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SOUND ATTENUATION PROVIDED BY PERFORATED EARMUFFS

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ABSTRACT

Sound attenuation characteristics were determined for two types of earmuffs with perforated shells. The muffs had been perforated to allow air pressure equalization when used in a chamber where rapid barometric pressure changes take place in the presence of highly intense noise. It was found that both types of perforated muffs provided a substantial amount of ear protection even though they were not as effective as intact muffs.

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FOREWORD

This report was prepared in the Otolaryngology Branch (Audiology) under task No. 775508. In 1964 at the request of the Preventive Medicine Branch, the data described here were collected for application to the noise hazards encountered in the hyperbaric chamber of the School. Because of general interest in the results of the tests, the material was recently re-examined and this report prepared. The paper was received for publication on 3 June 1968.

The earmuffs used in the study were manufactured by the David Clark Co., Inc., 260 Franklin St., Worcester, Mass.

This report has been reviewed and is approved.

GEORGE E. SCHAFER
Colonel, USAF, MC
Commander

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I. INTRODUCTION

A study was devised to measure the sound attenuation provided by two types of earmuffs (model 372-8A(C) and model 10A), the shells of which had been perforated for air pressure equalization. These muffs are used by personnel working in the hyperbaric chamber at the USAF School of Aerospace Medicine. Ear protection is required in the chamber because potentially hazardous noise levels are generated by air exchange during changes in barometric pressure. Such changing pressures bring about discomfort and even pain unless the ambient pressure can be equalized with that found beneath the earmuff. To achieve equalization, two holes of 1.1 mm. diameter each were drilled in each muff. The holes were positioned at approximately ½ inch above and ½ inch below the center of the muff shell. Figure 1 shows the type 10A earmuff with perforations. The foam rubber padding remained intact inside the earmuff shells. Experienced chamber personnel reported that this modification relieved the discomfort associated with pressure changes while still providing substantial subjective relief from the noise in the chamber.

FIGURE 1

Model 10A earmuffs with perforated shells.

II. PROCEDURE

Sound attenuation characteristics of the perforated muffs were measured by a method similar to that described by Nixon et al. in 1959 (1). Ten normal-hearing listeners participated in the tests at each of nine discrete frequencies (125 to 8000 Hz). A detailed description of the equipment used and of the procedure followed by each subject is given in the following paragraphs.

Pure tones at each test frequency were generated by a pushbutton audio oscillator (Hewlett-Packard model 241A) and delivered to the input of an audiometer (Grason-Stadler model E-800, Bekesy-type) set to the pulsing mode and adjusted for approximately 170-msec. pulses with 25 msec. rise/decay time, 50% duty cycle. Output of the audiometer was presented to a 12-in. loudspeaker located inside an anechoic chamber (12½ by 10 ft.). Subject was seated in a comfortable chair in front of the speaker, his head carefully positioned 36 in.

TABLE I

Sound attenuation in decibels for ten listeners using perforated earmuffs

Attenuation (dB)	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz	8000 Hz
					Model 372-8A(C)*				
Average (at 90-deg. angle)	10.4	16.6	29.6	44.1	36.6	42.1	40.6	35.1	33.7
Range (at 90-deg. angle)	2-18	9-18	25-35	37-53	28-44	35-54	31-46	21-51	23-44
Average (at zero-deg. angle)	9.0	16.7	27.2	38.0	31.7	36.4	36.4	40.7	36.2
Range (at zero-deg. angle)	4-19	14-20	24-31	34-43	23-41	31-42	28-46	26-57	24-50
					Model 10A*				
Average (at 90-deg. angle)	5.8	14.1	26.6	39.3	41.5	40.4	40.0	34.5	31.8
Range (at 90-deg. angle)	—3-14	6-19	19-29	31-46	39-49	33-50	32-50	21-45	24-43
Average (at zero-deg. angle)	6.1	13.4	25.8	39.8	41.7	35.4	37.6	36.2	32.5
Range (at zero-deg. angle)	0-14	11-17	24-28	33-47	33-50	31-39	28-45	30-44	22-39

*David Clark Company.

from the center of the loudspeaker cone. The subject controlled the level of the pulsed tone by means of a hand switch. He was directed to press the switch as soon as he heard the tone and to release the switch as soon as he could no longer hear it. In this manner, he traced his threshold for the test tone by continually "bracketing" above and below it. Threshold was defined as being midway between the "just heard" and "just not heard" points. Each subject performed two test runs, during one of which he faced directly toward the loudspeaker (90-degree incidence). For the other run, he faced parallel to the face of the loudspeaker so the sound met the ear canal at a zero-degree angle of incidence. For each condition, the attenuation afforded by the earmuff at each frequency was the difference in decibels between the uncovered and the covered thresholds for that frequency. The order of test presentations was counterbalanced to obviate the effects of learning.

III. RESULTS

Table I summarizes the results of all attenuation tests. Presented are the average and range of attenuation values for the ten listeners at each test frequency and for both angles of incidence. Examination of these data reveals two major findings:

1. For all test frequencies above 125 Hz, the perforated muffs provided a substantial degree of ear protection to all listeners under both conditions. At frequencies of 500 Hz and greater, the minimum attenuation recorded for any subject at any frequency was 19 dB.

2. The range of attenuation among subjects was fairly wide. The source of variability was not determined, but it is likely that differences were due in part to variations in headband tension, sealing gaskets, and alignment of the vent holes with the ear canal.

An estimate of the amount of attenuation lost through perforation of the muff shells was made by comparing the results of the present study with those of two previous investigations. Nixon et al. (1) reported the mean attenuation provided by the unperforated earmuff (372-8A(C)), and Sommer (2) has made like measures for the 10A protector. Figures 2 and 3 present graphic comparisons of the present data for perforated muffs with the

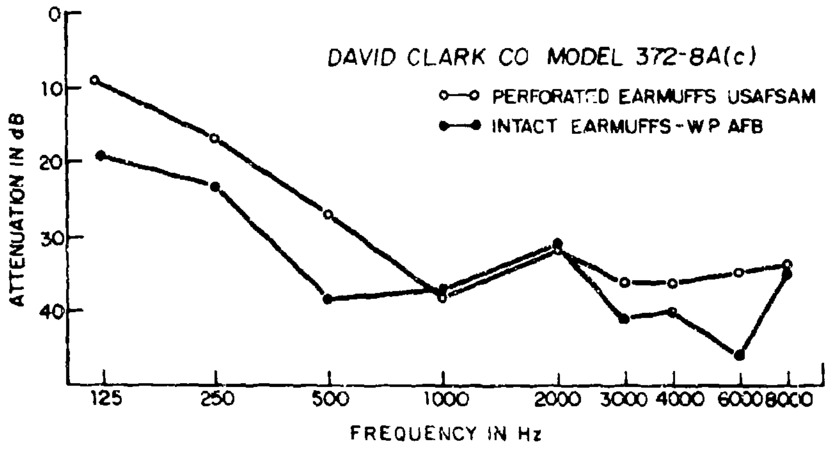

FIGURE 2

Sound attenuation provided by perforated and intact earmuffs, model 372-8A(C).

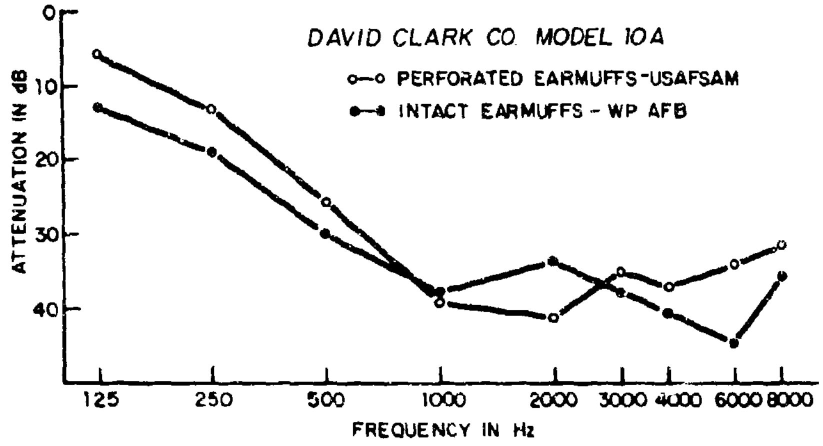

FIGURE 3

Sound attenuation provided by perforated and intact earmuffs, model 10A.

data for unperforated muffs of the same type. The charted points for perforated muffs represent the average attenuation in decibels achieved at each frequency under the poorer angle of incidence; that is, where different amounts of attenuation were measured for a given frequency for the two angles of incidence, the lesser of the two measures was plotted. Two factors emerge from study of figures 2 and 3. First, it is clear that the perforations made in the earmuffs did not destroy their function as ear protectors. Although some loss in attenuation was apparent, the attenuation characteristics of the perforated muffs approach those of the unperforated models very closely throughout much of the test range. Second, the loss in attenuation brought about by the perforations is strikingly similar for the two muffs. The amount lost differs by more than 3 dB at only two frequencies (500 and 2000 Hz). Considering the nature of the study, such agreement appears remarkable. This finding suggests that further studies should be carried out to determine the possibility of predicting from unperforated tests the effects of perforation upon the performance of an earmuff.

IV. DISCUSSION

The present study was undertaken to answer a particular question: whether or not perforation of two types of earmuffs for use in rapidly changing barometric pressures had destroyed their noise attenuation characteristics. Certain other findings, however, are of more general interest. The fact that perforated muffs retain considerable ability to attenuate noise may be of great importance in certain situations found in the armed services. In instances in which rapid pressure changes and high intensity noise are encountered simultaneously, such equipment is often needed. Although the amount of attenuation provided in the present study varied considerably from subject to subject, this variability may have resulted from uncontrolled factors such as headband tension and alignment of the perforations with the subject's ear canal. The striking agreement between average attenuation loss values for the two types of muffs indicates the possibility of predicting the effects of such venting upon the noise-excluding characteristics.

V. CONCLUSIONS

It may be concluded that it is possible to retain much of the attenuation provided by certain earmuffs (models 372-8A(C) and 10A) even when it is necessary to perforate the muff shells to prevent discomfort during rapid changes in barometric pressure. The loss in attenuation due to perforating the muffs varies from subject to subject, but was singularly similar at most frequencies for the two types of muffs tested. It is recommended that further investigation be carried out to study the effects of various perforation sizes and placement upon other types of ear protectors.

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2. Sommer, H. C. Biological Acoustics Branch, 6570 AMRL, Wright-Patterson AFB, Ohio. Personal communication to Captain W. Mabson, Brooks AFB, Tex., 10 Dec. 1964.

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