A Comparative Analysis of Attenuation and Maximum Permissible Ambient Noise Levels for Audiometric Headsets

Authors: Dr HL (Dirk) Koekemoer
Affiliation: GeoAxon
Keywords: MPANL, Maximum Permissible Ambient Noise Levels, audiometry, boothless audiometry, hearing assessment, acoustic standards, ANSI S3.1, sound attenuation, insert earphones, supra-aural earphones, circumaural earphones, audiometric headsets, hearing testing.
Date of Original Publication: June 08, 2025
Date of Revision/Expansion: N/A
Version: 1.0 (Original publication)
Competing Interests Statement: Dr. HL (Dirk) Koekemoer has a competing interest to declare. He is a consultant for GeoAxon, the manufacturer of the Kuduwave audiometer. This work was also supported by funding from GeoAxon, as noted in the Funding Statement. The author has strived to provide an objective, evidence-based analysis.
Funding Statement: This work was supported by GeoAxon.

Abstract

The accuracy of audiometric testing is fundamentally reliant on controlling ambient noise to prevent the masking of test stimuli. Various audiometric transducers, including supra-aural, circumaural, and insert earphones, as well as integrated headset systems, offer differing levels of passive sound attenuation. This white paper evaluates a range of commonly used audiometric headsets, determining their sound attenuation characteristics and calculating their specific Maximum Permissible Ambient Noise Levels (MPANLs) in accordance with ANSI S3.1-1999 (R2013) [1], or presenting published MPANLs where available. MPANLs are provided for testing to 0 dB HL. The objective is to identify transducers providing superior attenuation, thereby allowing for reliable audiometry in environments with higher ambient noise. A comprehensive table summarizes the 0 dB HL MPANLs for all evaluated headsets, highlighting the best-performing transducer at each standard audiometric frequency.

Executive Summary

This white paper provides a comparative analysis of sound attenuation and derived or published Maximum Permissible Ambient Noise Levels (MPANLs) for a variety of audiometric headsets used in clinical and research settings. Accurate audiometry requires that ambient noise in the test environment does not interfere with the perception of test tones. The ANSI S3.1-1999 (R2013) standard provides baseline "ears not covered" MPANLs, to which a transducer's specific attenuation can be added to determine its operational MPANLs if published values are not available.[1]

This report details the attenuation data and MPANLs for headsets including the RadioEar DD45, Telephonics TDH-39, RadioEar DD65v2, Sennheiser HDA 200, Sennheiser HDA 300, Sennheiser HD 280 PRO, E-A-RTONE 3A/5A insert earphones, RadioEar IP30 insert earphones, Amplivox Audiocups with TDH-39, GeoAxon Kuduwave, and WAHTS. For each, MPANLs are provided for testing hearing thresholds down to 0 dB HL. For the Kuduwave [2] and WAHTS [3] systems, published MPANLs are presented directly.

The findings indicate significant variability in attenuation performance across different transducer types and models. Generally, insert earphones and specialized integrated systems like the Kuduwave and WAHTS demonstrate higher attenuation, particularly at low frequencies, compared to traditional supra-aural or some circumaural headphones. This allows them to be used in environments with considerably higher ambient noise levels while maintaining test accuracy. A summary table directly compares the 0 dB HL MPANLs for all transducers, identifying those with the highest attenuation at each standard audiometric frequency. This information is critical for selecting appropriate equipment based on the acoustic conditions of the testing environment.

1. Introduction

The validity of audiometric assessments hinges on the precise control of the acoustic environment. Ambient noise, if unmanaged, can mask test stimuli, leading to inaccurate hearing thresholds and potentially erroneous clinical decisions.[1] Traditionally, sound-treated booths have been the standard for mitigating ambient noise. However, these booths can be costly, immobile, and not always accessible, particularly in field settings or resource-limited environments.[2]

The effectiveness of an audiometric transducer in noisy environments is determined by its ability to attenuate, or reduce, the level of ambient sound reaching the patient's ear. Higher attenuation allows for testing in noisier conditions without compromising results. Maximum Permissible Ambient Noise Levels (MPANLs) quantify the highest allowable sound pressure levels of ambient noise in a test room that will not significantly elevate hearing thresholds. Standards such as ANSI S3.1-1999 (R2013) provide methodologies for determining these levels.[1]

This white paper aims to:

- Compile or estimate the sound attenuation characteristics for a range of audiometric headsets.
- Calculate the MPANLs for these headsets based on ANSI S3.1-1999 (R2013) for testing at 0 dB HL, or present published MPANLs where available.[1]
- Present a comparative table of these MPANLs to identify headsets offering the greatest attenuation at various audiometric frequencies.

2. Methodology for MPANL Calculation

Where published MPANLs for a specific headset are not available, the calculation of headset-specific MPANLs relies on combining the baseline MPANLs for "ears not covered" conditions, as specified by ANSI S3.1-1999 (R2013), with the measured sound attenuation provided by the specific transducer.[1]

The fundamental formula for calculating the MPANL for testing to a 0 dB HL threshold is:

$$MPANL_{Headset\_0dBHL}(dB\ SPL) = MPANL_{ANSI\_EarsNotCovered\_0dBHL}(dB\ SPL) + Attenuation_{Headset}(dB)$$

Where:

- $MPANL_{Headset\_0dBHL}$ is the maximum permissible ambient sound pressure level for the specific headset when testing to 0 dB HL.
- $MPANL_{ANSI\_EarsNotCovered\_0dBHL}$ is the octave-band MPANL specified by ANSI S3.1-1999 (R2013) for the "ears not covered" condition for testing to 0 dB HL. These values are presented in Table 1.[1]
- $Attenuation_{Headset}$ is the mean sound attenuation provided by the headset at the corresponding octave-band frequency.[1]

Table 1: ANSI S3.1-1999 (R2013) Baseline MPANLs (Ears Not Covered, Octave Bands, 0 dB HL)
(Source: ANSI S3.1-1999, Table 3 1)

Frequency (Hz)	MPANL (dB SPL)
125	29.0
250	21.0
500	16.0
1000	13.0
2000	14.0
4000	11.0
8000	14.0

For headsets with published MPANLs (e.g., GeoAxon Kuduwave), those values are presented directly.[2]

3. Audiometric Transducer Attenuation Characteristics and MPANLs

This section details the attenuation data (where used for calculation) and calculated or published MPANLs for various audiometric transducers for testing to 0 dB HL. Where MPANLs are calculated, the tables show the ANSI S3.1-1999 (R2013) baseline MPANL for 'ears not covered', the specific headset attenuation, and the resulting calculated MPANL for the headset.[1] Where octave-band attenuation data was not directly available from manufacturer datasheets for calculation, values were estimated from published studies or graphical data, with such instances clearly noted.

3.1 Supra-aural Earphones

3.1.1 RadioEar DD45

The RadioEar DD45 is a commonly used supra-aural audiometric earphone. Attenuation data is estimated.

- **Calculated MPANLs (dB SPL) for DD45 (Estimated):**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB) (Estimated)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	10	39.0
250	21.0	15	36.0
500	16.0	25	41.0
1000	13.0	30	43.0
2000	14.0	30	44.0
4000	11.0	35	46.0
8000	14.0	35	49.0

(Attenuation values for DD45 are estimated based on commonly accepted figures as a specific datasheet with octave band attenuation was not available in the provided materials.)

3.1.2 Telephonics TDH-39 (with MX-41/AR cushions)

The TDH-39 with MX-41/AR cushions is a classic supra-aural earphone.

- **Calculated MPANLs (dB SPL) for TDH-39 (MX-41/AR):**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	11.5	40.5
250	21.0	15.1	36.1
500	16.0	23.4	39.4
1000	13.0	29.8	42.8
2000	14.0	32.5	46.5
4000	11.0	35.8	46.8
8000	14.0	28.5	42.5

(Source for Headset Attenuation: Schrøder et al., 1987, Table I [4])

3.2 Circumaural Earphones

3.2.1 RadioEar DD65v2

The DD65v2 is a circumaural headset designed for audiometry.

- **Calculated MPANLs (dB SPL) for DD65v2:**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	8.3	37.3
250	21.0	15.5	36.5
500	16.0	26.1	42.1
1000	13.0	32.4	45.4
2000	14.0	43.6	57.6
4000	11.0	43.8	54.8
8000	14.0	45.6	59.6

(Source for Headset Attenuation: DD65v2 Datasheet, Table 1 [5])

3.2.2 Sennheiser HDA 200

The HDA 200 is a closed, dynamic circumaural headphone.

- **Calculated MPANLs (dB SPL) for HDA 200:**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	14.3	43.3
250	21.0	15.9	36.9
500	16.0	22.5	38.5
1000	13.0	28.6	41.6
2000	14.0	30.3*	44.3
4000	11.0	45.7	56.7

8000	14.0	43.8	57.8

*(Source for Headset Attenuation: HDA 200 Datasheet.[6] *Attenuation at 2000 Hz interpolated from 1000 Hz (28.6 dB) and 3000 Hz (32.0 dB) values as per datasheet.[6])*

3.2.3 Sennheiser HDA 300

The HDA 300 is another circumaural audiometric headphone from Sennheiser.

- **Calculated MPANLs (dB SPL) for HDA 300:**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	12.4	41.4
250	21.0	12.7	33.7
500	16.0	9.4	25.4
1000	13.0	12.8	25.8
2000	14.0	15.1	29.1
4000	11.0	28.8	39.8
8000	14.0	26.2	40.2

(Source for Headset Attenuation: HDA 300 Datasheet, ISO 4869-1 [7])

3.2.4 Sennheiser HD 280 PRO

The HD 280 PRO is a popular closed-back circumaural headphone often used for monitoring, with claims of significant noise isolation. Attenuation data is estimated.

- **Calculated MPANLs (dB SPL) for HD 280 PRO (Estimated):**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	10	39.0
250	21.0	10	31.0
500	16.0	15	31.0
1000	13.0	25	38.0

2000	14.0	30	44.0
4000	11.0	30	41.0
8000	14.0	30	44.0

(Source for Headset Attenuation: Estimated from Rtings.com noise isolation graph and manufacturer claims, as datasheet provides a single overall value [8])

3.2.5 Amplivox Audiocups (with Telephonics TDH-39 & MX41/AR cushions)

Amplivox Audiocups are noise-reducing enclosures designed to be fitted with standard earphones like the TDH-39.

- **Calculated MPANLs (dB SPL) for Amplivox Audiocups (TDH-39/MX41AR):**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	9	38.0
250	21.0	13	34.0
500	16.0	24	40.0
1000	13.0	30	43.0
2000	14.0	39	53.0
4000	11.0	44	55.0
8000	14.0	35	49.0

(Source for Headset Attenuation: Amplivox Website [10])

3.3 Insert Earphones

Insert earphones are placed directly into the ear canal, typically offering good attenuation. The attenuation values below are based on ANSI S3.1-1999, Table A.2, "Mean attenuation values for insert earphones, Type ER-3A or equivalent with foam eartip fully inserted." These are considered representative for well-fitted E-A-RTONE 3A/5A and RadioEar IP30.[1]

3.3.1 E-A-RTONE 3A / 5A

- **Calculated MPANLs (dB SPL) for E-A-RTONE 3A/5A:**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL)	Headset Attenuation (ANSI S3.1-1999, Table A.2)	Calculated Headset MPANL (0 dB HL)

	(dB SPL)	(dB)	(dB SPL)
125	29.0	29.3	58.3
250	21.0	32.8	53.8
500	16.0	36.1	52.1
1000	13.0	37.1	50.1
2000	14.0	35.0	49.0
4000	11.0	41.2	52.2
8000	14.0	38.6	52.6

3.3.2 RadioEar IP30

- **Calculated MPANLs (dB SPL) for RadioEar IP30 (assumed similar to ER-3A type):**

Frequency (Hz)	ANSI S3.1 Baseline (Ears Not Covered, 0 dB HL) (dB SPL)	Headset Attenuation (ANSI S3.1-1999, Table A.2) (dB)	Calculated Headset MPANL (0 dB HL) (dB SPL)
125	29.0	29.3	58.3
250	21.0	32.8	53.8
500	16.0	36.1	52.1
1000	13.0	37.1	50.1
2000	14.0	35.0	49.0
4000	11.0	41.2	52.2
8000	14.0	38.6	52.6

3.4 Integrated Headset Systems

3.4.1 GeoAxon Kuduwave

The Kuduwave audiometer features an integrated headset with dual passive attenuation (earcup + eartip). The MPANLs presented below are published values.[2]

- **Published MPANLs (dB SPL) for Kuduwave (Foam Eartips):**

Frequency (Hz)	Published Kuduwave MPANL (0 dB HL) (dB SPL)
125	60.0
250	58.7
500	59.8
1000	53.8
2000	52.1
4000	63.3
8000	59.8

(Source: Koekemoer & Nel, 2025 [2])

- **Published MPANLs (dB SPL) for Kuduwave (Silicone Eartips):**

Frequency (Hz)	Published Kuduwave MPANL (0 dB HL) (dB SPL)
125	38.0
250	31.0
500	46.0
1000	42.7
2000	52.0
4000	55.3
8000	41.0

(Source: Koekemoer & Nel, 2025 [2])

3.4.2 WAHTS (Wireless Automated Hearing Test System)

The WAHTS is a wireless audiometer with large circumaural earcups providing significant attenuation. The MPANLs presented below are published values.[3]

- **Published MPANLs (dB SPL) for WAHTS:**

Frequency	Published WAHTS MPANL (0 dB HL)

(Hz)	(dB SPL)
125	59.5
250	52.7
500	53.6
1000	52.7
2000	48.8
4000	47.1
8000	50.4

(Source: WAHTS Attenuation & MPANLs Validation White Paper [3])

4. Comparative Summary of MPANLs for 0 dB HL Testing

Table 2 provides a summary of the calculated or published MPANLs for 0 dB HL testing based on ANSI S3.1-1999 (R2013) for all evaluated headsets.[1] The table is sorted by the 500 Hz MPANL values in descending order. The highest MPANL value (indicating the most attenuation) at each frequency is marked with an asterisk (*).

Table 2: Comparative MPANLs (dB SPL) for 0 dB HL Testing (ANSI S3.1-1999 Baseline or Published) - Sorted by 500 Hz Descending

Headset	Type	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
GeoAxon Kuduwave (Foam Eartips)	Integrated	**60.0***	**58.7***	**59.8***	**53.8***	52.1	**63.3***	59.8*
WAHTS	Integrated	59.5	52.7	53.6	52.7	48.8	47.1	50.4
E-A-RTONE 3A/5A (Insert)	Insert	58.3	53.8	52.1	50.1	49.0	52.2	52.6
RadioEar IP30 (Insert)	Insert	58.3	53.8	52.1	50.1	49.0	52.2	52.6
GeoAxon Kuduwave (Silicone Eartips)	Integrated	38.0	31.0	46.0	42.7	52.0	55.3	41.0
RadioEar DD65v2	Circumaural	37.3	36.5	42.1	45.4	57.6*	54.8	59.6
RadioEar DD45	Supra-aural	39.0	36.0	41.0	43.0	44.0	46.0	49.0

(Estimated)								
Amplivox Audiocups (TDH-39/MX41AR)	Circumaural	38.0	34.0	40.0	43.0	53.0	55.0	49.0
Telephonics TDH-39 (MX-41/AR)	Supra-aural	40.5	36.1	39.4	42.8	46.5	46.8	42.5
Sennheiser HDA 200 (2kHz interpolated)	Circumaural	43.3	36.9	38.5	41.6	44.3	56.7	57.8
Sennheiser HD 280 PRO (Estimated)	Circumaural	39.0	31.0	31.0	38.0	44.0	41.0	44.0
Sennheiser HDA 300	Circumaural	41.4	33.7	25.4	25.8	29.1	39.8	40.2

**Highest MPANL (most attenuation) for that frequency.*

5. Discussion

The MPANLs, whether calculated or published, reveal considerable differences in the ambient noise levels that various audiometric transducers can tolerate while ensuring accurate threshold measurements to 0 dB HL.

Supra-aural earphones, such as the RadioEar DD45 and Telephonics TDH-39, generally offer modest attenuation, resulting in lower MPANLs. This makes them more susceptible to ambient noise, particularly at lower frequencies where environmental noise is often predominant.

Circumaural earphones exhibit a wide range of attenuation capabilities. The RadioEar DD65v2 shows strong performance, especially at 2000 Hz and 8000 Hz.[5] The Sennheiser HDA 200 also provides good attenuation, particularly at 4000 Hz and 8000 Hz, though the 2000 Hz value was interpolated.[6] The Sennheiser HDA 300, based on its ISO 4869-1 attenuation data, surprisingly shows lower attenuation across several frequencies compared to other circumaural models.[7] The Sennheiser HD 280 PRO, with estimated attenuation values, offers moderate performance.[8] Amplivox Audiocups, when fitted with TDH-39 earphones, improve attenuation over the bare TDH-39, particularly in the mid to high frequencies, demonstrating the benefit of an external enclosure.[10]

Insert earphones, represented here by the E-A-RTONE 3A/5A and RadioEar IP30 (using standardized ANSI S3.1 attenuation data for ER-3A type inserts [1]), consistently provide good attenuation across the frequency spectrum. Their ability to achieve a deep seal in the ear canal contributes to this effectiveness, making them a robust choice for reducing background noise interference.

Integrated headset systems designed for boothless audiometry, such as the GeoAxon Kuduwave and WAHTS, demonstrate some of the highest MPANLs based on their published data.[2] The

Kuduwave with foam eartips, in particular, achieves the highest MPANLs at 125 Hz, 250 Hz, 500 Hz, 1000 Hz, and 4000 Hz.[2] This superior low-frequency attenuation is critical, as low-frequency noise is a common challenge in non-booth environments. The WAHTS system also shows strong attenuation and correspondingly high MPANLs, especially at 125 Hz.[3] The Kuduwave with silicone eartips offers less attenuation than with foam tips but still performs comparably to or better than many circumaural headphones, especially at 2000 Hz and 4000 Hz.[2]

The choice of eartip for systems like the Kuduwave significantly impacts attenuation; foam eartips consistently outperform silicone eartips, especially at lower frequencies.[2] This underscores the importance of proper eartip selection and fit to maximize the noise-reducing capabilities of such systems.

6. Conclusion

This white paper has demonstrated that the choice of audiometric transducer significantly impacts the level of ambient noise that can be tolerated during hearing testing to 0 dB HL. Based on calculated or published MPANLs:

- **GeoAxon Kuduwave with Foam Eartips** provides the highest MPANLs (best attenuation) at 125 Hz (60.0 dB SPL), 250 Hz (58.7 dB SPL), 500 Hz (59.8 dB SPL), 1000 Hz (53.8 dB SPL), and 4000 Hz (63.3 dB SPL). It also shares the highest MPANL at 8000 Hz (59.8 dB SPL).[2]
- **RadioEar DD65v2** provides the highest MPANL at 2000 Hz (57.6 dB SPL) and shares the highest MPANL at 8000 Hz (59.6 dB SPL, very close to Kuduwave Foam).[5]
- **WAHTS** also offers excellent attenuation, particularly at low frequencies (e.g., 125 Hz MPANL of 59.5 dB SPL).[3]
- **Insert earphones (E-A-RTONE 3A/5A, RadioEar IP30)** generally provide robust attenuation across all frequencies, consistently yielding high MPANLs compared to supra-aural and many circumaural headphones.[1]

For audiometry outside of a sound-treated booth, transducers with high attenuation, especially at low frequencies, are crucial. The integrated systems (Kuduwave with foam eartips, WAHTS) and insert earphones generally offer the best performance in this regard. Clinicians and researchers must consider the specific noise environment of their testing location and select transducers that provide adequate MPANLs to ensure valid and reliable audiometric results.

7. References

1. American National Standards Institute. (1999). *ANSI S3.1-1999 (R2013) American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms*. Acoustical Society of America.
2. Schrøder, A. C., Clausen, K. T., & Parving, A. (1987). Sound attenuation of TDH-39 earphones in a diffuse field of narrow-band noise. *Scandinavian Audiology, 16*(3), 153-157. (URL:(https://www.researchgate.net/publication/19218284_Sound_attenuation_of_TDH-39_earphones_in_a_diffuse_field_of_narrow-band_noise))
3. RadioEar. (n.d.). *DD65v2 Datasheet*. Retrieved from

(https://dmadminpanelstrapiprod04.blob.core.windows.net/strapi-uploads/assets/Radio_Ear_DD_65_V2_Datasheet_b1d6369683.pdf)

4. Sennheiser. (n.d.). *HDA 200 Datasheet*. Retrieved from (https://assets.sennheiser.com/global-downloads/file/720/HDA200_bda.pdf)
5. Sennheiser. (n.d.). *HDA 300 Instruction manual*. (Passive attenuation values according to ISO 4869-1:1994 / EN 24869-1:1993). Retrieved from (https://assets.sennheiser.com/downloads/download/file/4791/HDA300_545391_0913_EN.pdf)
6. Rtings.com. (n.d.). *Sennheiser HD 280 PRO 2018 Headphones Review*. Retrieved from https://www.rtings.com/headphones/reviews/sennheiser/hd-280-pro-2018
7. Sennheiser. (n.d.). *HD 280 Pro Product Page*. Retrieved from Sweetwater (https://www.sweetwater.com/store/detail/HD280Pro--sennheiser-hd-280-pro-closed-back-studio-and-live-monitoring-headphones) and CCI Solutions (https://shop.ccisolutions.com/StoreFront/product/sennheiser-hd280pro)
8. Amplivox. (n.d.). *Audiocups*. Retrieved from https://www.amplivox.com/products/audiometry/audiocups
9. GeoAxon. (2025). *Establishing Maximum Permissible Ambient Noise Levels for the Kuduwave Audiometer: A Guide for Clinical, Research, and Proposed Unified Global Applications*. (White Paper). GeoAxon. (User-provided document URL: https://geoaxon.com/establishing-maximum-permissible-ambient-noise-levels-for-the-kuduwave-audiometer-a-guide-for-clinical-research-and-proposed-unified-global-applications/)
10. PureToneDx. (n.d.). *WAHTS Attenuation, MPANLs, & Validation*. (White Paper). Retrieved from (https://puretonedx.com/wp-content/uploads/2024/12/MKT-006-WAHTS-Attenuation-MPANLs-Validation-1.pdf)

Works cited

1. Establishing Maximum Permissible Ambient Noise Levels for the Kuduwave Audiometer_ A Guide for Clinical, Research, and Proposed Unified Global Applications.pdf
2. Sennheiser (HD 280 PRO) Headphones - Professional - CCI Solutions, accessed on June 8, 2025, https://shop.ccisolutions.com/StoreFront/product/sennheiser-hd280pro
3. Audiocups | Noise-reducing enclosures | Amplivox, accessed on June 8, 2025, https://www.amplivox.com/products/audiometry/audiocups
4. (PDF) Sound attenuation of TDH-39 earphones in a diffuse field of ..., accessed on June 8, 2025, https://www.researchgate.net/publication/19218284_Sound_attenuation_of_TDH-39_earphones_in_a_diffuse_field_of_narrow-band_noise
5. DT 48 A.00 - Gear4music, accessed on June 8, 2025, https://r2.gear4music.com/media/4/43913/download_43913.pdf
6. Beyerdynamic DT48E - Stereo Headphones - 25 Ohms - B&H Photo, accessed on June 8, 2025, https://www.bhphotovideo.com/c/product/272007-REG/Beyerdynamic_404306_DT48E_Stereo_Headphones.html

7. DD65v2 - NET, accessed on June 8, 2025, https://dmadminpanelstrapiprod04.blob.core.windows.net/strapi-uploads/assets/Radio_Ear_DD_65_V2_Datasheet_b1d6369683.pdf
8. HDA 200 Audiometric Headphone - Sennheiser, accessed on June 8, 2025, https://assets.sennheiser.com/global-downloads/file/720/HDA200_bda.pdf
9. HDA 300 - Sennheiser, accessed on June 8, 2025, https://assets.sennheiser.com/downloads/download/file/4791/HDA300_545391_0913_EN.pdf
10. Sennheiser HD 280 Pro Closed-back Studio and Live Monitoring Headphones - Sweetwater, accessed on June 8, 2025, https://www.sweetwater.com/store/detail/HD280Pro--sennheiser-hd-280-pro-closed-back-studio-and-live-monitoring-headphones