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FREQUENCY DEPENDENCE OF IMPULSE NOISE ATTENUATION

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NOTICE

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TABLE OF CONTENTS

	Page No.
Abstract	ii
List of Tables	iv
List of Illustrations	v
Introduction	1
Method and Instrumentation	2
Results and Discussion	3
Conclusions	3
References	9

LIST OF TABLES

Table No.		Page No.
1	Mean and Standard Deviation Values in Decibels of the Real-Ear Attenuation Characteristics of the Roanwell P/N 125/460-640 (C-20) Communication Headset	4

LIST OF ILLUSTRATIONS

Figure No.		Page No.
1	Time History of Wide-Band Impulse	5
2	Time History of Low-Frequency Impulse	6
3	Energy Density Spectrum of Wide-Band Impulse Measured Without Hearing Protector	7
4	Energy Density Spectrum of Low-Frequency Impulse Measured Without Hearing Protector	8

FREQUENCY DEPENDENCE OF IMPULSE NOISE ATTENUATION

INTRODUCTION

Impulse noise, like other types of noises, often reaches such magnitudes that we must ask the question "Is the available hearing protection adequate?" Unfortunately the answer to this question is not simple. The problem lies in a fundamental difference in the characterization of the attenuation of hearing protectors and the characterization of impulse noise used in our commonly accepted damage risk criteria. The prescription of hearing protectors for personnel in hazardous acoustic environments requires a knowledge of spectral characteristics (frequency content) of the noise and knowledge of the real-ear attenuation characteristics of the hearing protectors. The frequency content of the noise may be determined with various types of sound analyzers. The real-ear attenuation characteristics are usually determined by the ANSI Standard Z24.22-1957 method. In accordance with ANSI Standard Z24.22-1957, attenuation is measured at nine frequencies between 125 Hz and 8000 Hz. There is no standard method for combining the nine values into one for describing overall real-ear attenuation. As a result, there is not one value of attenuation, but nine values depending on frequency. Therefore, single values of real-ear attenuation are not valid for accurately calculating the effective attenuation of sound provided by hearing protectors.

The current Army hearing conservation criterion for impulse noise (TB MED 251) is based on the peak pressure as was the CHABA Damage Risk Criterion (1968). The latter criterion also utilized the duration of the initial pulse and a measure of total duration called the "B-duration". Measuring of peak pressure and duration alone do not provide spectral information that would tell us at what frequencies the energy lies. Two impulses may have identical peak pressure values with a distribution of primary energy at totally different frequencies. Without this spectral information we do not know which attenuation value to apply in estimating the peak reduction to be expected from using the hearing protector. As a result, any damage risk criterion specified in terms of a peak pressure and duration does not permit extrapolation based on the attenuation of hearing protectors as determined by the standard (ANSI, 1957) method. In spite of this difficulty, this criterion was translated into the impulse noise limits for Army Materiel (MIL-STD-1474) using nominal attenuation values for single hearing protection (plugs or circumaural protectors) and for double hearing protection (plugs and circumaural protectors) by extrapolating the original CHABA damage risk criterion upward. More recently this process has been reversed (Hodge, et.al., 1976) by using the nominal attenuation values to make statements concerning the hazard from such diverse impulse noise sources as the DRAGON fired from enclosures and the M198/M203 155 mm howitzer. Herein lies a problem. No single value of attenuation can be used indiscriminately to represent the amount of peak reduction to be applied to a variety of impulses. Given the variation of attenuation values across frequencies which all hearing protectors show (Camp 1972), it is intuitively obvious that any protector should attenuate some impulses more than others. This report contains a simple demonstration of this concept. It is intended to demonstrate with measurement obtained using real acoustic impulses and real hearing protectors on real human heads that this variation in amount of attenuation can be so large that significant errors in assessing hazard can result.

METHOD AND INSTRUMENTATION

The time histories and energy density spectra (distribution of energy across frequencies) were obtained at the entrance of the ear canal of a human head. These records were obtained with and without a circumaural hearing protector in place. Two impulses were selected for consideration. One had primarily low frequency energy; the other had energy more widely distributed.

The measurements at the ear canal entrance were made with a miniature electret condenser type microphone with extremely small wires that do not affect the seal of the hearing protector. This transducer is embedded in a disposable earplug (silaflex) seated in the ear canal. The measurements were accomplished in an anechoic chamber which contains an Altec A-7 speaker system. The impulses were generated by delivering electrical transients to the speaker system. These produced acoustic impulses of approximately 120 dB peak pressure at the ear canal. The output of the electret microphone was passed through a General Radio Type 1560-P40 preamplifier and a Brüel and Kjaer Type 2606 measuring amplifier to the Time Data TD 1923-A Time series analyzer. A time history and narrow band analysis of the acoustic impulses at the ear canal (with and without the circumaural protector) were obtained with a Time Data Series Analyzer, (TD 1923-A).

The circumaural hearing protector used was Roanwell model 125-260-640. This protector had been proposed by the developer of the MICV for use by personnel in this vehicle. The attenuation values for this muff obtained with the ANSI Z24.22-1957 method are shown in Table I (Nelson, et. al., 1977).

RESULTS AND DISCUSSION

Figures 1 and 2 contain the time histories of the two impulses used as measured with and without the hearing protector. As can be seen, the low frequency impulse was reduced by only about 6 dB (half peak pressure) while the high frequency impulse was reduced by approximately 23 dB. The energy density spectra shown in Figures 3 and 4 show the different spectral characteristics of these two impulses.

The B-duration of the low frequency is 12 msec, somewhat longer than the high frequency impulse at 3 msec. The CHABA damage risk contour would predict the low frequency pulse to be 3 dB more hazardous than the high frequency pulse at the same peak pressures. However, there is approximately 17 dB difference in the amount of peak reduction afforded by this circumaural hearing protector. This would lead to the prediction that the low frequency pulse is 20 dB more hazardous than the high frequency pulse when the Roanwell circumaural protectors are used. Conversely, if a constant amount of attenuation were used for both impulses a 17 dB error in estimated safe peak exposures could be made.

CONCLUSIONS

No single attenuation value can be used to represent the protection of a hearing protector against all impulse noise. Each combination of protector and impulse must be assessed.

The impulse damage risk criterion should be rewritten to include spectral information to facilitate the assessment of auditory hazard when hearing protectors are used.

TABLE I

Mean and Standard Deviation Values in Decibels of the Real-Ear Attenuation Characteristics of the Roanwell P/N 125-460-640 (C-20) Communication Headset

Test Frequencies in Hertz	Mean Attenuation in Decibels	Standard Deviation in Decibels
75	8.2	2.8
125	5.3	2.2
250	4.8	5.6
500	16.8	5.6
1000	33.0	5.6
2000	21.6	3.9
3000	31.3	5.7
4000	36.7	5.3
6000	34.2	10.2
8000	27.6	7.0

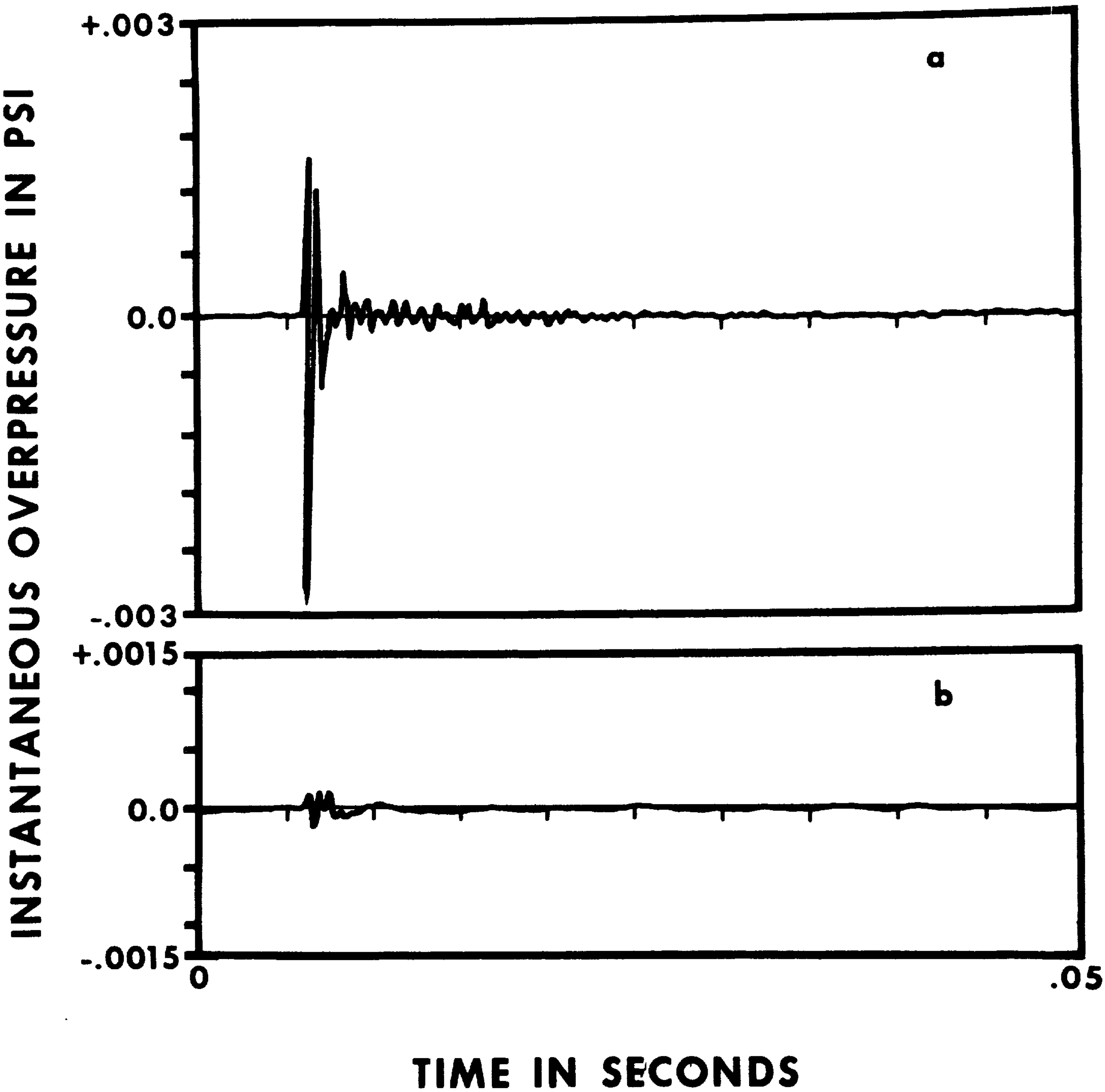

Figure 1 Time history of wide-band impulse,
a: without hearing protector
b: with hearing protector

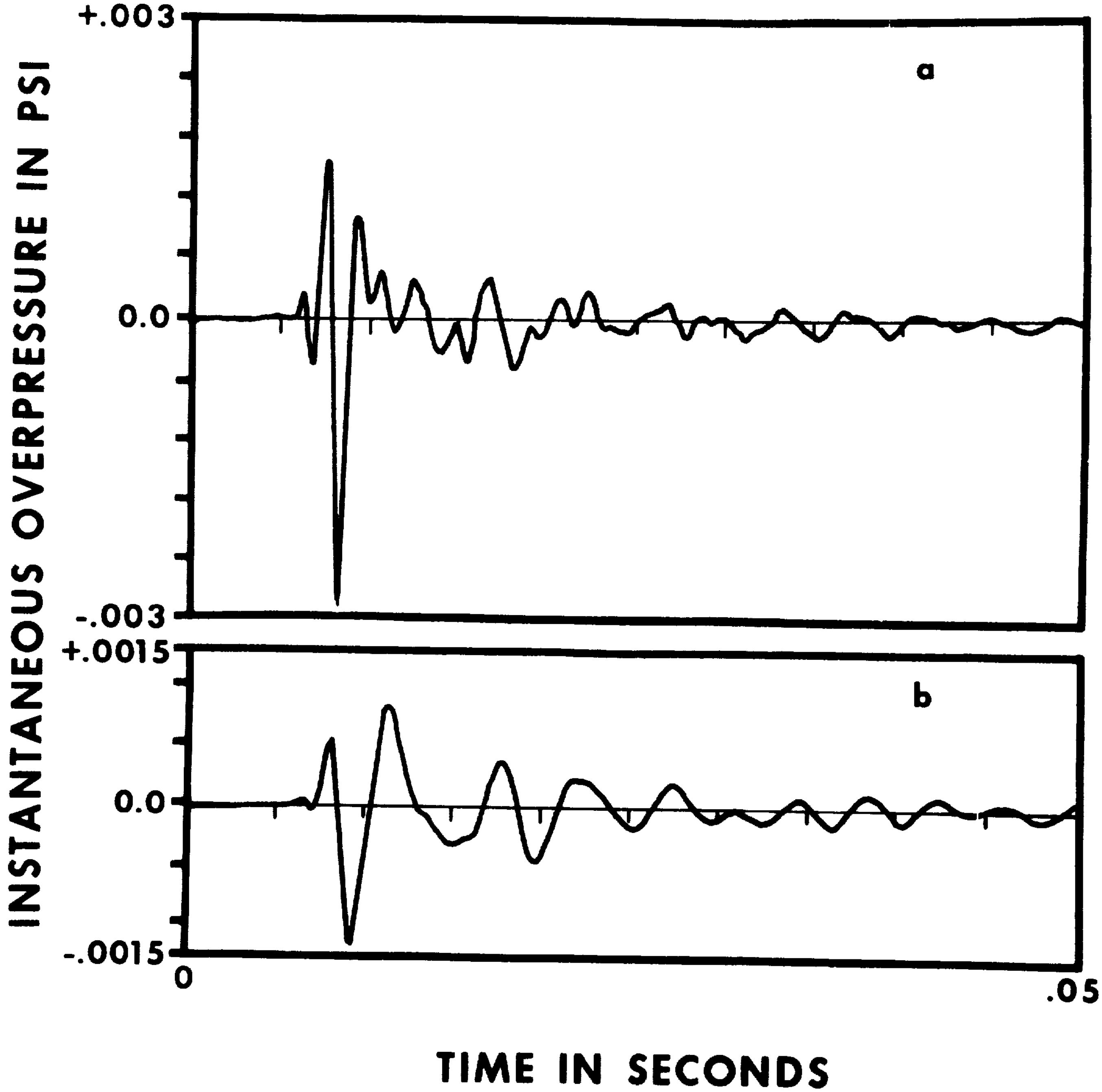

Figure 2 Time history of low-frequency impulse,
a: without hearing protector
b: with hearing protector

Figure 3 Energy density spectrum of wide-band impulse measured without hearing protector

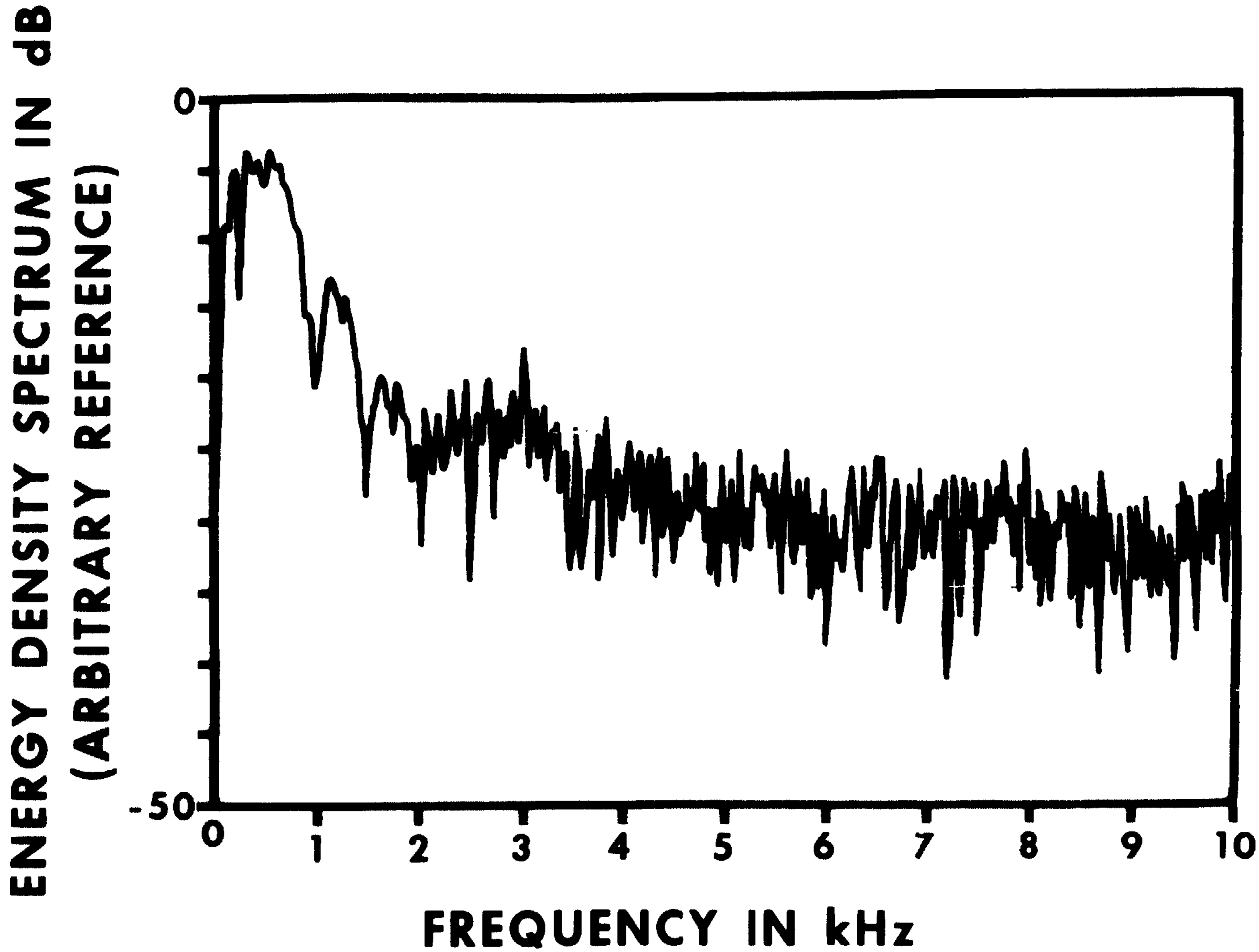

Figure 4 Energy density spectrum of low-frequency impulse measured without hearing protector

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