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# AEROMEDICAL FACTORS IN AIR-REFUELED EXTENDED HELICOPTER FLIGHT

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EXTENDED HELICOPTER FLIGHT**

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## **FOREWORD**

This research was conducted by personnel of the Biodynamics and Bionics Division, Biomedical Laboratory of the Aerospace Medical Research Laboratories, in support of project 7231, Biomechanics of Aerospace Operation; task 723101, Effects of Vibration and Impact.

The author, Captain Charles R. O'Briant, USAF, MC, was assigned as a third year resident in Aerospace Medicine at the Aerospace Medical Research Laboratories. He expresses his appreciation for the assistance of Lieutenant Colonel Elizabeth Guild, Chief, Biological Acoustics Branch, Biodynamics and Bionics Division, and to Major William D. Eastman, HH-3E Helicopter Flight Test Project Officer, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

This technical report has been reviewed and is approved.

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Technical Director  
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## **ABSTRACT**

The development of a helicopter air-refueling capability now greatly extends the time of nonstop flight possible. Helicopter crews may now be exposed to the possible adverse effects of prolonged periods of noise and vibration. A flight surgeon worked closely with the aircrews on the test program and flew as a crewmember on an 18-hour nonstop mission, which covered 2200 nautical miles and included several aerial refuelings. No notable adverse effects or detectable physiological changes in the crewmembers occurred as a result of this extended 18-hour helicopter flight.

# AEROMEDICAL FACTORS IN AIR-REFUELED EXTENDED HELICOPTER FLIGHT

## INTRODUCTION

This study was a part of the aerospace medical support furnished in the development and testing of air refueling of the HH-3E helicopter. With the development of an air refueling capability, helicopter range and time of flight will be greatly extended. Consequently, attention must be given to the physiological and other aeromedical effects on the crewmen of such extended flight, and some guidelines developed establishing crew duty time and fatigue factors.

Very little information is available on the aeromedical aspects of prolonged nonstop helicopter flight, because air refueling is a recent development. Dean et al (ref 3) reported on the effects of 6-hour exposures to simulated helicopter noise and vibration and Marchbanks et al (ref 5) have reported on the stress response of a 6-hour, air-refueled, over-water mission in fighter type aircraft. Recent thorough discussion of fatigue factors in aviation can be found in a Federal Aviation Agency report by Mohler (ref 6) and in a special report published in Aerospace Medicine (ref 1).

## METHOD OF STUDY

In order to evaluate the aeromedical factors of extended helicopter flight, a flight surgeon participated in the testing of the air-refueling capability, with particular emphasis on the noise, vibration, and fatigue factors. This consisted of actual experience of the flight stress on training refueling missions in both the CH-3C helicopter and the HC-130P tanker, in-flight noise and vibration surveys, and observations of crewmembers to identify any possible aeromedical hazards. The next phase consisted of evaluating the same factors on an extended, nonstop flight with air refuelings. This was accomplished when three pilots, a flight engineer, and a flight surgeon flew an HH-3E 2200 nautical miles nonstop in 18 hours with several air refuelings (fig. 1 and 2). The flight surgeon, as a crewmember on this flight, was particularly interested in developing criteria for crew duty time, work-rest cycles, long mission food and water requirements, storage, crew rest station, fatigue factors, elimination, and effects of prolonged exposure to extended helicopter flight.



Figure 1  
Aerial Refueling of the HH-3E Helicopter from HC-130P Tanker



Figure 2  
HH-3E Helicopter As Seen from the Aerial Tanker

## RESULTS

During the initial test phase, sound level surveys revealed that noise levels were sufficient to warrant the use of some type of hearing protection at all times, especially when in the rest station. Figure 3 shows noise levels representative of those measured by Guild (ref 4) during in-flight surveys. Vibration was perceptible at all times and was noted to increase moderately in the refueling profile, probably owing to buffeting from the prop-wash of the HC-130P. Under operational conditions these periods of increased vibration would be of short duration and infrequent enough so that it probably does not represent a significant increase in the fatigue factors. Guild's analysis of available data showed the vibration to be greatest in the vertical direction in the cockpit but in the longitudinal direction within the cabin. The vibratory energy throughout the aircraft peaks at about 18 Hz. The g levels increase with airspeed and when flying in formation with the aerial tanker. The g levels on the floor for the vertical axis are well below the tolerance limit for short-time exposures as described by von Gierke (ref 6). (In terms of g level per Hz, the cockpit vibration in the peak low frequency band [16-20 Hz] ranges up to 0.55 g in the vertical direction, 0.20 g in the lateral axis, and 0.33 g in the longitudinal. For the frequency range least tolerable for human comfort [4-8 Hz], levels range up to 0.04 g/Hz in the vertical and lateral axes, and up to 0.09 g/Hz in the longitudinal direction. The latter is definitely greater at the slower speeds, 0.03 g/Hz being the highest level measured at 120 knots indicated, ref 4.) Lack of complete information on the vibration levels transmitted to the crew and of firm criteria for tolerance to random six-degree vibration precludes estimates of overall tolerance with time. Guild's analysis pointed up the complexity of the vibration environment inherent in helicopter flight and the importance to future tolerance decisions of obtaining detailed measurements when appropriate instrumentation can be found.

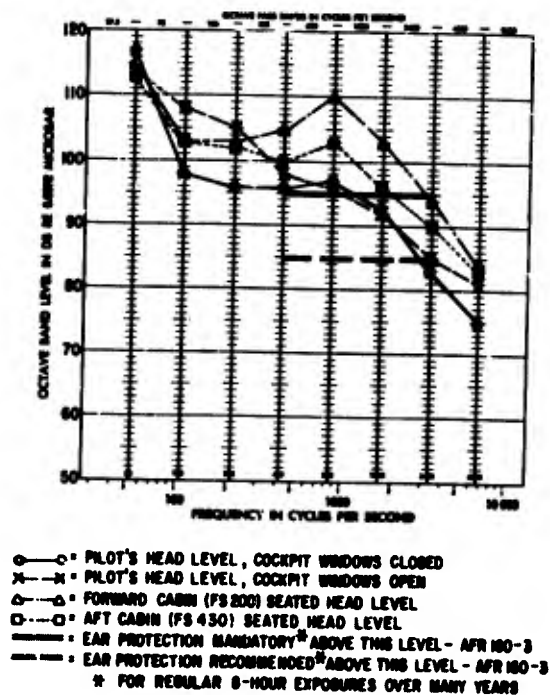


Figure 3  
CH-3C Representative Noise Conditions (125 KIAS, 103% RPM)

For the long flight, a crew rest-station, consisting of two mounted litters, one over the other, with a thin foam rubber mattress, and a sleeping bag, was established in the aft section near the cargo ramp. Food requirements were met in the following manner. The first meal was eaten within 5 hours, the "shelf-life" of an ordinary flight lunch, supplemented with milk. The second and third meals were prepacked, in-flight meals, supplemented with canned juice. An electric cup warmer was on board to heat any of the cans from the in-flight meals. The prepacked meals presented no storage problem and have a shelf-life of many months or years. Water was supplied by means of standard aircraft water containers. Elimination was accomplished via standard aircraft relief tubes.

Noise protection was afforded by one of the following devices during the test: (1) Air Force flying helmet with MX 2088/U ear cushion, (2) H-157 headset, or (3) over-the-ear type defender. One of these was in place at all times. Their effectiveness, together with that of the Air Force earplugs is shown in figures 4 and 5 from Guild's data (ref 4).

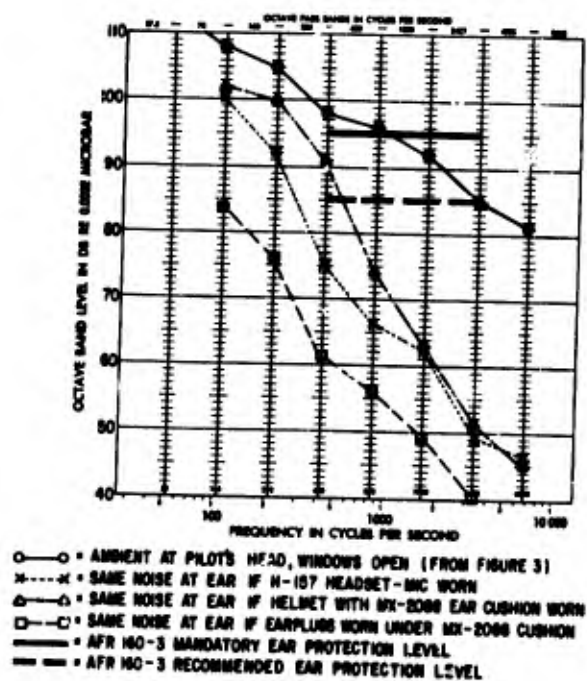


Figure 4  
Attenuation of CH-3C Cockpit Noise by Ear Protectors

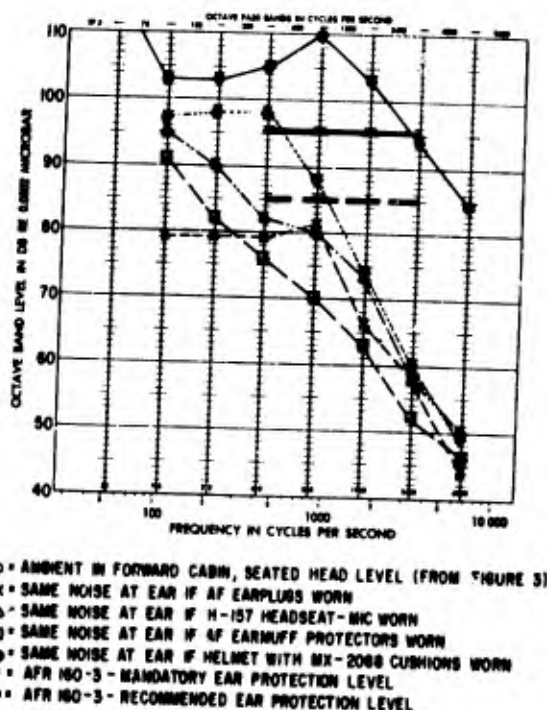


Figure 5  
Attenuation of CH-3C Cabin Noise by Ear Protectors

The three pilots were pretested by the flight surgeon for sensitivity to sleep medication and stimulant-type medication. None of the crewmen had any adverse reaction to either type. This information is useful, with the development of long missions, because the aircrew's sleep-awake cycle may be greatly altered and may require some medication for sleep before a long mission under unusual circumstances. Also, after prolonged flight, some short-acting stimulant might be necessary before a refueling. None was needed during this 18-hour flight.

During the flight a satisfactory work-rest cycle was developed for the three-pilot crew. During the first 12 hours of the flight the three pilots were rotated every two hours in the following manner: left seat, right seat, rest; so that in a 6-hour period, each pilot had two hours rest and four hours cockpit time. This cycle was performed twice for a total of 12

hours, and then one-hour rotations in each position were tried for the next 6 hours; i.e., 1 hour rest, 1 hour left seat and 1 hour right seat. All three pilots used the rest station during their rest periods and the flight surgeon noted that all three were able to sleep soundly during the 2-hour rest periods.

Preflight and postflight physical examinations were done on the pilots by the flight surgeon and compared to see if any changes had occurred. None of the crewmen showed any adverse effects as reflected by the pulse rate or blood pressure (table I), coordination, reaction times, or handwriting changes. Preflight and postflight audiometric tracings were not available. However, none of the crew (including the flight surgeon) noted any subjective auditory changes during or after the flight, such as difficulty of hearing, or tinnitus.

No adverse effect or detectable physiological change was noted as a result of this helicopter flight of 18 hours duration. Fatigue seemed to be minimal and the crew was completely alert at the end of the mission. Throughout the flight, the weather was good and the flying conditions very favorable.

**TABLE I**

**Blood Pressure and Pulse Before and After  
18-hour Flight**

Pilot No.	Preflight Sleep Hours	Preflight		Postflight	
		Pulse	Blood Pressure	Pulse	Blood Pressure
1	5½	88	130/85	90	130/80
2	5	84	128/78	68	120/75
3	5¾	60	110/75	72	115/75

### CONCLUSIONS

On extended flights with this aircraft some form of ear protection should be used at all times as the noise levels are above the hearing damage risk (ref 2). No risk of permanent hearing loss is involved if head sets, helmets, over-the-ear or insert-type defenders are used. To insure against any temporary loss of hearing, insert-type earplugs underneath the helmets or headsets should be used for at least part of the time. In-flight communications are satisfactory when insert-type earplugs are used.

A crew rest-station can be readily provided in the aft part of the cargo section. Since both noise and vibration are less severe in the rear of the cabin, location of rest facilities in that area appears preferable. If needed, locating one litter to either side would be more desirable than placing one litter over the other as was done for this test. Crewmembers must wear ear protection when using the rest area. A "shower curtain" arrangement could be erected around the area to block out light or flicker if desired.

The prepacked, in-flight feedings proved very successful in this test and do not represent any compromise in food sanitation or risk of spoilage, and refrigeration is not required. A choice of several menus is available to afford a wide selection of meals. Careful attention must be given to insure that adequate water is on board to meet the requirements for the number of people and length of mission.

Augmented pilot crew duty time can probably be up to 18 hours on missions similar to the test flight, such as ferry or certain search missions. Crew work-rest cycles will vary with different crews and the nature of the mission. However, the cycle of 4 hours cockpit time and 2 hours rest worked well with this three-pilot crew.

All crewmembers should be pretested by a flight surgeon on rest and stimulant type medications so that the side effects, if any, can be noted. Under most circumstances, medication should not be needed, but the occasion may arise when this pretest information would be of great value.

Finally, more experience will be needed to determine with what frequency crewmen can fly missions of this length in helicopters without presenting possible hazards to the individual or to flying safety.

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The development of a helicopter air refueling capability now greatly extends the time of nonstop flight possible. Helicopter crews may now be exposed to the possible adverse effects of prolonged periods of noise and vibration. A flight surgeon worked closely with the aircrews on the test program and flew as a crewmember on an 18-hour nonstop mission, which covered 2200 nautical miles and included several aerial refuelings. No notable adverse effects on or detectable physiological changes in the crewmembers occurred as a result of this extended 18-hour helicopter flight.

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