

DD 45 earphone

Recommended RadioEar calibration values

Introduction

RadioEar has recently introduced the DD 45 earphone as its preferred supra-aural audiometric earphone to be used by different manufactures of audiometric equipment. Standardized calibration values are not yet available for this earphone, but adequate reference calibration values have been established by two accredited laboratories:

1. DTU, Department of Electrical Engineering, Hearing Systems and Communication, Technical University of Denmark, Lyngby, Denmark.
2. PTB, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

The calibration values for the DD 45 are published in a series of reports and journal articles, and the data are obtained in accordance with the guidelines and recommendations described in ISO 389-9:2009. The publications give all the necessary information both regarding the psycho-acoustic methods and the mechanical (e.g. ear cushion, headband, application force etc.), technical, and acoustical details. This information will therefore not be summarized here.

Data from the two laboratories provide *reference threshold values for pure tones* and *free-field correction values* for the DD 45 coupled to two different artificial ears:

- IEC 60318-1:1998 (3-chamber artificial ear or *ear simulator*)
- IEC 60318-3:1998 (6cc coupler, NBS 9A or *acoustic coupler*)

In order to arrive at a common set of calibration values the results from the two laboratories are averaged by giving equal weight to the two sets of values.

DD 45 - pure tone calibration.

In the reports from DTU and PTB, the pure tone calibration values are rounded to the nearest 0.5 dB, but for the present calculations the exact values are used, as shown in Table 1 and 2. The pure tone data are only measured at specific frequencies, and therefore, the values at intermediate frequencies are calculated by linear interpolation of the measured mean values (in dB) referring to a logarithmic frequency axis. Because measured values at 5000 Hz are only available from PTB, the corresponding values from DTU are found by interpolation prior to averaging. In Table 1 and 2, the interpolated values are indicated by underlined numbers, and finally, the averaged and interpolated values are rounded to the nearest 0.5 dB.

DD45 - IEC 60318-1 ear simulator						
Pure Tone Frequency [Hz]	ISO 389-1 Table 2 RETSPL [dB SPL]	DTU RETSPL [dB SPL]	PTB RETSPL [dB SPL]	avg. and interpol. RETSPL [dB SPL]	DD45 RETSPL [dB SPL]	Difference DD45 - (ISO 389-1) [dB SPL]
125	45.0	45.2	45.9	45.6	45.5	0.5
160	38.5			39.2	39.0	0.5
200	32.5			33.5	33.5	1.0
250	27.0	26.7	28.9	27.8	28.0	1.0
315	22.0			23.2	23.0	1.0
400	17.0			18.4	18.5	1.5
500	13.5	14.1	13.9	14.0	14.0	0.5
630	10.5			10.2	10.0	-0.5
750	9.0	7.5	7.3	7.4	7.5	-1.5
800	8.5			7.3	7.5	-1.0
1000	7.5	6.9	6.6	6.8	7.0	-0.5
1250	7.5			7.9	8.0	0.5
1500	7.5	9.0	8.7	8.9	9.0	1.5
1600	8.0			9.0	9.0	1.0
2000	9.0	9.9	8.9	9.4	9.5	0.5
2500	10.5			10.4	10.5	0.0
3000	11.5	11.7	10.7	11.2	11.0	-0.5
3150	11.5			11.4	11.5	0.0
4000	12.0	14.9	10.0	12.5	12.5	0.5
5000	11.0	18.0	8.0	13.0	13.0	2.0
6000	16.0	20.5	16.5	18.5	18.5	2.5
6300	21.0			18.2	18.0	-3.0
8000	15.5	16.7	17.0	16.9	17.0	1.5

Table 1. Pure tone calibration values for DD 45 in the ear simulator

DD45 - IEC 60318-3 (NBS 9A) acoustic coupler						
Pure Tone Frequency [Hz]	ISO 389-1 Table 1 RETSPL [dB SPL]	DTU RETSPL [dB SPL]	PTB ETSPS [dB SPL]	avg. and interpol. RETSPL [dB SPL]	WDH RETSPL [dB SPL]	Difference WDH - (ISO 389-1) [dB SPL]
125	45.0	47.2	47.8	47.5	47.5	2.5
160	37.5			40.3	40.5	3.0
200	31.5			33.7	33.5	2.0
250	25.5	26.3	28.1	27.2	27.0	1.5
315	20.0			22.4	22.5	2.5
400	15.0			17.5	17.5	2.5
500	11.5	13.0	12.8	12.9	13.0	1.5
630	8.5			9.2	9.0	0.5
750	7.5	6.5	6.3	6.4	6.5	-1.0
800	7.0			6.3	6.5	-0.5
1000	7.0	5.8	5.8	5.8	6.0	-1.0
1250	6.5			6.9	7.0	0.5
1500	6.5	8.1	7.6	7.9	8.0	1.5
1600	7.0			7.9	8.0	1.0
2000	9.0	8.7	7.5	8.1	8.0	-1.0
2500	9.5			7.9	8.0	-1.5
3000	10.0	7.5	8.0	7.8	8.0	-2.0
3150	10.0			7.9	8.0	-2.0
4000	9.5	10.4	7.1	8.8	9.0	-0.5
5000	13.0	16.3	9.9	13.1	13.0	0.0
6000	15.5	21.2	19.9	20.6	20.5	5.0
6300	15.0			19.1	19.0	4.0
8000	13.0	12.5	11.2	11.9	12.0	-1.0

Table 2. Pure tone calibration values for DD 45 in the acoustic coupler (NBS 9A)

Recommendation

- (1) Ear simulator: The DD 45 earphone comply with the physical/mechanical characteristics listed in ISO 389-1:1998 (part 4.3: Other supra-aural earphones), and the combined RETSPL-values from DTU and PTB (DD45 RETSPL in Table 1) deviate only marginally from the values in ISO 389-1:1998 (Table 2). RadioEar recommends therefore, that the standardized RETSPL-values in ISO 389-1:1998 (Table 2) are used for the pure tone calibration of DD 45 in the ear simulator. The values are shown in 'bold' in Table 1.
- (2) Acoustic coupler (NBS 9A): RadioEar recommends that the combined RETSPL-values from DTU and PTB (RadioEar RETSPL in Table 2) are used for the pure tone calibration of DD 45 in the acoustic coupler (NBS 9A). The values are shown in 'bold' in Table 2.

DD 45 - free-field correction values.

The free-field correction values are obtained by means of loudness balance measurements of one-third octave noise bands presented alternatively in the free-field and from the DD 45 earphones. The CCITT speech shaped noise correction values are finally calculated. All the averaged values are rounded to the nearest 0.5 dB.

DD45 - IEC 60318-1 ear simulator				
NB noise	DTU	PTB	Average	WDH
Frequency	FF corr	FF corr	FF corr	FF corr
[Hz]	[dB]	[dB]	[dB]	[dB]
125	-19.4	-19.3	-19.4	-19.5
160	-14.9	-17.3	-16.1	-16.0
200	-11.5	-15.6	-13.6	-13.5
250	-10.3	-13.9	-12.1	-12.0
315	-8.1	-11.4	-9.8	-10.0
400	-6.6	-8.9	-7.8	-8.0
500	-8.5	-7.1	-7.8	-8.0
630	-8.6	-6.0	-7.3	-7.5
800	-4.4	-4.9	-4.7	-4.5
1000	-4.8	-3.9	-4.4	-4.5
1250	-5.2	-3.1	-4.2	-4.0
1600	-7.3	-10.2	-8.8	-9.0
2000	-8.1	-8.0	-8.1	-8.0
2500	-9.2	-11.1	-10.2	-10.0
3150	-13.5	-16.5	-15.0	-15.0
4000	-9.6	-13.6	-11.6	-11.5
5000	-6.6	-6.9	-6.8	-7.0
6300	-9.8	-13.9	-11.9	-12.0
8000	-12.5	-8.0	-10.3	-10.5
CCITT speech noise (Westra CD - track 32)				8.0

Table 3. Free-field correction values for DD 45 in the ear simulator

DD45 - IEC 60318-3 (NBS 9A) acoustic coupler				
NB noise	DTU	PTB	Mean	WDH
Frequency	FF corr	FF corr	FF corr	FF corr
[Hz]	[dB]	[dB]	[dB]	[dB]
125	-21.8	-21.2	-21.5	-21.5
160	-16.9	-18.4	-17.7	-17.5
200	-13.0	-15.8	-14.4	-14.5
250	-10.5	-13.3	-11.9	-12.0
315	-8.3	-10.5	-9.4	-9.5
400	-5.8	-7.7	-6.8	-7.0
500	-7.9	-6.0	-7.0	-7.0
630	-8.0	-5.1	-6.6	-6.5
800	-3.8	-4.1	-4.0	-4.0
1000	-4.1	-3.2	-3.7	-3.5
1250	-4.7	-2.3	-3.5	-3.5
1600	-6.8	-7.3	-7.1	-7.0
2000	-7.2	-6.7	-7.0	-7.0
2500	-8.4	-10.3	-9.4	-9.5
3150	-10.3	-13.2	-11.8	-12.0
4000	-6.1	-10.2	-8.2	-8.0
5000	-6.7	-10.5	-8.6	-8.5
6300	-5.3	-12.3	-8.8	-9.0
8000	-2.0	-0.5	-1.3	-1.5
CCITT speech noise (Westra CD - track 32)				7.5

Table 4. Free-field correction values for DD 45 in the acoustic coupler (NBS 9A)

Recommendation

- (1) Ear simulator: RadioEar recommends that the combined free-field correction values from DTU and PTB (RadioEar FF corr in Table 3) are used for speech level calibration of the DD 45 in the ear simulator. The values are shown in 'bold' in Table 3.
- (2) Acoustic coupler (NBS 9A): RadioEar recommends that the combined free-field correction values from DTU and PTB (RadioEar FF corr in Table 4) are used for speech level calibration of the DD 45 in the acoustic coupler. The values are shown in 'bold' in Table 4.

References

1. DTU-report (2010). Poulsen, T. "Equivalent threshold sound pressure levels (ETSPL) for Interacoustics DD 45 supra-aural audiometric earphones," Int. J. Aud. 49, 11, 850-855.
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3. IEC 60318-1 (1998). "Electroacoustics - Simulators of human head and ear - Part 1: Ear simulator for the calibration of supra-aural earphones," International Electrotechnical Commission, Geneva, Switzerland.

4. IEC 60318-3 (**1998**). "Electroacoustics - Simulators of human head and ear - Part 3: Acoustic coupler for the calibration of supra-aural earphones used in audiometry," International Electrotechnical Commission, Geneva, Switzerland.
5. ISO 389-1 (**1998**). "Acoustics - Reference zero for the calibration of audiometric equipment. - Part 1: Reference equivalent threshold sound pressure levels for pure tones and supra-aural earphones," International Organization for Standardization, Geneva, Switzerland.
6. ISO 389-9 (**2009**). "Acoustics - Reference zero for the calibration of audiometric equipment. - Part 9: Preferred test conditions for the determination of reference hearing threshold levels," International Organization for Standardization, Geneva, Switzerland.
7. PTB-report (**2009**): "Determination of reference equivalent threshold sound pressure levels for pure tones of an audiometric headphone," Physikalisch-Technische Bundesanstalt, Braunschweig, Germany, Ref. no: 1.61 – 4039503/09.
8. PTB-report (**2010**): "Determination of the difference between free-field sensitivity level and coupler sensitivity level for an audiometric headphone," Physikalisch-Technische Bundesanstalt, Braunschweig, Germany, Ref. no: 1.61 – 4044361/09.