	-1.7	-1.3	.8	-.2	-.4
SPEED CORRECTION, EPNDB	-.0	-.0	.0	.0	-.0	-.1	-.1	-.0
DURATION CORRECTION, EPNDB	.7	.8	.6	.6	.5	-.3	.1	.1
THRUST CORRECTION, EPNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	99.4	96.9	95.1	92.8	93.0	89.7	91.6	92.2
EPNL, EPNDB	99.1	96.6	94.9	93.3	92.2	89.5	89.7	91.5
OASPL, DB	92.9	91.3	90.3	87.9	88.4	84.8	86.5	86.7
DBA, DB	84.5	85.2	83.6	80.6	80.9	77.2	79.5	78.4

TABLE VIII.- Continued

(a) Continued

	Take-off with cutback		Landing approach correction					
RUN NUMBER	12	19	33	35	37	39	40	41
OVERHEAD TIME	10: 3:53.4	11:17:51.5	11:20:20.4	11:37:33.9	11:50:58.7	9:32:13.0	9:40:14.3	9:48: 6.6
TIME OF PNLTM	10: 3:57.0	11:17:56.0	11:20:21.0	11:37:34.5	11:50:59.5	9:32:14.5	9:40:16.0	9:48: 8.0
REFERENCE CONDITIONS								
ALTITUDE, M	684.3	684.3	112.8	112.8	112.8	112.8	112.8	112.8
LATERAL DISPLACEMENT, M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	4.7	4.7	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
CLOSEST APPROACH, M	681.9	681.9	112.6	112.6	112.6	112.6	112.6	112.6
PATH SPEED, M/SEC	92.5	92.5	72.8	72.8	72.8	72.8	72.8	72.8
NORMALIZED THRUST, N	42038.0	42038.0	23850.2	23850.2	23850.2	23850.2	23850.2	23850.2
SLANT RANGE, M	709.8	741.5	112.9	112.9	117.7	133.7	140.0	126.9
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, M	685.3	663.2	116.7	117.9	84.6	110.6	113.6	113.8
LATERAL DISPLACEMENT, M	-29.0	-13.2	-55.2	-58.9	-56.5	-49.4	-53.1	-56.9
PATH ANGLE, DEG.	5.2	5.8	-3.1	-2.9	-2.7	-3.4	-2.4	-3.1
CLOSEST APPROACH, M	683.1	659.9	128.9	131.7	101.7	120.9	125.3	127.1
PATH SPEED, M/SEC	90.2	89.9	70.8	71.2	71.5	78.1	78.5	73.8
NORMALIZED THRUST, N	41926.8	39805.2	19842.5	17671.9	14229.2	28645.1	30829.1	26990.5
SLANT RANGE, M	711.0	717.5	129.3	132.0	106.3	143.6	155.8	143.2
TEMPERATURE, DEG. CENT.	11.2	13.6	13.6	14.2	15.8	11.5	12.2	12.7
RELATIVE HUMIDITY, PERCENT	34.0	30.4	43.3	45.2	38.4	51.5	51.0	46.6
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-.2	-.3	-5.6	-5.2	-6.1	-5.6	-5.7	-5.9
TONE BAND, KHZ	0.0	0.0	6.3	6.3	5.0	0.0	0.0	8.0
TONE CORRECTION, PNDB	0.0	0.0	.7	.7	1.8	0.0	0.0	.5
PNLTM, PNDB	87.6	87.7	100.5	99.6	101.4	104.2	105.2	103.7
EPNL, EPNDB	87.5	87.5	95.0	94.4	95.4	98.6	99.5	97.8
OASPL, DB	85.0	85.1	90.9	90.2	90.5	95.3	96.3	93.6
DBA, DB	78.4	77.5	87.3	86.6	87.3	91.1	92.0	90.1
CORRECTED LEVELS								
TONE BAND, KHZ	0.0	0.0	6.3	6.3	5.0	0.0	8.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	.6	.7	1.6	0.0	.5	0.0
WEATHER CORRECTION, EPNDB	2.4	1.8	1.1	.8	1.5	1.0	1.5	.6
PATH CORRECTION, EPNDB	.0	-.4	1.4	1.6	-1.1	.8	1.2	1.3
SPEED CORRECTION, EPNDB	-.1	-.1	-.1	-.1	-.1	.3	.3	.1
DURATION CORRECTION, EPNDB	-.0	.1	-.6	-.7	.4	-.3	-.5	-.5
THRUST CORRECTION, EPNDB	.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	90.1	89.1	103.0	102.0	101.8	105.9	107.8	105.6
EPNL, EPNDB	89.9	90.1	96.8	96.1	96.1	100.3	102.0	99.3
OASPL, DB	84.9	84.6	92.4	91.7	89.8	96.0	97.4	95.0
DBA, DB	78.5	77.2	89.1	88.4	86.8	92.1	93.3	91.8

TABLE VIII.- Continued

(a) Concluded

		Landing approach		
RUN NUMBER	51	27	28	32
OVERHEAD TIME	11:19:35.5	10:14:49.9	10:33:31.1	11:10:32.7
TIME OF PNLTM	11:19:37.0	10:14:50.5	10:33:31.5	11:10:33.5
REFERENCE CONDITIONS				
ALTITUDE, M	112.8	112.8	112.8	112.8
LATERAL DISPLACEMENT, M	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	-3.0	-3.0	-3.0	-3.0
CLOSEST APPROACH, M	112.6	112.6	112.6	112.6
PATH SPEED, M/SEC	72.8	72.7	72.7	72.7
NORMALIZED THRUST, N	23850.2	23850.2	23850.2	23850.2
SLANT RANGE, M	130.6	113.1	112.7	113.9
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS				
ALTITUDE, M	110.2	105.0	89.2	121.2
LATERAL DISPLACEMENT, M	-57.0	-59.0	-48.1	-61.4
PATH ANGLE, DEG.	-3.1	-3.1	-2.6	-3.6
CLOSEST APPROACH, M	123.9	120.3	101.3	135.7
PATH SPEED, M/SEC	73.0	69.9	69.3	70.5
NORMALIZED THRUST, N	24201.6	24495.1	22502.4	24539.6
SLANT RANGE, M	143.7	120.9	101.3	137.2
TEMPERATURE, DEG. CENT.	14.4	11.7	12.3	13.3
RELATIVE HUMIDITY, PERCENT	35.8	49.7	51.7	46.8
UNCORRECTED LEVELS				
DURATION FACTOR, PNDB	-5.7	-6.3	-6.0	-4.9
TONE BAND, KHZ	8.0	8.0	6.3	0.0
TONE CORRECTION, PNDB	.5	.6	.6	0.0
PNLTM, PNDB	101.7	104.3	104.2	101.6
EPNL, EPNDB	96.0	98.0	98.2	96.7
OASPL, DB	92.4	94.2	94.3	93.1
DBA, DB	88.6	90.4	90.6	89.0
CORRECTED LEVELS				
TONE BAND, KHZ	0.0	8.0	6.3	0.0
TONE CORRECTION, PNDB	0.0	.6	.5	0.0
WEATHER CORRECTION, EPNDB	1.2	.7	.5	1.0
PATH CORRECTION, EPNDB	1.0	.7	-1.1	2.0
SPEED CORRECTION, EPNDB	.0	-.2	-.2	-.1
DURATION CORRECTION, EPNDB	-.4	-.3	.5	-.8
THRUST CORRECTION, EPNDB	0.0	-.3	.5	-.3
PNLTM, PNDB	103.9	105.7	103.6	104.5
EPNL, EPNDB	97.8	98.6	98.4	98.4
OASPL, DB	93.6	94.9	93.4	94.9
DBA, DB	90.3	91.4	89.8	91.0

TABLE VIII.- Continued

(b) U.S. Customary Units

	Take-off correction					Cutback correction		
RUN NUMBER	54	56	60	61	62	21	22	23
OVERHEAD TIME	9:46: 6.2	10: 1:26.6	10:30:10.7	10:36:51.8	10:47:12.1	11:33:48.3	11:42:10.4	11:49:25.2
TIME OF PNLTM	9:46:14.5	10: 1:29.5	10:30:14.0	10:36:55.5	10:47:16.0	11:33:54.0	11:42:16.0	11:49:32.5
REFERENCE CONDITIONS								
ALTITUDE, FT	2472.0	2472.0	2472.0	2472.0	2472.0	2245.0	2245.0	2245.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	8.8	8.8	8.8	8.8	8.8	4.7	4.7	4.7
CLOSEST APPROACH, FT	2442.7	2442.7	2442.7	2442.7	2442.7	2237.4	2237.4	2237.4
PATH SPEED, FT/SEC	304.4	304.4	304.4	304.4	304.4	303.3	303.3	303.3
NORMALIZED THRUST, LBF	13891.0	13891.0	13891.0	13891.0	13891.0	9451.0	9451.0	9451.0
SLANT RANGE, FT	3419.2	2544.6	2568.0	2607.5	2615.7	2516.4	2564.3	2819.9
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, FT	2117.1	2066.9	2152.5	2134.3	2214.1	2399.6	2213.3	2189.0
LATERAL DISPLACEMENT, FT	11.6	-205.2	153.6	-11.0	62.1	-111.9	-74.9	17.8
PATH ANGLE, DEG.	8.9	8.4	8.0	7.5	7.7	6.1	6.2	5.6
CLOSEST APPROACH, FT	2091.6	2055.0	2137.1	2116.1	2195.0	2388.6	2201.6	2178.6
PATH SPEED, FT/SEC	303.5	304.2	305.9	305.0	302.7	296.2	297.8	301.3
NORMALIZED THRUST, LBF	13661.0	12827.0	12102.0	11191.0	10763.0	9154.0	8933.0	9071.0
SLANT RANGE, FT	2927.8	2140.8	2246.7	2258.9	2350.5	2686.5	2523.3	2745.9
TEMPERATURE, DEG. FAHR.	55.3	56.1	57.4	58.5	59.1	56.4	56.7	56.9
RELATIVE HUMIDITY, PERCENT	42.5	44.8	43.6	39.6	39.7	27.5	27.4	25.8
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-.9	-1.1	-.8	-.1	-1.2	.1	-1.9	-.8
TONE BAND, KHZ	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	100.4	98.2	96.0	93.6	93.4	86.8	89.6	89.1
EPNL, EPNDB	99.5	97.1	95.2	93.4	92.1	86.9	87.7	88.4
OASPL, DB	94.7	93.2	91.9	89.5	89.7	84.2	86.7	87.0
DBA, DB	86.7	87.5	85.4	82.5	82.4	76.3	79.4	77.9
CORRECTED LEVELS								
TONE BAND, KHZ	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WEATHER CORRECTION, EPNDB	.7	.8	.8	1.0	.9	2.1	2.2	3.4
PATH CORRECTION, EPNDB	-1.8	-2.1	-1.6	-1.7	-1.3	.8	-.2	-.4
SPEED CORRECTION, EPNDB	-.0	-.0	.0	.0	-.0	-.1	-.1	-.0
DURATION CORRECTION, EPNDB	.7	.8	.6	.6	.5	-.3	.1	.1
THRUST CORRECTION, EPNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	99.4	96.9	95.1	92.8	93.0	89.7	91.6	92.2
EPNL, EPNDB	99.1	96.6	94.9	93.3	92.2	89.5	89.7	91.5
OASPL, DB	92.9	91.3	90.3	87.9	88.4	84.8	86.5	86.7
DBA, DB	84.5	85.2	83.6	80.6	80.9	77.2	79.5	78.4

TABLE VIII.- Continued

(b) Continued

	Take-off with cutback		Landing approach correction					
RUN NUMBER	12	19	33	35	37	39	40	41
OVERHEAD TIME	10: 3:53.4	11:17:51.5	11:20:20.4	11:37:33.9	11:50:58.7	9:32:13.0	9:40:14.3	9:48: 6.6
TIME OF PNLTM	10: 3:57.0	11:17:56.0	11:20:21.0	11:37:34.5	11:50:59.5	9:32:14.5	9:40:16.0	9:48: 8.0
REFERENCE CONDITIONS								
ALTITUDE, FT	2245.0	2245.0	370.0	370.0	370.0	370.0	370.0	370.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	4.7	4.7	-3.0	-3.0	-3.0	-3.0	-3.0	-3.0
CLOSEST APPROACH, FT	2237.4	2237.4	369.5	369.5	369.5	369.5	369.5	369.5
PATH SPEED, FT/SEC	303.3	303.3	238.7	238.7	238.7	238.7	238.7	238.7
NORMALIZED THRUST, LBF	9451.0	9451.0	5362.0	5362.0	5362.0	5362.0	5362.0	5362.0
SLANT RANGE, FT	2328.8	2432.7	370.4	370.4	386.2	438.7	459.4	416.4
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, FT	2248.4	2175.8	382.9	386.8	277.6	362.7	372.6	373.4
LATERAL DISPLACEMENT, FT	-95.1	-43.3	-181.0	-193.4	-185.4	-162.2	-174.1	-186.7
PATH ANGLE, DEG.	5.2	5.8	-3.1	-2.9	-2.7	-3.4	-2.4	-3.1
CLOSEST APPROACH, FT	2241.2	2165.1	423.0	432.0	333.6	396.7	411.0	417.0
PATH SPEED, FT/SEC	295.9	294.9	232.3	233.5	234.5	256.1	257.4	242.2
NORMALIZED THRUST, LBF	9426.0	8949.0	4461.0	3973.0	3199.0	6440.0	6931.0	6068.0
SLANT RANGE, FT	2332.8	2354.1	424.1	433.0	348.7	471.1	511.0	469.9
TEMPERATURE, DEG. FAHR.	52.1	56.5	56.5	57.5	60.5	52.7	53.9	54.9
RELATIVE HUMIDITY, PERCENT	34.0	30.4	43.3	45.2	38.4	51.5	51.0	46.6
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-.2	-.3	-5.6	-5.2	-6.1	-5.6	-5.7	-5.9
TONE BAND, KHZ	0.0	0.0	6.3	6.3	5.0	0.0	0.0	8.0
TONE CORRECTION, PNDB	0.0	0.0	.7	.7	1.8	0.0	0.0	.5
PNLTM, PNDB	87.6	87.7	100.5	99.6	101.4	104.2	105.2	103.7
EPNL, EPNDB	87.5	87.5	95.0	94.4	95.4	98.6	99.5	97.8
OASPL, DB	85.0	85.1	90.9	90.2	90.5	95.3	96.3	93.6
DBA, DB	78.4	77.5	87.3	86.6	87.3	91.1	92.0	90.1
CORRECTED LEVELS								
TONE BAND, KHZ	0.0	0.0	6.3	6.3	5.0	0.0	8.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	.6	.7	1.6	0.0	.5	0.0
WEATHER CORRECTION, EPNDB	2.4	1.8	1.1	.8	1.5	1.0	1.5	.6
PATH CORRECTION, EPNDB	.0	-.4	1.4	1.6	-1.1	.8	1.2	1.3
SPEED CORRECTION, EPNDB	-.1	-.1	-.1	-.1	-.1	.3	.3	.1
DURATION CORRECTION, EPNDB	-.0	.1	-.6	-.7	.4	-.3	-.5	-.5
THRUST CORRECTION, EPNDB	.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	90.1	89.1	103.0	102.0	101.8	105.9	107.8	105.6
EPNL, EPNDB	89.9	90.1	96.8	96.1	96.1	100.3	102.0	99.3
OASPL, DB	84.9	84.6	92.4	91.7	89.8	96.0	97.4	95.0
DBA, DB	78.5	77.2	89.1	88.4	86.8	92.1	93.3	91.8

TABLE VIII.- Concluded

(b) Concluded

		Landing approach		
RUN NUMBER	51	27	28	32
OVERHEAD TIME	11:19:35.5	10:14:49.9	10:33:31.1	11:10:32.7
TIME OF PNLTM	11:19:37.0	10:14:50.5	10:33:31.5	11:10:33.5
REFERENCE CONDITIONS				
ALTITUDE, FT	370.0	370.0	370.0	370.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	-3.0	-3.0	-3.0	-3.0
CLOSEST APPROACH, FT	369.5	369.5	369.5	369.5
PATH SPEED, FT/SEC	238.7	238.7	238.7	238.7
NORMALIZED THRUST, LBF	5362.0	5362.0	5362.0	5362.0
SLANT RANGE, FT	428.4	371.1	369.7	373.6
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS				
ALTITUDE, FT	361.5	344.5	292.8	397.7
LATERAL DISPLACEMENT, FT	-186.9	-193.7	-157.8	-201.5
PATH ANGLE, DEG.	-3.1	-3.1	-2.6	-3.6
CLOSEST APPROACH, FT	406.5	394.8	332.3	445.1
PATH SPEED, FT/SEC	239.5	229.4	227.5	231.4
NORMALIZED THRUST, LBF	5441.0	5507.0	5059.0	5517.0
SLANT RANGE, FT	471.3	396.5	332.5	450.1
TEMPERATURE, DEG. FAHR.	58.0	53.1	54.1	56.0
RELATIVE HUMIDITY, PERCENT	35.8	49.7	51.7	46.8
UNCORRECTED LEVELS				
DURATION FACTOR, PNDB	-5.7	-6.3	-6.0	-4.9
TONE BAND, KHZ	8.0	8.0	6.3	0.0
TONE CORRECTION, PNDB	.5	.6	.6	0.0
PNLTM, PNDB	101.7	104.3	104.2	101.6
EPNL, EPNDB	96.0	98.0	98.2	96.7
OASPL, DB	92.4	94.2	94.3	93.1
DBA, DB	88.6	90.4	90.6	89.0
CORRECTED LEVELS				
TONE BAND, KHZ	0.0	8.0	6.3	0.0
TONE CORRECTION, PNDB	0.0	.6	.5	0.0
WEATHER CORRECTION, EPNDB	1.2	.7	.5	1.0
PATH CORRECTION, EPNDB	1.0	.7	-1.1	2.0
SPEED CORRECTION, EPNDB	.0	-.2	-.2	-.1
DURATION CORRECTION, EPNDB	-.4	-.3	.5	-.8
THRUST CORRECTION, EPNDB	0.0	-.3	.5	-.3
PNLTM, PNDB	103.9	105.7	103.6	104.5
EPNL, EPNDB	97.8	98.6	98.4	98.4
OASPL, DB	93.6	94.9	93.4	94.9
DBA, DB	90.3	91.4	89.8	91.0

TABLE IX.- SUMMARY OF HARDWALL DATA ANALYSES

(a) SI Units

	Take-off correction					Cutback correction		
RUN NUMBER	37	38	43	45	47	39	40	41
OVERHEAD TIME	4:59:10.8	5:11:32.9	5:54:41.7	6:10:57.5	6:27:17.3	5:20: 2.7	5:28:24.2	5:36:57.2
TIME OF PNLTM	4:59:13.5	5:11:36.0	5:54:47.0	6:11: 1.5	6:27:20.5	5:20: 6.0	5:28:28.5	5:37: 1.5
REFERENCE CONDITIONS								
ALTITUDE, M	655.6	655.6	655.6	655.6	655.6	515.7	515.7	515.7
LATERAL DISPLACEMENT, M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	8.1	8.1	8.1	8.1	8.1	4.4	4.4	4.4
CLOSEST APPROACH, M	649.1	649.1	649.1	649.1	649.1	514.2	514.2	514.2
PATH SPEED, M/SEC	91.8	91.8	91.8	91.8	91.8	92.4	92.4	92.4
NORMALIZED THRUST, N	57352.5	57352.5	57352.5	57352.5	57352.5	40063.1	40063.1	40063.1
SLANT RANGE, M	707.0	695.4	829.0	722.2	683.1	563.0	588.0	586.8
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, M	413.5	524.4	487.1	507.3	521.4	468.5	516.3	520.3
LATERAL DISPLACEMENT, M	-90.2	-122.1	-50.0	-45.0	-74.5	-69.7	-30.7	-60.5
PATH ANGLE, DEG.	6.6	7.1	6.5	2.9	2.2	4.5	4.1	4.2
CLOSEST APPROACH, M	420.5	534.5	486.6	508.6	526.3	472.2	515.9	522.4
PATH SPEED, M/SEC	98.8	98.9	95.0	94.7	96.6	97.4	96.9	97.4
NORMALIZED THRUST, N	49448.4	56934.4	47469.1	36687.1	31020.4	40752.6	40988.3	40899.4
SLANT RANGE, M	458.0	572.6	621.4	565.9	553.8	517.0	589.9	596.1
TEMPERATURE, DEG. CENT.	14.6	15.4	18.3	18.4	16.7	15.6	16.1	17.2
RELATIVE HUMIDITY, PERCENT	26.0	28.7	15.8	12.8	16.6	21.6	19.3	17.4
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-1.8	-.5	-.4	-1.3	-1.7	-1.6	-.8	-1.5
TONE BAND, KHZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	102.5	102.0	98.8	93.2	90.2	96.6	95.2	95.4
EPNL, EPNDB	100.7	101.5	98.4	91.9	88.6	94.9	94.3	94.0
OASPL, DB	98.9	98.8	97.2	90.4	87.2	93.8	92.2	93.1
DBA, DB	93.0	92.6	88.0	83.5	81.1	86.5	84.9	84.9
CORRECTED LEVELS								
TONE BAND, KHZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WEATHER CORRECTION, EPNDB	1.9	2.0	3.0	3.5	3.1	2.2	2.3	2.4
PATH CORRECTION, EPNDB	-4.7	-2.1	-3.1	-2.7	-2.4	-.9	.0	.2
SPEED CORRECTION, EPNDB	.3	.3	.1	.1	.2	.2	.2	.2
DURATION CORRECTION, EPNDB	1.9	.8	1.3	1.1	.9	.4	-.0	-.1
THRUST CORRECTION, EPNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	99.7	101.9	98.7	93.9	91.0	97.9	97.5	98.0
EPNL, EPNDB	100.0	102.6	99.7	93.8	90.5	96.9	96.8	96.7
OASPL, DB	94.6	96.7	94.6	88.6	85.5	93.0	92.4	93.4
DBA, DB	88.6	90.5	85.7	82.5	79.9	86.0	85.6	85.7

TABLE IX.- Continued

(a) Continued

	Take-off with cutback				Landing approach correction			
RUN NUMBER	42	29	31	36	3	4	11	12
OVERHEAD TIME	5:45:24.7	8: 9:41.6	8:30:12.0	9:19:11.9	10:11:43.9	10:20: 8.3	11:21:37.1	11:30:30.2
TIME OF PNLTM	5:45:28.5	8: 9:43.5	8:30:15.0	9:19:15.5	10:11:46.0	10:20:10.0	11:21:39.0	11:30:31.5
REFERENCE CONDITIONS								
ALTITUDE, M	515.7	515.7	515.7	515.7	112.8	112.8	112.8	112.8
LATERAL DISPLACEMENT, M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	4.4	4.4	4.4	4.4	-3.0	-3.0	-3.0	-3.0
CLOSEST APPROACH, M	514.2	514.2	514.2	514.2	112.6	112.6	112.6	112.6
PATH SPEED, M/SEC	92.4	92.4	92.4	92.4	73.4	73.4	73.4	73.4
NORMALIZED THRUST, N	40063.1	40063.1	40063.1	40063.1	24148.2	24148.2	24148.2	24148.2
SLANT RANGE, M	566.7	526.6	549.1	560.1	152.7	135.6	141.6	122.8
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, M	518.0	401.1	484.1	533.5	113.2	122.3	118.1	118.5
LATERAL DISPLACEMENT, M	39.8	-97.5	-7.7	-97.0	-69.3	-49.7	-50.4	-62.0
PATH ANGLE, DEG.	3.9	3.6	3.5	4.6	-3.3	-3.5	-3.8	-3.3
CLOSEST APPROACH, M	518.4	412.0	483.3	540.6	132.6	131.9	128.2	133.5
PATH SPEED, M/SEC	96.2	100.1	102.0	101.2	81.1	77.5	73.9	74.4
NORMALIZED THRUST, N	40699.2	40490.1	41224.1	40814.8	27039.4	25647.2	21386.0	20091.6
SLANT RANGE, M	571.3	421.9	516.1	588.8	179.7	158.8	161.2	145.7
TEMPERATURE, DEG. CENT.	17.6	13.3	14.7	18.9	18.9	18.3	16.4	16.2
RELATIVE HUMIDITY, PERCENT	16.9	36.1	31.1	28.3	28.5	30.1	35.5	36.0
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-.8	-1.8	-1.6	-.9	-5.2	-4.8	-5.1	-4.5
TONE BAND, KHZ	0.0	0.0	0.0	0.0	2.5	2.5	4.0	4.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	1.2	1.0	1.3	1.1
PNLTM, PNDB	95.2	99.2	97.5	95.7	111.7	110.0	108.6	107.7
EPNL, EPNDB	94.3	97.4	95.9	94.8	106.5	105.2	103.5	103.2
OASPL, DB	92.5	94.1	93.0	92.2	99.8	97.6	95.7	94.2
DBA, DB	84.6	89.6	87.0	86.2	96.6	95.0	92.9	92.2
CORRECTED LEVELS								
TONE BAND, KHZ	0.0	0.0	0.0	0.0	4.0	4.0	4.0	4.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	1.3	1.1	1.3	1.2
WEATHER CORRECTION, EPNDB	2.5	2.1	1.9	2.2	3.0	2.8	2.7	2.5
PATH CORRECTION, EPNDB	.1	-2.6	-.7	.6	1.9	1.8	1.5	1.9
SPEED CORRECTION, EPNDB	.2	.3	.4	.4	.4	.2	.0	.1
DURATION CORRECTION, EPNDB	-.0	1.0	.3	-.2	-.7	-.7	-.6	-.7
THRUST CORRECTION, EPNDB	0.0	-.2	-.6	-.4	0.0	0.0	0.0	0.0
PNLTM, PNDB	97.7	98.8	98.7	98.5	116.7	114.6	112.9	112.2
EPNL, EPNDB	97.1	98.1	97.3	97.3	111.2	109.4	107.2	107.0
OASPL, DB	92.7	91.9	92.4	92.7	102.3	100.1	97.9	96.9
DBA, DB	85.5	87.4	86.6	86.8	100.2	98.5	96.1	95.8

TABLE IX.- Continued

(a) Concluded

		Landing approach	
RUN NUMBER	13	5	10
OVERHEAD TIME	11:38:35.8	10:28:20.7	11:12:48.5
TIME OF PNLTM	11:38:37.5	10:28:22.5	11:12:50.0
REFERENCE CONDITIONS			
ALTITUDE, M	112.8	112.8	112.8
LATERAL DISPLACEMENT, M	0.0	0.0	0.0
PATH ANGLE, DEG.	-3.0	-3.0	-3.0
CLOSEST APPROACH, M	112.6	112.6	112.6
PATH SPEED, M/SEC	73.4	73.4	73.4
NORMALIZED THRUST, N	24148.2	24148.2	24148.2
SLANT RANGE, M	135.2	131.7	130.2
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0
ACTUAL CONDITIONS			
ALTITUDE, M	110.6	126.6	111.1
LATERAL DISPLACEMENT, M	-68.5	-73.1	-52.0
PATH ANGLE, DEG.	-2.8	-3.7	-3.7
CLOSEST APPROACH, M	130.0	146.0	122.5
PATH SPEED, M/SEC	73.9	74.2	72.1
NORMALIZED THRUST, N	18405.8	22809.3	21506.1
SLANT RANGE, M	156.1	170.7	141.6
TEMPERATURE, DEG. CENT.	15.0	18.2	17.1
RELATIVE HUMIDITY, PERCENT	34.9	30.4	32.9
UNCORRECTED LEVELS			
DURATION FACTOR, PNDB	-4.4	-4.8	-5.0
TONE BAND, KHZ	0.0	2.5	4.0
TONE CORRECTION, PNDB	0.0	1.4	1.3
PNLTM, PNDB	107.9	108.2	109.3
EPNL, EPNDB	103.5	103.4	104.3
OASPL, DB	95.2	95.9	95.8
DBA, DB	93.5	92.8	93.4
CORRECTED LEVELS			
TONE BAND, KHZ	0.0	2.5	4.0
TONE CORRECTION, PNDB	0.0	1.4	1.3
WEATHER CORRECTION, EPNDB	2.6	2.1	2.5
PATH CORRECTION, EPNDB	1.7	3.0	1.0
SPEED CORRECTION, EPNDB	.0	.0	-.1
DURATION CORRECTION, EPNDB	-.6	-1.1	-.4
THRUST CORRECTION, EPNDB	0.0	.6	1.3
PNLTM, PNDB	112.1	113.3	112.8
EPNL, EPNDB	107.1	108.1	108.6
OASPL, DB	98.2	99.2	97.6
DBA, DB	97.3	97.1	96.1

TABLE IX.- Continued

(b) U.S. Customary Units

	Take-off correction					Cutback correction		
RUN NUMBER	37	38	43	45	47	39	40	41
OVERHEAD TIME	4:59:10.8	5:11:32.9	5:54:41.7	6:10:57.5	6:27:17.3	5:20: 2.7	5:28:24.2	5:36:57.2
TIME OF PNLTM	4:59:13.5	5:11:36.0	5:54:47.0	6:11: 1.5	6:27:20.5	5:20: 6.0	5:28:28.5	5:37: 1.5
REFERENCE CONDITIONS								
ALTITUDE, FT	2151.0	2151.0	2151.0	2151.0	2151.0	1692.0	1692.0	1692.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	8.1	8.1	8.1	8.1	8.1	4.4	4.4	4.4
CLOSEST APPROACH, FT	2129.8	2129.8	2129.8	2129.8	2129.8	1687.1	1687.1	1687.1
PATH SPEED, FT/SEC	301.3	301.3	301.3	301.3	301.3	303.1	303.1	303.1
NORMALIZED THRUST, LBF	12894.0	12894.0	12894.0	12894.0	12894.0	9007.0	9007.0	9007.0
SLANT RANGE, FT	2319.5	2281.4	2719.8	2369.5	2241.2	1847.2	1929.0	1925.1
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, FT	1356.5	1720.4	1598.2	1664.3	1710.5	1537.0	1694.0	1707.0
LATERAL DISPLACEMENT, FT	-295.9	-400.6	-164.0	-147.8	-244.3	-228.6	-100.8	-198.6
PATH ANGLE, DEG.	6.6	7.1	6.5	2.9	2.2	4.5	4.1	4.2
CLOSEST APPROACH, FT	1379.6	1753.6	1596.4	1668.7	1726.6	1549.2	1692.7	1714.0
PATH SPEED, FT/SEC	324.3	324.4	311.8	310.6	316.8	319.7	317.9	319.5
NORMALIZED THRUST, LBF	11117.0	12800.0	10672.0	8248.0	6974.0	9162.0	9215.0	9195.0
SLANT RANGE, FT	1502.5	1878.5	2038.6	1856.6	1817.0	1696.3	1935.5	1955.8
TEMPERATURE, DEG. FAHR.	58.3	59.7	65.0	65.2	62.0	60.0	61.0	62.9
RELATIVE HUMIDITY, PERCENT	26.0	28.7	15.8	12.8	16.6	21.6	19.3	17.4
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-1.8	-.5	-.4	-1.3	-1.7	-1.6	-.8	-1.5
TONE BAND, KHZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	102.5	102.0	98.8	93.2	90.2	96.6	95.2	95.4
EPNL, EPNDB	100.7	101.5	98.4	91.9	88.6	94.9	94.3	94.0
OASPL, DB	98.9	98.8	97.2	90.4	87.2	93.8	92.2	93.1
DBA, DB	93.0	92.6	88.0	83.5	81.1	86.5	84.9	84.9
CORRECTED LEVELS								
TONE BAND, KHZ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WEATHER CORRECTION, EPNDB	1.9	2.0	3.0	3.5	3.1	2.2	2.3	2.4
PATH CORRECTION, EPNDB	-4.7	-2.1	-3.1	-2.7	-2.4	-.9	.0	.2
SPEED CORRECTION, EPNDB	.3	.3	.1	.1	.2	.2	.2	.2
DURATION CORRECTION, EPNDB	1.9	.8	1.3	1.1	.9	.4	-.0	-.1
THRUST CORRECTION, EPNDB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PNLTM, PNDB	99.7	101.9	98.7	93.9	91.0	97.9	97.5	98.0
EPNL, EPNDB	100.0	102.6	99.7	93.8	90.5	96.9	96.8	96.7
OASPL, DB	94.6	96.7	94.6	88.6	85.5	93.0	92.4	93.4
DBA, DB	88.6	90.5	85.7	82.5	79.9	86.0	85.6	85.7

TABLE IX.- Continued

(b) Continued

	Take-off with cutback				Landing approach correction			
RUN NUMBER	42	29	31	36	3	4	11	12
OVERHEAD TIME	5:45:24.7	8: 9:41.6	8:30:12.0	9:19:11.9	10:11:43.9	10:20: 8.3	11:21:37.1	11:30:30.2
TIME OF PNLTM	5:45:28.5	8: 9:43.5	8:30:15.0	9:19:15.5	10:11:46.0	10:20:10.0	11:21:39.0	11:30:31.5
REFERENCE CONDITIONS								
ALTITUDE, FT	1692.0	1692.0	1692.0	1692.0	370.0	370.0	370.0	370.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	4.4	4.4	4.4	4.4	-3.0	-3.0	-3.0	-3.0
CLOSEST APPROACH, FT	1687.1	1687.1	1687.1	1687.1	369.5	369.5	369.5	369.5
PATH SPEED, FT/SEC	303.1	303.1	303.1	303.1	240.7	240.7	240.7	240.7
NORMALIZED THRUST, LBF	9007.0	9007.0	9007.0	9007.0	5429.0	5429.0	5429.0	5429.0
SLANT RANGE, FT	1859.4	1727.8	1801.5	1837.6	500.9	444.9	464.5	403.0
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0	77.0	77.0	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS								
ALTITUDE, FT	1699.6	1315.8	1588.3	1750.4	371.5	401.4	387.6	388.7
LATERAL DISPLACEMENT, FT	130.7	-319.8	-25.4	-318.4	-227.4	-163.2	-165.4	-203.4
PATH ANGLE, DEG.	3.9	3.6	3.5	4.6	-3.3	-3.5	-3.8	-3.3
CLOSEST APPROACH, FT	1700.7	1351.6	1585.5	1773.6	435.0	432.6	420.6	438.1
PATH SPEED, FT/SEC	315.7	328.5	334.7	332.0	266.2	254.4	242.4	244.2
NORMALIZED THRUST, LBF	9150.0	9103.0	9268.0	9176.0	6079.0	5766.0	4808.0	4517.0
SLANT RANGE, FT	1874.4	1384.2	1693.1	1931.8	589.7	520.9	528.8	477.9
TEMPERATURE, DEG. FAHR.	63.7	56.0	58.5	66.0	66.0	65.0	61.5	61.1
RELATIVE HUMIDITY, PERCENT	16.9	36.1	31.1	28.3	28.5	30.1	35.5	36.0
UNCORRECTED LEVELS								
DURATION FACTOR, PNDB	-.8	-1.8	-1.6	-.9	-5.2	-4.8	-5.1	-4.5
TONE BAND, KHZ	0.0	0.0	0.0	0.0	2.5	2.5	4.0	4.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	1.2	1.0	1.3	1.1
PNLTM, PNDB	95.2	99.2	97.5	95.7	111.7	110.0	108.6	107.7
EPNL, EPNDB	94.3	97.4	95.9	94.8	106.5	105.2	103.5	103.2
OASPL, DB	92.5	94.1	93.0	92.2	99.8	97.6	95.7	94.2
DBA, DB	84.6	89.6	87.0	86.2	96.6	95.0	92.9	92.2
CORRECTED LEVELS								
TONE BAND, KHZ	0.0	0.0	0.0	0.0	4.0	4.0	4.0	4.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	1.3	1.1	1.3	1.2
WEATHER CORRECTION, EPNDB	2.5	2.1	1.9	2.2	3.0	2.8	2.7	2.5
PATH CORRECTION, EPNDB	.1	-2.6	-.7	.6	1.9	1.8	1.5	1.9
SPEED CORRECTION, EPNDB	.2	.3	.4	.4	.4	.2	.0	.1
DURATION CORRECTION, EPNDB	-.0	1.0	.3	-.2	-.7	-.7	-.6	-.7
THRUST CORRECTION, EPNDB	0.0	-.2	-.6	-.4	0.0	0.0	0.0	0.0
PNLTM, PNDB	97.7	98.8	98.7	98.5	116.7	114.6	112.9	112.2
EPNL, EPNDB	97.1	98.1	97.3	97.3	111.2	109.4	107.2	107.0
OASPL, DB	92.7	91.9	92.4	92.7	102.3	100.1	97.9	96.9
DBA, DB	85.5	87.4	86.6	86.8	100.2	98.5	96.1	95.8

TABLE IX.- Concluded

(b) Concluded

	Landing approach		
RUN NUMBER	13	5	10
OVERHEAD TIME	11:38:35.8	10:28:20.7	11:12:48.5
TIME OF PNLTM	11:38:37.5	10:28:22.5	11:12:50.0
REFERENCE CONDITIONS			
ALTITUDE, FT	370.0	370.0	370.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0
PATH ANGLE, DEG.	-3.0	-3.0	-3.0
CLOSEST APPROACH, FT	369.5	369.5	369.5
PATH SPEED, FT/SEC	240.7	240.7	240.7
NORMALIZED THRUST, LBF	5429.0	5429.0	5429.0
SLANT RANGE, FT	443.7	432.0	427.3
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0
ACTUAL CONDITIONS			
ALTITUDE, FT	362.7	415.5	364.5
LATERAL DISPLACEMENT, FT	-224.8	-239.8	-170.6
PATH ANGLE, DEG.	-2.8	-3.7	-3.7
CLOSEST APPROACH, FT	426.3	479.0	401.8
PATH SPEED, FT/SEC	242.4	243.4	236.5
NORMALIZED THRUST, LBF	4138.0	5128.0	4835.0
SLANT RANGE, FT	512.0	560.0	464.6
TEMPERATURE, DEG. FAHR.	60.8	64.8	62.8
RELATIVE HUMIDITY, PERCENT	34.9	30.4	32.9
UNCORRECTED LEVELS			
DURATION FACTOR, PNDB	-4.4	-4.8	-5.0
TONE BAND, KHZ	0.0	2.5	4.0
TONE CORRECTION, PNDB	0.0	1.4	1.3
PNLTM, PNDB	107.9	108.2	109.3
EPNL, EPNDB	103.5	103.4	104.3
OASPL, DB	95.2	95.9	95.8
DBA, DB	93.5	92.8	93.4
CORRECTED LEVELS			
TONE BAND, KHZ	0.0	2.5	4.0
TONE CORRECTION, PNDB	0.0	1.4	1.3
WEATHER CORRECTION, EPNDB	2.6	2.1	2.5
PATH CORRECTION, EPNDB	1.7	3.0	1.0
SPEED CORRECTION, EPNDB	.0	.0	-.1
DURATION CORRECTION, EPNDB	-.6	-1.1	-.4
THRUST CORRECTION, EPNDB	0.0	.6	1.3
PNLTM, PNDB	112.1	113.3	112.8
EPNL, EPNDB	107.1	108.1	108.6
OASPL, DB	98.2	99.2	97.6
DBA, DB	97.3	97.1	96.1

TABLE X.- SUMMARY OF REFAN II DATA ANALYSES

(a) SI Units

	Take-off with cutback			Landing approach	
RUN NUMBER	17	18	22	1	6
OVERHEAD TIME	8:33:50.5	8:45:56.5	9:23:46.7	10:32:49.3	11:17:57.8
TIME OF PNLTM	8:33:53.5	8:45:58.5	9:23:50.0	10:32:51.0	11:18: 0.0
REFERENCE CONDITIONS					
ALTITUDE, M	684.3	684.3	684.3	112.8	112.8
LATERAL DISPLACEMENT, M	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	4.7	4.7	4.7	-3.0	-3.0
CLOSEST APPROACH, M	681.9	681.9	681.9	112.6	112.6
PATH SPEED, M/SEC	92.5	92.5	92.5	72.7	72.7
NORMALIZED THRUST, N	42038.0	42038.0	42038.0	23850.2	23850.2
SLANT RANGE, M	713.5	688.3	708.9	132.6	147.0
TEMPERATURE, DEG. CENT.	25.0	25.0	25.0	25.0	25.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS					
ALTITUDE, M	558.6	567.4	658.1	122.0	120.5
LATERAL DISPLACEMENT, M	1.8	-4.7	-12.3	-69.3	-72.9
PATH ANGLE, DEG.	4.4	4.5	4.8	-2.6	-3.2
CLOSEST APPROACH, M	557.0	565.7	655.9	140.2	140.7
PATH SPEED, M/SEC	99.8	102.0	99.9	76.1	75.1
NORMALIZED THRUST, N	40298.9	40734.8	39573.9	24072.6	21737.4
SLANT RANGE, M	582.8	571.0	681.8	165.1	183.6
TEMPERATURE, DEG. CENT.	14.6	15.3	19.3	17.9	16.1
RELATIVE HUMIDITY, PERCENT	33.2	32.1	27.8	31.6	36.9
UNCORRECTED LEVELS					
DURATION FACTOR, PNDB	-2.5	-2.2	-1.4	-5.0	-5.6
TONE BAND, KHZ	0.0	0.0	0.0	0.0	6.3
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	.6
PNLTM, PNDB	90.8	90.3	88.1	100.6	100.8
EPNL, EPNDB	88.3	88.1	86.6	95.6	95.2
OASPL, DB	87.0	86.4	84.8	92.9	92.9
DBA, DB	79.7	80.1	77.8	88.7	88.3
CORRECTED LEVELS					
TONE BAND, KHZ	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	0.0
WEATHER CORRECTION, EPNDB	1.4	1.6	1.9	1.6	.8
PATH CORRECTION, EPNDB	-2.4	-2.2	-.4	2.3	2.4
SPEED CORRECTION, EPNDB	.3	.4	.3	.2	.1
DURATION CORRECTION, EPNDB	.9	.8	.2	-1.0	-1.0
THRUST CORRECTION, EPNDB	.9	.7	1.3	-.1	.8
PNLTM, PNDB	89.8	89.7	89.5	104.5	104.1
EPNL, EPNDB	89.4	89.5	89.9	98.6	98.4
OASPL, DB	84.9	84.5	84.3	95.0	95.1
DBA, DB	77.5	78.1	77.3	91.3	90.9

TABLE X.- Concluded

(b) U.S. Customary Units

	Take-off with cutback			Landing approach	
RUN NUMBER	17	18	22	1	6
OVERHEAD TIME	8:33:50.5	8:45:56.5	9:23:46.7	10:32:49.3	11:17:57.8
TIME OF PNLTM	8:33:53.5	8:45:58.5	9:23:50.0	10:32:51.0	11:18: 0.0
REFERENCE CONDITIONS					
ALTITUDE, FT	2245.0	2245.0	2245.0	370.0	370.0
LATERAL DISPLACEMENT, FT	0.0	0.0	0.0	0.0	0.0
PATH ANGLE, DEG.	4.7	4.7	4.7	-3.0	-3.0
CLOSEST APPROACH, FT	2237.4	2237.4	2237.4	369.5	369.5
PATH SPEED, FT/SEC	303.3	303.3	303.3	238.7	238.7
NORMALIZED THRUST, LBF	9451.0	9451.0	9451.0	5362.0	5362.0
SLANT RANGE, FT	2340.9	2258.3	2325.9	435.0	482.3
TEMPERATURE, DEG. FAHR.	77.0	77.0	77.0	77.0	77.0
RELATIVE HUMIDITY, PERCENT	70.0	70.0	70.0	70.0	70.0
ACTUAL CONDITIONS					
ALTITUDE, FT	1832.8	1861.7	2159.0	400.4	395.4
LATERAL DISPLACEMENT, FT	6.0	-15.4	-40.3	-227.4	-239.1
PATH ANGLE, DEG.	4.4	4.5	4.8	-2.6	-3.2
CLOSEST APPROACH, FT	1827.4	1856.0	2151.8	460.1	461.5
PATH SPEED, FT/SEC	327.3	334.7	327.8	249.7	246.3
NORMALIZED THRUST, LBF	9060.0	9158.0	8897.0	5412.0	4887.0
SLANT RANGE, FT	1911.9	1873.4	2236.9	541.7	602.5
TEMPERATURE, DEG. FAHR.	58.3	59.5	66.8	64.2	61.0
RELATIVE HUMIDITY, PERCENT	33.2	32.1	27.8	31.6	36.9
UNCORRECTED LEVELS					
DURATION FACTOR, PNDB	-2.5	-2.2	-1.4	-5.0	-5.6
TONE BAND, KHZ	0.0	0.0	0.0	0.0	6.3
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	.6
PNLTM, PNDB	90.8	90.3	88.1	100.6	100.8
EPNL, EPNDB	88.3	88.1	86.6	95.6	95.2
OASPL, DB	87.0	86.4	84.8	92.9	92.9
DBA, DB	79.7	80.1	77.8	88.7	88.3
CORRECTED LEVELS					
TONE BAND, KHZ	0.0	0.0	0.0	0.0	0.0
TONE CORRECTION, PNDB	0.0	0.0	0.0	0.0	0.0
WEATHER CORRECTION, EPNDB	1.4	1.6	1.9	1.6	.8
PATH CORRECTION, EPNDB	-2.4	-2.2	-.4	2.3	2.4
SPEED CORRECTION, EPNDB	.3	.4	.3	.2	.1
DURATION CORRECTION, EPNDB	.9	.8	.2	-1.0	-1.0
THRUST CORRECTION, EPNDB	.9	.7	1.3	-.1	.8
PNLTM, PNDB	89.8	89.7	89.5	104.5	104.1
EPNL, EPNDB	89.4	89.5	89.9	98.6	98.4
OASPL, DB	84.9	84.5	84.3	95.0	95.1
DBA, DB	77.5	78.1	77.3	91.3	90.9

TABLE XI.- TABULATION OF VALUES OF ACOUSTIC DESCRIPTORS

COMPUTED BY GROUPS A AND B

Condition	Reference*		Run	Duration factor, EPNdB		Duration correction factor, EPNdB		Speed correction, EPNdB	
	Table	Page		A	B	A	B	A	B
Take-off with cutback	VIII	33	12	-0.2	0.0	-0.0	-0.0	-0.1	-0.1
	VIII	33	19	-.3	-.8	.1	.1	-.1	-.1
	X	44	17R	-2.5	-1.8	.9	.9	.3	.3
	X	44	18R	-2.2	-1.5	.8	.8	.4	.4
	X	44	22R	-1.4	-.4	.2	.2	.3	.3
	IX	39	29	-1.8	-2.2	1.0	1.0	.3	.4
	IX	39	31	-1.6	-1.2	-.3	-.3	.4	.4
	IX	39	36	-.9	-1.2	-.2	-.2	.4	.4
Take-off correction	VIII	32	54	-0.9	-0.4	0.7	0.7	-0.0	-0.0
	IX	38	37	-1.8	-2.1	1.9	.9	.3	.3
	IX	38	38	-.5	-.5	.8	-.2	.3	.3
	IX	38	43	-.4	-.9	1.3	.3	.1	.1
	IX	38	45	-1.3	-1.2	1.1	.1	.1	.1
	IX	38	47	-1.7	-1.4	.9	-.1	.2	.2
Refan landing approach	VIII	34	27	-6.3	-6.2	-0.3	-0.3	-0.2	-0.2
	VIII	34	28	-6.0	-6.2	.5	.5	-.2	-.2
	VIII	34	32	-4.9	-5.7	-.8	-.7	-.1	-.1
	X	44	1R	-5.0	-5.2	-1.0	-1.0	.2	.2
	X	44	6R	-5.6	-5.6	-1.0	-1.0	.1	.1
Hardwall landing approach and landing approach correction	IX	40	5	-4.8	-4.7	-1.1	-1.1	0.0	0.0
	IX	40	10	-5.0	-5.0	-.4	-.4	-.1	-.1
	IX	39	11	-5.1	-4.9	-.6	-.6	.0	.0
	IX	39	12	-4.5	-4.1	-.7	-.7	.1	.1
	IX	40	13	-4.4	-4.7	-.6	-.6	.0	.0

*For group A values. Group B values were obtained from reference 7.

TABLE XI.- Continued

Condition	Reference		Run	Thrust correction, EPNdB		Atmospheric correction, EPNdB		Tone correction* (corrected), PNdB		Tone band (corrected), kHz	
	Table	Page		A	B	A	B	A	B	A	B
Take-off with cutback	VIII	33	12	0.1	0.0	2.4	0.2	0.0	0.0	---	---
	VIII	33	19	1.2	.7	1.4	.0	.0	.0	---	---
	X	44	17R	.9	.5	-1.0	-1.9	.0	.0	---	---
	X	44	18R	.7	.4	-.6	-1.4	.0	.0	---	---
	X	44	22R	1.3	.8	1.5	-.0	.0	.0	---	---
	IX	39	29	-.2	-.2	-.5	-1.9	.0	.0	---	---
	IX	39	31	-.6	-.5	1.2	.4	.0	.0	---	---
	IX	39	36	-.4	-.3	2.8	1.3	.0	.0	---	---
Take-off correction	VIII	32	54	0.0	0.0	-1.1	-1.6	3.5	0.0	1.0	---
	IX	38	37	.0	.0	-2.8	-1.7	.0	.0	---	---
	IX	38	38	.0	.0	-.1	.8	.0	.0	---	---
	IX	38	43	.0	.0	-.1	.4	.0	.0	---	---
	IX	38	45	.0	.0	.8	2.1	.0	.0	---	---
	IX	38	47	.0	.0	.7	2.0	.0	.0	---	---
Refan landing approach	VIII	34	27	-0.3	-0.3	1.4	1.4	0.6	0.6	8.0	8.0
	VIII	34	28	.5	.5	-.6	-.5	.5	.7	6.3	8.0
	VIII	34	32	-.3	-.3	3.0	2.2	.0	.6	---	8.0
	X	44	1R	-.1	-.1	3.9	3.5	.0	.5	---	8.0
	X	44	6R	.8	.9	3.2	3.3	.0	.6	---	.8
Hardwall landing approach and landing approach correction	IX	40	5	0.6	0.3	5.1	4.5	1.4	1.1	2.5	2.5
	IX	40	10	1.3	.7	3.5	3.0	1.3	1.1	4.0	4.0
	IX	39	11	-.0	.0	4.2	3.4	1.3	1.2	4.0	4.0
	IX	39	12	-.0	.0	4.4	3.5	1.2	2.3	4.0	3.1
	IX	40	13	.0	.0	4.3	3.5	.0	.0	---	---

*Tone correction removed from group B data if tone band was <800 Hz.

TABLE XI.- Continued

Condition	Reference		Run	Measured PNL,** PNdB		Corrected PNL,** PNdB		Measured PNLTM,* PNdB		Corrected PNLTM, PNdB	
	Table	Page		A	B	A	B	A	B	A	B
Take-off with cutback	VIII	33	12	87.6	87.1	90.1	87.3	87.6	87.1	90.1	87.3
	VIII	33	19	87.7	87.5	89.1	87.5	87.7	87.5	89.1	87.5
	X	44	17R	90.8	88.7	89.8	86.8	90.8	88.7	89.8	86.8
	X	44	18R	90.3	88.9	89.7	87.4	90.3	88.9	89.7	87.4
	X	44	22R	88.1	87.0	89.5	87.0	88.1	87.0	89.5	87.0
	IX	39	29	99.2	99.4	98.8	97.5	99.2	99.4	98.8	97.5
	IX	39	31	97.5	96.7	98.7	97.1	97.5	96.7	98.7	97.1
	IX	39	36	95.7	95.2	98.5	96.6	95.7	95.2	98.5	96.6
Take-off correction	VIII	32	54	96.8	98.3	95.9	96.6	100.4	98.3	99.4	96.6
	IX	38	37	102.5	102.3	99.7	100.7	102.5	102.3	99.7	100.7
	IX	38	38	102.0	102.0	101.9	102.8	102.0	102.0	101.9	102.8
	IX	38	43	98.8	98.6	98.7	99.1	98.8	98.6	98.7	99.1
	IX	38	45	93.2	93.2	93.9	95.3	93.2	93.2	93.9	95.3
	IX	38	47	90.2	90.4	91.0	92.4	90.2	90.4	91.0	92.4
Refan landing approach	VIII	34	27	103.7	103.0	105.1	104.4	104.3	103.6	105.7	105.0
	VIII	34	28	103.6	103.0	103.1	102.5	104.2	103.7	103.6	103.2
	VIII	34	32	101.6	101.3	104.5	103.6	101.6	101.9	104.5	104.2
	X	44	1R	100.6	99.6	104.5	103.3	100.6	100.3	104.5	103.8
	X	44	6R	100.2	99.9	104.1	103.3	100.8	100.6	104.1	103.9
Hardwall landing approach and landing approach correction	IX	40	5	106.8	105.9	111.9	110.4	108.2	107.0	113.3	111.5
	IX	40	10	108.0	106.3	111.5	109.2	109.3	107.4	112.8	110.4
	IX	39	11	107.3	105.6	111.6	108.9	108.6	106.7	112.9	110.1
	IX	39	12	106.6	103.8	111.0	107.4	107.7	106.2	112.2	109.7
	IX	40	13	107.9	106.2	112.1	109.7	107.9	106.2	112.1	109.7

*Tone correction removed from group B data if tone band was <800 Hz.

**At time of PNLTM.

TABLE XI.- Concluded

Condition	Reference		Run	Measured EPNL,* EPNdB		Corrected EPNL,* EPNdB	
	Table	Page		A	B	A	B
Take-off with cutback	VIII	33	12	87.5	87.1	89.9	87.3
	VIII	33	19	87.5	86.7	90.1	87.4
	X	44	17R	88.3	86.9	89.4	86.7
	X	44	18R	88.1	87.4	89.5	87.5
	X	44	22R	86.6	86.6	89.9	87.8
	IX	39	29	97.4	97.2	98.1	96.5
	IX	39	31	95.9	95.5	97.3	96.1
	IX	39	36	94.8	94.1	97.3	95.3
Take-off correction	VIII	32	54	99.5	97.9	99.1	97.0
	IX	38	37	100.7	100.2	100.0	99.7
	IX	38	38	101.5	101.5	102.6	102.4
	IX	38	43	98.4	97.7	99.7	98.5
	IX	38	45	91.9	92.0	93.8	94.3
	IX	38	47	88.6	89.0	90.5	91.1
Refan landing approach	VIII	34	27	98.0	97.4	98.6	98.1
	VIII	34	28	98.2	97.5	98.4	97.7
	VIII	34	32	96.7	96.3	98.4	97.4
	X	44	1R	95.6	95.1	98.6	97.8
	X	44	6R	95.2	95.0	98.4	98.3
Hardwall landing approach and landing approach correction	IX	40	5	103.4	102.3	108.1	106.0
	IX	40	10	104.3	102.4	108.6	105.6
	IX	39	11	103.5	101.8	107.2	104.7
	IX	39	12	103.2	102.0	107.0	104.9
	IX	40	13	103.5	101.5	107.1	104.4

*Tone correction removed from group B data if tone band was <800 Hz.

TABLE XII.- MEAN AND STANDARD DEVIATION OF DIFFERENCE* BETWEEN GROUP A AND GROUP B DESCRIPTORS

	Refan and hardwall take-off with cutback		Refan and hardwall take-off correction		Refan 50° flap landing approach		Hardwall 50° flap landing approach and approach correction		Total	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Duration factor, EPNdB	-0.23	0.57	-0.02	0.37	0.22	0.35	-0.08	0.26	-0.05	0.43
Duration factor correction, EPNdB	.0	.0	.83	.41	-.01	.04	.0	.0	.20	.42
Speed correction factor, EPNdB	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Thrust correction, EPNdB	.20	.26	.0	.0	.11	.25	.0	.0	.10	.21
Atmosphere correction, EPNdB	1.31	.47	-.77	.69	.20	.39	.72	.16	.44	.94
Tone correction** (corrected), PNdB	.0	.0	.58	1.43	-.38	.27	-.10	.57	.05	.80
Measured*** PNL, PNdB	0.80	0.73	-0.22	0.65	0.58	0.29	1.76	0.68	0.78	0.77
Corrected PNL,*** PNdB	2.13	.62	-.97	.39	.84	.23	2.50	.76	1.16	1.47
Measured PNLTM,** PNdB	0.80	0.73	0.38	0.85	0.28	0.38	1.64	0.30	0.76	0.78
Corrected PNLTM,** PNdB	2.13	.62	-.38	1.60	.46	.23	2.38	.36	1.20	1.44
Measured EPNL,** EPNdB	0.58	0.43	0.38	0.72	0.48	0.19	1.58	0.41	0.72	0.64
Corrected** EPNL, EPNdB	2.11	.54	.45	1.04	.62	.34	2.48	.39	1.46	1.08

*Group A value minus group B value. Values are computed from data in table XI.
**Tone correction removed from group B data if tone band was <800 Hz.
***At time of PNLTM.

TABLE XIII.- TABULATION OF PNL VALUES COMPUTED FROM EXTRAPOLATED AND TRUNCATED GROUP A CORRECTED SPECTRA

Condition	Run	PNLTM time, hr:min:sec	Corrected PNL,* PNdB	Corrected PNL,** PNdB	Extrapolated band, kHz
Take-off with cutback	12	10: 03: 57.0	90.1	87.5	2.0 to 10.0
	19	11: 17: 56.0	89.1	87.4	2.0 to 10.0
	17R	08: 33: 53.5	89.8	88.7	3.15 to 10.0
	18R	08: 45: 58.5	89.7	88.4	2.0 to 10.0
	22R	09: 23: 50.0	89.5	87.3	2.0 to 10.0
	29	08: 09: 43.5	98.8	97.2	4.0 to 10.0
	31	08: 30: 15.0	98.7	96.9	3.15 to 10.0
	36	09: 19: 15.5	98.5	96.1	2.5 to 10.0
Take-off correction	54	09: 46: 14.5	95.9	94.7	2.0 to 10.0
	37	04: 59: 13.5	99.7	98.3	2.5 to 10.0
	38	05: 11: 36.0	101.9	100.0	2.0 to 10.0
	43	05: 54: 47.0	98.7	96.1	1.6 to 10.0
	45	06: 11: 01.5	93.9	91.8	2.0 to 10.0
	47	06: 27: 20.5	91.0	88.8	2.0 to 10.0

*Computed from corrected one-third-octave bands up to 10 kHz including extrapolated band levels.

**Computed from corrected one-third-octave band levels up to the first band for which the measured level is within 5 dB of the ambient level.

TABLE XIV.- MEAN AND STANDARD DEVIATION OF DIFFERENCE* BETWEEN PNL VALUES COMPUTED FROM EXTRAPOLATED AND TRUNCATED PNLTM SPECTRA

Condition	$\bar{x}$	s
Take-off with cutback	1.84	0.53
Take-off correction	1.90	0.52
Total population	1.86	0.50

*Extrapolated PNL minus truncated PNL. Extrapolation was at a rate of 6 dB/octave beginning with the first band in the measured spectrum that fell within 5 dB of the ambient band level. Values are computed from data in table XIII.

TABLE XV.- TABULATION OF PNL VALUES COMPUTED FROM SPECTRA MEASURED BY GROUPS A AND B

Condition	Run	Time, hr:min:sec	Measured PNL			Preemphasis bands, kHz
			Group A	Group B*	Group B**	
Take-off with cutback	12	10:04:00.0	86.5	87.1	86.7	1.6 to 2.5
	19	11:17:56.5	87.4	87.5	87.3	2.0 to 3.15
	17R	08:33:54.5	89.0	88.7	88.3	2.5 to 3.15
	18R	08:45:59.5	89.5	88.9	88.3	2.5 to 4.0
	22R	09:23:51.0	86.7	87.0	86.5	2.0 to 3.15
	29	08:09:45.5	98.2	99.4	99.0	3.15 to 4.0
	31	08:30:16.0	96.4	96.7	96.4	3.15 to 5.0
	36	09:19:16.5	95.4	95.2	94.8	2.5 to 5.0
Take-off correction	54	09:46:09.5	99.5	98.3	98.3	4.0
	37	04:59:15.0	101.6	102.3	102.0	2.0 to 3.15
	38	05:11:39.0	101.1	102.0	101.6	1.6 to 2.5
	43	05:54:46.5	98.7	98.6	98.5	2.0 to 2.5
	45	06:11:02.5	92.2	93.2	92.7	1.6 to 3.15
	47	06:27:18.0	87.3	90.4	90.4	2.0 to 3.15

*Computed from group B spectra including preemphasis.

**Computed from group B spectrum using the same bands as group A spectrum.

TABLE XVI.- MEAN AND STANDARD DEVIATION

OF DIFFERENCE* BETWEEN GROUP A

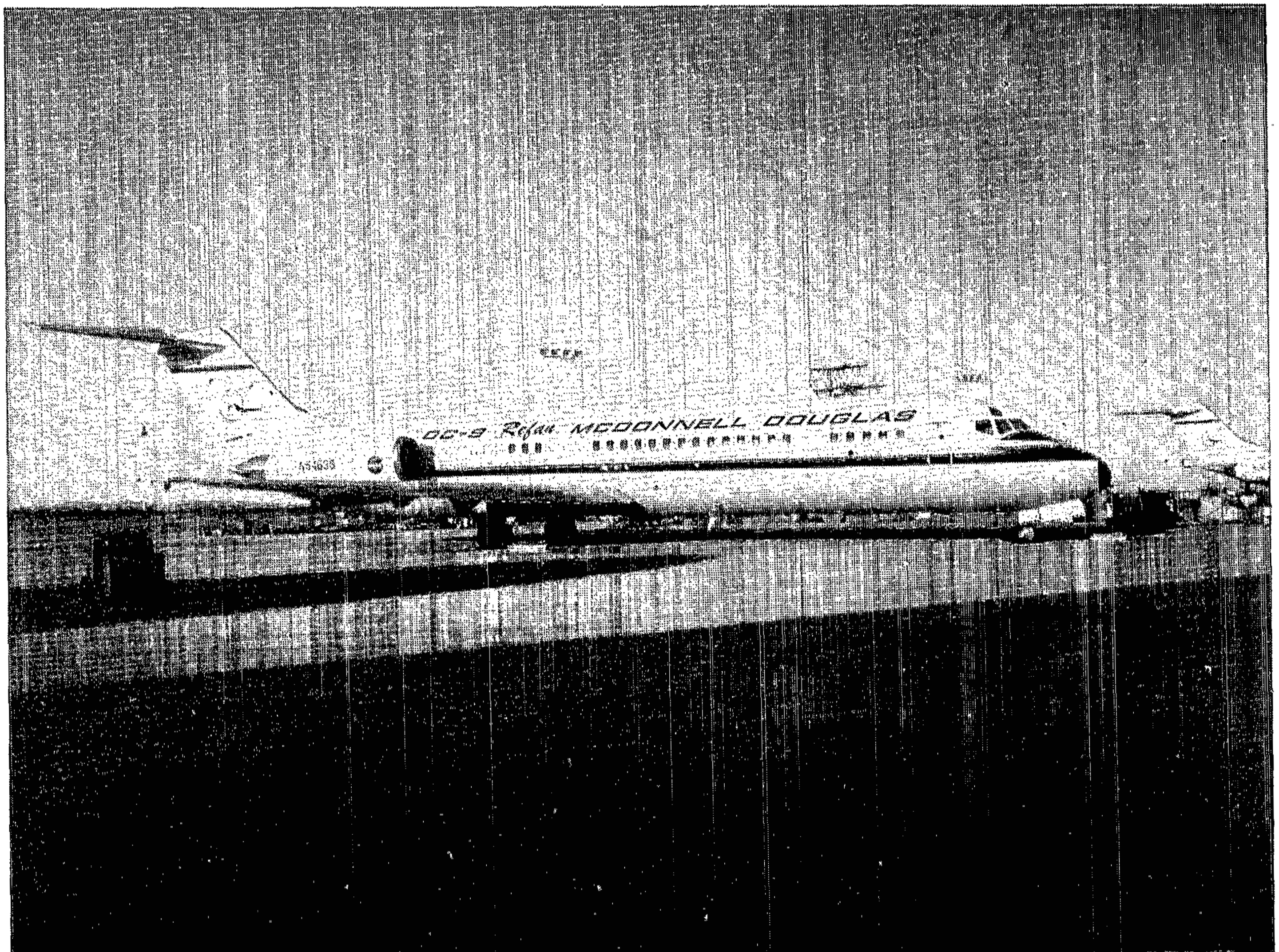
AND GROUP B PNL VALUES

Condition	A - B**		A - B***	
	$\bar{x}$	s	$\bar{x}$	s
Take-off with cutback	-0.18	0.57	0.23	0.61
Take-off correction	-0.73	1.42	-0.52	1.42
Total population	-0.41	1.02	-0.09	1.06

*Group A minus group B. Values are computed from data in table XV.

**Computed from group B spectra including preemphasis.

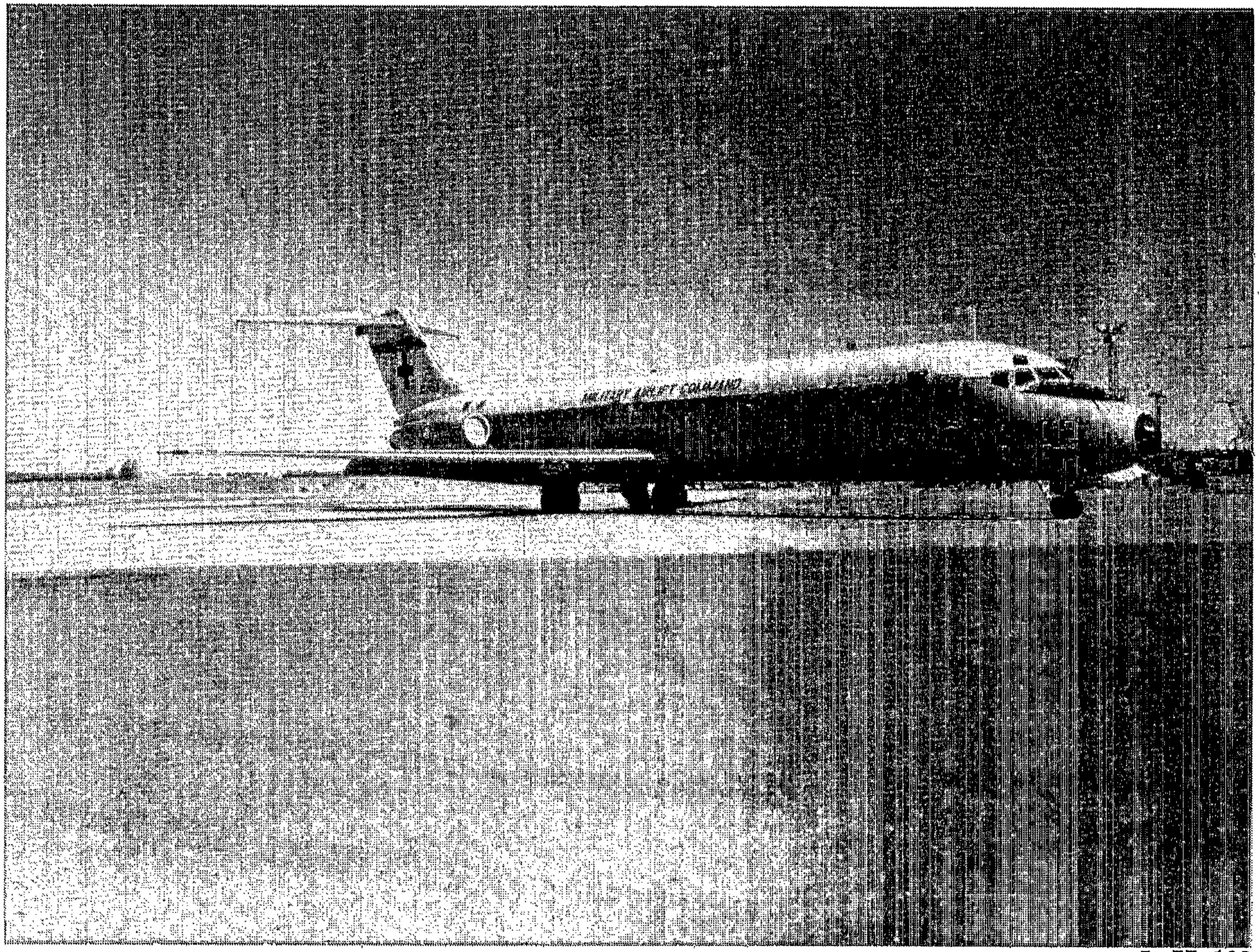
***Computed from group B spectra using the same bands as group A spectra (that is, without preemphasis).



L-77-102

(a) Refanned airplane.

Figure 1.- Test airplanes.



L-77-103

(b) Hardwall airplane.

Figure 1.- Concluded.

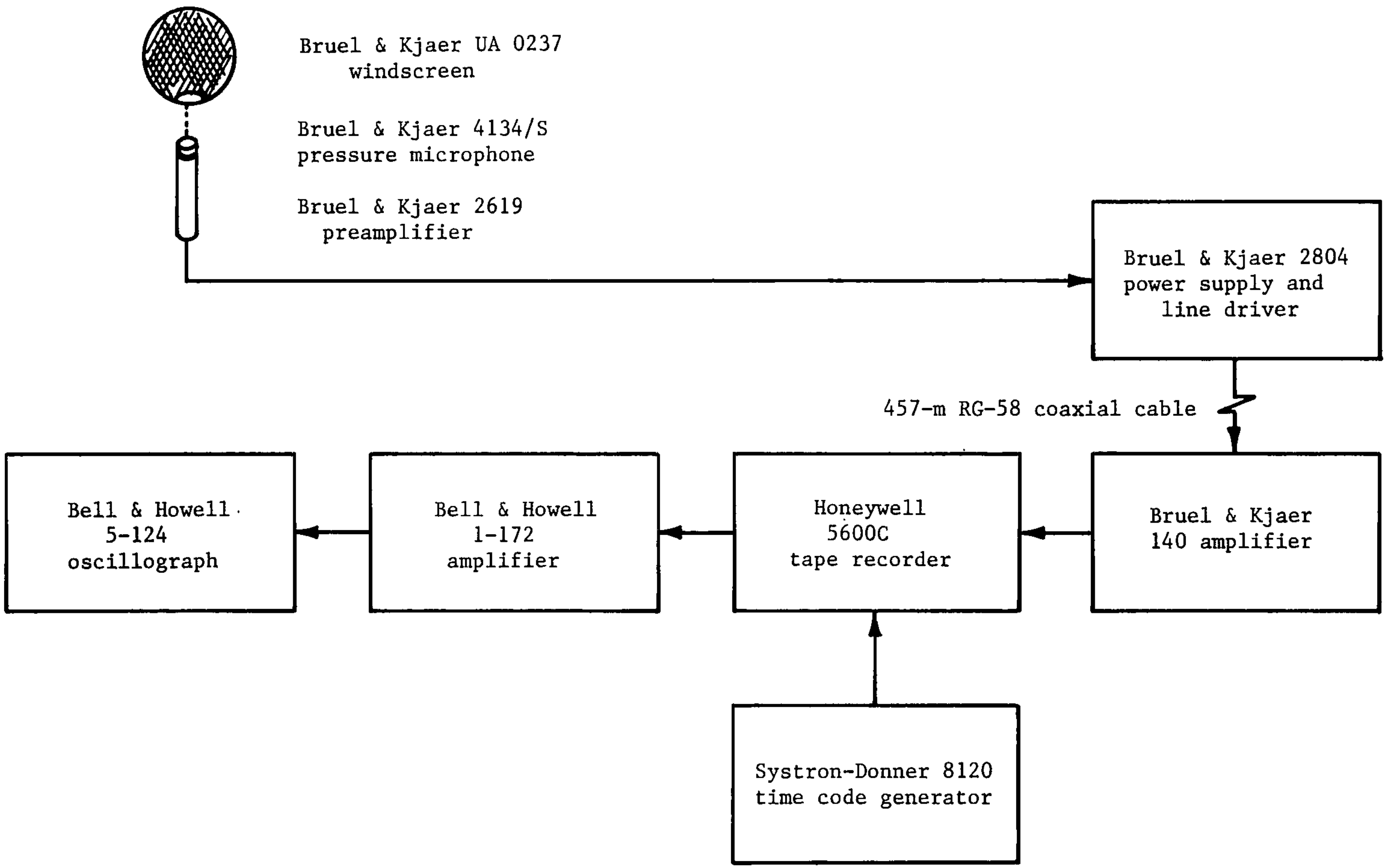


Figure 2.- Acoustic data acquisition block diagram for a typical group A microphone channel.

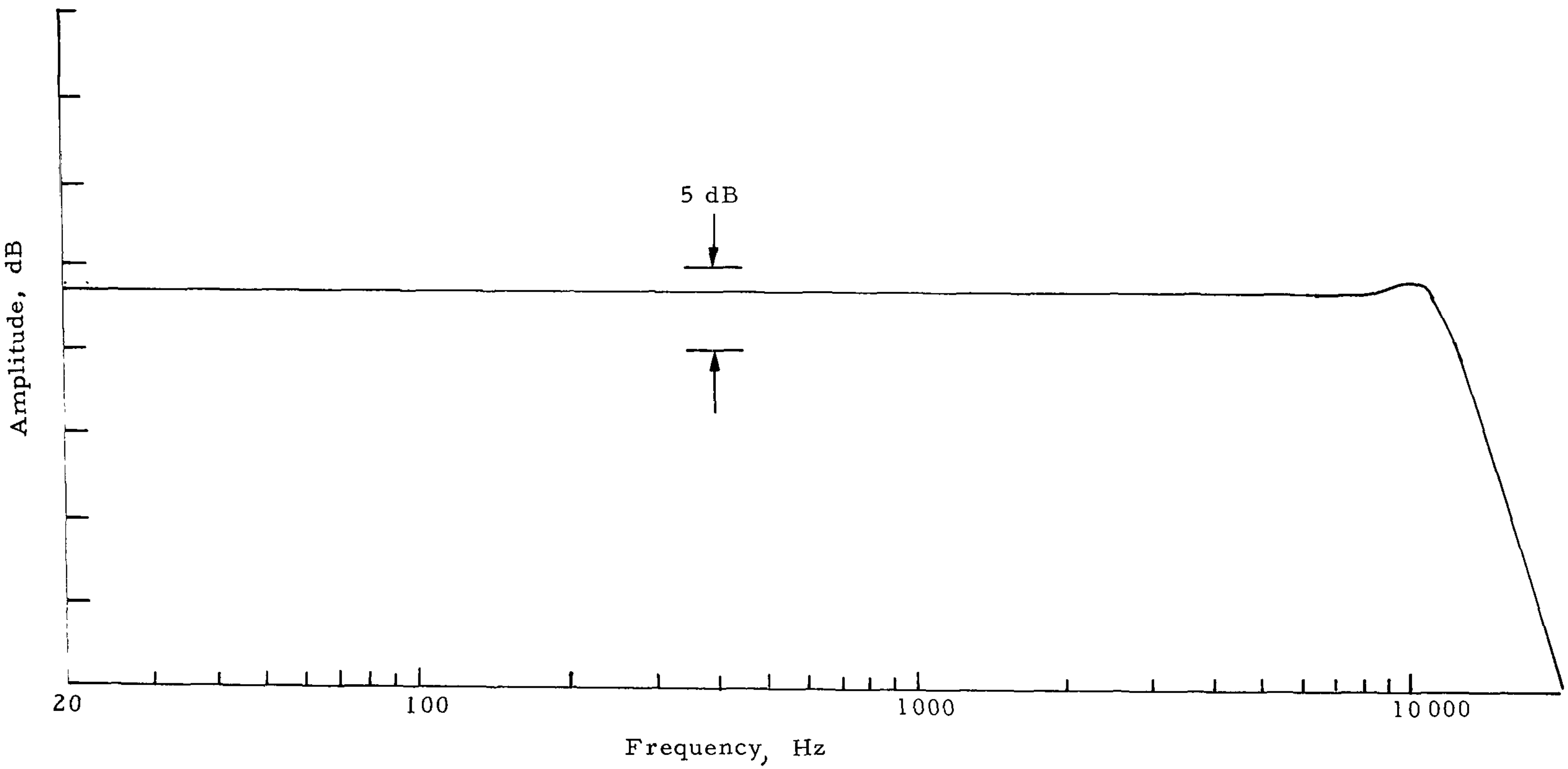


Figure 3.- Typical microphone channel frequency response for group A acoustic apparatus.

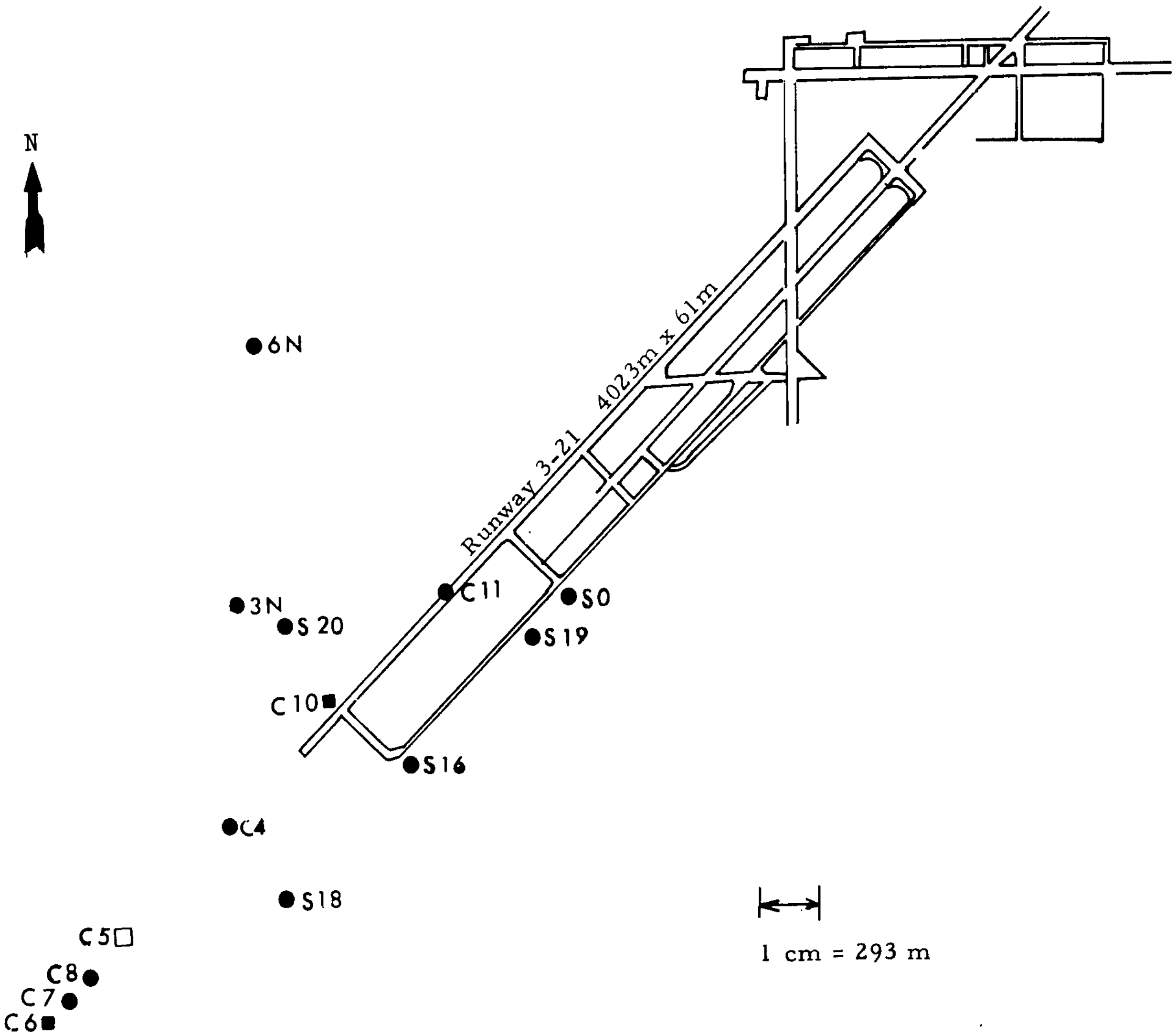
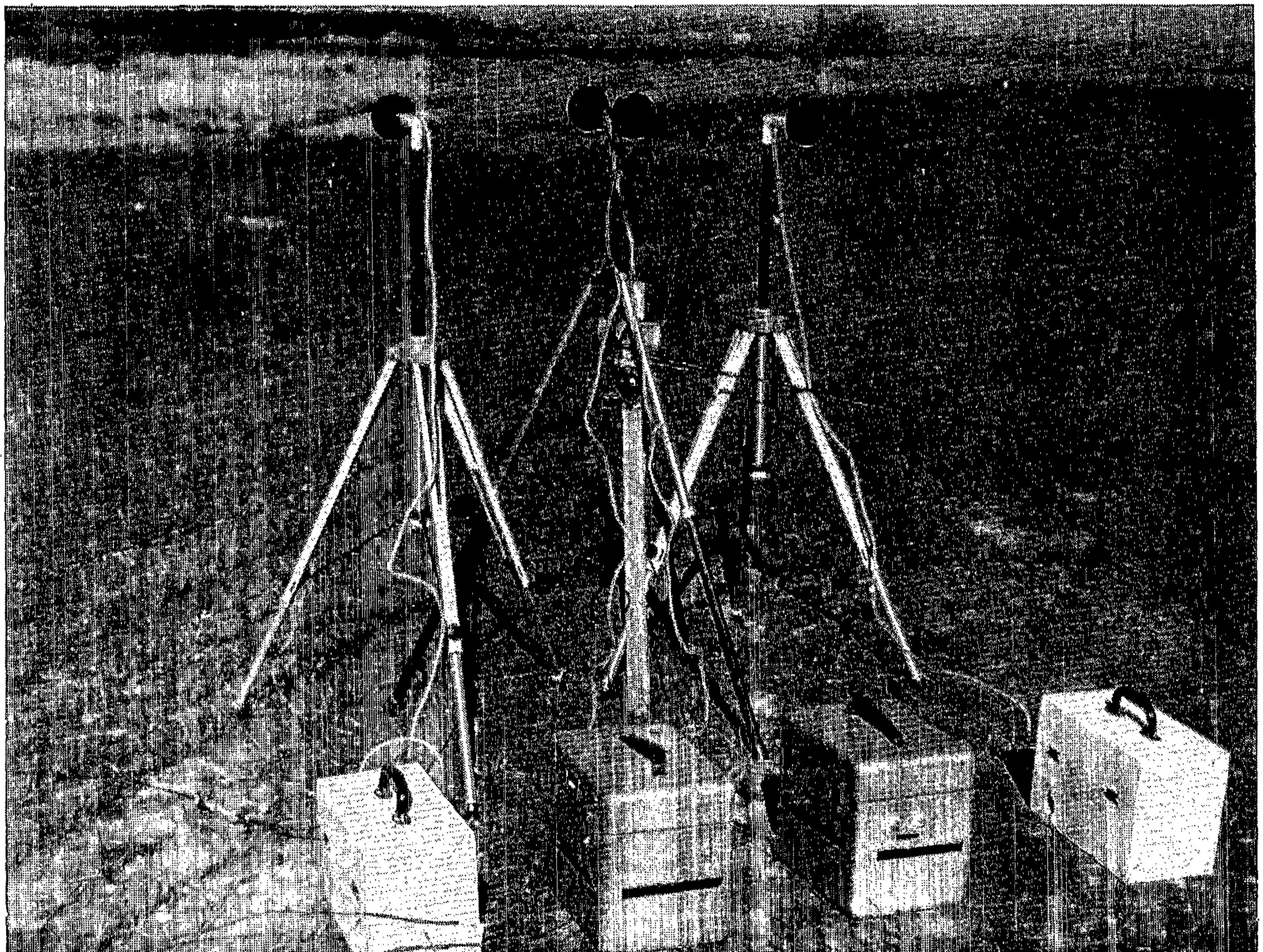


Figure 4.- Microphone sites used to measure flyover noise data reported in references 7 and 8. Joint group measurements were made at location C5 for the uncontrolled flyovers and at locations C6 and C10 for the controlled take-offs and landing approaches, respectively.



L-77-104

Figure 5.- Typical microphone array used for parallel flyover noise measurements. Group A microphones are 45.7 cm (18 in.) from the group B microphones at 1.2 m (4 ft).

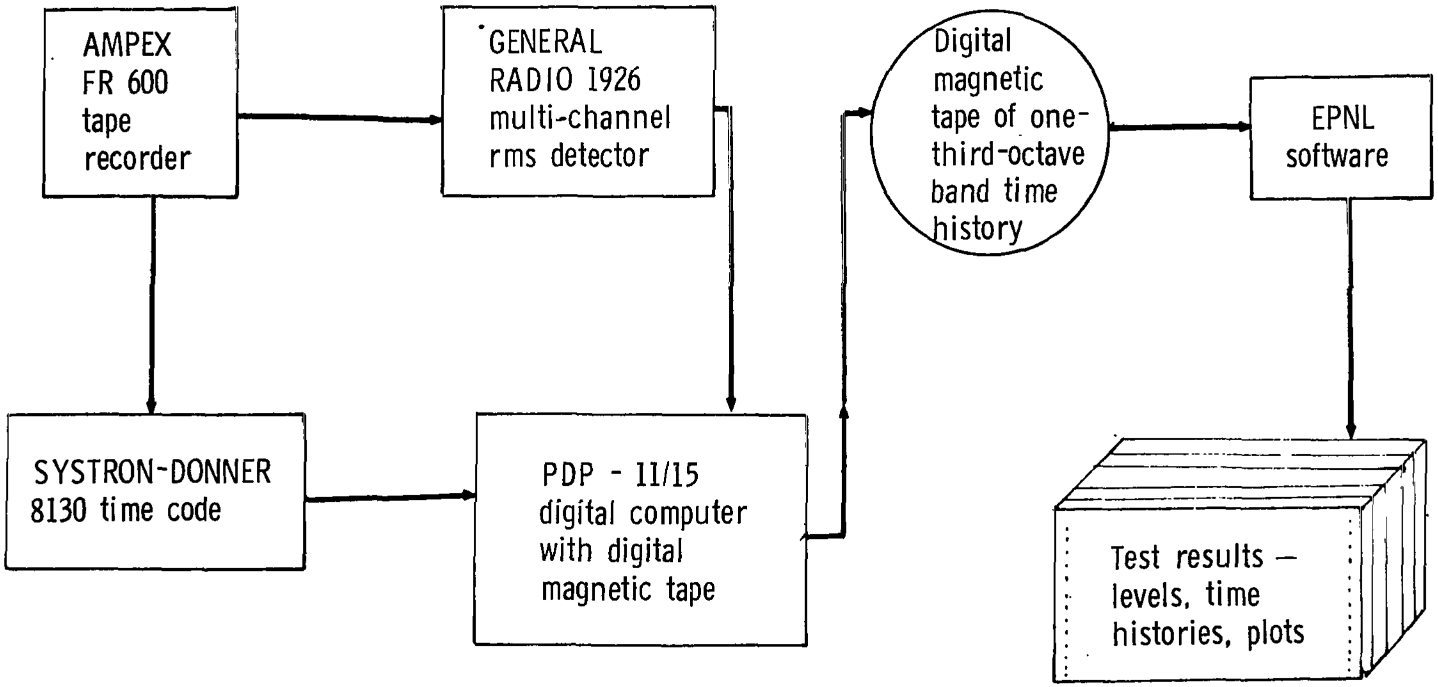


Figure 6.- Block diagram of the group A data analysis system.

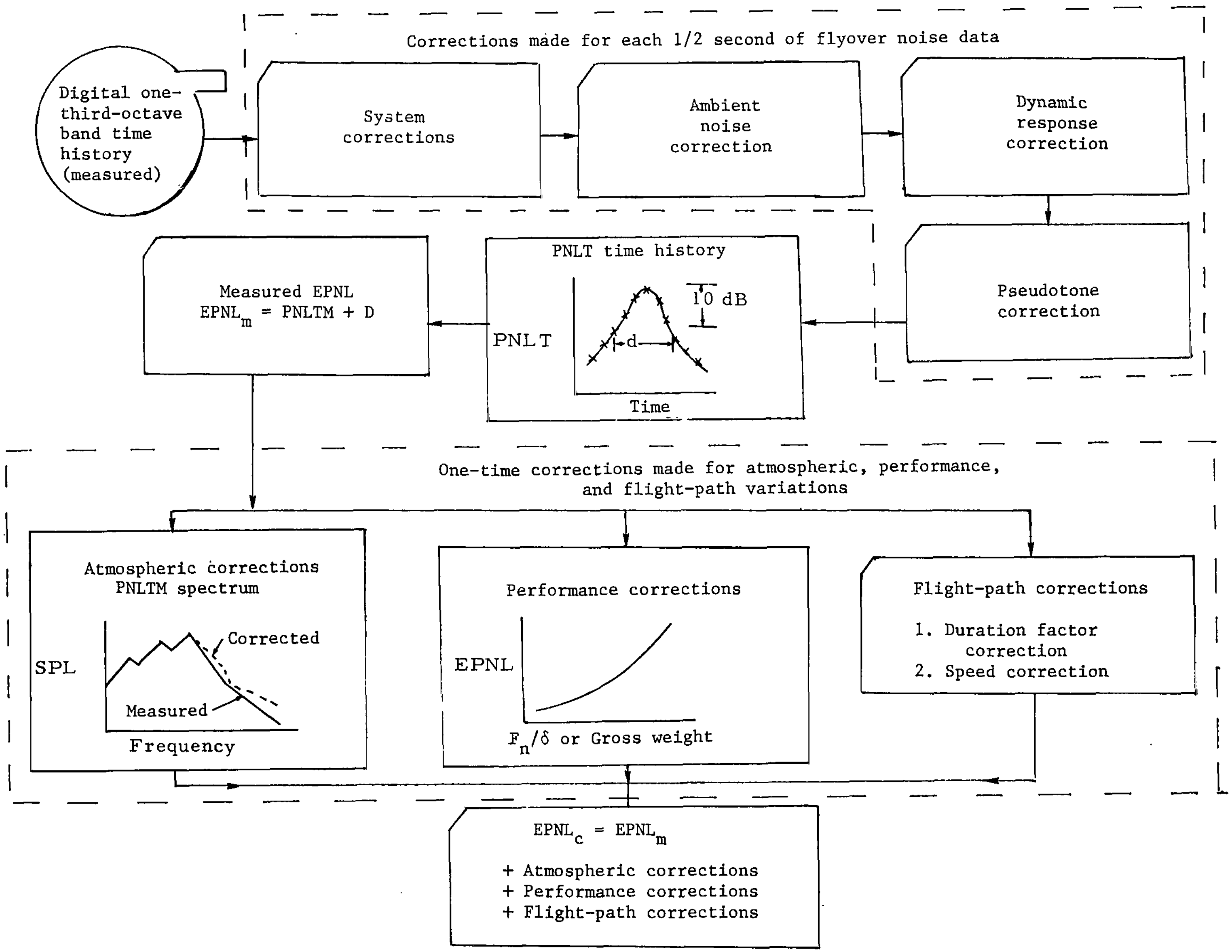


Figure 7.- Flow chart for FAR 36 flyover noise analysis as implemented by group A.

Composite correction values
(free field plus windscreen)

One-third-octave-band center frequency	Correction
1 000	-0.03
1 250	-0.18
1 600	-0.36
2 000	-0.51
2 500	-0.67
3 150	-0.61
4 000	-0.02
5 000	+0.69
6 300	+0.72
8 000	+0.55
10 000	+1.32
12 500	+1.53
16 000	+2.5

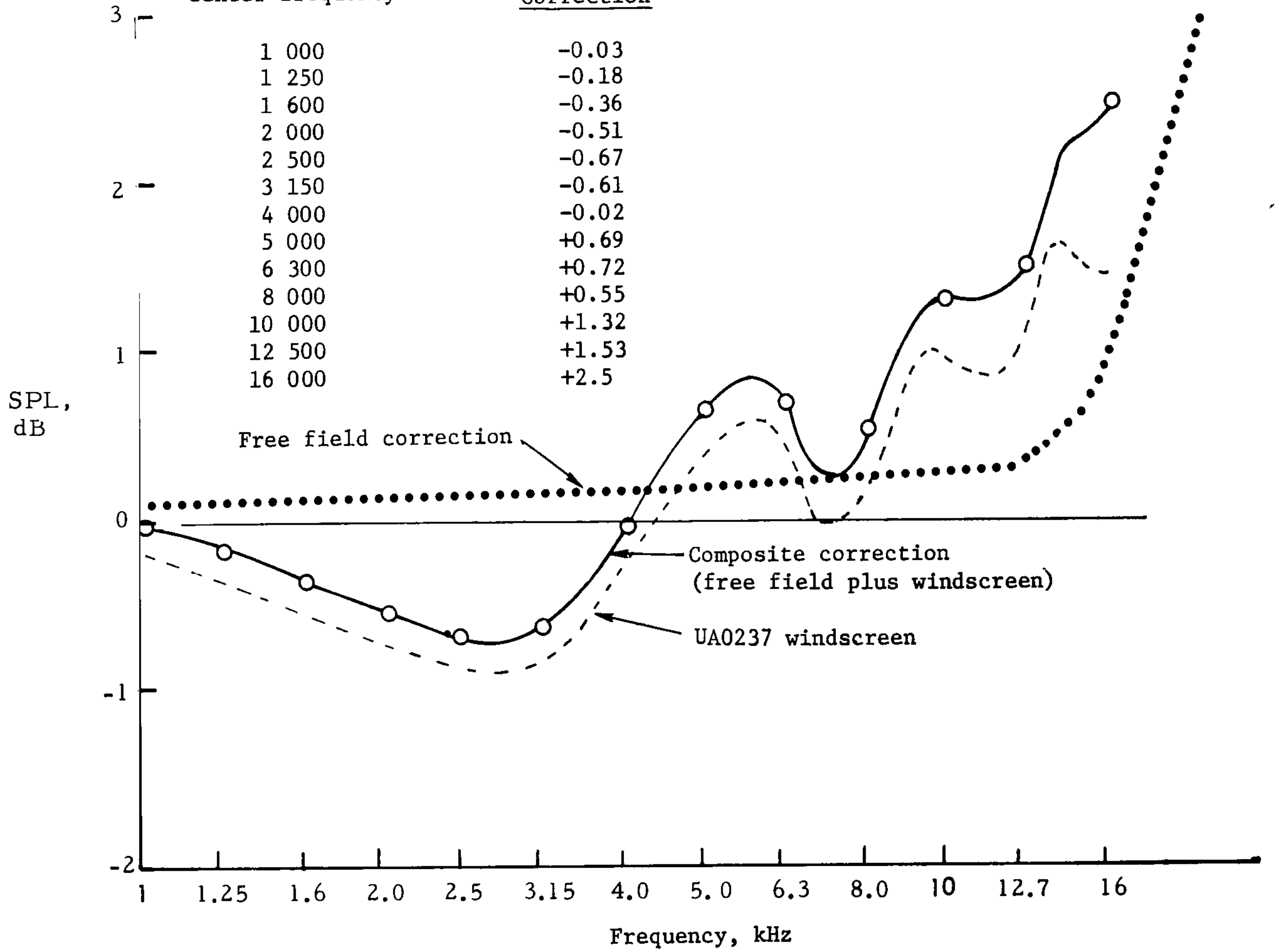


Figure 8.- Composite, windscreen, and free field system corrections for 1.27 cm (1/2 in.) B & K microphone and 90° (grazing) incidence.

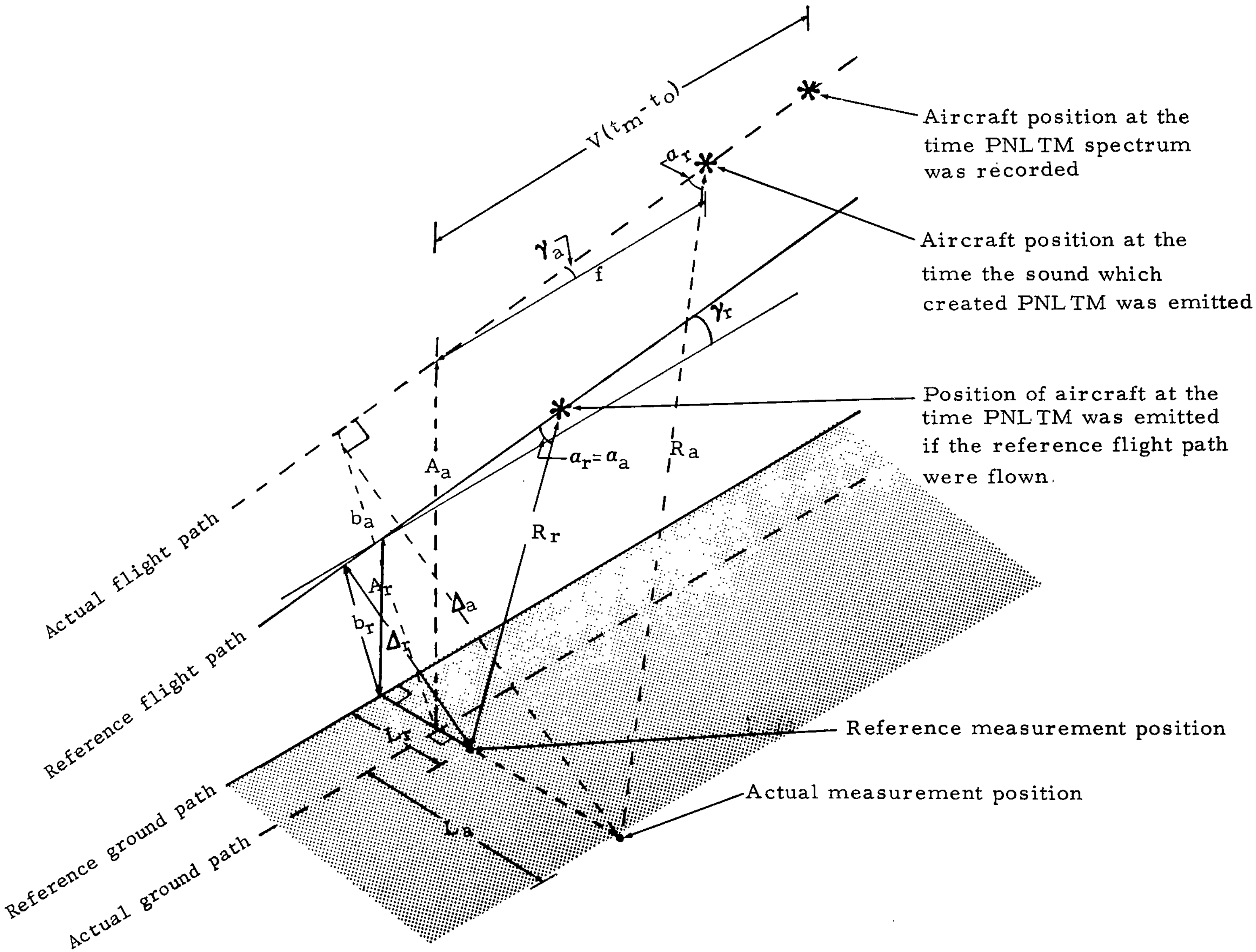


Figure 9.- General test geometry for reference and actual test conditions.

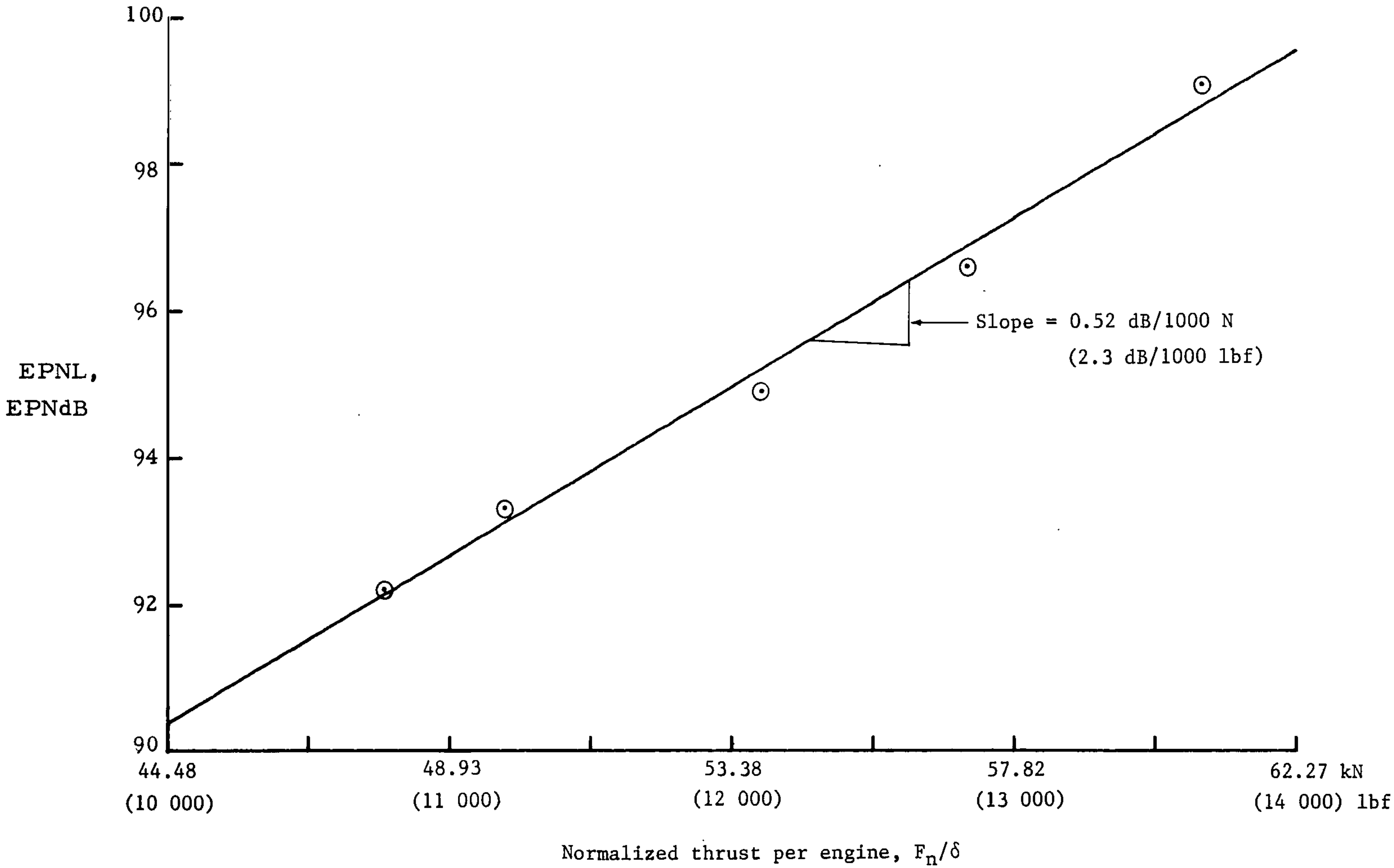


Figure 10.- Refan take-off correction curve. Reference thrust for take-off with cutback is 42 038 N (9451 lbf). The curve is defined by the equation $EPNL = A \frac{F_n}{\delta} + B$ where F_n/δ is measured in units of lbf, $A = 0.0023$ EPNdB/lbf and $B = 67.34$ EPNdB.

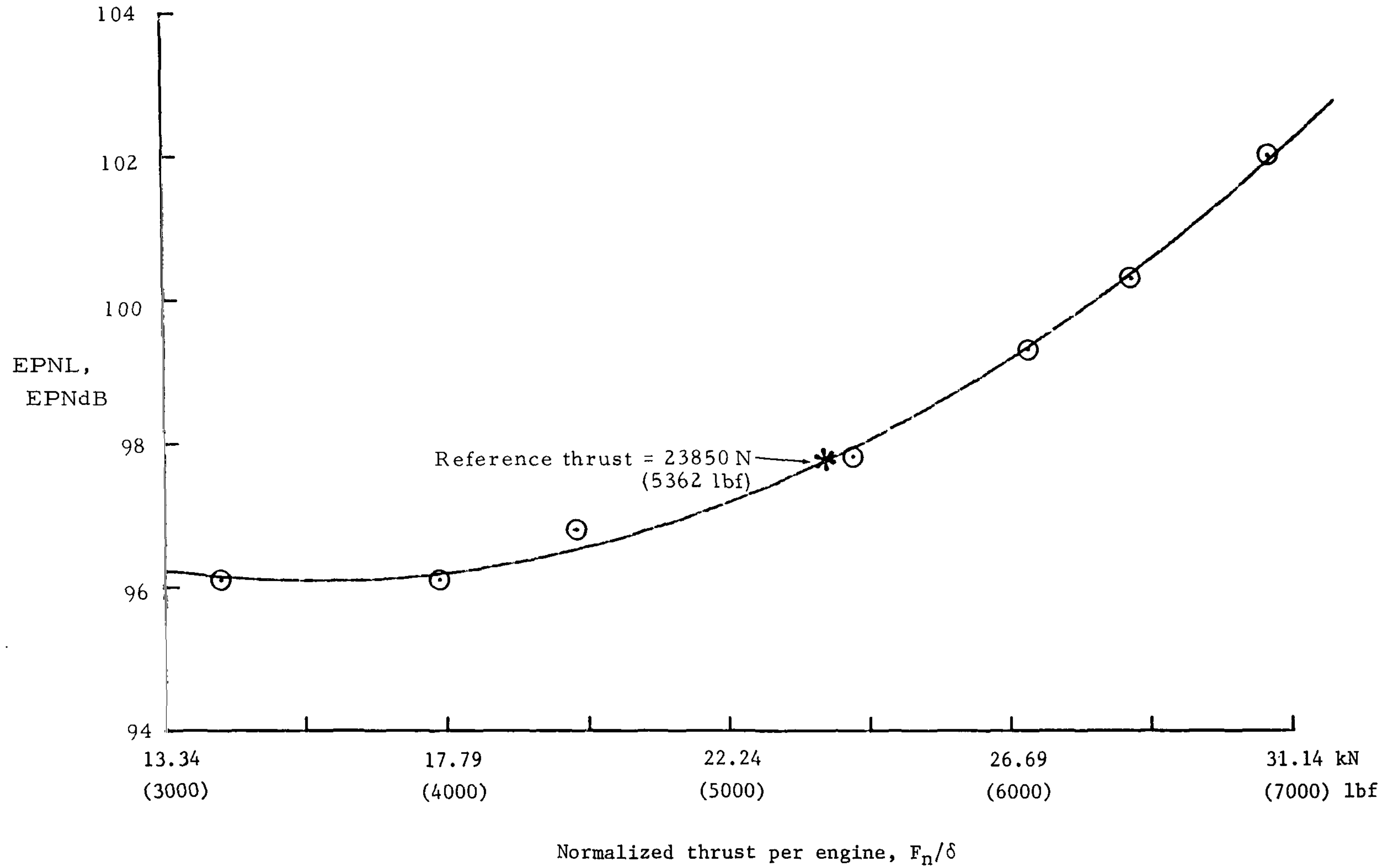


Figure 11.- Refan landing approach correction curve. The curve is defined by the equation

$$\mathrm{EPNL} = 10\left[A - B\,\frac{F_n}{\delta} + C\left(\frac{F_n}{\delta}\right)^2\right]$$

where F_n/δ is measured in units of klbf,

A = 10.23 EPNdB, B = 0.35 EPNdB/lbf, and C = 0.05 EPNdB/(lbf)^2.

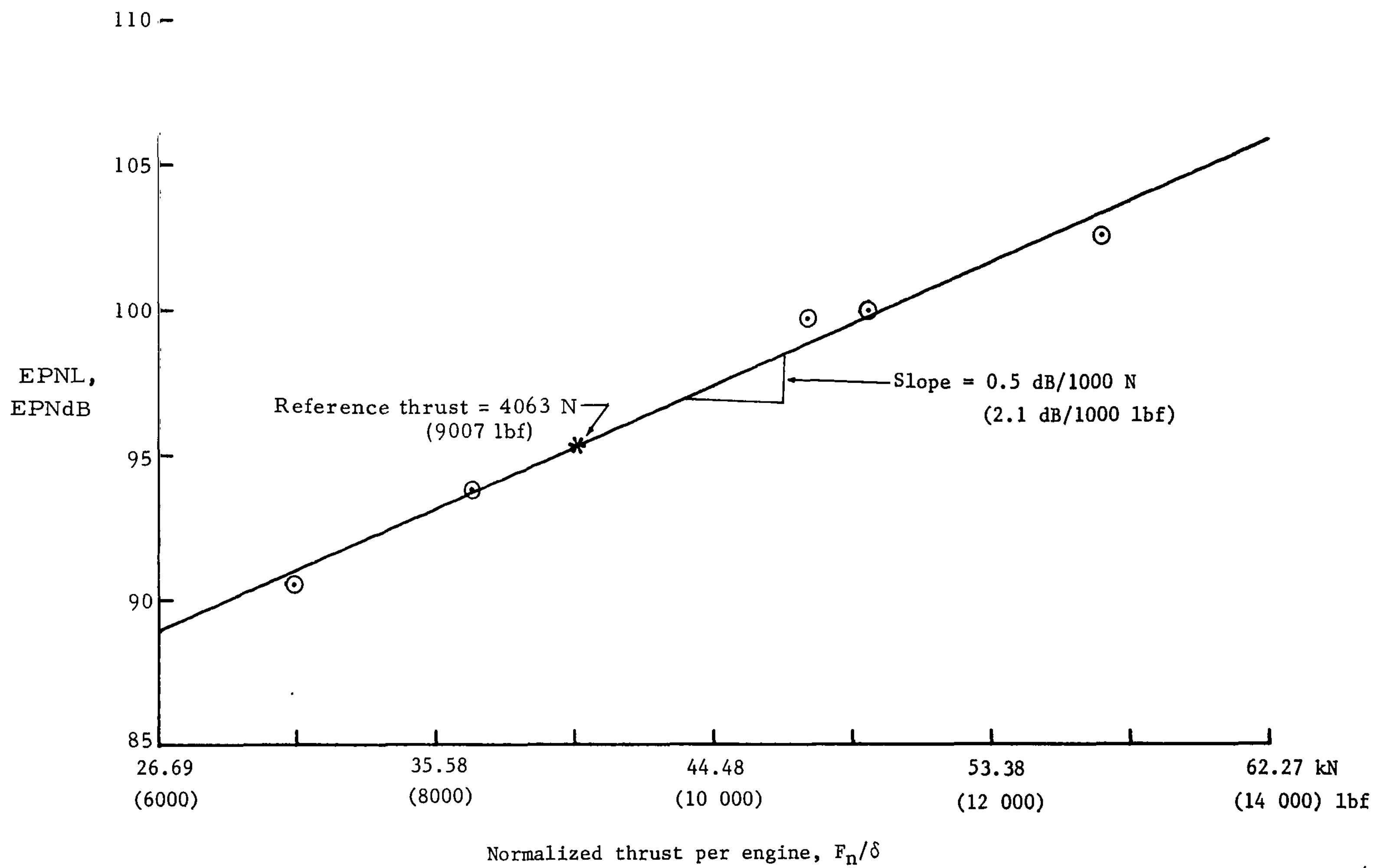


Figure 12.- Hardwall take-off correction curve. The curve is defined by the equation EPNL = $A \frac{F_n}{\delta} + B$ where F_n/δ is measured in units of lbf, A = 0.00212 EPNdB/lbf, and B = 76.2 EPNdB.

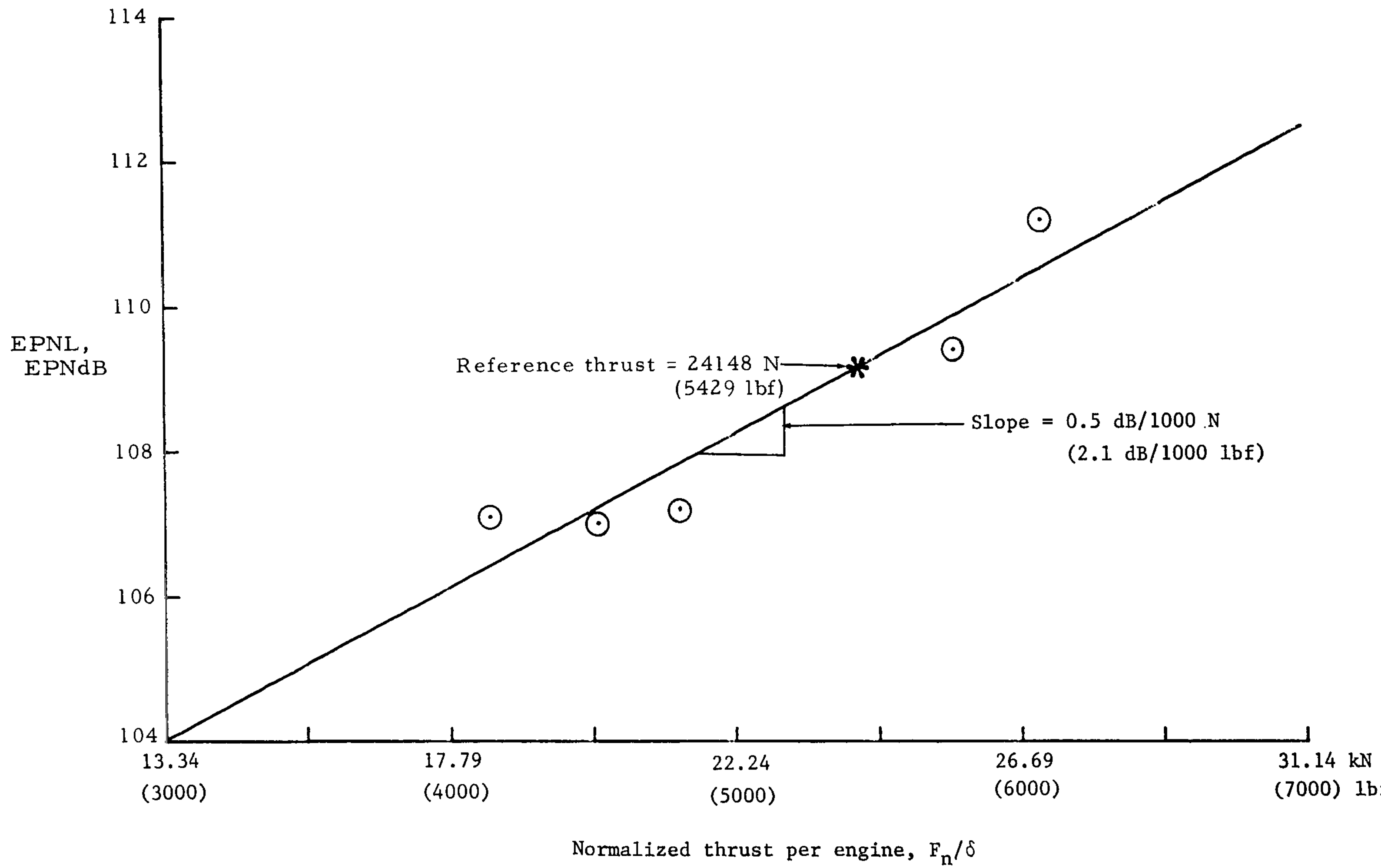


Figure 13.- Hardwall landing approach correction curve. The curve is defined by the equation $EPNL = A \frac{F_n}{\delta} + B$ where F_n/δ is measured in units of lbf, $A = 0.00212$ EPNdB/lbf, and $B = 97.6$ EPNdB.

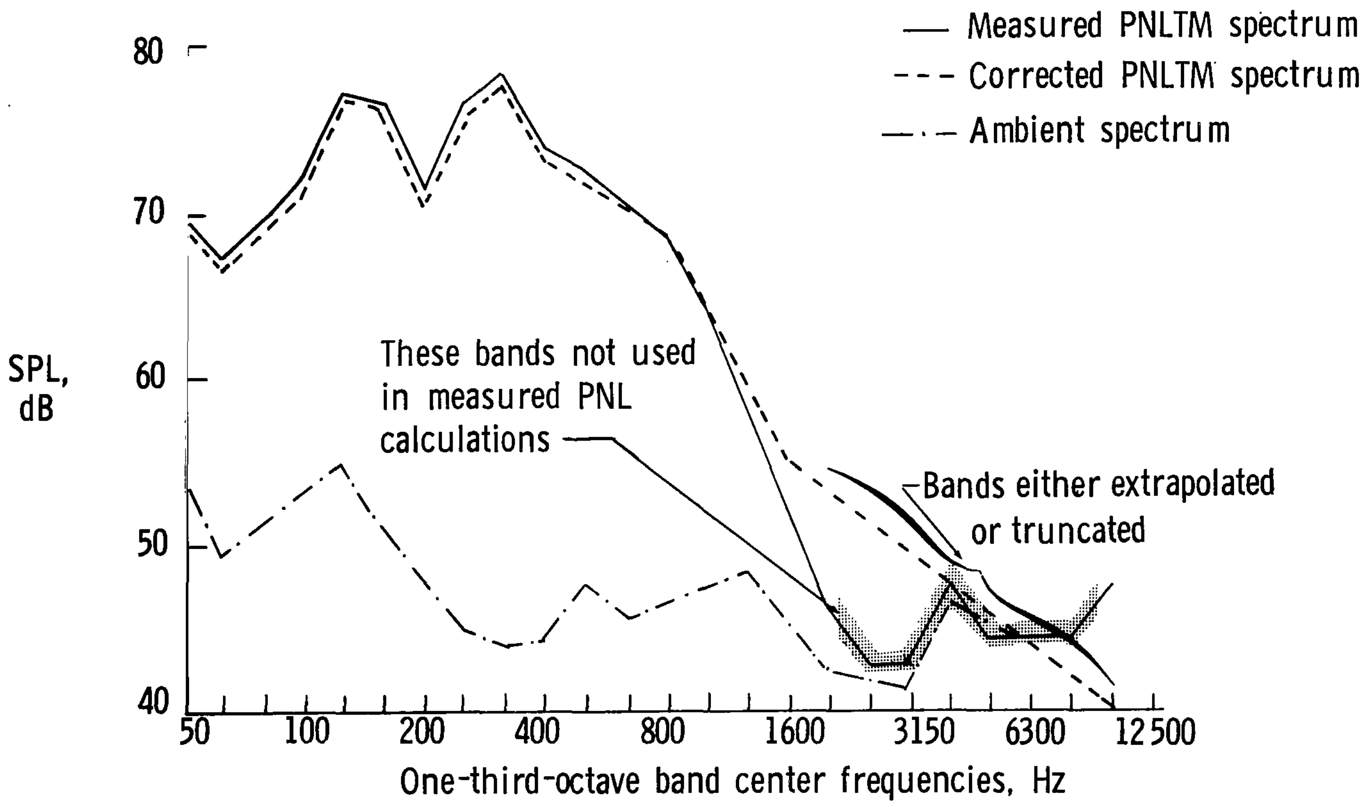


Figure 14.- Effect of extrapolation or truncation on the corrected PNLTM spectrum. The two groups treated the high-frequency bands differently when computing the corrected PNLTM.

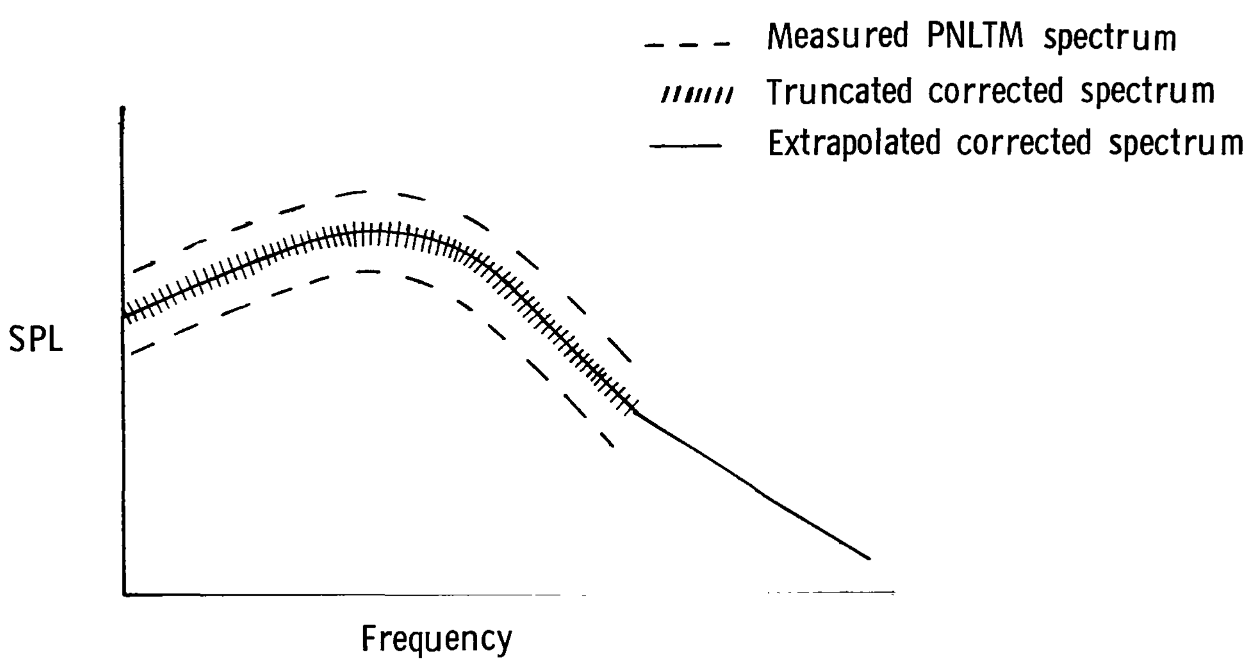


Figure 15.- Possible configurations of measured and corrected PNLTM spectra.

NASA-Langley, 1977 L-11102

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