

Measuring noise exposure from communication headsets and earpieces using a Head and Torso Simulator

By Liz Brueck MIOA, Health and Safety Executive, Buxton

Noise from communication headsets and earpieces can contribute to a person's daily noise exposure. There are two standard methods to determine personal noise exposure from these devices:

- Microphone In Real Ear (MIRE) technique BS EN ISO 11904-1:2002 [1]; and
- Manikin or Head and Torso simulator (HATS) technique BS EN ISO 11904-2:2004 [2].

There are also devices that monitor the electrical signal to the listening device used, and give an indication of the corresponding sound exposure. These are useful for long-term monitoring.

HSE scientists use a range of measurement methods within the laboratory, but when monitoring exposure from headsets and ear pieces in static work situations (such as call centres or control rooms) HSE scientists usually use a HATS method. This method allows us to copy how the ear piece is worn by the listener and allows the listener to work normally while we are monitoring. This is how we do it.



Figure 1 Head and torso simulator conforming to ANSI S12.42 (other models are available)

The HATS

Our HATS device is a simulated human head with simulations of the human ear; with a pinna, ear canal and a microphone at the ear drum to measure the sound. Sound is amplified in the ear canal so the sound measured must be corrected using a frequency dependent correction (transfer function) before it can be used to predict a person's noise exposure.

For reliable measurements, the HATS must match average human dimensions and include a realistic pinna and simulated ear canal. HSE guidance: 'L108 Controlling Noise at Work [3]' recommends the HATS should meet the requirements of clauses 3.4 and 4 in 'IEC/TR 60959:1990' or the equivalent US standard 'ANSI S3.36:1985'. These standards are now withdrawn. However, the HATS design has been adapted in 'ANSI S12.42:2010 [4]' which specifies a similar device, but with shoulders rather than a full torso. This is the type of device we currently use. An example is shown in Figure 1.

Why not use a MIRE measurement?

Measurements of sound from sources close to the ear are sometimes made using a miniature or probe microphone in a person's ear, also known as the MIRE (microphone in real ear) method. However, when the person is speaking as well as listening, the MIRE measurement will pick up the sound of their own voice reaching the ear by bone conduction. This will invalidate the measurement.

The HATS transfer function

Personal noise exposure is normally calculated from the sound level and time spent in noisy locations by the individual during their working day. This value is directly comparable to the exposure action and limit values given in the 'Control of Noise at Work Regulations 2005 [3]'. Sound is amplified in the ear and a transfer function must be used to convert the in-ear level to the equivalent level in an open space.

The ear canal amplification varies with frequency. The transfer function is therefore frequency-dependent and is usually applied as a series of corrections in decibels for each frequency band of the sound spectrum. We use a third octave band spectrum and associated transfer function. You can use narrower frequency bands, but an octave band transfer function has insufficient resolution.

We use a free-field transfer function corresponding to the equivalent level if the person was facing a single source of sound. (An example is given in Table 1 on the next page). You can also correct to the equivalent diffuse field level.

Obtaining a transfer function

Some manufacturers will supply a generic transfer function for their HATS model. This should be adequate, but HSE

Table 1: Example free field transfer function measured for a HATS

Frequency Hz	Unweighted transfer function dB		A-weighting dB	Weighted transfer function dB(A)	
	Left ear	Right ear TF		Left ear TF	Right ear TF
40	-0.8	-1.1	-34.6	-35.4	-35.7
50	0.5	-1.8	-30.2	-29.7	-32.0
63	0.9	0.8	-26.2	-25.4	-25.4
80	0.8	0.9	-22.5	-21.7	-21.6
100	-2.0	-1.6	-19.1	-21.1	-20.7
125	-1.5	-2.2	-16.1	-17.6	-18.3
160	-3.4	-7.3	-13.4	-16.8	-20.7
200	-0.5	-0.8	-10.9	-11.4	-11.7
250	1.6	-0.1	-8.6	-7.1	-8.7
315	0.2	1.4	-6.6	-6.4	-5.2
400	-1.9	-2.4	-4.8	-6.7	-7.2
500	-2.2	-1.9	-3.2	-5.4	-5.1
630	-2.7	-2.3	-1.9	-4.6	-4.2
800	-3.6	-3.8	-0.8	-4.4	-4.6
1000	-7.0	-6.4	0.0	-7.0	-6.4
1250	-6.7	-6.6	0.6	-6.1	-6.0
1600	-7.7	-8.1	1.0	-6.7	-7.1
2000	-13.7	-12.8	1.2	-12.5	-11.6
2500	-16.5	-14.4	1.3	-15.2	-13.1
3150	-16.0	-14.6	1.2	-14.8	-13.4
4000	-16.8	-15.3	1.0	-15.8	-14.3
5000	-13.5	-11.6	0.5	-13.0	-11.1
6300	-11.9	-9.2	-0.1	-12.0	-9.3
8000	-12.8	-11.1	-1.1	-13.9	-12.2
10000	-9.0	-8.2	-2.5	-11.5	-10.7

scientists would recommend you measure a transfer function for each ear of your HATS. Individual HATS of the same model, and even the left and right ears on the same HATS, can vary in response. It is useful to repeat the transfer function measurement after any repairs or part replacements as a performance check.

This is how to measure a third octave band transfer function:

Equipment needed

- the HATS and its associated sound calibrator;

- a third octave band analysis system for measurement of the spectrum from the HATS;
- a sound level meter with third octave band analysis or free field response microphone and third octave band analyser combination that meets Class 1 requirements of ‘BS 61672-1’ (or Type 1 of older standards);
- a source of approximately pink noise providing sound over a range from at least 100 Hz to 10 kHz; and
- a quiet, non-reverberant test space (we use an anechoic chamber) with background levels in each frequency band at least 20 dB below the test levels.

Transfer function measurement steps:

1. make calibration checks of your HATS and measurement instrumentation with the associated sound calibrators;
2. position the HATS facing the sound source and measure the third octave band levels from the instrumented ears of the HATS;
3. replace the HATS with the open space measurement microphone/sound level meter at a position corresponding to the midpoint between the HATS ears and repeat the spectrum measurement;
4. the open space level in dB minus the HATS ear level in dB gives the HATS transfer function value in dB for the frequency band; and
5. arithmetically add the A-weighting values to your unweighted transfer function to obtain an A-weighted transfer function, which can then be used to obtain the equivalent A-weighted spectrum in an open space from the HATS measurement.

Applying the transfer function to the HATS spectrum:

1. arithmetically add the transfer function values in dB(A) to your third octave band levels measured from the HATS to obtain the equivalent A-weighted spectrum in an open space; and
2. sum the equivalent A-weighted spectrum levels from each frequency band using a dB summation (not an arithmetic summation) to obtain the equivalent broad band A-weighted level in an open space.

At HSE, our scientists use a computer-based analysis system that applies the transfer function and A-weighting to give the broadband equivalent A-weighted level in real time.

Measurements of a headset

Measurements of a headset sound level usually need to be made while the headset wearer is taking working calls. We use a second headset of the same model for the HATS measurements and work next to the call handler.

If a second headset socket is available at the call handler's work station we connect to this. You need the output set to the same listening level as the call handler uses. If there are no fixed gain settings we would ask the call handler to subjectively set the HATS headset to their chosen listening level.

Alternatively, split the signal between the HATS headset and the operator headset and ask the operator to restore the output of both headsets to their chosen listening level.

Fit the headset on the HATS ear as the operator chooses to wear it. If the operator is listening with the headset resting on the side of the head, i.e. listening primarily by bone conduction, a valid measurement is not possible.

Background noise measurements and influence

If the HATS is close to the workstation you are monitoring, you will record all the sound entering the ear, the background noise, the call handler's voice and the sound from the headset. However, it is important to have a separate measurement of the background noise level as excessive background levels could affect the chosen listening level. If background noise


is intrusive, most people choose to listen at a level 5 to 10 dB above the background. Logging noise dosimeters positioned on the edge of workstations, or at a vacant workstation in a busy area, provide a useful indication of the variations in background noise throughout the day.

Calculation of daily personal noise exposure

Guidance on calculating daily personal noise exposure can be found in 'Controlling Noise at Work [3]'. An exposure calculator is also available at <http://www.hse.gov.uk/noise/calculator.htm>. You will need estimates of the sound level and duration for each activity and type of call in a working day.

Control of noise exposure

We have not often found instances where people choose to listen to speech communication from headsets at levels likely to give a noise exposure over the action values. But if the background noise is intrusive, listening levels can be raised to excessive levels. Background noise in the workplace should be controlled using simple actions such as removing or screening off noisy equipment, providing screens around work stations, sound absorbent materials on surfaces in the work space while also minimising the intrusion of outside noise.

Modern headsets are designed to cut out sustained tonal sounds such as some alarms, dialling tones and sounds that might occur with a fault, or during a malicious call. HSE encourages duty holders to supply appropriate headsets and access to replacements if faulty. If there are calls which are known to have excessive noise (such as radio static) it is best to filter the noise from the signal before it reaches the headset. 

References

1. BS EN ISO 11904-1:2002 Acoustics. Determination of sound immission from sound sources placed close to the ear. Technique using a microphone in a real ear (MIRE technique)
2. BS EN ISO 11904-2:2004 Acoustics. Determination of sound immission from sound sources placed close to the ear. Technique using a manikin.
3. Controlling noise at work. The Control of Noise at Work Regulations 2005. Guidance on Regulations. HSE publication L108 www.hse.gov.uk/pubns/books/L108.htm.
4. ANSI/ASA S12.42-2010 Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures.
5. The Control of Noise at Work Regulations 2005, Statutory Instrument No. 1643 http://www.legislation.gov.uk/ukxi/2005/1643/pdfs/ukxi_20051643_en.pdf

This publication and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the author alone and do not necessarily reflect HSE policy.

© Crown copyright 2018