AMRL-TR-68-70

NOISE ENVIRONS AND HELMET PERFORMANCE FOR THE P-1127 V/STOL AIRCRAFT

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Foreword

This study was accomplished by the Biodynamics and Bionics Division of the Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, in response to a request of the Bioastronautics Branch of the 6510th USAF Hospital, Edwards Air Force Base, California. The research was conducted by Mr. Henry C. Sommer, Major Justus F. Rose, Jr., and SSgt William C. Knoblach under Project 7231, "Biomechanics of Aerospace Operations," and Task 723103, "Biological Acoustics in Aerospace Environments," and 723104, "Biodynamic Environments of Aerospace Flight Operations." Acknowledgment is made to the Bioastronautics Branch of the 6510th USAF Hospital, V/STOL Operations Division, and Flight Test Division, Edwards Air Force Base, California, for their assistance in arranging the data acquisition phase of this study and to Mr. R. England for his assistance in reproducing the measured environment in the laboratory. Acknowledgment is also made to Mr. Ivan Dille, Clothing Branch, Directorate of Crew and Age Subsystems Engineering, and SSgt B. R. Wirt, Physiological Training Branch, USAF Hospital, for their support in providing and fitting the helmets and liners evaluated in the study. The work covered herein was accomplished in the period of October 1967 to March 1968.

This technical report has been reviewed and is approved.

C. H. KRATOCHVIL, Colonel, USAF, MC
Commander
Aerospace Medical Research Laboratory

Abstract

The purpose of this evaluation was (1) to measure the acoustic noise environment in the cockpit of the United Kingdom Hawker Siddeley P-1127 V/STOL aircraft that would serve as an acoustic guideline for cockpit noise levels of other V/STOL aircraft being contemplated or under construction, and (2) to determine the acoustic attenuation of various Air Force flight helmets in the inventory or being contemplated for Air Force inventory items. Cockpit sound pressure levels in the United Kingdom Hawker Siddeley P-1127 V/STOL aircraft at engine rpm settings of idle, 45%, 60%, 80% and maximum were measured. The cockpit noise environment at maximum engine rpm was reproduced in the laboratory and used to obtain objective attenuation data for three Air Force flight helmet/liner configurations (HGU-2A/P helmet with 17P liner, H-154 ear cup liner and Gentex ear cup liner). Measurement of Real-Ear Attenuation at Threshold (REAT) were also accomplished on the helmet/liner configurations. On the basis of the cockpit noise environment and the attenuation characteristics of the helmet/liner configurations tested, no hearing damage would be expected to result when exposure durations do not exceed 1 hour continuous exposure. The Gentex ear cup liner provides approximately 4 to 9 dB more attenuation than the 17P liner throughout the frequency range tested and from 13 to 26 dB more attenuation than the H-154 ear cup liner at test frequencies from 3 to 8K Hz.

Section I.

INTRODUCTION

The high level of noise generated by the propulsive system(s) of V/STOL aircraft already being tested, particularly during takeoff and landing, are reflected in the cockpit area. These excessive noise levels pose a serious hearing damage problem to the pilot and crew members. Unless adequate steps are taken to protect the individuals from these intense noise fields, serious consequences may result.

The Hawker Siddeley P-1127 V/STOL aircraft is reported to be less noisy than other aircraft in this category, namely the German VJ-101C, DO-31 and American XC-142. Since the Air Force had procured several P-1127 aircraft for testing, it was desired to document the noise levels in the cockpit to serve as an acoustic guideline for cockpit noise levels of other V/STOL aircraft being contemplated or under construction.

The purpose of this report is to describe the acoustic noise environment in the cockpit of the P-1127 V/STOL aircraft (Section II) and to report acoustic attenuation of various flight helmets in the inventory or being contemplated for Air Force inventory items (Section III). The results of these measures are then combined to estimate the amount of noise present at the ear of the pilot in the P-1127 aircraft during various rpm settings from which hearing damage risk can be determined (Section IV).

Section II.

COCKPIT NOISE ENVIRONMENT OF P-1127 V/STOL AIRCRAFT

NOISE MEASUREMENTS AND ANALYSIS

Sound Pressure Level (SPL) measurements were made in the cockpit of the United Kingdom Hawker Siddeley P-1127 at Edwards AFB, California during static flight test operations. The aircraft, equipped with a Pegasus 5 cartridge start axial flow engine, was operated at idle, 45%, 60%, 80%, and maximum rpm during the measurement program. A microphone was positioned to measure the sound field at head level, approximately 4 inches from the pilot's helmet during all of the runs. The aircraft was mounted on a hydraulic lift thrust stand that could be raised to a height of 15 feet above the ground. The 45%, 60%, 80% and maximum rpm measurements were made while the aircraft was at this height and the exhaust nozzles were in the downward thrust configuration; the idle rpm measurement was made while the aircraft was at ground level with the exhaust nozzles in the longitudinal thrust configuration.

SUPPLEMENTAL MEASURES

In addition to inside the cockpit, sound pressure level measurements were recorded at the maintenance position on the left side of the aircraft just aft of the engine intake where the ground communication jack joint is located. The engine was at idle rpm during the measurements, which is the normal power setting used while ground support personnel are operating in close proximity to the aircraft. The air temperature was 54 F, (12 C), relative humidity 19% pressure altitude 30.22 in. Hg, and the wind velocity 4 knots. The noise survey microphone was hand held at a height of 5 to 6 feet (approximate level of the ear) above the concrete pad surrounding the thrust stand. Laterally, there were no large reflecting surfaces within 150 feet of the aircraft that were considered to have any effect on the SPL measured. An ambient sound pressure measurement was taken with a ground power cart operating. The cart was located 10 to 12 feet from the aircraft during the normal ground start configuration. This ambient noise represents the noise environment that ground personnel are exposed to any time electrical power is supplied to the aircraft with the aircraft engine not running.

INSTRUMENTATION AND DATA REDUCTION

A portable, high quality instrumentation package (PORTAPAK) developed in this laboratory was used to acquire the noise data. This system (figure 1a) employs condenser microphones for acoustic transducers, signal conditioning equipment to provide maximum signal to noise and dynamic range, and a battery-operated portable magnetic tape recorder. Specifications for this system in brief are as follows: an essentially flat frequency response from 20 Hz to 20 KHz, dynamic range with 1-inch condenser microphone 59 to 135 dB, and gain capability range of 45 dB. A battery-operated pistonphone was used as a reference sound pressure level in field calibration. Due to the arrangement of the thrust stand (figure 2) and the downwash created with the exhaust nozzles in the downward thrust configuration, the recorder was located 150 feet from the aircraft and connected to the condenser microphone by means of a cable and a unity gain line driver.

Spectral analyses of the recorded data were accomplished in the laboratory using an analog data processing system employing a third octave band filter, graphic level recorder, vacuum tube volt meter (VTVM) and an oscilloscope (figure 1b). The entire system was calibrated and small corrections were applied to the data to compensate for system response. Care was taken to insure at least a 10 dB signal to noise ratio at all times.

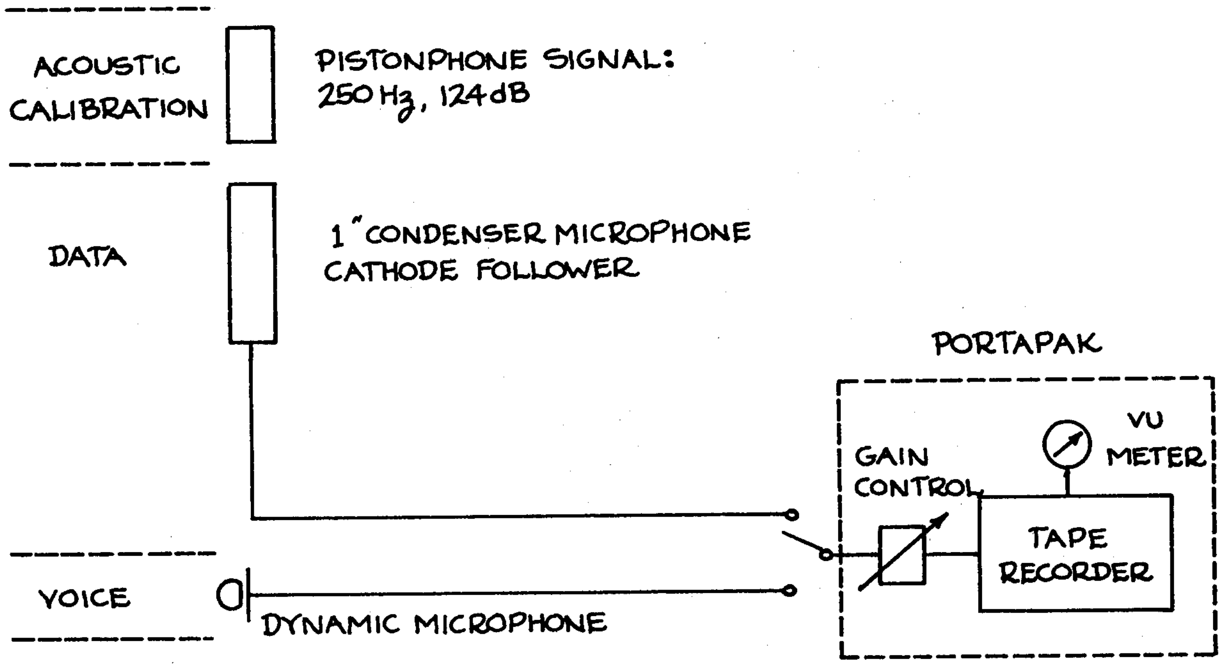


Figure 1a. Portable data acquisition system

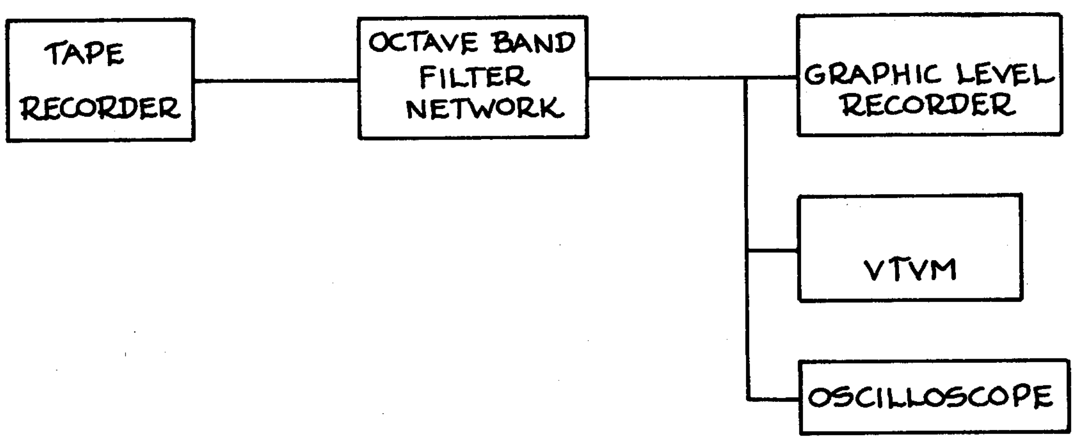


Figure 1b. Analog data processing system

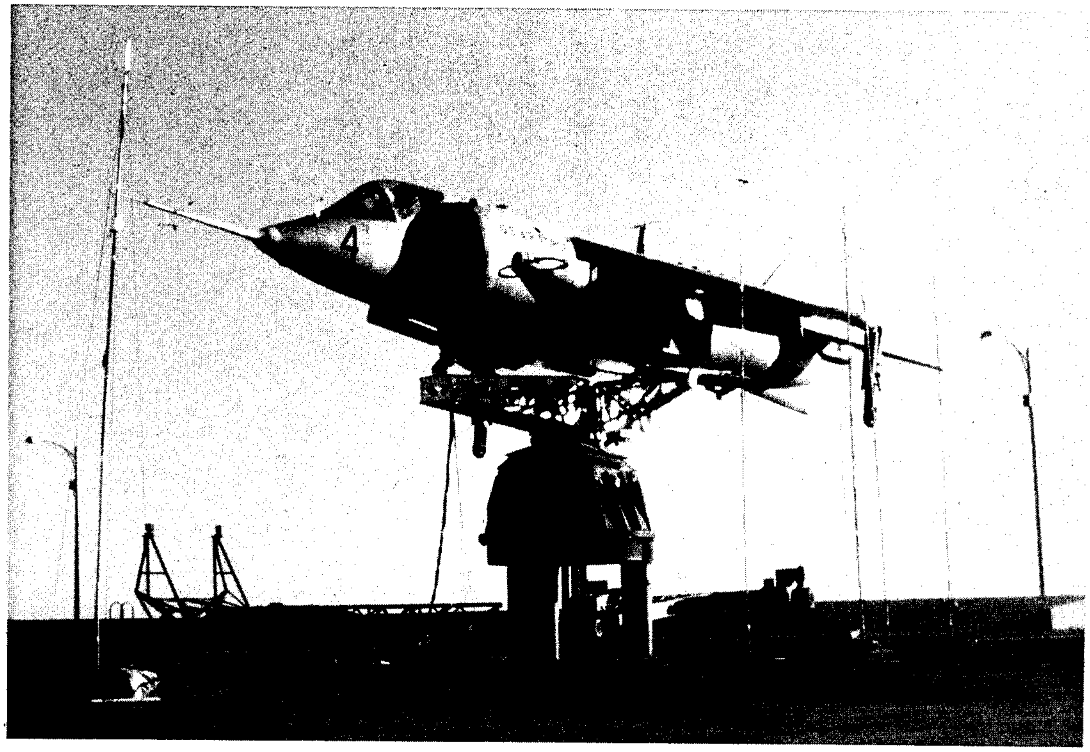


Figure 2. P-1127 V/STOL aircraft mounted on thrust stand

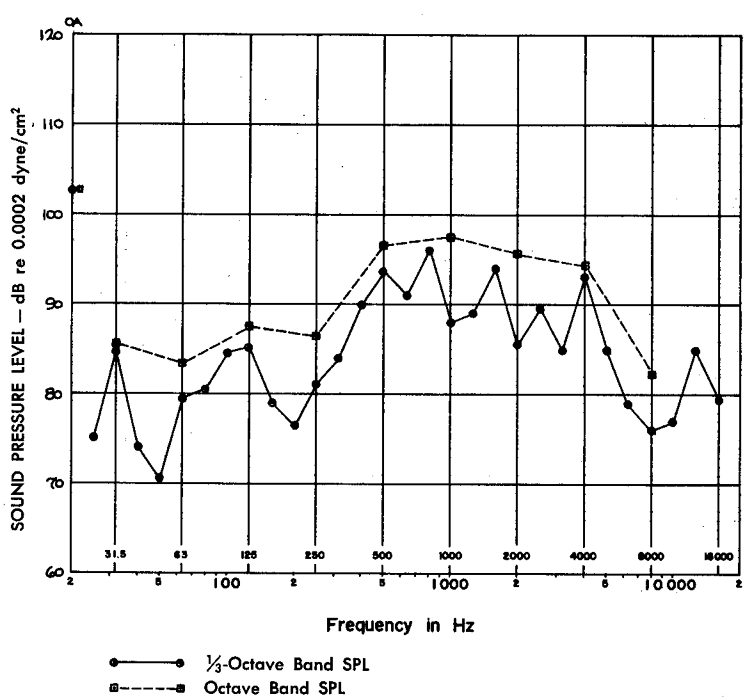


Figure 3. Third-octave and full-octave band sound pressure level spectrum inside cockpit of P-1127 V/STOL with engine operating at idle rpm, longitudinal thrust configuration.

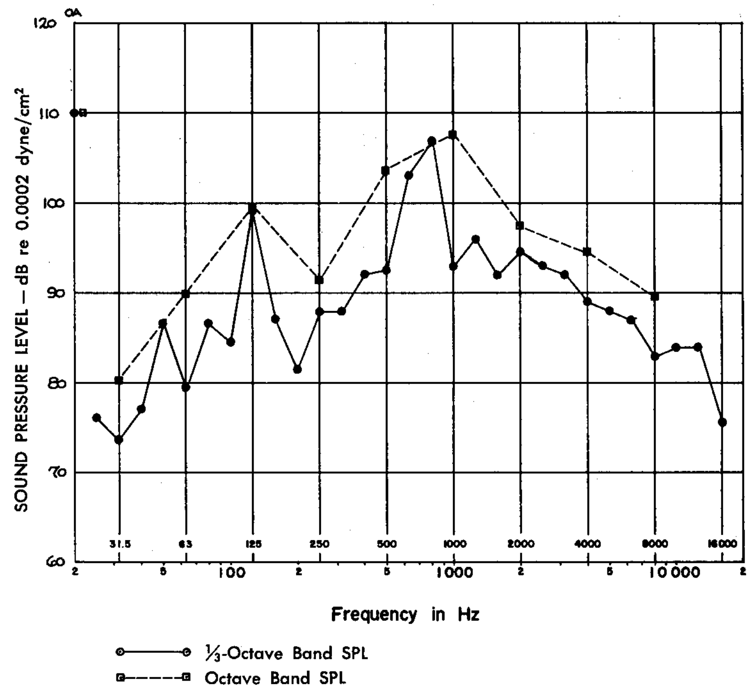


Figure 4. Third-octave and full-octave band sound pressure level spectrum inside cockpit of P-1127 V/STOL with engine operating at 45% rpm, downward thrust configuration.

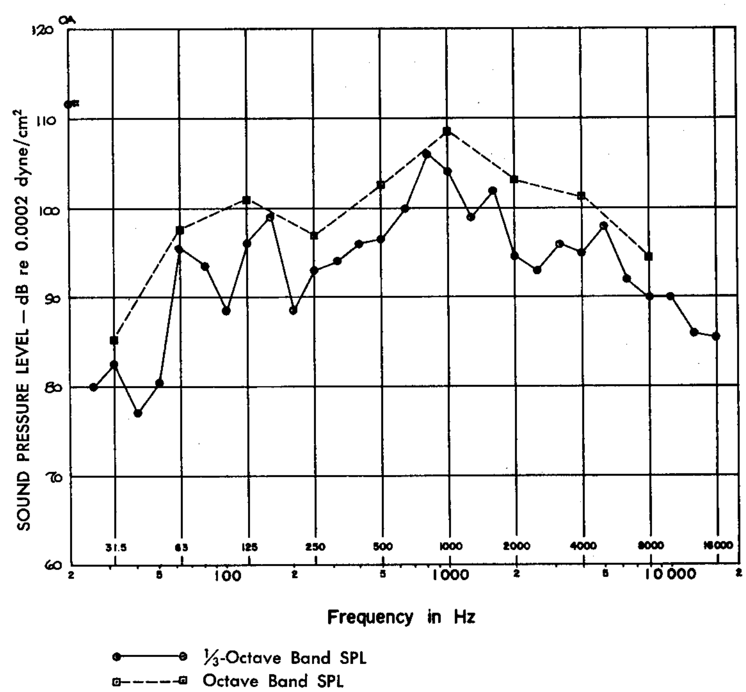
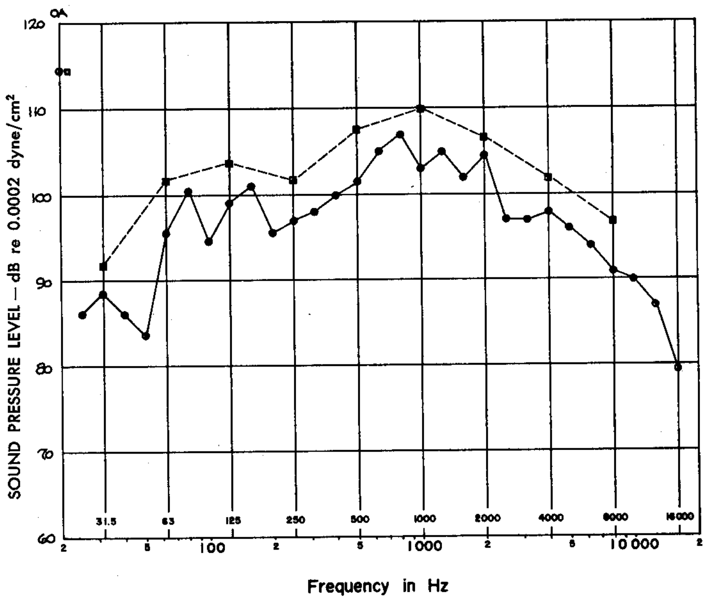
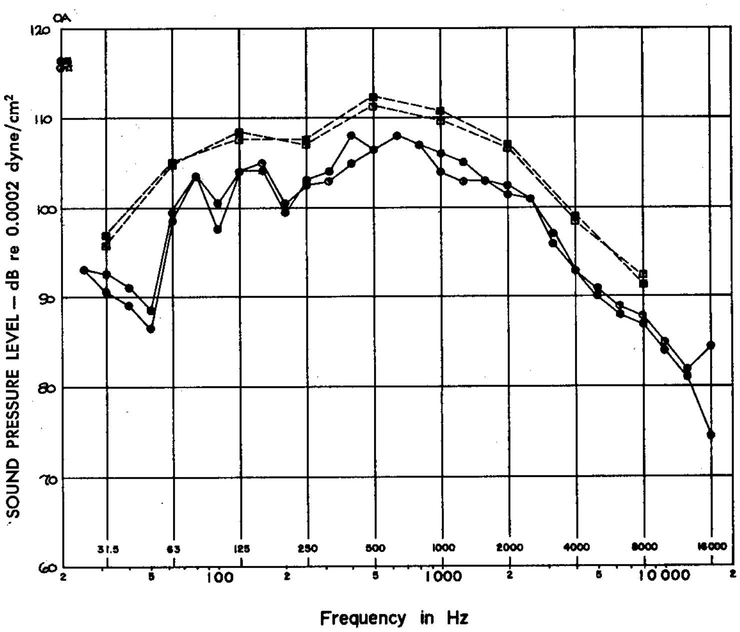


Figure 5. Third-octave and full-octave band sound pressure level spectrum inside cockpit of P-1127 V/STOL with engine operating at 60% rpm, downward thrust configuration.



⅓-Octave Band SPL
Octave Band SPL

Figure 6. Third-octave and full-octave band sound pressure level spectrum inside cockpit of P-1127 V/STOL with engine operating at 80% rpm, downward thrust configuration.



⅓-Octave Band SPL with Air Conditioner ON
⅓-Octave Band SPL with Air Conditioner OFF
Octave Band SPL with Air Conditioner ON
Octave Band SPL with Air Conditioner OFF

Figure 7. Third-octave and full-octave band sound pressure level spectrum inside cockpit of P-1127 V/STOL with engine operating at maximum rpm, downward thrust configuration.

RESULTS

The measured cockpit sound pressure levels are shown in figures 3 through 7 for idle, 45%, 60%, 80% and maximum rpm with both third-octave and full-octave band resolution. All data are fully corrected for the response characteristics of all instrumentation and are considered to be accurate within ±2 dB. Overall SPL range between 103 dB at idle rpm and 116 dB at maximum rpm, with the peak SPL present at 800 Hz (⅓-octave band resolution) for all engine rpm settings with the exception of maximum rpm where the peak appears at 600 Hz. From the data, the cockpit air conditioner does not appreciably contribute to the band levels at the maximum rpm power setting (figure 7).

The sound pressure levels at the maintenance position on the left side of the aircraft just aft of the engine intake where the ground communication jack point is located are shown in figure 8. During idle rpm the overall SPL is 115.5 dB with the spectrum being relatively flat throughout the frequency range measured. Both curves represent the noise levels with the electrical power cart operating.

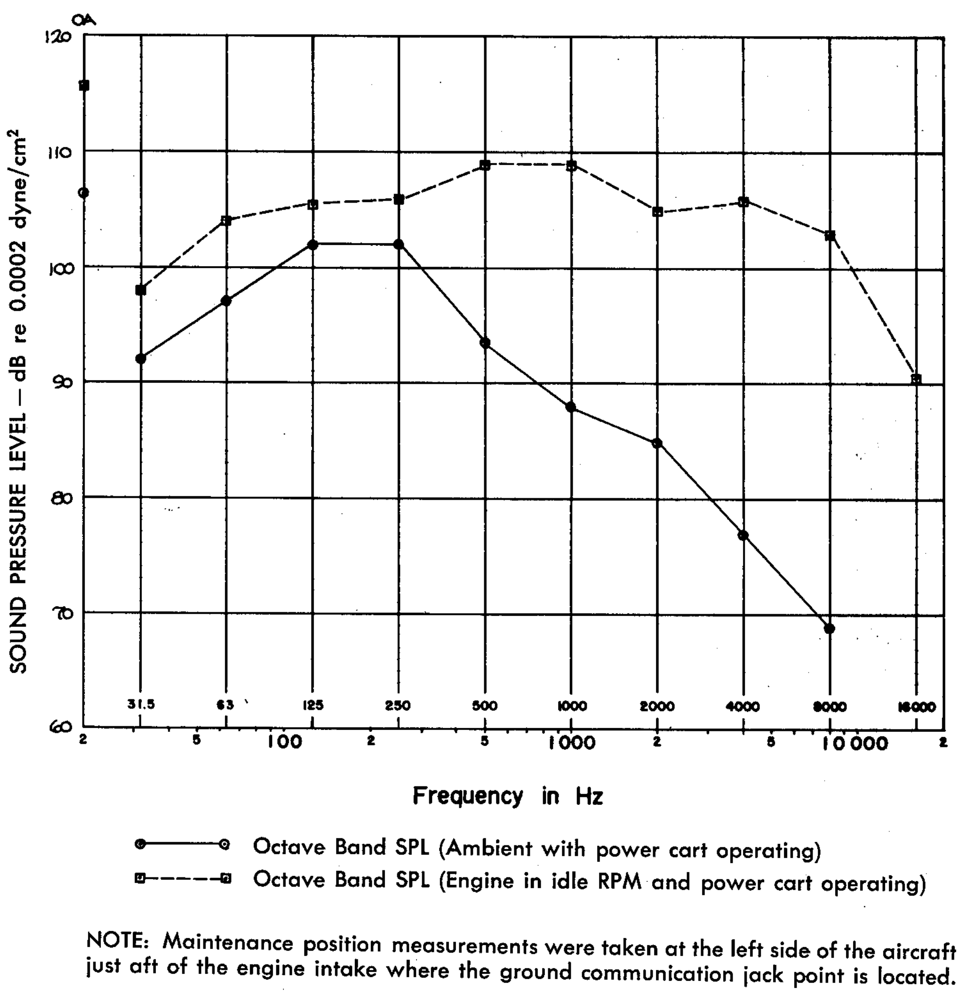


Figure 8. Third-octave and full-octave band sound pressure level spectrum at the ground maintenance position of the P-1127 V/STOL aircraft with engine operating at idle rpm, longitudinal thrust configuration.

Section III.

ACOUSTIC ATTENUATION OF VARIOUS FLIGHT HELMETS

AIR FORCE FLIGHT HELMET/LINER CONFIGURATIONS

To determine the amount of acoustical protection available to the pilot, three Air Force flight helmet/liner configurations were evaluated. All helmet/liner configurations used the same type shell, namely the HGU-2A/P, which is available in six sizes. The variations existed in the type liner used in the helmet shell. Each of the helmet/liner configurations is pictorially shown in figure 9. Basically the H-154 ear cup liner is the standard USAF model available to pilots; consisting of ear cups mounted on a spring loaded suspension. The 17P liner is an alternate to the H-154 ear cup liner consisting of seals mounted on plastic bags serving as ear cups. The Gentex ear cup liner is a development item being evaluated by the Tactical Air Command (TAC) for possible inclusion in the Air Force inventory. In this unit the ear cups are suspended by foam padding. The Gentex ear cup liner has been adopted for use by the Navy.

The acoustic attenuation was determined by two methods: (a) measurement of transmission loss through the helmet, and (b) subjective attenuation, measured by the Real-Ear-Attenuation at Threshold method[1] (REAT). Each subject was personally fitted with the helmets by technicians trained in the art of fitting helmets.

MEASUREMENT OF TRANSMISSION LOSS

The noise generated at the maximum rpm setting in the downward thrust configuration was selected for simulation, since the sound pressure levels generated in this configuration would approximate the maximum expected in an operational situation. Simulation was accomplished using a 14-kilowatt (kw) loudspeaker system. Third-octave band analysis was first performed on the signal from a miniature microphone outside the helmet to determine the ambient sound pressure levels for each third-octave band during simulation. The miniature microphone was then placed at the entrance to the ear canal. While keeping the outside noise environment the same, the third-octave band measurement was performed with and without the helmets in place.

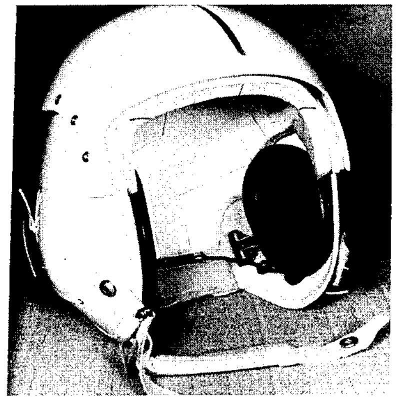
Simulation

A 5-minute sample of the noise recorded for the maximum power setting, downward thrust configuration, was used as an input to a 14-kw loudspeaker system. A condenser microphone was placed in the reverberation chamber housing the loudspeakers associated with the 14-kw system. The condenser microphone was used to determine third-octave band sound pressure levels of the simulated spectrum. A block diagram of the associated components used in this portion of the investigation is shown in figure 10. By manipulating the various shaping networks associated with the 14-kw loudspeaker system, the desired spectrum was generated. The simulation approximated that of the actual measured spectrum within the frequency range from 200 to 4000 Hz as can be seen in figure 11.

Miniature Microphone

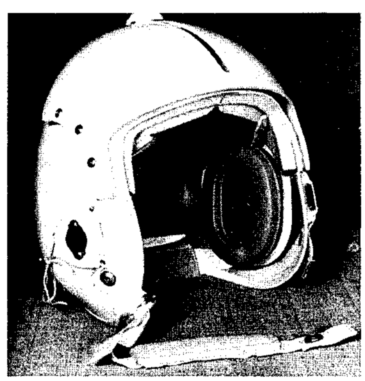
A small microphone (4mm x 4mm x 2mm) was used to record the noise at the entrance to the ear canal when the subject was placed in the noise environment described above. The miniature size of this microphone allowed it to be placed in the concha of the external ear with the diaphragm opening at the entrance to the canal. The relative placement of the microphone hous-

1. Standard Z24.22-1957 United States of America Standards Institute, United Engineering Center, 345 East 47th Street, New York, N. Y.



A. HGU-2A/P with H-154 ear cup liner

B. HGU-2A/P with 17P liner



C. HGU-2A/P with Gentex ear cup liner

Figure 9. Three helmets evaluated for sound attenuation characteristics

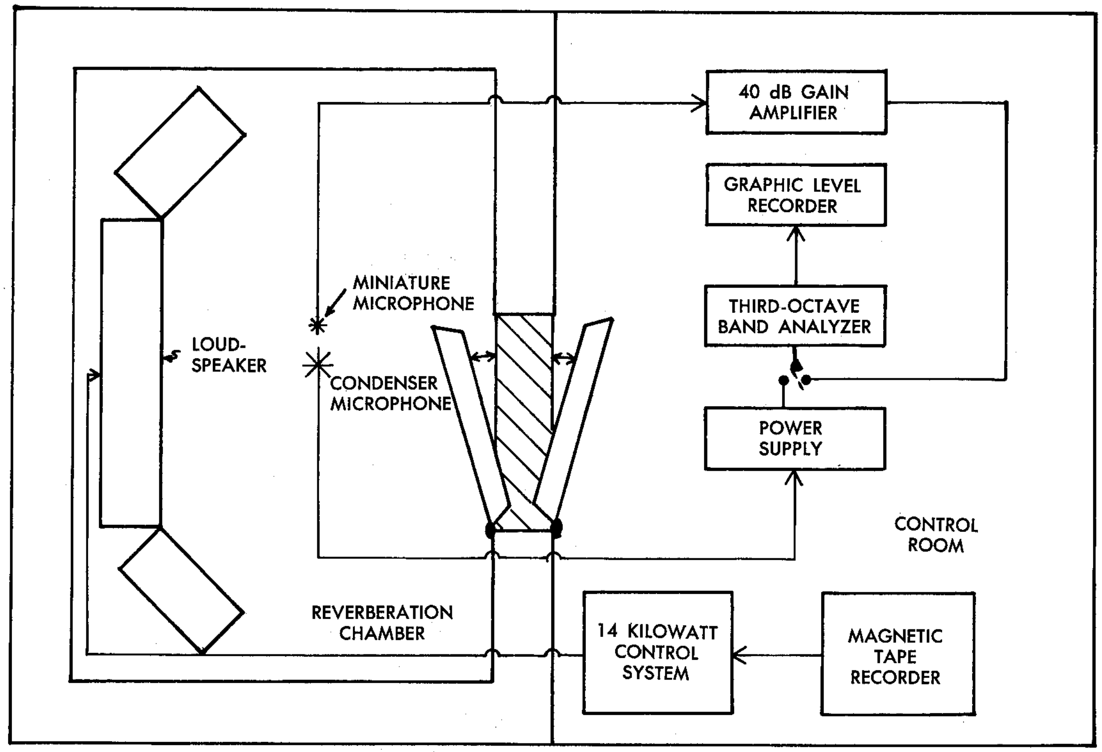


Figure 10. Block diagram of components utilized in the transmission loss portion of the investigation.

ing and receiver portion, relative to the canal entrance, is shown in figure 12. This microphone did not occupy excessive volume in the cup. The wires from the microphone were small enough to be passed through the intratragic notch and against the skin so as not to interfere with the sealing characteristics of the ear cup.

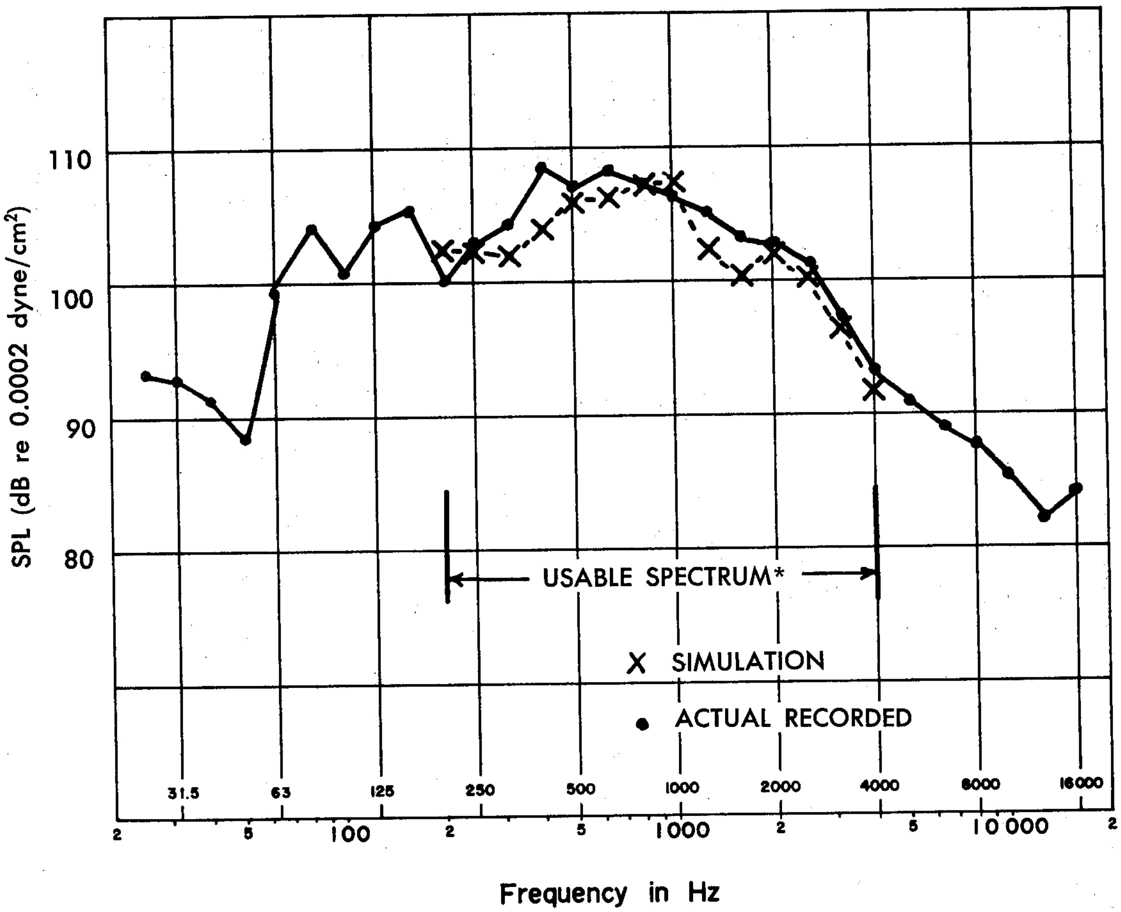
The frequency response of the microphone was determined by inserting it into a known sound field and by comparing it to the response of a microphone of known sensitivity measured in the same sound field. The response of the microphone for perpendicular incidence is shown in figure 13. From this response, the frequency range for purposes of the analyses was from 200 to 4000 cps.

A 40 dB gain amplifier placed in series with the miniature microphone provided sufficient gain to enable one-third octave band analysis to be performed and readings obtained on a graphic level recorder. To determine amplitude linearity across frequency for various levels, the input to the calibration chamber was reduced in 10 dB steps to insure the microphone followed this response. The dynamic range was found to be approximately 50 dB.

The output of the miniature microphone was compared to the condenser microphone response in the free field condition. The results of this comparison insured that the miniature microphone outputs could be compared for external (outside helmet) and internal (at entrance to ear canal under ear cup) measures.

Measurements

For each subject the third-octave band sound pressure level measurements were made using the following arrangements: (1) condenser microphone, free field, no subject in place, (2) minia-



*Usable spectrum refers to the frequency range of the miniature microphone which is limited from 200 to 4000 Hz.

Figure 11. Actual measured third-octave band-sound pressure level spectrum in cockpit of P-1127 V/STOL aircraft compared to the simulated spectrum utilizing the 14-kilowatt loudspeaker system.

ture microphone, free field, no subject in place, (3) miniature microphone, 12 inches from helmeted subject at level of ear, (4) miniature microphone at entrance to left ear canal of subject without helmet, ear canal not occuluded, (5) miniature microphone at entrance to left ear canal with subject wearing each of three helmets evaluated, ear canal not occuluded. All free field noise measures were made with the microphone at a fixed point, the subject being placed so the left ear was level with and 12 inches from the microphone.

Transmission loss due to the helmet was determined as the difference in noise measurements; (4) versus (5), and (3) versus (5). Measurement 2 versus 3 was used to secure a knowledge of

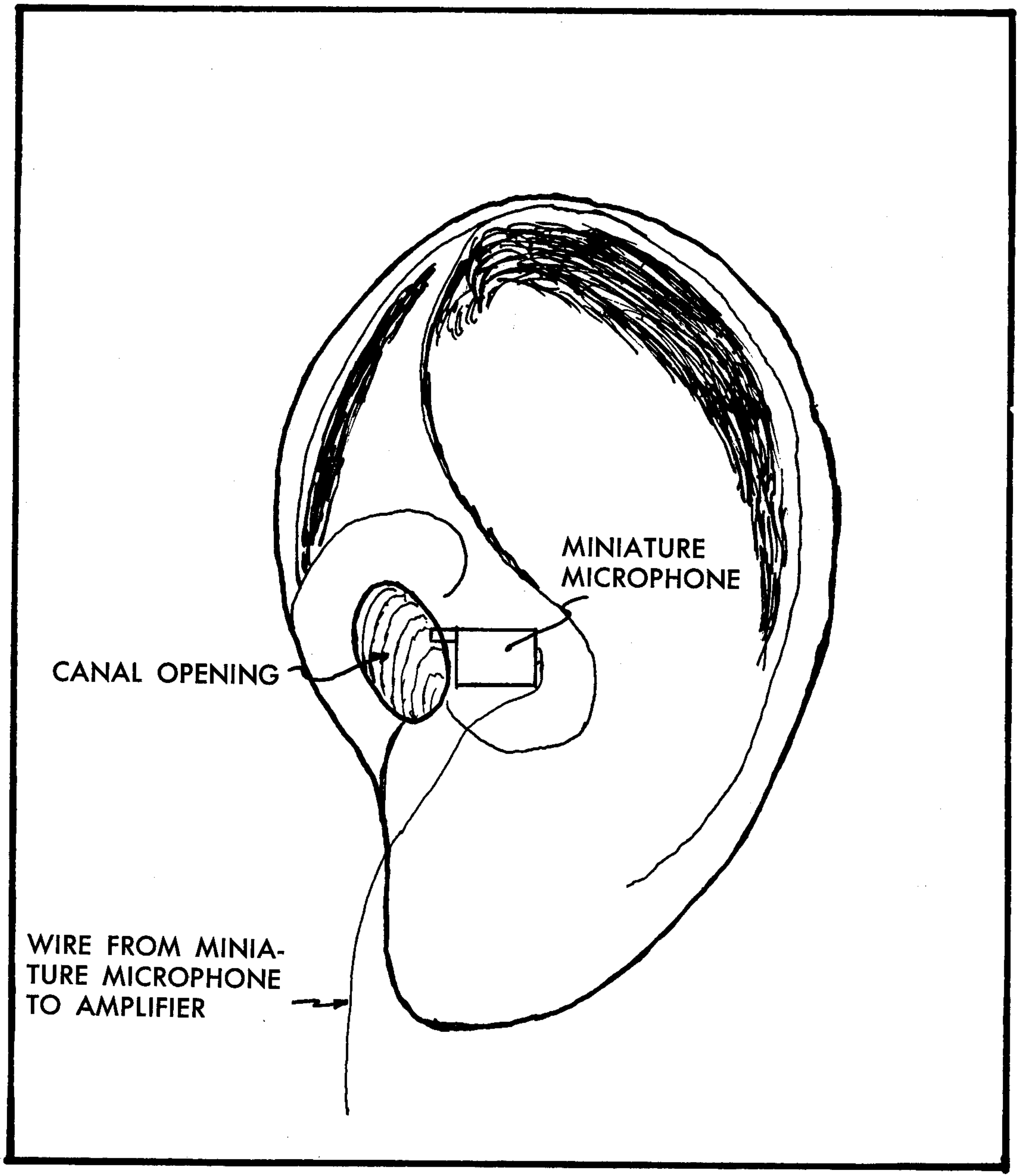


Figure 12. Miniature microphone placement relative to the external auditory canal entrance

the effects of helmet reflection and subject absorption. Measurement (1) was used as the known free field response to which measurement (2), miniature microphone in a free field condition, was compared.

Results

Transmission loss for helmets determined by the two methods are shown in figures 14 and 15. These figures show mean transmission loss in dB for three subjects as a function of third-octave band frequency for each helmet/liner evaluated. The difference between the measurements made with the miniature microphone placed inside (measurement 5) and outside (measurement 3) the

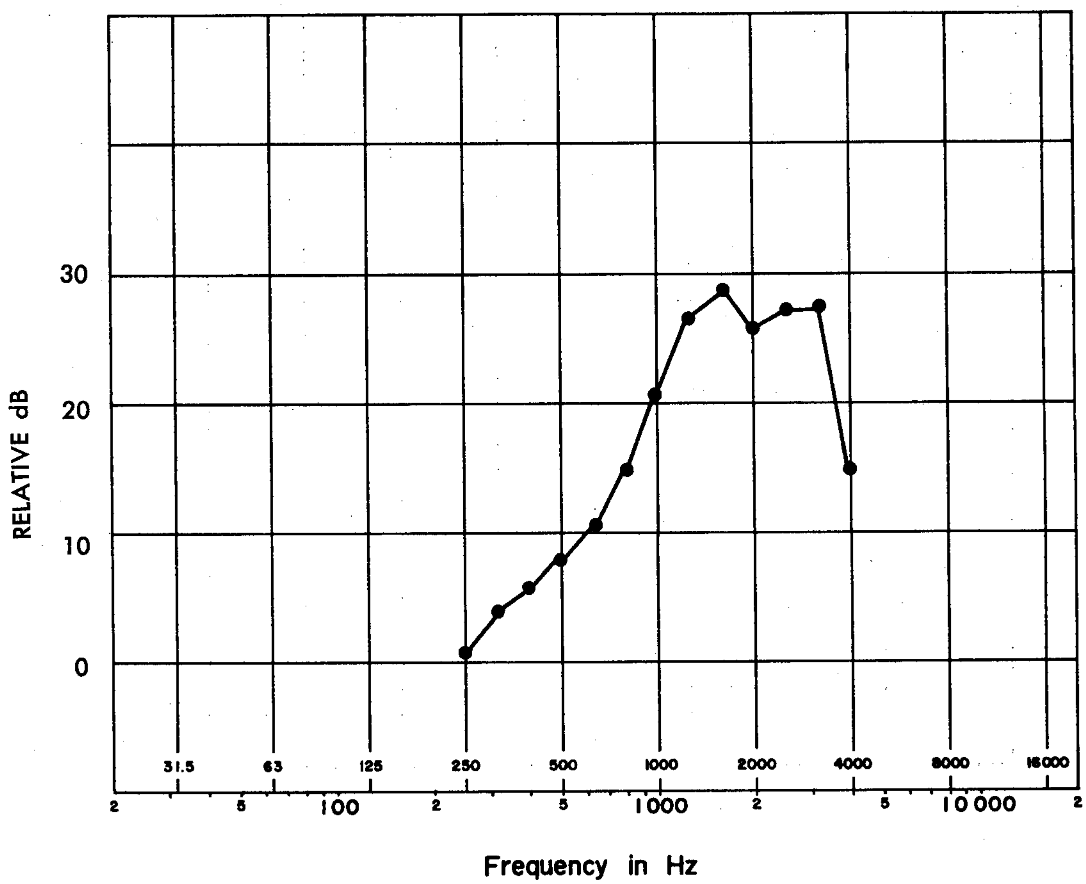


Figure 13. Frequency response of miniature microphone

helmets is shown in figure 14. Figure 15 results from the difference between the measurements made with the miniature microphone placed at the entrance to the ear canal with (measurement 5) and without (measurement 4) the helmets in place. The results displayed in figure 15 accounts for ear canal resonance for both measures and is a more common method for expressing transmission of a particular unit.[2] In general, the helmet with the 17P liner provides less attenuation at all frequencies than does the helmet with Gentex ear cup liner. The helmet with H-154 ear cup liner provides less attenuation than does the Gentex ear cup liner at all frequencies with the exception of 1250 Hz, but more than the helmet with the 17P liner at all frequencies with the exception of 200, 2500, 3150, and 4000 Hz.

MEASUREMENT OF REAL-EAR ATTENUATION AT THRESHOLD (REAT)

Method

These attenuation test procedures measured the shift in threshold of hearing in a free field condition induced by the helmet. The mean differences between these values were designated as the amount of attenuation provided by the helmet. With the exception of measuring real-ear

2. Dickson, E. D., R. Hinchcliffe, and L. J. Wheeler, *Ear Defenders,* Great Britain Air Ministry Report FPRC 884, (June 1954).

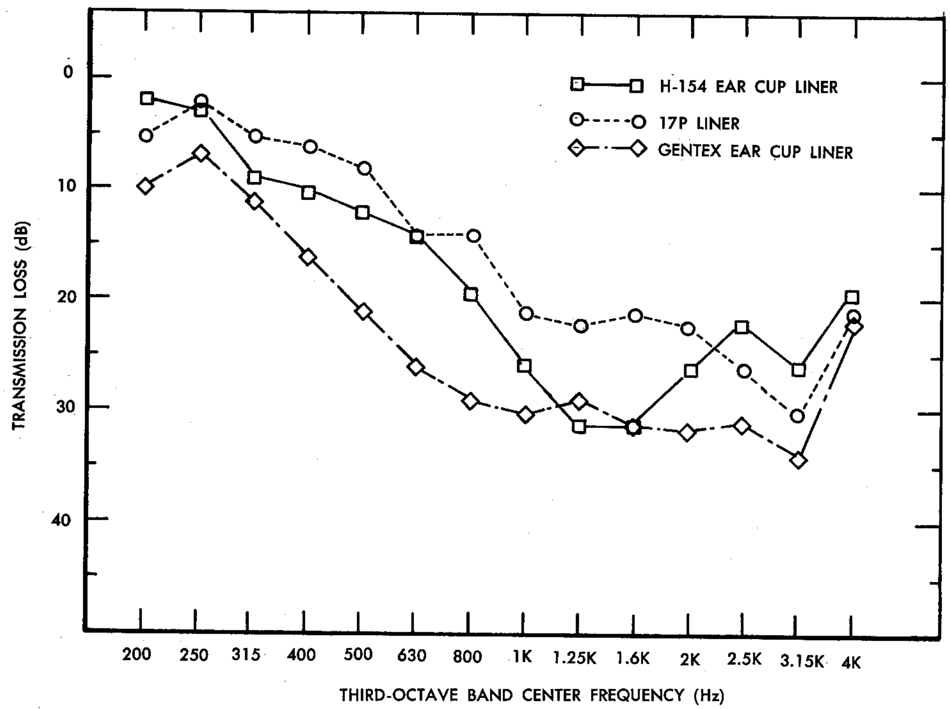


Figure 14. Transmission loss as determined by miniature microphone placed outside the helmet, 12 inches from and level with the left ear, versus miniature microphone placed inside the helmet at the entrance to the ear canal.

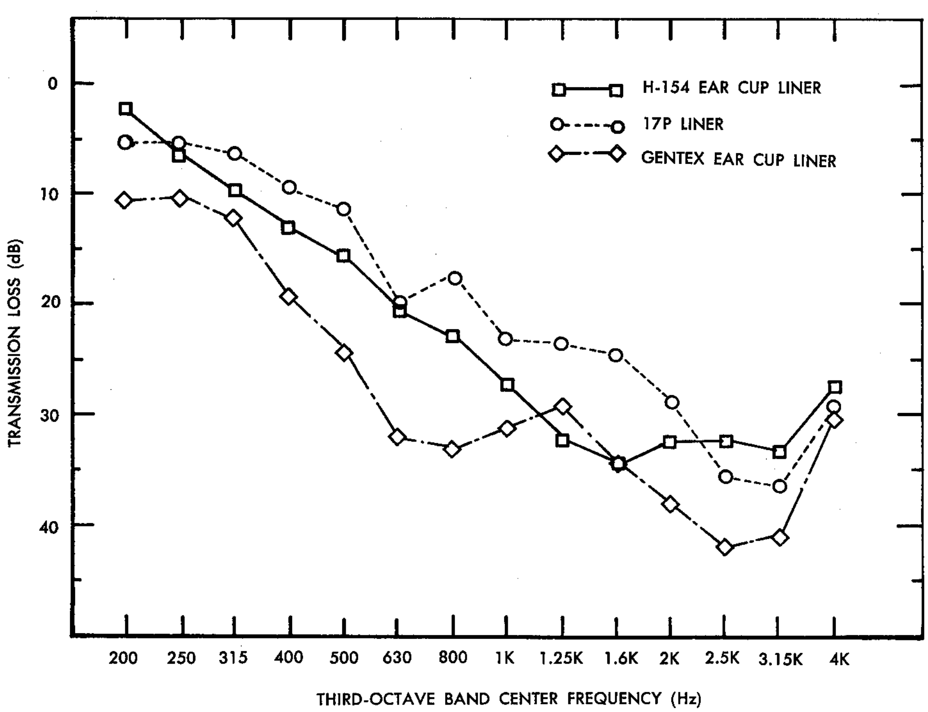


Figure 15. Transmission loss as determined by miniature microphone placed at the entrance to the ear canal with and without the helmet in place

attenuation at threshold for several angles of sound incidence, the evaluation was in accordance with the United States Standards Institute (formerly American Standards Association) method for the measurement of real-ear attenuation at threshold for ear protectors. This method of measurement used ten normal hearing university students ranging in age from 18 years to 24 years.

Threshold of hearing data for nine discrete frequencies: 125, 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz were obtained from the subjects in the following conditions: (1) without helmet, (2) with helmet.

Instrumentation and Procedure

The instrumentation for measuring REAT consisted of: an audio oscillator, an electronic switch, an operators' attenuator (110 dB total range in 1 dB steps), a subjects' attenuator (110 dB total range in 1 dB steps), an audio amplifier, and a 25-watt loudspeaker. The loudspeaker was positioned 4 feet in front of the subject. The harmonic distortion was less than 3 percent over the levels and frequency range used. The subjects found their threshold of hearing by varying their attenuator until the test tone was barely audible. Each subject found his threshold three repeat times for each frequency without and with each helmet that was evaluated.

Results

The mean attenuation for ten subjects, three repeat times (30 measures for each frequency), for each helmet/liner configuration is presented in figure 16. The Gentex ear cup liner provides greater attenuation at all frequencies than the 17P liner or the H-154 ear cup liner. The helmet with the H-154 ear cup liner provides considerably less attenuation than does the 17P or Gentex ear cup liner at the frequencies above 2000 Hz. The Gentex ear cup liner provides from 4-9 dB more protection than the 17P at all frequencies with the exception of 6000 and 8000 Hz where both liners provide approximately the same attenuation.

COMPARISON OF TRANSMISSION LOSS MEASURES AND REAT MEASURES

Comparative Attenuation Data

Comparative attenuation data for both transmission loss and REAT measures for each independent helmet assembly is presented in figures 17, 18, and 19.

Differences between transmission loss methods of measurement, (a) outside versus inside with helmet (figure 14), and (b) inside without helmet versus inside with helmet (figure 15) are attributed to higher inside levels due to the increase in sound pressure level at the entrance to the ear canal. Due to the resonant nature of the ear canal, similar to a resonant tube closed at one end, in addition to acoustic reflection of the ear, causes increases in SPL at some frequencies. These increases in SPL add to attenuation when the microphone is placed at the entrance to the ear canal for both with and without helmets. Transmission loss measurements made with the microphone placed at the entrance to the ear canal for both with and without the helmet would be the preferred method to compare to the REAT method. However, unrestricted comparison of these different methods of measurement is difficult because a microphone, no matter how small, does interfere to some extent, with the acoustic properties of the external auditory meatus. In addition the physical method (transmission loss) uses bands of noise that together produced the desired spectrum where the REAT method uses only selected pure tones. Binaural hearing is used in the REAT method, where monaural measurement is used in transmission loss.

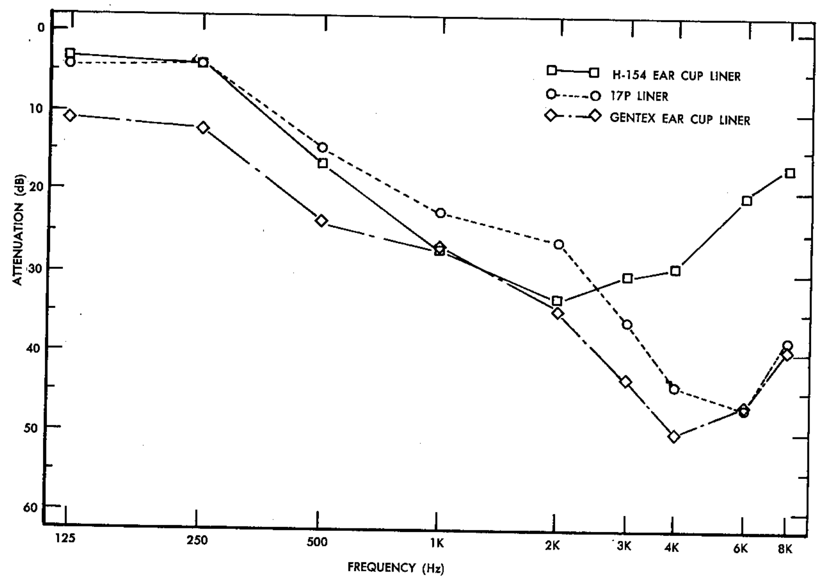


Figure 16. Attenuation for each helmet/liner evaluated as determined by the REAT method

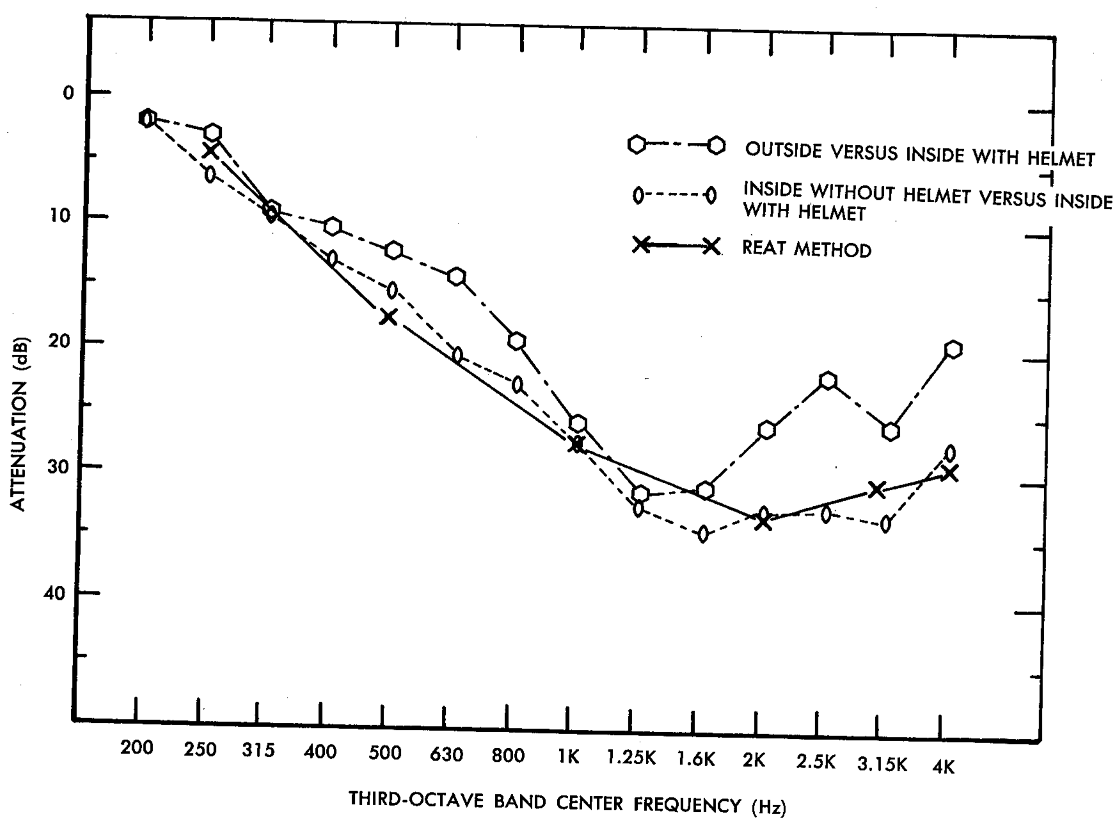


Figure 17. Comparison of two methods of determining transmission loss versus REAT method for the H-154 ear cup liner.

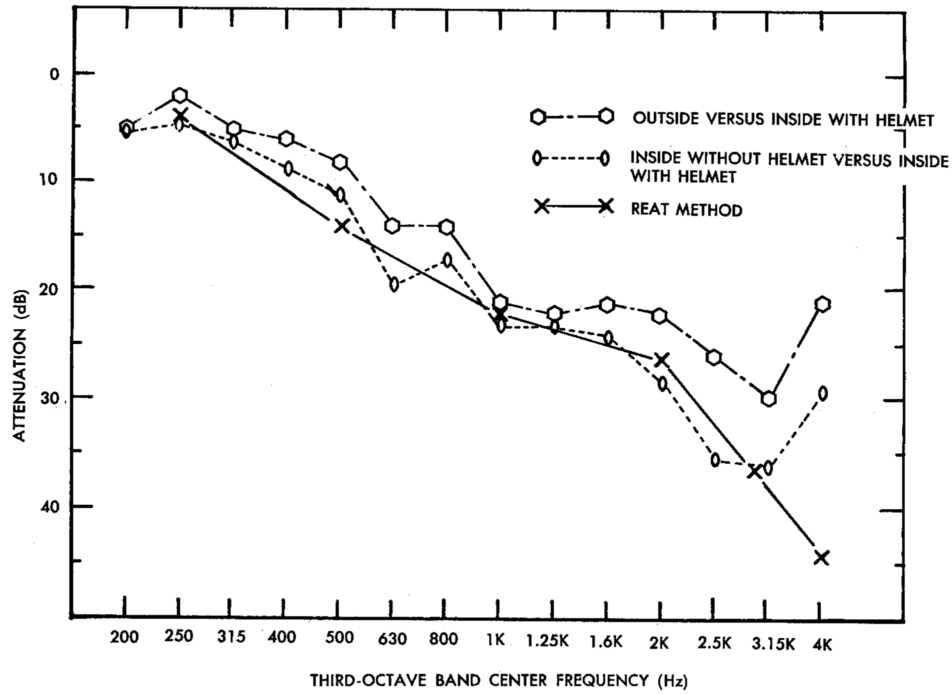


Figure 18. Comparison of two methods of determining transmission loss versus REAT method for the 17P liner.

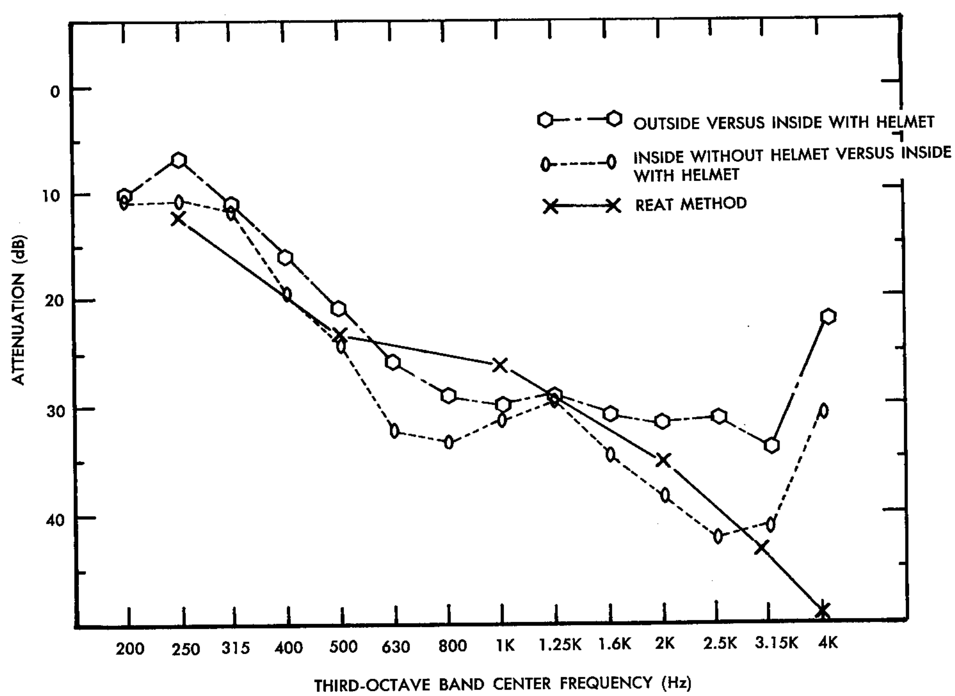


Figure 19. Comparison of two methods of determining transmission loss versus REAT method for the Gentex ear cup liner.

Section IV.

SOUND PRESSURE LEVELS AT THE EAR DURING VARIOUS RPM SETTINGS OF P-1127

HEARING DAMAGE RISK

Using the REAT attenuation data for the various flight helmets an estimate of the octave band sound pressure levels at the pilot's ear can be obtained. Figure 20 shows this data for 45% rpm, figure 21 for 60% rpm, figure 22 for 80% rpm, and figure 23 for maximum rpm.

Hearing damage risk contours for exposure to octave bands of noise are shown in figure 24. These levels were taken from a report on hazardous exposure to noise prepared by the Committee on Hearing, Bioacoustics and Biomechanics, NAS, of the National Research Council.[3] The hearing damage risk levels have been derived so that on the average most persons will not suffer serious hearing losses if the exposure levels for the bands of noise and durations are less than those indicated on figure 24.

The family of hearing damage risk curves represented in figure 24 apply to the particular cockpit noise evaluated in this report. When applying the flight helmet attenuation data to other cockpit noise data to determine hearing damage risk the report of CHABA working group 46, by K. D. Kryter[3] should be consulted, since different types of spectra at the ear may necessitate the use of a different set of hearing damage risk curves.

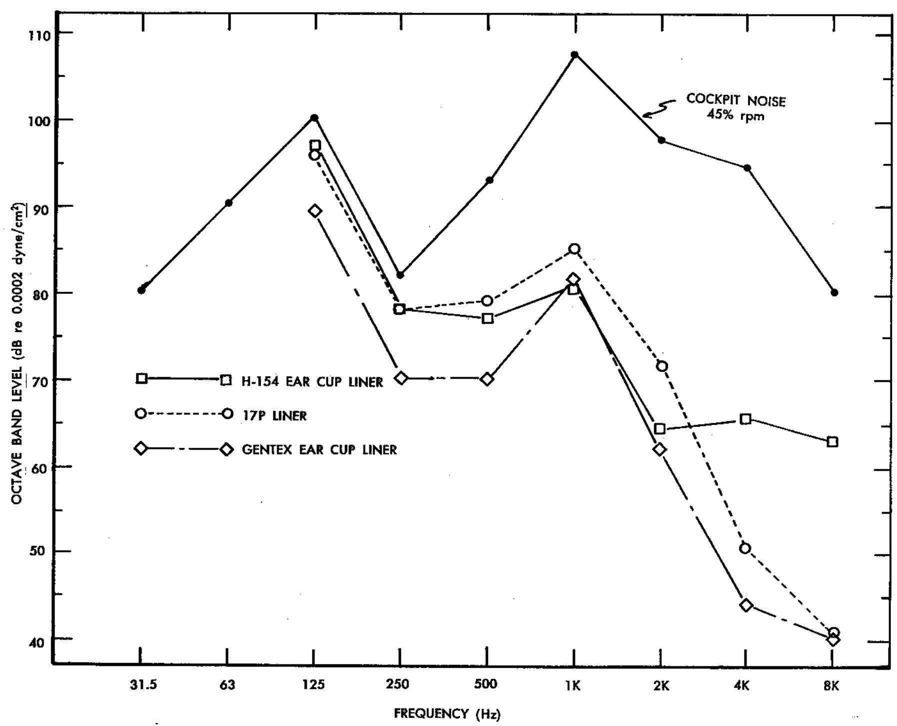


Figure 20. Sound pressure levels at the pilot's ear during 45% rpm downward thrust configuration while wearing each of the helmet/liner assemblies

3. Kryter, K. D., "Hazardous Exposure to Intermittent and Steady-State Noise," Committee on Hearing, Bioacoustics and Biomechanics of National Research Council, Report of Working Group 46, Jan. 65.

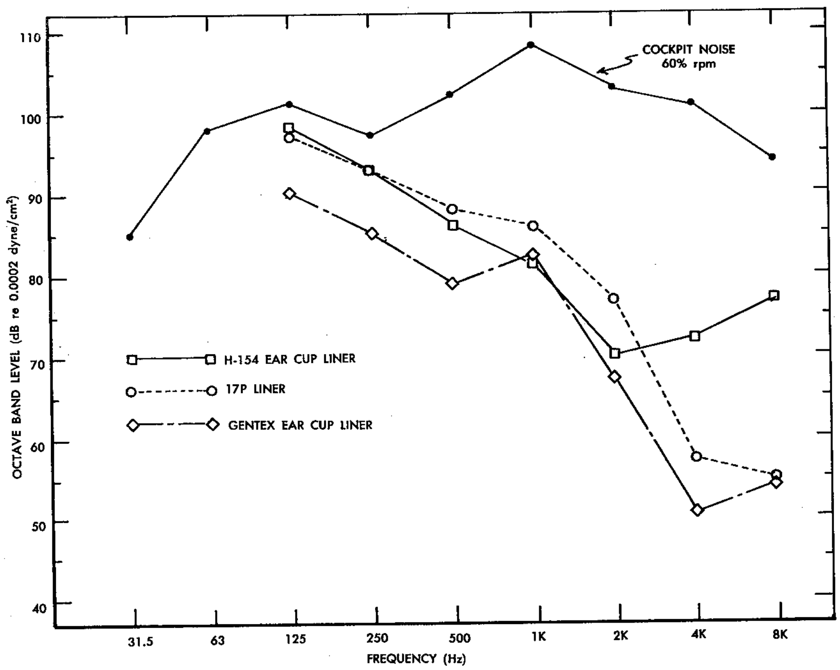


Figure 21. Sound pressure levels at the pilot's ear during 60% rpm downward thrust configuration while wearing each of the helmet/liner assemblies

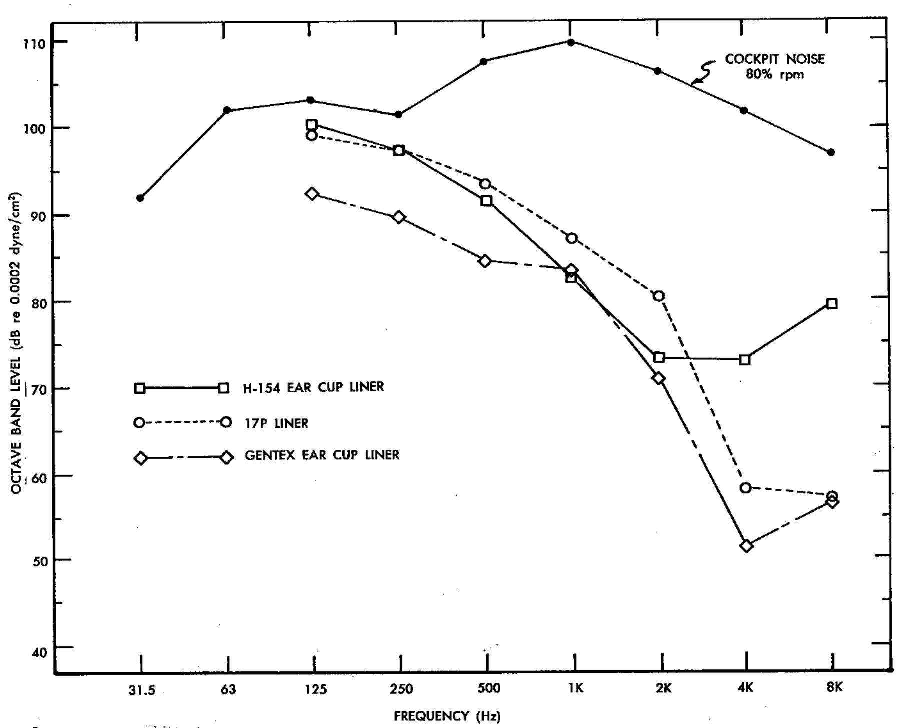


Figure 22. Sound pressure levels at the pilot's ear during 80% rpm downward thrust configuration while wearing each of the helmet/liner assemblies

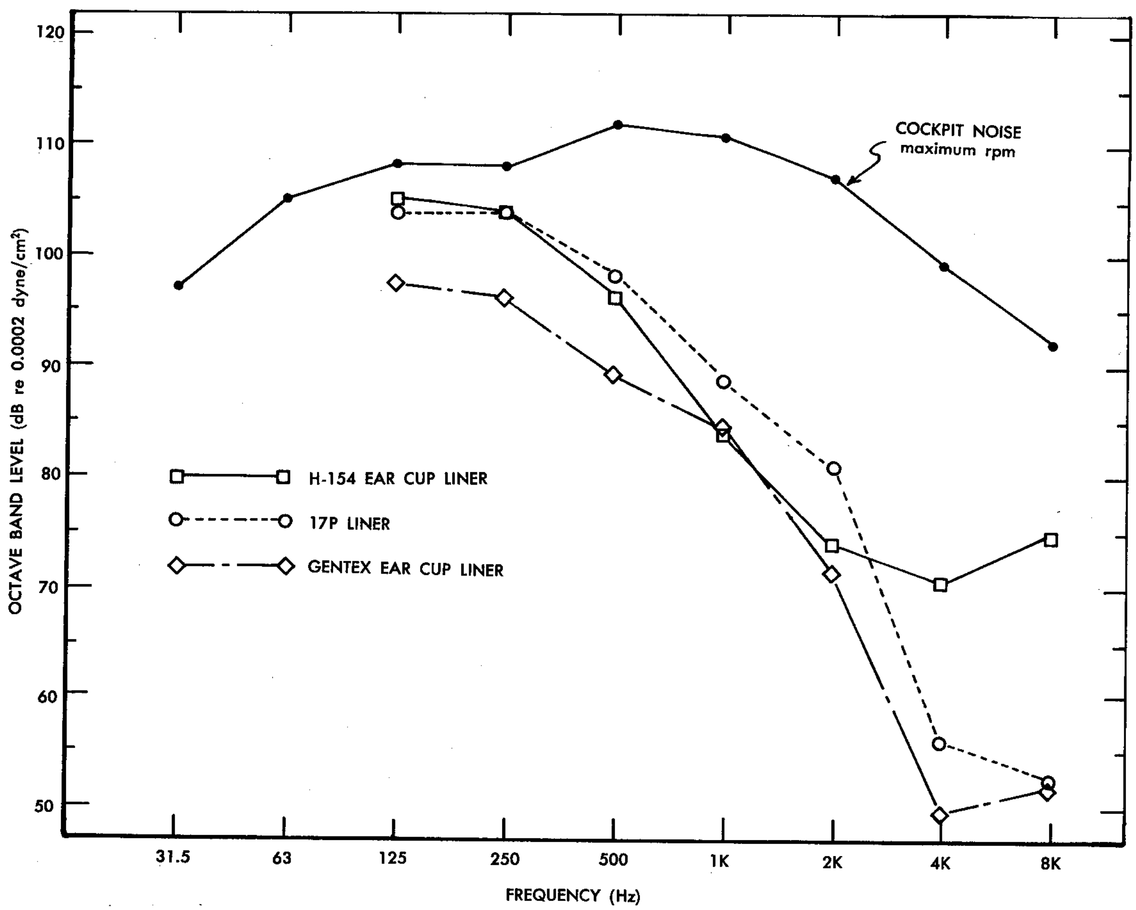
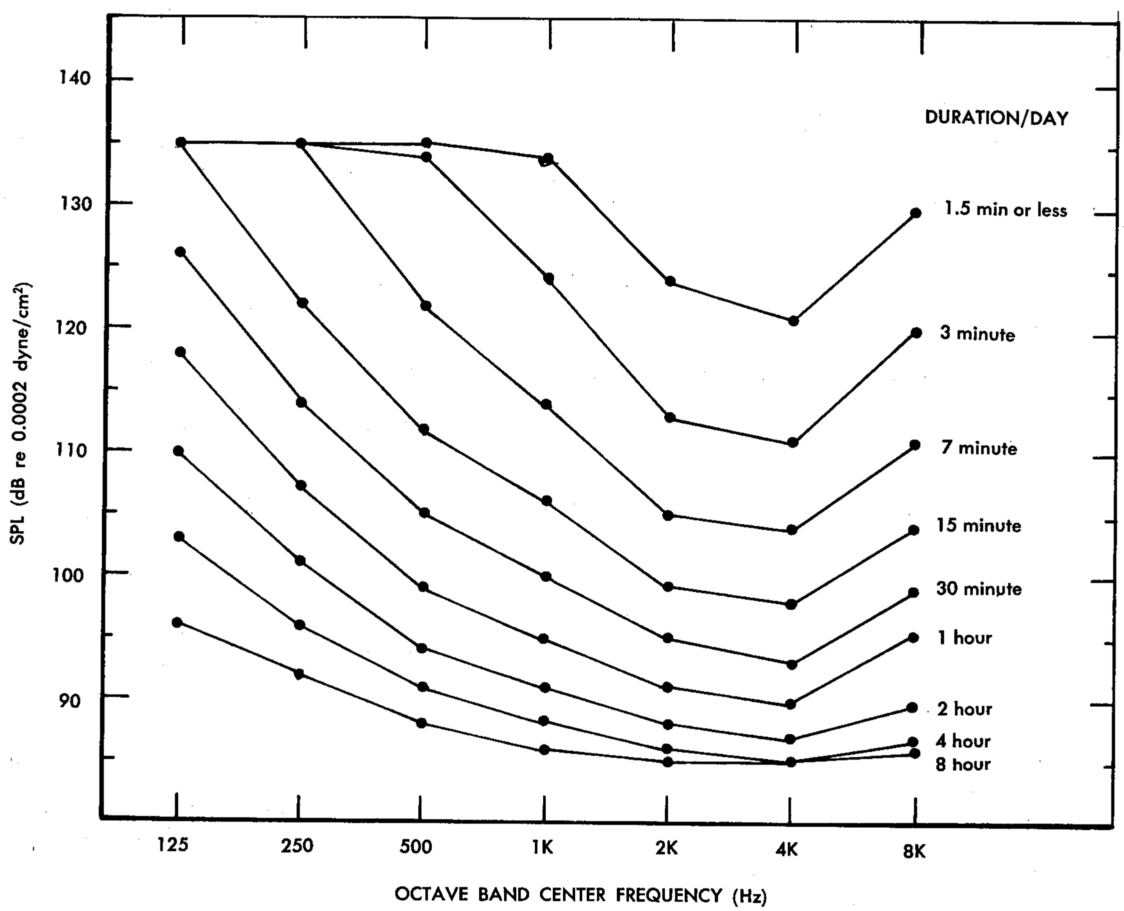


Figure 23. Sound pressure levels at the pilot's ear during maximum rpm downward thrust configuration while wearing each of the helmet/liner assemblies.

In the idle rpm setting the noise environment in the cockpit does not exceed the 15-minute hearing damage risk criteria without protection as specified in reference above. All the helmet liners tested when properly fit and worn, would provide sufficient protection during idle to reduce the hearing damage risk to below that risk associated with 8-hours continuous exposure. In the case of 45% rpm (figure 20), all helmet liner configurations provide enough protection so the sound pressure levels at the ear do not exceed the 8-hour hearing-damage risk contour at any octave band. For 60% rpm (figure 21), the sound pressure levels at the ear for all helmet/liner assemblies do not exceed the 4-hour hearing damage risk values. In the case of 80% rpm (figure 22), the H-154 ear cup liner and 17P liner provide protection that would limit exposure to 2 hours, where the Gentex ear cup liner provides protection in excess of the 8-hour damage risk contours at any octave band. At maximum rpm the protection provided by the H-154 ear cup liner and 17P liner limit exposures to less than 1 hour where the Gentex ear cup liner upper time limit for continuous exposure is 4 hours.

GROUND CREW PROTECTION

During idle rpm with the power cart operating the noise levels (figure 8) generated at the left side of the aircraft, aft of the engine intake, are sufficient to limit exposure to 3 minutes without protection. Using an over-the-ear protector, including those with communication ability procured centrally by the USAF, the hearing damage risk exposure will be reduced to 8-hours continuous exposure. This report does not consider outside noise measured during the other rpm settings, therefore, interpretation of hearing damage risk for ground crew personnel is limited to the idle rpm condition.



Section V.

CONCLUSIONS

NOISE MEASUREMENTS

The noise generated by the P-1127 aircraft positioned on a static test stand was measured inside the cockpit and at one ground maintenance position for various rpm settings ranging from idle to maximum rpm. The noise generated during actual flying operations would be expected to differ somewhat due to the airflow over the cockpit canopy as well as other aircraft surfaces. The airflow generates additional noise commonly referred to as boundary layer noise. Previous experience with noise measurements taken during static test and in actual flight have shown that this boundary layer noise increases the noise spectra in some octave bands.

The cockpit air conditioner of the P-1127 does not significantly alter the noise spectra measured during maximum rpm. Since cockpit noise measures were not obtained at other rpm settings without the air conditioner in operation, the contribution of the air conditioner to the noise spectra reported during idle, 45%, 60%, and 80% rpm cannot be determined.

HELMET ATTENUATION

In general the HGU-2A/P helmet using the Gentex ear cup liner provides better attenuation than does the HGU-2A/P with the H-154 ear cup liner or 17P liner. This was found to be true by both methods of measurement (1) transmission loss and (2) Real-Ear-Attenuation at Threshold. At frequencies above 2000 Hz the HGU-2A/P with the H-154 cup liner provides much less attenuation than the same helmet with the Gentex ear cup liner or 17P liner.

HEARING DAMAGE RISK

During maximum rpm, downward thrust configuration, in which the maximum noise levels are reported, to insure no hearing damage risk according to the CHABA Working Group report, cockpit exposure time should not exceed 1-hour continuous exposure when wearing the HGU-2A/P with the H-154 ear cup liner or 17P liner. When wearing the HGU-2A/P with the Gentex ear cup liner, exposure time can be increased to a maximum of 4-hours continuous exposure without risk of hearing damage. These time limitations are based upon continuous exposure at maximum rpm. During actual flight sorties a brief rest period between exposures may occur, thereby increasing the total allowable exposure time. To determine the effect of intermittent exposure, the report of K. D. Kryter[3], page 18, should be consulted.

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13. ABSTRACT

The purpose of this evaluation was (1) to measure the acoustic noise environment in the cockpit of the United Kingdom Hawker Siddeley P-1127 V/STOL aircraft that would serve as an acoustic guideline for cockpit noise levels of other V/STOL aircraft being contemplated or under construction, and (2) to determine the acoustic attenuation of various Air Force flight helmets in the inventory or being contemplated for Air Force inventory items. Cockpit sound pressure levels in the United Kingdom Hawker Siddeley P-1127 V/STOL aircraft at engine rpm settings of idle, 45%, 60%, 80% and maximum were measured. The cockpit noise environment at maximum engine rpm was reproduced in the laboratory and used to obtain objective attenuation data for three Air Force flight helmet/liner configurations (HGU-2A/P helmet with 17P liner, H-154 ear cup liner and Gentex ear cup liner). Measurement of Real-Ear Attenuation at Threshold (REAT) were also accomplished on the helmet/liner configurations. On the basis of the cockpit noise environment and the attenuation characteristics of the helmet/liner configurations tested, no hearing damage would be expected to result when exposure durations do not exceed 1 hour continuous exposure. The Gentex ear cup liner provides approximately 4 to 9 dB more attenuation than the 17P liner throughout the frequency range tested and from 13 to 26 dB more attenuation than the H-154 ear cup liner at test frequencies from 3 to 8K Hz.

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