

British Society of Audiology

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Recommended Procedure

Surveillance Audiometry

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General foreword

This document presents a Recommended Procedure by the British Society of Audiology (BSA). A Recommended Procedure provides a reference standard for the conduct of an audiological intervention that represents, to the best knowledge of the BSA, the evidence-base and consensus on good practice given the stated methodology and scope of the document and at the time of publication.

Although care has been taken in preparing this information, the BSA does not and cannot guarantee the interpretation and application of it. The BSA cannot be held responsible for any errors or omissions, and the BSA accepts no liability whatsoever for any loss or damage howsoever arising. This document supersedes the BSA Recommended Procedure: Industrial Audiometry (2012) and stands until superseded or withdrawn by the BSA.

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2. Introduction

This procedure is based on the BSA Recommended Procedure: Pure-tone air-conduction and bone-conduction threshold audiometry with and without masking. Surveillance Audiometry requires air-conduction testing only, without masking, and the frequencies tested may vary from those used for other pure-tone audiometric assessments. This procedure should be used to conduct hearing tests for the purpose of meeting the requirements of the Health & Safety Executive for those exposed to noise at work (HSE, 2005). Such tests should only be carried out by those who have received appropriate training in accordance with BSA Minimum Training Guidelines: Surveillance Audiometry (formerly Industrial Audiometry).

This document replaces all previous versions. Its purpose is to describe a standard procedure, and to provide recommendations, for effective pure-tone surveillance audiometry primarily on those exposed to noise at work. It also includes the recommended format for audiogram forms. This document is not intended to provide guidance on specific circumstances or on interpretation of results (for guidance on the interpretation of results see HSE, 2005). It is important that the competent person carrying out, or responsible for, the test (the 'tester') uses professional judgement when





deciding on the particular approach to be used with each person being tested (the 'subject'), given the specific circumstances and the tester's level of competency.

The term 'shall' is used in this document to refer to essential practice, and 'should' to refer to desirable practice.

Unless stated otherwise this document represents the consensus of expert opinion based on the best available evidence as interpreted by the BSA Professional Guidance Group. The document was developed in accordance with BSA Procedure for Processing Documents.

3. Scope

3.1 Subjects

This document describes procedures suitable for use with adults and older children. It may not be appropriate for certain populations (e.g. adults with learning difficulties) and in these cases some modification of the test method may be required, although this may result in a less accurate measurement of hearing threshold levels (see section 6.7).

3.2 Procedures

Procedures are described for manual pure-tone audiometry using air-conduction only. This document does not cover screening or automated audiometry (including Bekesy audiometry), bone-conduction or masking.

4. Equipment and test environment

4.1 Audiometric equipment

Audiometers shall meet the performance and calibration requirements of the relevant and current BS EN ISO standards (see Section 8 and Appendices A and C). The audiometer, earphones (or transducers) and response button shall be clean.





4.2 Audiometric test environment

The subject's face shall be clearly visible to the tester. The subject shall not be able to see or hear the tester adjust the audiometer controls. When the test is controlled from outside the audiometric test room the subject shall be monitored through a window or by a closed-circuit TV system. Audible communication with the subject should also be possible.

Excessive ambient noise will affect the test results, and ambient noise should not exceed the levels set out in the BS EN ISO standards (see Appendix B for further comments and details of the permitted ambient noise). Testers should also be alert to the problems of intermittent or transient ambient noise during the test.

In general, the ambient noise should not exceed 35 dB (A). If it is higher than this then it is recommended that audiometry should not proceed.

5. Preparation for testing

5.1 Preparation of test subjects

The tester shall adopt an effective communication strategy with the subject throughout. This must take account of the subject's age, hearing level, language skills and any other possible communication difficulties. Any significant communication problems shall be recorded on the audiogram form as these may affect the subject's performance.

Audiometry shall be preceded by otoscopic examination (see BSA Recommended Procedure: Ear Examination) and the findings recorded, including the presence of wax.

Occluding wax may be removed prior to audiometry but if wax is removed the procedure shall only be undertaken by someone who is qualified and competent to do so.

The subject shall be asked about any exposure to loud noise during the previous 24 hours, as this can cause a temporary hearing loss. If the answer is yes then more details should be obtained regarding the exposure and results recorded on the audiogram form. Noise can be considered 'loud' if it is necessary to shout or use a raised voice to





communicate at a distance of 1 metre or 3 feet. If the results may have been affected by recent noise exposure then it may be necessary to re-test the subject at a time when they have had no recent exposure to noise.

Subjects shall be asked if they have tinnitus, as this may affect their ability to detect tones in one or both ears (see Sections 6.1 and 6.7). Subjects shall be asked if they have better hearing in one ear; if so testing should commence with that ear, otherwise testing can start in either ear.

If applicable, inform the subject about intercom facilities. After giving the test instructions, remove any hearing aids, also any glasses, headwear or ear-rings that may obstruct the correct placement of the earphones, cause discomfort or affect sound transmission. Wherever possible, hair, scarves etc., should not be allowed to sit between the ear and the earphone.

5.2 Test time

Care should be taken not to fatigue the subject as this can affect the reliability of the test results. In the unlikely event that the test time exceeds 20 minutes subjects should be offered a short break.

6. Air-conduction audiometry

6.1 Instructions

Instructions shall give clear information about the task. This could be as follows:

“I am going to test your hearing by measuring the quietest sounds that you can hear. As soon as you hear a sound (tone), press the button. Keep it pressed for as long as you hear the sound (tone), no matter which ear you hear it in. Release the button as soon as you no longer hear the sound (tone). Whatever the sound, and no matter how faint the sound, press the button as soon as you think you hear it and release it as soon as you think it stops.”

Alternative wording is acceptable providing the same points of instruction are included. The provision of an abbreviated printed version of these instructions may be





advantageous. The subject should be asked if they understand the instructions. They should also be told that they should sit quietly during the procedure, but may interrupt the testing in case of discomfort or difficulty.

Subjects with tinnitus present at the time of the test should be asked to ignore their tinnitus as much as possible and to respond to the test tones. They should be instructed to inform the tester if they experience difficulty in discriminating between their tinnitus and the test tones. A note to that effect should be made on the audiogram form, including which frequencies were affected (see also Section 6.7).

6.2 Subject's response

The subject's response to the test tone should clearly indicate when the test tone is heard and when it is no longer heard. The response system should be inaudible, with a response button connected to a signal light being the preferred method. When testing adults with learning difficulties, or subjects with attention difficulties, a more engaging response method may be required, and if so this shall be recorded.

6.3 Earphones

There are three main types of earphones that can be used for air-conduction audiometry: supra-aural, circum-aural and insert earphones. Supra-aural earphones (e.g. Telephonics TDH39 and TDH49) rest on the ear and have traditionally been used for air-conduction audiometry. Circum-aural earphones (e.g. Sennheiser HDA200) surround and cover the entire ear. However, both supra- and circum-aural earphones can be cumbersome and may cause the ear canal to change shape, partially close or collapse. Insert earphones (e.g. Etymotic Research ER3 and ER5) use a disposable foam tip for directing the sound straight into the ear canal and therefore prevent the ear canal from changing shape. However, insert earphones may not be appropriate in ears with infections, obstructions or abnormalities. In cases of excessive wax, insert earphones could also push the wax further into the canal and therefore must be avoided.

The tester shall fit the earphones and the subject should be instructed not to hold or move them, after checking with the subject that there is no discomfort. The sound opening of a supra- or circum-aural earphone shall be aligned with the ear canal entrance. If insert earphones are used, the appropriately sized ear tip of an insert earphone should be inserted so the outer edge is flush with the entrance to the ear





canal when the plug is fully expanded. In all cases, incorrect placement may invalidate calibration and provide less protection from ambient noise.

With air-conduction audiometry, vibrotactile perception can occur at 500 Hz at high hearing levels. The tester should be aware of the possibility that high thresholds at this frequency may be vibrotactile.

6.4 Test order

Routine calibration checks on the audiometer must be carried out before the hearing test (see section 8.1)

Start with the better-hearing ear (according to the subject's account) and at 1000 Hz. Next, test 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, 8000 Hz, and 500 Hz in that order. Then, for the first ear only, retest at 1000 Hz. If the retest value is no more than 5 dB different from the original value take the more sensitive threshold as the final value, but if the retest value differs from the original value by more than 5 dB then the reason for the variation shall be investigated. The subject may need to be re-instructed and the full test repeated for that ear (but see also Sections 5.2 and 6.8 regarding the effects of a test taking too long). Unusually variable results shall be noted on the audiogram form. Test the opposite ear in the same order. The retest at 1000 Hz is normally not required for the second ear unless tests in the first ear revealed significant variation.

6.5 Timing of the test stimuli

The duration of the presented tone shall be varied between 1 and 3 seconds. The interval between the tones shall be varied between 1 second and at least 3 seconds. The tester must ensure that the timing of each tone is not predictable; random variations in durations are intended as a check against false positive responses. It is important that the tester does not stop the signal as soon as the subject responds, signals must be of the full duration and the subject must respond throughout each one.

6.6 Initial familiarisation

To ensure the subject is familiar with the task, present a tone of 1000 Hz that is clearly audible (e.g. at 40 dB HL for a normally hearing subject or approximately 30 dB above the estimated threshold for a subject with a hearing impairment, but never more than





80 dB HL). If there is no response, increase the level of the tone in 10 dB steps until a response occurs. If the tone is still inaudible at 80 dB HL, increase the level of the tone in 5 dB steps until a response occurs, taking care to monitor the subject for discomfort.

If the responses are consistent with the tone presentation (i.e. onset and offset) the subject is familiarised with the task. If not, repeat. If after this repeat the responses are unsatisfactory, re-instruct the subject.

6.7 Method for finding threshold

1. Following a satisfactory positive response, reduce the level of the tone in 10 dB steps until no further response occurs.
2. Increase the level of the tone in 5 dB steps until a response occurs.
3. After the first response using an ascending approach, decrease the level by 10 dB and begin another ascending 5 dB series until the subject responds again.
4. Continue to decrease the level by 10 dB and increase by 5 dB until the subject responds at the same level on two out of two, three or four (i.e. 50 % or more) responses on the ascent. This is the hearing threshold level. Threshold is defined as the lowest level at which responses occur in at least half of a series of ascending trials with a minimum of two responses required at that level.
5. Proceed to the next frequency, starting at a clearly audible level (e.g. 30 dB above the adjacent threshold, but see notes on familiarisation in Section 6.5) and use the 10 dB-down, 5 dB-up sequence described in Step 4 until the threshold criterion is satisfied.

6.8 Variations in method

Subjects with short attention spans, and some elderly subjects, may find the full test rather tiring. In these cases it may be appropriate to test fewer frequencies, as it is better to have accurate results than to attempt a complete test on a subject where the accuracy will be in doubt. When frequencies are omitted from the test the reason shall be recorded on the audiogram form. With such subjects other modifications to technique may be required, such as the use of longer test tones or alternative response methods. Again these variations in technique shall be recorded.





If the subject is unable to perform an accurate test at some frequencies due to an inability to distinguish between their tinnitus and the test tone, then a frequency-modulated or warble tone may be used as a stimulus. Subjects often find a warble tone easier to hear against their tinnitus than a pure-tone. However, there are calibration and perception problems with warble tones, and the thresholds measured may be in error as a result. It is essential to record, on the audiogram form, at which frequencies and in which ears warble tones were used. The use of pulsed tones and narrow-band noise is not advised due to calibration and perception problems.

If there is any reason to suspect that the hearing thresholds are unreliable, this shall be noted on the audiogram form.

7. Recommended format for audiogram forms

7.1 Audiogram form

Hearing threshold levels can be plotted graphically on an audiogram form. The aspect ratio should be fixed at 20 dB:1 octave in all cases to ease interpretation. The recommended format is shown below. Other audiogram forms are acceptable, as long as the required information is recorded clearly.

7.2 Symbols

Symbols are shown with the audiogram below.

If no response occurs at the maximum output level of the audiometer, at a particular frequency, the appropriate threshold symbol should be drawn at this level on the audiogram form with a downward arrow drawn onto the symbol to indicate that no response occurred.

Note:

Some of the symbols used in audiological software packages may differ from those recommended here. This is acceptable as long as the results are clear and unambiguous.





7.3 Notes

If the tester has any doubts about the accuracy of any results, these shall be recorded on the audiogram form.

The tester's name, signature and date of test should be recorded on the audiogram form. For electronic copies of the audiogram, the tester's name without signature is acceptable. A note should also be made of the audiometer used, including its type, serial number, the type of earphones, and the date of the last objective calibration.

When a computerised audiometer is used, care must be taken to ensure all results are checked, recorded and stored correctly.





Recommended format for a pure-tone audiogram

Name:

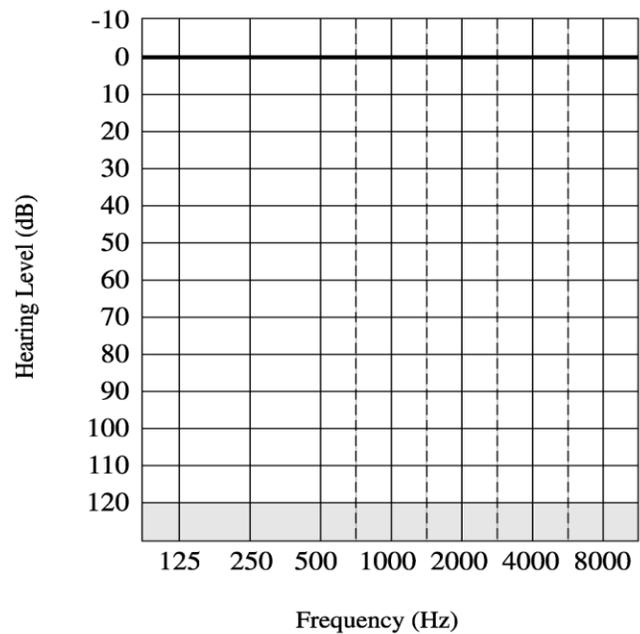
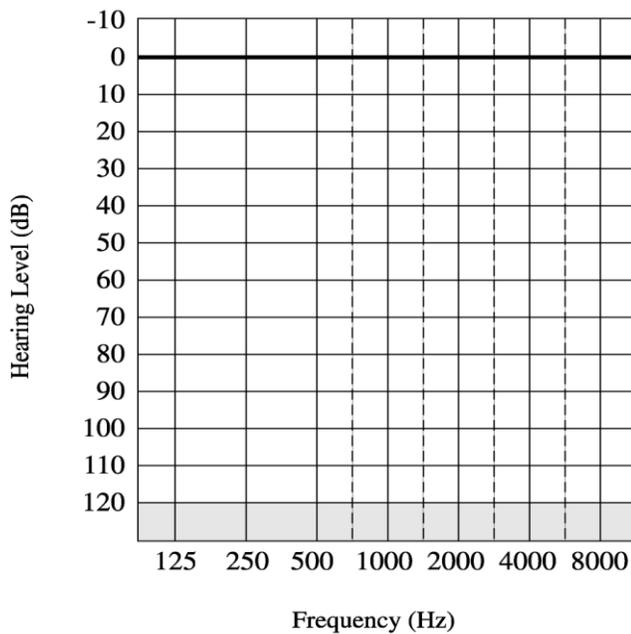
Date:

Date of birth:

Case No:

RIGHT

LEFT



Right

Left

Hearing Thresholds:

O

X

Audiometer type & serial number: _____

Earphone type: _____

Date of last calibration: _____

Tester: _____ Signature: _____

Comments: _____





8. Calibration

8.1 Stage A: routine checking and subjective tests

In order to check the audiometer is functioning across the range of frequencies and output levels, checks shall be carried out by someone with sufficiently good hearing to detect any faults such as described below. They should be carried out in the normal test room, with the equipment set up as installed. These checks should be logged. Where apparent faults are noted, equipment shall not be used until correct performance has been confirmed.

Tests 1 to 7 should be carried out daily.

1. Clean and examine the audiometer and all accessories. Check earphone cushions, plugs, mains leads and accessory leads for signs of wear or damage. Any badly worn or damaged parts should be replaced. If any earphones are replaced, then the audiometer must undergo a Stage B check (see Appendix C).
2. Switch on equipment and leave for the recommended warm-up time. (If no warm-up period is quoted by the manufacturer, allow 5 minutes.) Carry out any setting-up adjustments as specified by the manufacturer. On battery-powered equipment, check battery state using the specified method. Check that earphone serial numbers tally with those on the instrument's calibration certificate. An instrument's earphones shall not be changed unless a full Stage B calibration is undertaken.
3. Check that the audiometer output is approximately correct by listening to tones of all the test frequencies, at a just audible hearing level (e.g. 10 or 15 dB HL), from each earphone separately.
4. Perform a high-level listening check on both earphones at all frequencies used (e.g. 60 dB HL). Listen for proper functioning, absence of distortion, freedom from clicks when presenting the tone etc.
5. Check both earphones for absence of distortion and intermittency; check plugs and leads for intermittency.
6. Check that all the switches are secure and that lights and indicators work correctly.
7. Check that the subject response button works correctly.





Tests 8 to 11 should be carried out weekly.

8. Listen at low levels for any sign of noise, hum, or unwanted sounds. Check that attenuators do attenuate the signals over their full range and that attenuators are free from electrical or mechanical noise. Check that interrupter keys operate silently and that no noise radiated from the instrument is audible at the subject's position.
9. Check subject communication speech circuits, if applicable.
10. Check tension of headset headband. Ensure that swivel joints are free to return without being excessively slack. Check headband and swivel joints for signs of wear strain or metal fatigue.
11. Perform an audiogram on a known subject and check for significant deviation from previous audiograms (e.g. 10 dB or greater).

Further objective calibration will also need to be carried out by a specialist, see Appendix C for details.

9. References

Documents referenced below without dates are the versions shown as current on the appropriate website.

BSA Procedure for Processing Documents. British Society of Audiology
www.thebsa.org.uk

BSA Minimum Training Guidelines: Surveillance Audiometry (formerly Industrial Audiometry). British Society of Audiology www.thebsa.org.uk

BSA Recommended Procedure: Pure tone air-conduction and bone-conduction threshold audiometry with and without masking. British Society of Audiology
www.thebsa.org.uk

BSA Recommended Procedure: Ear Examination. British Society of Audiology
www.thebsa.org.uk





The Health & Safety Executive (2005) Controlling Noise at Work. The Control of Noise at Work Regulations 2005. Guidance on Regulations. Crown.

Appendix A. Standards relevant to surveillance audiometry

BS EN ISO 389-1: Acoustics. Reference zero for the calibration of audiometric equipment. Part 1: Reference Equivalent Threshold Sound Pressure Levels for pure-tones and supra-aural earphones.

BS EN ISO 389-2: Acoustics. Reference zero for the calibration of audiometric equipment. Part 2: Reference Equivalent Threshold Sound Pressure Levels for pure-tones and insert earphones.

BS EN ISO 389-4: Acoustics. Reference zero for the calibration of audiometric equipment. Part 8: Reference Equivalent Threshold Sound Pressure Levels for pure-tones and circum-aural earphones.

BS EN ISO 8253-1: Acoustics. Audiometric test methods. Part 1: Pure-tone air-conduction and bone-conduction audiometry.

BS EN 60645-1: Audiometric equipment. Part 1: Equipment for pure-tone audiometry.

Further information relevant to audiometric standards can be found on the National Physical Laboratory website: www.npl.co.uk.





Appendix B. Permitted ambient noise levels

To enable the accurate testing of normal air-conduction hearing threshold levels down to 0 dB HL, ambient sound pressure levels should not exceed any of the levels shown in the table below (this is a partial extract taken from BS EN ISO 8253-1).

Maximum permissible ambient sound pressure levels for measuring air-conduction audiometry (supra-aural earphones) to a minimum hearing level of 0 dB HL between test tone frequencies of 250 Hz and 8000 Hz.

Mid-frequency of 1/3 octave band (Hz)	dB re 20 µPa	Mid-frequency of 1/3 octave band (Hz)	dB re 20 µPa	Mid-frequency of 1/3 octave band (Hz)	dB re 20 µPa
31.5	66	250	19	2000	30
40	62	315	18	2500	32
50	57	400	18	3150	34
63	52	500	18	4000	36
80	48	630	18	5000	35
100	43	800	20	6300	34
125	39	1000	23	8000	33
160	30	1250	25		
200	20	1600	27		

Notes on ambient noise:

Insert earphones (e.g. Etymotic Research ER3 and ER5) and noise-excluding earphones (e.g. audiocups) will not require such stringent ambient noise levels as they reduce the amount of ambient noise reaching the ears, if they are fitted correctly. However, full details of the frequency-specific attenuation characteristics of these devices need to be considered (see BS EN ISO 8253-1), together with full details of the ambient noise, before tests can be carried out in environments that exceed the noise levels listed above. Further details can be found in the BSA Recommended Procedure: Pure tone air-conduction and bone-conduction threshold audiometry with and without masking.





Appendix C. Objective Calibration

In addition to the daily and weekly subjective calibration described in section 8.1, specialist objective calibration is required as described below.

Stage B: periodic objective tests

Stage B checks are objective tests which ideally should be performed every 3 months, although this period can be extended provided the Stage A checks are regularly and carefully applied and it can be shown that the equipment is stable and reliable. The maximum interval between checks should not exceed 12 months. They should preferably be carried out in the normal test room, with the equipment set up as installed, particularly if inter-connecting leads are used through a booth wall.

Measure and compare with the appropriate standards:

1. Frequencies of test signals
2. Sound pressure levels in an acoustic coupler or artificial ear from earphones
3. Attenuator steps over a significant part of the range
4. Harmonic distortion

Where necessary the audiometer shall be adjusted to compensate for any differences between its performance and the standards.

Stage C: basic calibration tests

Stage C checks need not be employed on a routine basis if Stage A and B checks are regularly performed. They will only be required when a serious error or fault occurs, or when, after a long period of time, it is suspected that the equipment may no longer be performing fully to specifications. It may be advisable to submit equipment for a Stage C check after, for example, five years' use if it has not received such a test in that time in the course of repair.





Stage C checks should be such that after the audiometric equipment has been submitted for a basic calibration, it shall meet the relevant requirements given in BS EN 60645-1. A suggested minimum requirement for a Stage C check would include all items covered at Stage B plus:

5. Rise and fall times of test tones
6. Interrupter effectiveness
7. Cross-talk between transducers and channels

Note:

If insert earphones are used, separate measurements at all three stages must be made for them. On some equipment it is possible to store two sets of calibration values, however for others it may be necessary to use correction factors for the second set of earphones.

