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PURE-TONE THRESHOLD WITH TDH-49 EARPHONES

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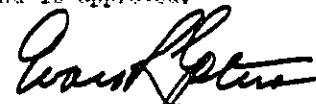
FOREWORD

This study was conducted in the Audiology and Hearing Conservation Function, Otolaryngology Branch, Clinical Sciences Division, under task No. 775508, in 1967. The work was done in response to information that the TDH-49 earphone was expected to supersede the popular TDH-39 type. After all data were collected and analyzed, word was received that the TDH-49 would no longer be manufactured and information about it would be of no value to the Air Force.

It has now been learned that TDH-49 earphones are being used with some commercial audiometers by the Air Force. This report is being published to provide the information necessary to properly calibrate audiometers with TDH-49 earphones. The manuscript was submitted for publication on 27 April 1972.

Richard C. McNee of the Biometrics Division performed the data analysis.

This report has been reviewed and is approved.



EVAN R. GOLTRA, Colonel, USAF, MC
Commander

ABSTRACT

Pure-tone thresholds of 24 normal-hearing listeners were determined at 11 audiometric frequencies on two TDH-49 and two TDH-39 earphones. Thresholds were recorded in decibels of sound pressure level, as measured with a National Bureau of Standards type 9-A earphone coupler. Threshold data were used to compute appropriate calibration values for audiometers with TDH-49 earphones, reference Appendix F of ANSI S3.6-1969.

PURE-TONE THRESHOLD WITH TDH-49 EARPHONES

I. INTRODUCTION

Another earphone type has become available for use with audiometers, the Telephonics model TDH-49.¹ Because it appears to be gaining acceptance and is now being installed on some Air Force-owned audiometers, some appropriate intensity calibration values are needed.

Pure-tone intensity from the earphone of an audiometer is customarily measured by use of an NBS (National Bureau of Standards) type 9-A coupler (1). The measurement is in decibels (dB) of sound pressure level (SPL). Both the American National Standards Institute (ANSI) and the International Organization for Standards (ISO) have recommended a set of values for audiometer calibration (1, 2). These, however, are based on the Western Electric 705-A earphone which has not been manufactured for a number of years. Although the 9-A coupler was intended to simulate the acoustic properties of the human external ear structure, it does not relate subjective human ear thresholds to electroacoustically measured SPL in the same manner for all earphone types. For this reason, separate values must be provided for each make of earphone that is calibrated. Both the ANSI and the ISO recommend techniques for determining appropriate values for earphones other than the WE 705-A. These techniques involve comparing the test earphone with a WE 705-A, with human listeners.

Appendix F of the ANSI S3.6-1969 recommendation suggests values for a variety of earphone types, including the popular TDH-39 earphone, but not for the newer TDH-49. This study determines appropriate calibration values for the TDH-49 earphone.

II. PROCEDURE

Our apparatus is diagrammed in figure 1. The signal from a pure-tone oscillator is pulsed with an electronic switch and routed through an appropriate amplifier and transformer, through a recording attenuator and into an anechoic chamber, then through a 1-dB step attenuator and into whichever earphone is selected. Two TDH-49 and two TDH-39 earphones were used. Frequency response characteristics of the four earphones are displayed in figure 2. A handswitch which controlled the direction of attenuation change was provided so that Bekesy audiometry could be performed.

Subjects were 24 young Air Force basic trainees with hearing levels no poorer than 15 dB re ASA-1951 (3), at pure-tone frequencies 500 through 6000 Hz.

¹All references in this paper to an earphone imply the earphone plus an MX-41/AR ear cushion unless otherwise specified.

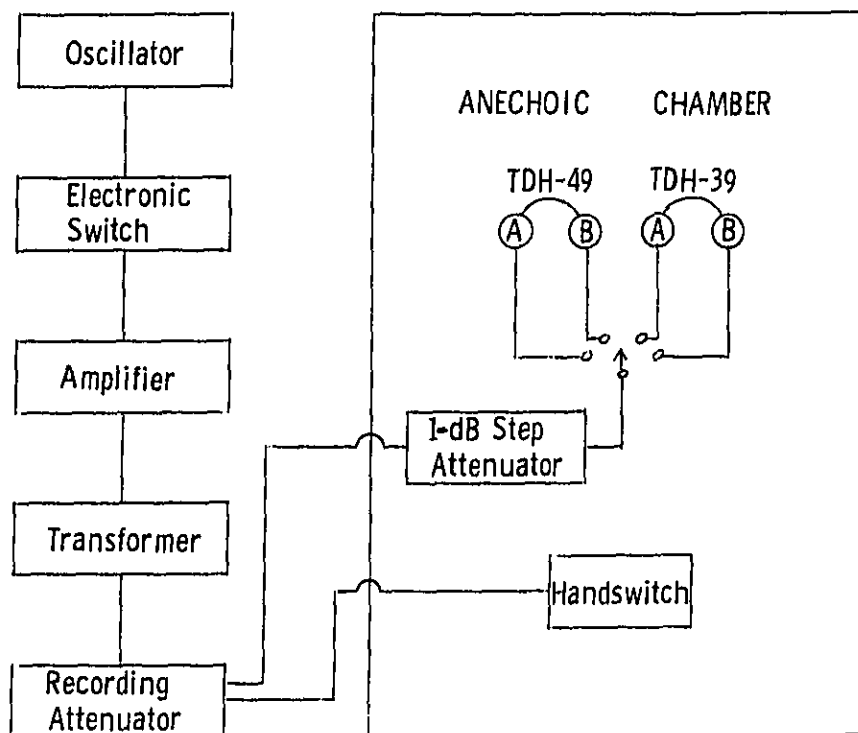


FIGURE 1

Block diagram of test apparatus.

Pure-tone threshold, in decibels SPL, was determined for one ear of each subject at 125, 250, 500, 750, 1000, 1500, 2000, 3000, 4000, 6000, and 8000 Hz with each of the four earphones. Use of right or left ear was alternated. Earphone test order was arranged in a Latin square design (six squares). Threshold was determined with Bekesy-type audiometry, with a minimum of 30 seconds tracing time at each frequency. The order of frequency presentation was always 1000, 1500, 2000, 3000, 4000, 6000, 8000, 750, 500, 250, and 125 Hz.

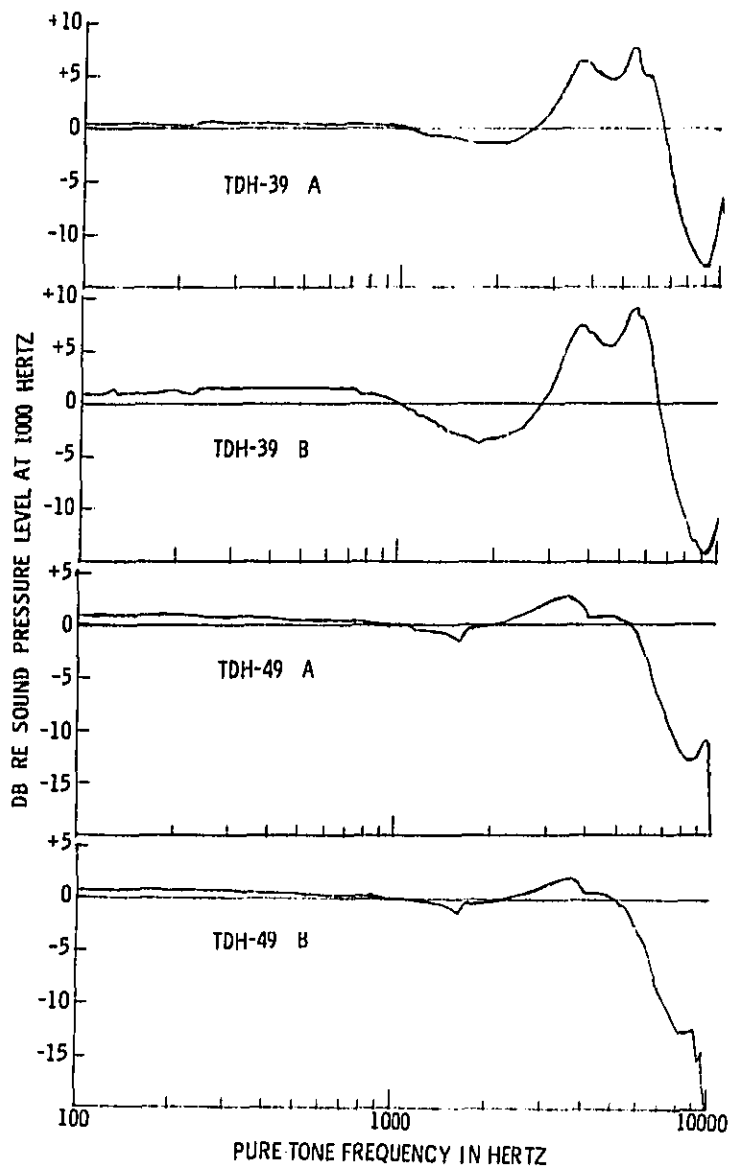


FIGURE 2

Earphone pure-tone frequency response.

Each threshold was the measured sound pressure level with no attenuation in the system, less the attenuation the subject used to reach threshold. Threshold was based on the midpoint of the Bekesy tracings. Sound pressure level at each frequency with no attenuation was measured three times for each of the four earphones. The averages of the three measurements, SPL in a 9-A coupler, are shown in table I. These values were used in computing subjective threshold SPL.

III. RESULTS

Table II shows the computation of recommended sound pressure level at zero hearing level for TDH-49 earphones as measured with a 9-A coupler. Line 1 is the list of sound pressure levels for zero hearing level recommended in Appendix F of ANSI S3.6-1969 for the TDH-39 earphone. Line 2 is the difference between TDH-39 and TDH-49 earphones as determined in this study and as rounded to the nearest 0.5 dB. Line 3 is the recommended SPL for zero hearing level for TDH-49 earphones. The recommended SPL for 750 Hz was obtained by interpolation from a graphic display of SPLs at other pure-tone frequencies.

Average threshold SPLs for the 24 subjects at each pure-tone frequency with each of the four earphones are shown in table III. Differences between the TDH-39 and the TDH-49 earphones were significant at 1500 Hz ($P < .05$), 2000 Hz ($P < .001$), and 6000 Hz ($P < .001$). The order of testing was significant at the .05 level at 250, 500, 750, and 1500 Hz. The average threshold for the first test was the highest for all four of these frequencies. The largest difference between average threshold on the first test order and average threshold for any other test order for these frequencies was 2.46 dB. This occurred at 1500 Hz. The same pattern was present to an insignificant degree at all other frequencies except 6000 Hz and 8000 Hz. These average differences are small in the practical sense, but still indicate a tendency for threshold to improve with practice. They emphasize the need to recognize order as a factor in studies involving pure-tone thresholds.

Stewart and Burgi (4), through a loudness-balance procedure, determined NBS-9-A coupler pressures in decibels of SPL (corresponding to normal threshold reference, ASA 224.5-1951, ref. 3) for three TDH-39 earphones and one TDH-49 earphone. The TDH-39 earphone with an MX-41/AR ear cushion that Stewart and Burgi used appeared considerably different from (1) their standard WE 705-A earphone, (2) the experimental WE 705-A earphone, (3) two TDH-39 earphones with cushions that were not MX-41/ARs, and (4) the TDH-49 earphones with MX-41/AR cushions.

The differences in values they found between the TDH-49 and the TDH-39 earphones are listed in table IV, lines 1, 2, and 3. The differences we found between two TDH-39 and two TDH-49 earphones are given on line 4 of the same table. Excellent agreement is seen between lines 1 and 4, with the greatest discrepancy, 1.5 dB, at 8000 Hz. Reasonably good agreement is present between lines 2 and 4, but lines 3 and 4 differ substantially.

TABLE I

Sound pressure level (in dB) in 9-A coupler with no attenuation,
average of three measurements

Earphone	Frequency (Hz)										
	125	250	500	750	1000	1500	2000	3000	4000	6000	8000
TDH-39 A	75.93	75.96	75.80	75.66	75.30	74.36	74.16	79.03	81.30	81.20	64.16
B	77.13	77.30	77.50	77.13	75.76	73.10	73.13	79.13	82.73	82.33	64.66
TDH-49 A	77.26	77.00	76.96	76.63	76.33	75.30	76.90	79.43	77.93	74.00	64.20
B	76.90	76.83	76.70	76.93	76.63	75.76	76.46	78.60	77.56	73.53	64.13

TABLE II

Computation of appropriate SPL (in dB) at zero hearing level for TDH-49 earphones

Earphone	Frequency (Hz)										
	125	250	500	750	1000	1500	2000	3000	4000	6000	8000
1. TDH-39	45.0	25.5	11.5		7.0	6.5	9.0	10.0	9.5	15.5	13.0
2. Difference	0	0	+0.5	0	0	+1.0	+2.0	0	0	-4.5	+0.5
3. TDH-49	45.0	25.5	12.0	8.5*	7.0	7.5	11.0	10.0	9.5	11.0	13.5

*Interpolated.

Note: Line 1 = Sound pressure level (SPL) corresponding to zero hearing level for TDH-39 earphones as recommended in Appendix F of ANSI S3.6-1969.

Line 2 = Difference in decibels between TDH-39 and TDH-49 earphones at the same hearing level, measured in a 9-A coupler, as determined in this study.

Line 3 = Recommended SPL for zero hearing level for TDH-49 earphones.

TABLE III

Average threshold SPL (in dB) for 24 listeners with each of four earphones

Earphone	Frequencies (Hz)										
	125	250	500	750	1000	1500	2000	3000	4000	6000	8000
TDH-39 A	45.27	24.58	12.26	8.49	7.84	4.57	6.37	11.83	10.88	20.57	12.78
B	46.56	23.92	12.08	8.47	7.84	4.47	5.77	11.52	11.66	19.30	11.24
Average	45.91	24.25	12.17	8.48	7.84	4.52	6.07	11.67	11.27	19.93	12.01
TDH-49 A	46.13	24.63	12.71	8.52	8.17	5.22	8.11	11.48	11.07	15.92	13.53
B	45.98	24.01	12.49	8.40	7.77	5.92	7.83	11.52	11.35	14.96	11.43
Average	46.05	24.32	12.60	8.46	7.97	5.57	7.97	11.50	11.21	15.44	12.48
TDH-49 minus TDH-39	+0.14	+0.07	+0.43	-0.02	+0.13	+1.05	+1.90	-0.17	-0.06	-4.49	+0.47

TABLE IV

Difference in dB SPL, measured in a type 9-A coupler, between TDH-39 and TDH-49 earphones at the same hearing level. (Negative means higher coupler SPL for the TDH-39 earphone)

Earphone	Frequency (Hz)							
	250	500	1000	2000	3000	4000	6000	8000
1. TDH-39 Not MX-41/AR	1.2	0.4	0.3	1.0	-0.1	1.0	-3.8	2.0
2. TDH-39 Not MX-41/AR	3.7	2.0	0.5	3.8	3.5	-0.8	-5.3	-4.0
3. TDH-39 MX-41/AR	-5.7	-4.6	-5.3	-4.0	-7.2	3.5	-2.6	-6.5
4. TDH-39 USAFSAM	0.1	0.4	0.1	1.9	-0.2	-0.1	-4.5	0.5

Note: Lines 1, 2, and 3 are computations from data reported by Stewart and Burgi (4).

It is recommended that audiometers assembled with the TDH-49 earphones be calibrated to correspond to the SPL given in line 3 of table II. It is important to note that this recommendation is based on tests in which only two TDH-49 earphones were compared with only two TDH-39 earphones. The two TDH-39 earphones chosen for this study performed very much alike, with average threshold differences not exceeding 1.54 dB (at 8000 Hz, table III). The two TDH-49 earphones also showed their greatest difference, 2.1 dB, at 8000 Hz. However, the two TDH-39 earphones with other than MX-41/AR ear cushions, as reported by Stewart and Burgi (4), were different by 2.5 dB at 250 Hz, by 2.8 dB at 2000 Hz, by 3.6 dB at 3000 Hz, and by 6.0 dB at 8000 Hz. Their TDH-39 earphone with an MX-41/AR cushion was even more different (table IV). Various studies of this type will possibly yield somewhat differing answers, but the need exists, nevertheless, for a specific standard for Air Force use as suggested in this paper.

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