**Calibration of DT100 headphones for mono reproduction of test signals and implementation of test signals**

To firstly determine the frequency response of the headphones and implement a correction filter to compensate for it, they were placed onto the B&K 4100 Head & Torso Simulator (HATS). A three minute white noise signal was fed to the headphones from one of the task laptops to ensure that the entire system, including the laptops soundcard was being tested.

This signal, reproduced by the headphones was recorded via the HATS type 4189–A–002 microphone/preamplifier assemblies, each comprising a ½? Falcon Range Microphone Type 4189, located in the bottom of the concha. These measurement grade microphones have a relatively flat response at the frequencies under scrutiny, so it was assumed this response was negligibly affecting the results. This process was repeated 16 times to account for different placement positions of the headphones and also to test a number of different sets in case of any major differences between them.

The major factor influencing the headphone response was the placement on the HATS. A noticeable change in the frequency response of the recorded signal was observed when placing and replacing the headphones onto the head. In some instances, a tight seal was not made with the head leaving a small gap which severely affected the headphones low frequency reproduction. A mean signal was created from these 16 signals for each ear to account for subjects placing the headphones on too loosely or over hair (B&K 4100 is bald). As a result of these observations, clear instructions must be given to subjects to ensure they place the headphones on properly for accurate signal reproduction.

The recorded mean white noise signals frequency responses were compared to the original signal using Adobe Audition, highlighting the headphones frequency response. A third octave band filter was used to filter the recorded signals until they closely matched the original input signal, thus compensating for the headphones frequency response at both ears.

To faithfully reproduce calibrated dB levels measured using an omnidirectional sound level meter, a further stage of corrections were applied to all test signals. Sound level meters measure the sound pressure level from a point source within a space. The reproduction of this level over headphones requires a filter stage to account for head and ear effects at different frequencies.

B&K publish free field (FF) and diffuse field (DF) corrections at third octave band frequencies for the 4100 HATS. As these apply only to the extreme conditions of a FF or DF environment, independent measurements of these corrections were made in a room with a similar RT60 to the majority of classrooms analysed in the study.

The HATS was placed 3m from a Genelec 8030A loudspeaker, generating white noise. The SPL of this noise was measured at third octave bands using a calibrated SvanTek 959 type 1 sound level meter. This was repeated using the calibrated HATS facing the speaker at 0 degrees. The differences in these third octave band measurements were then compared to the published correction factors from B&K. It was observed that they sat roughly midway between the FF and DF corrections, but there were some anomalies at higher frequencies possibly due to room effects. Based on this, it was decided to use the mean correction factor of the FF and DF conditions. A second filter bank was created using Adobe Audition to apply these corrections to the test signals.

Measurements of samples of interfering noise from classroom lesson noise measurements were made during two lessons in the subject areas Science and History.

Data represent measurements of sections where the interfering noise is the dominant noise source.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Subject** | **Sample** | **Length (s)** | **LAeq** | **LAmax** | **LAmin** | **LA10** | **LA90** |
| Video | Science | 1 | 3 | 48.2 | 51.7 | 43.4 | 50.3 | 48.3 |
| Video | Science | 2 | 3 | 49.2 | 54.3 | 44 | 54.1 | 46.9 |
| Pupils | History | 3 | 4 | 46.8 | 54 | 40.3 | 52.1 | 42.5 |
| Pupils | History | 4 | 17 | 44.1 | 49.3 | 38.6 | 47.1 | 40.3 |
| Pupils | History | 5 | 16 | 45.9 | 55.2 | 39.6 | 47.9 | 41.7 |
| Pupils | History | 6 | 4 | 44.6 | 50.1 | 40.1 | 50.1 | 40.5 |
| Pupils | History | 7 | 8 | 43.7 | 47.3 | 40.6 | 45.8 | 42.4 |
| Pupils | History | 8 | 7 | 45.3 | 49.8 | 41.5 | 46.7 | 42.5 |

**Summary data**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Subject** | **LAeq**  **(Log mean)** | **LAmax**  **(max)** | **LAmin**  **(min)** | **LA10**  **(Log mean)** | **LA90**  **(Log mean)** |
| Video | Science | 48.7 | 54.3 | 43.4 | 52.6 | 47.7 |
| Pupils | History | 45.1 | 55.2 | 38.6 | 48 | 41.5 |

**Activity levels in lessons during interfering noise**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Subject** | **Sample** | **Length (s)** | **(A) Interfering noise (LAeq)** | **(B) Activity noise including interfering noise**  **(LAeq)** | **(C) Activity noise level minus contribution of interfering noise (LAeq)** | **Diff (C) – (A)**  **(LAeq)** |
| Video | Science | 1 | 3 | 48.2 | 52.2 | 50.0 | 1.8 |
| Video | Science | 2 | 3 | 49.2 | 52.2 | 49.2 | 0 |
| Pupils | History | 3 | 4 | 46.8 | 64 | 63.9 | 17.1 |
| Pupils | History | 4 | 17 | 44.1 | 64 | 64.0 | 19.9 |
| Pupils | History | 5 | 16 | 45.9 | 64 | 63.9 | 18 |
| Pupils | History | 6 | 4 | 44.6 | 68.5 | 68.5 | 23.9 |
| Pupils | History | 7 | 8 | 43.7 | 50.9 | 50.0 | 6.3 |
| Pupils | History | 8 | 7 | 45.3 | 68.6 | 68.6 | 23.3 |

Average difference for video = -1.8 dBA

Average difference for pupils = 18.1 dBA

The babble is at 50dBA & 70dBA with the video at 48.2dBA & 68.2dBA (the difference seen in measured classes).

The video signal used is a free audiobook, which is aimed at "older children" but is not directly related to the KS3 & KS4 curriculum content. It was chosen because of the female speaker, the consistency of the speech in terms of level and its distance from the curriculum.

The audio used is “Royal Children of English History” by E. Nesbit (1858 - 1924). The video signal was convolved with an impulse response (IR), to simulate the transmission effects on the video signal as it leaks through a classroom wall. The IR was recorded through the wall and door of two adjoining rooms similar in style to adjoining classrooms using the WinMLS swept sine method. A measurement mic was placed one metre from the door on the office side with the Genelec 6030A loudspeaker in the kitchen facing into the room parallel with the door around 2m from the door.

The signals used were as follows:

1. 50dBA Babble (A&B)

2. 70dBA Babble (A&B)

3. 50dBA Babble + 48.2dBA Video (A&B)

4. 70dBA Babble + 68.2dBA Video (A&B)

The raw test signals were then filtered using the two filter banks created previously and played back via the test laptop and DT100 headphones. The LAeQ 5 mins was measured for each test signal with the signals adjusted to the maximum default level of 70dB. When the signals were reproduced at differing levels, the signal is attenuated relative to this maximum default level. The video levels were set relative to the babble level.