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BSI Standards Publication

Sound system equipment: headphones and earphones associated with personal music players — maximum sound pressure level measurement methodology

Part 3: measurement method for sound dose management

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National foreword

This British Standard is the UK implementation of EN 50332-3:2017.

The UK participation in its preparation was entrusted to Technical Committee EPL/108, Safety of electronic equipment within the field of audio/video, information technology and communication technology.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Sound system equipment: headphones and earphones associated with personal music players - maximum sound pressure level measurement methodology - Part 3: measurement method for sound dose management

Équipements de diffusion sonore: casques et écouteurs associés avec un lecteur de musique individuel - Méthode de mesure de niveau maximal de pression acoustique - Partie 3: Méthode de mesure pour la gestion de la dose de bruit

Elektroakustische Geräte: Kopfhörer und Ohrhörer in Verbindung mit tragbaren Audiogeräten - Verfahren zur Messung des maximalen Schalldruckpegels - Teil 3: Messmethode für Schalldosis Management

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European foreword

This document (EN 50332-3:2017) has been prepared by CLC/TC/108X "*Safety of electronic equipment within the fields of Audio/Video, Information Technology and Communication Technology*".

The following dates are fixed:

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Introduction

Ideally, sound exposure assessment should be done with a normalized dosimeter located close to the head (ears) of the user during the whole time of the exposure. However, in the context of leisure activities, and for evident practical and economical reasons, this ideal methodology cannot be applied. For a user of a Personal Music Player (PMP), a dosimeter would even have to sit inside the ear canal, close to the tympanic membrane, with exposure data transformed to diffuse field equivalent. The aim of this European Standard is to define an alternative and more applicable methodology for estimating sound exposure from PMPs.

A PMP should inform the user about potentially harmful sound exposure, long-term as well as short-term. This is accomplished by including a rolling calculation of sound dose, *CSD*, and an estimation of momentary sound exposure level, *MEL*. In case *CSD* or *MEL* exceeds defined thresholds, the user is warned and/or PMP gain is lowered. All protections should remain in place when listening to any kind of typical PMP source (music, broadcast, game etc.), but not when, for instance, having a phone call. Annex A shows a block diagram of how a complete protection system might be realized.

By adding actual PMP dose estimation to EN 50332-1 and EN 50332-2, rather than assuming the average energy of programs and tracks, warnings become more relevant to the user. Relevance and trustworthiness is essential for one of the standard's objectives: its educational value.

If estimation relies only on feed-forward principles, some uncertainty in the prediction of *in vivo* dose will persist, for instance how earplugs or headphones are mounted, spread between transducers, spectral properties of transducers, broken transducers etc. Some uncertainties can be effectively dealt with when known combinations of PMPs and headphones are employed, while it may add to the uncertainty when components are acquired separately.

Regardless that earphones, earbuds or headphones for use with PMPs may not exceed defined limits with regard to sensitivity, it is acknowledged that extra uncertainty in the exposure estimation with arbitrary combinations of PMPs and transducers will persist. However, with this part 3, actual electrical measurement of source audio as part of dose estimation, a major contributor to warning errors in general, is eliminated.

1 Scope

This European Standard specifies sound dose measurement, and the alerts associated, to reduce the risk of listeners developing hearing impairment when using a Personal Music Player (PMP). The standard does not cover exposure from other sources than PMPs.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50332-1:2013, *Sound system equipment: Headphones and earphones associated with personal music players - Maximum sound pressure level measurement methodology - Part 1: General method for "one package equipment"*

EN 50332-2:2013, *Sound system equipment: Headphones and earphones associated with personal music players - Maximum sound pressure level measurement methodology - Part 2: Matching of sets with headphones if either or both are offered separately, or are offered as one package equipment but with standardised connectors between the two allowing to combine components of different manufacturers or different design*

EN 62368-1, *Audio/video, information and communication technology equipment - Part 1: Safety requirements (IEC 62368-1:2014)*

HD 483.1 S2, *Sound system equipment - Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions of EN 50332-1:2013, EN 50332-2:2013 and EN 62368-1 apply.

4 Limits and calibration

4.1 General

EN 50332-3 builds on definitions from EN 50332-1 and EN 50332-2. Output limits and the calibration of the electro-acoustic loop remain unchanged, but actual audio shall be taken into account to determine maximum and minimum gain settings.

With the test signal, the relationship between sound exposure level and r.m.s. voltage remains the same, e.g. 80 dB SPL and 15 mV (EN 50332-2), see Figure 1.

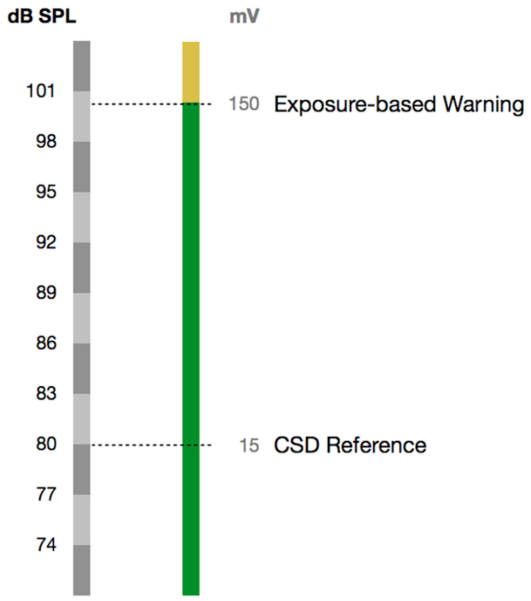

Figure 1 — Relationship between SPL and analog output voltage (mV r.m.s.), *CSD* reference and *MEL*-based warning; for the standard test signal

4.2 Headset Type variations

If a manufacturer implements a means of detecting the sensitivity of a headset plugged in, or provides a user selectable option, this sensitivity can be used to re-calibrate the electro-acoustic loop used for the limits and dose calculation, as long as the acoustic limits remain unchanged.

4.3 Headset Fit-variation

If a manufacturer implements a system accounting for headset fit-variation, in which the acoustic level estimates are more accurate than the proposed feed-forward system (for example, a closed-loop or hybrid system), these levels can serve as the limits and inputs to the dose calculation, as long as the acoustic limits remain unchanged.

5 Testing

5.1 General

This procedure verifies PMP sound exposure and dose estimation, based on the HATS method for acoustic testing, see EN 50332-1. (Five times re-seat calibration ref).

The “programme simulation” test signal specified in EN 50332-1 and EN 50332−2 is here referred to as “HD 483”. The same signal, but attenuated by 12 dB, is referred to as “HD 483-12L”.

Additional signals and more extensive procedures could be included to test the warning system rigorously; for example, mark-space ratio noise, test music etc. To keep it simple, however, requirements are based only on continuous noise as described in EN 50332–1 and −2, as the intentions behind dose estimation should be clear.

5.2 Test of PMP with headphones/plugs included

1) Exposure-based warning: Use measurement procedure of EN 50332-1. Play the HD 483 signal and adjust PMP gain control until the *MEL* warning is just activated. Measure the manikin diffuse field equivalent sound exposure and verify performance to be within tolerances, +- 3 dB.

   In case PMP maximum SPL is less than 99 dB, no Exposure-based warning is required.

2a) Dose estimation: Reset the *CSD* measurement and adjust the gain for a close to 100 dB SPL diffuse field equivalent measurement. Based on Table 1 and on the SPL measured, verify the time it takes for *CSD* to reach 100 %. Duration tolerance: +/- 3 dB time equivalents (Table 1). Verify that an appropriate *CSD* warning is given.

2b) Continue playing and verify that SPL is reduced to 80 dB SPL +/- 3 dB when a *CSD* of 500 % is reached. Duration tolerance: +/- 3 dB time equivalents (Table 1).

In case PMP maximum SPL is less than 80 dB, no Dose estimation is required. In case PMP max SPL is between 80 dB and 100 dB, set max PMP gain and use interpolation to verify dose estimates.

3) EBU R128 compatibility (optional): Switch source to HD 483-12L and verify that gain can be turned up high enough to produce SPL greater than or equal to 90 dB.

5.3 Test of PMP with headphones/plugs not included

1) Exposure warning: Play the HD 483 test signal and adjust PMP gain control until the *MEL* warning is just activated. Measure the output r.m.s. voltage and verify performance within tolerances, 133 mV - 169 mV = +/- 1dB.In case PMP maximum output is less than 133 mV, no Exposure-based warning is required.

2a) Dose estimation: Reset the *CSD* measurement and adjust the gain for a close to 150 mV r.m.s. per channel reading. Based on Table 1 and on the voltage measured, verify the time it takes for *CSD* to reach 100 %. Duration tolerance: +/- 1 dB time equivalents (Table 1). Verify that an appropriate *CSD* warning is given.

2b) Continue playing and verify that output voltage is reduced to 15 mV +/- 1 dB when a *CSD* of 500 % is reached. Duration tolerance: +/- 1 dB time equivalents (Table 1).

In case the PMP's maximum output voltage less than or equal to 15 mV, no dose estimation is required. In case the PMP's maximum output voltage is between 15 mV and 150 mV, set max PMP gain and use interpolation to verify dose estimates.

3) EBU R128 compatibility (optional): Switch source to HD 483-12L and verify that the gain can be turned up high enough to generate an output voltage of greated than or equal to 47 mV.

Table 1 — Testing of *CSD* alert, based on SPL or on Electrical Level

SPL	Analog Level r.m.s.	Duration for 100 %CSD	Duration for 500 %CSD
103,0 dB(A)	211,9 mV	12 min	59,5 min
102,5 dB(A)	200,0 mV	13,5 min	67 min
102,0 dB(A)	188,8 mV	15 min	75 min
101,5 dB(A)	178,3 mV	17 min	84 min
101,0 dB(A)	168,3 mV	19 min	94,5 min
100,5 dB(A)	158,9 mV	21 min	106 min
100,0 dB(A)	150,0 mV	23,5 min	119 min
99,5 dB(A)	141,6 mV	26,5 min	133,5 min
99,0 dB(A)	133,7 mV	30 min	150 min
98,5 dB(A)	126,2 mV	33,5 min	168,5 min
98,0 dB(A)	119,1 mV	37,5 min	189 min
97,5 dB(A)	112,5 mV	42 min	212 min
97,0 dB(A)	106,2 mV	47,5 min	238 min
96,5 dB(A)	100,3 mV	53 min	267,5 min
96,0 dB(A)	94,6 mV	59,5 min	300 min
95,5 dB(A)	89,3 mV	67 min	337 min
95,0 dB(A)	**84,4 mV**	**75 min**	**378 min**
94,5 dB(A)	79,6 mV	84 min	424 min
94,0 dB(A)	75,2 mV	94,5 min	476,5 min
93,5 dB(A)	71,0 mV	106 min	534,5 min
93,0 dB(A)	67,0 mV	119 min	600 min
92,5 dB(A)	63,3 mV	133 min	673,5 min
92,0 dB(A)	59,7 mV	150 min	756 min

When testing *CSD*, this table may be used in case the PMP's gain control does not allow hitting an SPL or voltage level precisely enough. (Duration rounded to 1/2 min values).

Annex A
(Informative)

Example of how the basic protections could be achieved

To reduce measurement uncertainty, electro-acoustical ("E-A") tuning should be invoked when a known PMP and headphone combination is employed.

In order for PMPs to accommodate EBU R128 broadcast level, a gain stage with integrated sample-peak or true-peak limiting just before (or integrated with) the gain control of Figure A.1 is recommended. Digital gain of up to +10 dB would constitute good design practice.

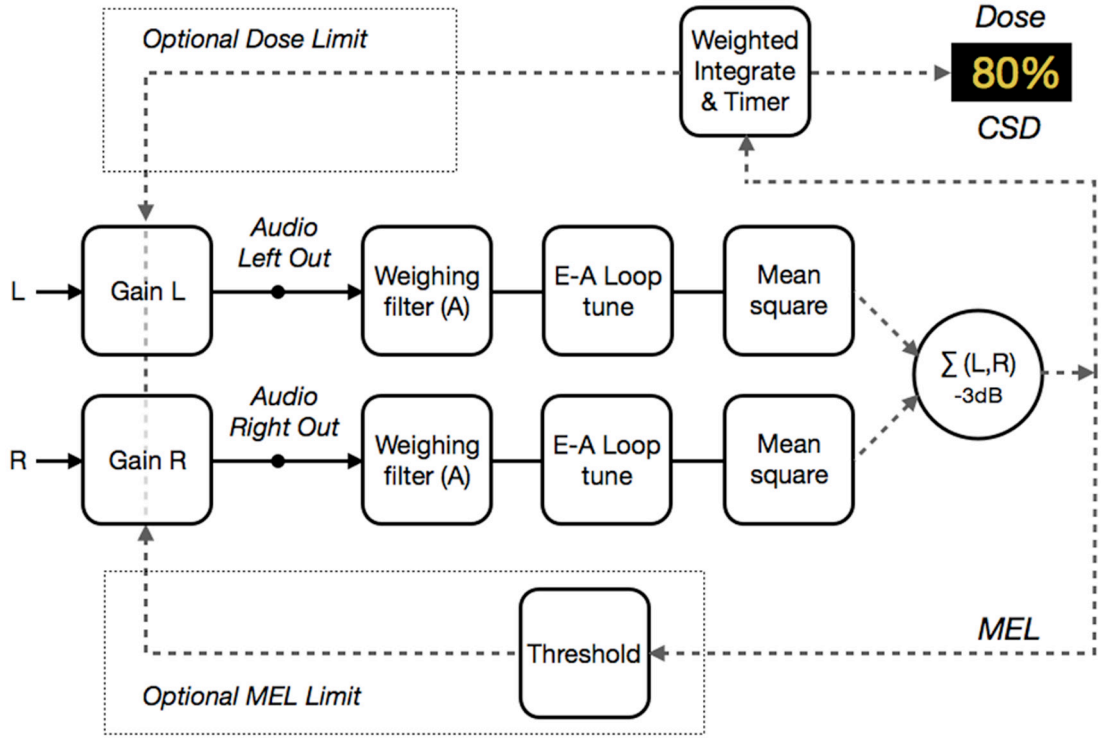

Figure A.1 — Functional block diagram to realize the protective measures of EN 50332-3

Annex B
(Informative)

Background information

B.1 Motivation

Considering:

— that between 2,5 and 10 million people in EU are projected to develop hearing impairment as a result of listening to portable music players (PMPs) [1];

— that the risk of developing such hearing impairment correlates in well-known ways with the time spent and the sound pressure level (SPL) used when listening to PMPs;

— that this type of hearing impairment represents an immediate and/or a delayed loss of ability to communicate and to socialise for the persons affected;

— that treatment of potentially millions of people will put a strain on health and welfare systems in EU;

considering further:

— that regulation of SPL in PMPs should be based on calculating sound dose rather than on general assumptions about the audio. This reduces the risk of false negative warnings, i.e. the user not being warned about harmful listening conditions. It also reduces the risk of false positive warnings, i.e. the user being wrongly warned about not-harmful listening conditions;

— that regulation of SPL in PMPs based on general assumptions about the audio rather than on calculating sound dose may be neither relevant, nor educational to the user;

— that regulation of SPL in PMPs based on general assumptions about the audio, or based on calculating only long-term sound dose, offers limited protection against short but still potentially harmful sound exposure level;

— that regulation of SPL in PMPs based on general assumptions rather than on calculating sound dose encourages the use of procedures in production that harm European music heritage, film and broadcast [2, 7];

the following is recommended:

— to add the requirement for user-warnings, based on long-term sound dose, measured at the headphone output of the PMP;

— to add the requirement for user-warnings, based on short-term exposure level, measured at the headphone output of the PMP;

— to encourage a PMP gain-structure that accommodates programs distributed at the level specified by the European Broadcasting Union in the EBU R128 standard;

— to encourage a PMP design that includes automatic SPL reduction, for instance based on short-term (“Momentary”) exposure level.

B.2 Loudness Normalization and EBU R128

Based on the EBU R128 standard [4], tracks and programmes can be transparently pre-normalized in order to reduce the jump in level that would have otherwise occurred between them. The document also describes how normalization of content during distribution reduces the temptation to dynamically compress tracks and programs in order to sound louder.

Less dynamic compression is also benign for the PMP user: “Compressed music delivered by most portable music players is closer to noise than the original music because the overall intensity of the whole spectrum is higher. This global increase and the disappearance of quiet transients could harm the auditory system on a long-term basis.” [6]

Normalization is desirable to the user and it also reduces the risk of wild jumps in exposure level from track to track, thereby making acute warnings for a PMP user less of a need for her protection. Furthermore, the listener is prevented from entering a “turn-it-up-spiral”, when a louder track otherwise makes a softer one afterwards tend to appear soft and need another nudge up [7].

EN 50332-1 and EN 50332-2 standards without dose-estimation prevent loudness normalization from being adopted in streaming, so that currently works against the intentions of these standards.

Because broadcast for mobile devices in EU is based on EBU R128, WG3 recommend a gain structure and a PMP design that accommodates normalization at −23 LUFS. A formal liaison with EBU keeps EN 50332-3 aligned with the R128 standard and vice versa.

B.3 Explanation of *MEL*

MEL is similar to SEL in that A weighted sound energy is integrated over the measurement period, but instead of the averaging over an arbitrary measurement period, a reference duration of 1 s is used. The units are the decibel (dB). The 1 s timebase makes calculated *MEL* comparable to results obtainable from audio analysers performing transformed HATS measurements, and to results from diffuse field SPL analysis.

For each second, *MEL* returns one number, namely an estimate of A-weighted sound pressure level of Left and Right channel summed, less 3 dB. The electro-acoustic characteristics of the PMP-headphone combination should be taken into account wherever possible. A single headphone channel measurement consequently registers 3 dB soft compared to a transformed HATS per channel analyser using the “programme simulation” test signal, but *MEL* should be on par with a HATS L+R diffuse field transformation. *MEL* may be calculated using a sliding rectangular window of 1 s. To keep the computational load low, and because 1 s is short compared to the intervals of concern, no measurement overlaps are required.

MEL may be used to compute *CSD*, to flag mandatory short-term warnings, and (optionally) to reduce the output gain in case hazardous level would otherwise result.

B.4 Explanation of *CSD*

B.4.1 General

CSD is an estimate of sound exposure in accordance with the European noise at work directive lower action value and Commission Decision of 23rd of June 2009, i.e. based on exposure normalized to a 40 h working week, see Table B.1.

CSD uses a continuously rolling window of 7 days. For instance, a paused/sleeping/off PMP is logged as not producing any exposure. *CSD* may obtained by integrating MEL over time.

CSD is used to flag a mandatory dose-warning at 100 %, and (optionally) to reduce the *MEL* to 80 dB or lower in case a weekly sound exposure level of 85 dB is reached.

Table B.1 — 100 % Sound Dose daily and weekly for different exposure levels(3 dB exchange rate)

Sound Exposure Level in dB	Time/Day	Time/Week
107	1 min	4,5 min
104	2 min	9,5 min
101	4 min	19 min
98	7,5 min	37,5 min
95	15 min	75 min
92	30 min	2,5 h
89	1 h	5 h
86	2 h	10 h
83	4 h	20 h
80	8 h	40 h
Numbers rounded to half hour / half minute values. Criterion is based on the EU “Noise at Work Directive” [5] with lower exposure action values as stipulated in [3]. If the exposure time is doubled, the total sound exposure increases by 3 dB. Similarly if the Dose was 100 %, then doubling the exposure time results in a total dose of 200 %.		

B.4.2 *CSD* per 24 h or per week?

There could be reasons for choosing either time-base. A week-based measure, however, where exposure is normalized to a 5 day at 8 h working week, is in line with the Commission Decision of 23 June 2009 [3]. It is therefore the foundation of this European Standard.

B.5 Sound of non-PMP origin

If a manufacturer implements a system accounting for other sources of exposure than a PMP, for example sound at a concert, cinema, dance club, car race, airplane, while diving etc., such additional information may also be made available to the user.

The PMP fraction of the total dose, however, shall be clear, and the acoustic limits remain unchanged. Extra alerts may be given to the user, at the manufacturer’s discretion.

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