Back to basics – understanding audiometry calibration in the occupational setting

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Abstract

Faulty audiometry equipment will lead to an inaccurate test result being recorded. This paper provides the reader with information regarding the calibration of the equipment. Three different methods of calibration, namely electro-acoustic calibration, biological or subjective testing, and daily listening checks, are described. South African standards relating to the testing environment, particularly with respect to mobile testing facilities, are explained. Finally, information regarding record keeping and indications of faulty calibration is given.

Key words: audiometry, calibration, quality, audiometrist

Introduction

Audiometry testing is performed to determine an individual's hearing threshold at a given point in time and in occupational health the relevance is to determine if and when an employee may have hearing loss that is occupational in nature. The audiometry test is performed in varied settings which may influence the test results if these settings are not controlled. In addition equipment that is faulty will also lead to an inaccurate test result being recorded. The purpose of this is to provide the reader with information regarding the calibration of the audiometry equipment.

Calibration – why?

Calibration is defined as the process of measuring against a known standard.[1] In terms of audiometry, the reason for calibration is to verify that the tones and decibels being presented to the client from the audiometer are within the required parameters, i.e. that when 1000 Hz is presented to the client that the correct number of wavelengths are in fact generated. Regular calibration is vital since an un-calibrated audiometer may present inaccurate tones and/or decibels. This possible inaccuracy of the un-calibrated audiometer may in turn cause the person being tested to have an audiogram recorded that does not accurately represent their hearing threshold at that time.

Audiometer and headphones used to perform audiometry

Types of calibration

There are three different methods of calibration that must be completed on a regular basis and at predetermined intervals. These are commonly referred to as electro-acoustic calibration, biological or subjective testing, and daily listening checks.[2] Table 1 provides a summary of the different calibrations and checks as explained in SANS 8253-1.[2]

1. Electro-acoustic calibration

This calibration is performed annually by a person who has been suitably trained to do the test. The test is performed to verify that the Hertz and the decibels are correctly presented in terms of the number of wavelengths per second and the volume respectively. The calibration needs to be performed on an annual basis by a competent person and must be conducted according to the SANS 10154-1.[3] Some important points to remember when having this calibration performed follow.

- Ensure that the company/person performing the calibration is adequately trained and qualified. They should present you with a certificate to prove this and this certificate should be kept with the audiometer.
- Ensure the equipment used to calibrate the audiometer has been calibrated by an internationally traceable SANAS approved laboratory. The calibration equipment must have a valid certificate not older than 12 months.
- The person requesting the calibration should ask to see these documents to ensure they are using a suitable technician.

2. Biological or subjective testing

Biological calibration or subjective testing is the audiometrist's way of showing that the audiometer remains calibrated between the annual electro-acoustic calibrations. This check does not replace the annual electro-acoustic calibration and can be performed either on an individual (human subject) or on an electro-acoustic ear (OSCAR) as detailed in SANS 8253-1.[2] The three methods are described hereafter. Subjective testing performed with OSCAR instead of the human subject has the advantage that the ear is not

Table 1. Comparisons of the three forms of calibration as explained in SANS 8253-1[2]

	Type A	Type B	Type C
SANS 8253-1 title	Routine checking and subjective tests.	Periodic objective checks.	Basic calibration tests.
Common title	Daily listening checks and biological calibration.	Electro-acoustic calibration.	Factory calibration.
Interval	Daily and weekly (or as required for mobile testing).	Annual if A is done regularly.	When required i.e. after a major fault and audiometer found not calibrated.
Purpose	To ensure equipment is working correctly and calibration is not altered, and that attachments are free from defects.	To measure and compare results for frequencies and ensure decibels are within accepted standards.	To return equipment to calibration after a major failure.
Note	Subjective tests are very important. Ambient noise during a subjective test to be no worse than it would be at normal testing.	Recommended that a calibration check label be attached to indicate date of next objective check.	Only required when the equipment cannot be calibrated on site due to a major failure.

"The audiometry test is performed in varied settings which may influence the test results if these settings are not controlled."

affected by illnesses or other human related factors. The authors suggest two methods that can be followed when performing this check with the human ear.

2.1. Method 1 with human subject [2]

1. Switch the audiometer on and allow the unit to stand for 5 minutes to stabilise.
2. Ensure the person being used has normal hearing (threshold below 25 dB), is not ill or suffering from any illnesses that may affect the test results and has not been exposed to noise above 80 dB in the past 16 hours.
3. Place the left transducer on the person's left ear and run a standard audiometric test from the lowest to the highest frequency (e.g. 500 Hz to 8000 Hz.)
4. Record the results – either automatically or manually on an audiogram.
5. Once the left ear has been tested, remove the headset and swop the transducers around so that the right transducer is on the person's left ear and repeat the test.
6. Record the results again. Note that you are using the same ear to test both transducers and so you should get the same results.
7. Once the test is completed both audiograms should be within 10 dB of each other on all frequencies.
8. If the results differ by more than 10 dB at any frequency the audiometer must not be used until it has been recalibrated (electro-acoustic).

2.2. Method 2 with human subject [2]

The methodology is the same except for the following difference. Place the transducers on the subject's head as you would for a normal audiogram. Conduct a full audiogram in which the right and left ears are tested. The results of this audiogram are then compared to those of a previous audiogram for the same individual performed under the same circumstances (same audiometer, same booth, same ambient noise levels and same subject) and usually conducted within the past week. If the results differ by more than 10 dB the audiometer should be removed from operation until corrected as it is an indication that either the ambient noise levels are too high or that the audiometer is no longer calibrated.

2.3. Method with OSCAR [2]

- Immediately after the annual electro-acoustic calibration has been performed, place the headphones on the OSCAR and run a standard test – this will be the standard against which the future biological checks will be compared.
- Daily or weekly, depending on the volume of testing that is performed, run a biological test and compare the results to the standard that was initially recorded.
- If the results differ by more than 10 dB at any frequency then the audiometer must not be used until it has been recalibrated.

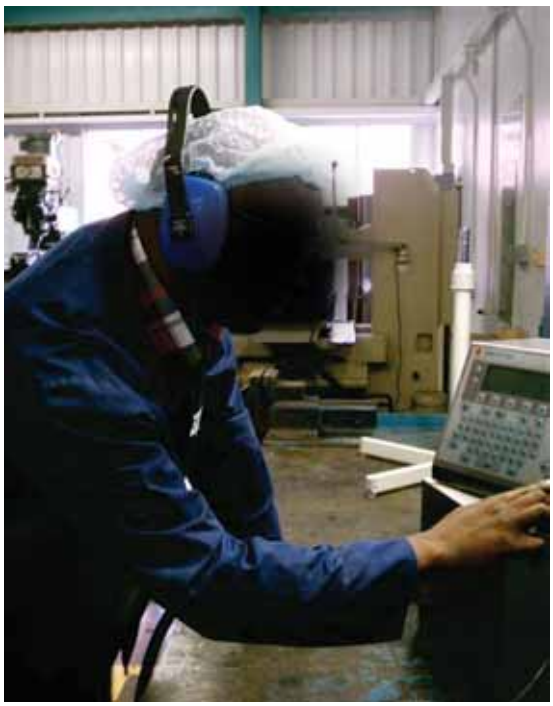
3. Daily listening checks

A daily visual and listening check should be performed on the audiometer.[2,3] The purpose of this inspection and check is to ensure the equipment is functioning correctly. The audiometrist will visually inspect the audiometer, headphones and booth and then listen to the tones and decibels. This is done after cleaning the audiometer and all accessories. The daily listening check methodology is explained hereafter.

3.1. Visual inspection

Visually inspect:

- the cables (power cable, headphone cable, patient response button and interface cables) for any signs of damage;
- the headband, cushions and transducers (earphones) for damage;
- the seal on the booth door for any sign that the seal is compromised;
- press the patient response button and check the light illuminates on the panel; and
- press the tone interrupt switch and check its light illuminates.



Employee wearing the correct hearing protection at work

3.2. Listening check

- Place headphone to your ear and listen. There should be no extraneous sounds heard.
- While still holding the headphone to your ear press the tone interrupt switch. Change the tone and press again. Work through all the frequencies and you should hear a change in the tone that is presented each time.
- Press the presentation button and listen. Make the sound level higher and ensure you hear the sound increase.

Should any of the above-mentioned components be damaged or faulty – it is advisable to contact the supplier of the equipment and the audiometer should be removed from service until it has been repaired or the faulty/damaged components have been replaced.

Testing environment

SANS 10182[5] requires that specific ambient (environmental) noise level criteria be met at each frequency (octaves from 125 Hz to 8 KHz) while an audiometry test is conducted. Testing outside a booth is acceptable if the ambient noise levels have been measured and conform to the requirements in SANS 10182[5] at each test. The reason a booth should be used is that the exposure to ambient noise can be better controlled if the client is sitting in a booth. A room may on the odd occasion meet the required criteria. However, there are many factors influencing the ambient noise levels which are then beyond the control of the audiometrist. Vibration from passing vehicles, fluorescent lights, air conditioners and computer fans are examples of factors that can influence the ambient noise levels. These factors can be better controlled if a booth is being used. Screening booths that meet this same standard are manufactured to ensure that unwanted noise does not enter the booth and that possible internal noise be absorbed within the acoustic materials of the booth.[5] The booth is certified annually to ensure that the attenuation meets the requirements of SANS 10182.5 This verification is then stated in the calibration certificate. If one is not using a booth then the ambient noise levels need to be carefully monitored. This is difficult as well as expensive since the only correct method is to use a Type 1 Sound Level Meter with an octave filter.

Mobile test facilities

For the purposes of screening occupational audiometry, it is not always possible to bring the client to a fixed site clinic for testing. For that reason, it is now common practice to set up a mobile audiometry testing facility and move this to different locations in order to perform the audiometry on the client's premises. In such cases, it is just as important that the audiometrist can verify the calibration at the time of testing and that the journey to the testing site has not affected the calibration of the equipment. SANS 10154 (Annexure A) addresses the calibration of mobile equipment for use at different testing sites.[3] In addition to the usual registration of the audiometrist, it is also essential that the organisation register with the Department of Labour and or the Department of Minerals and Energy.[3]

Calibration requirements

The relevant standard stipulates that the audiometer be mounted on an anti-vibration platform, stays within the calibration specifications and the design specific SANS 10182[5] requirements, and that subjective testing is carried out before the audiometer is used. The standard refers to a calibration interval and stipulates that the equipment should be electro-acoustically (EA) calibrated at its original site (e.g. the depot) and must have another EA calibration performed on its return to the original site or within three months whichever is the shortest.

Practical application

Practically this would mean that the audiometer must have the EA calibration and a subjective or biological calibration done at the depot.[3] The subjective or biological calibration must be performed immediately after the EA calibration at the site where the EA was performed. When it arrives at the testing site, a subjective calibration must be repeated and compared to the subjective test performed at the original site. If this calibration fails, the EA calibration would then need to be repeated. If the calibration passes then the equipment is ready to be used to record audiograms. It is important to keep the subjective test as a record of this calibration check. It is thus not necessary to perform the EA at the testing site if the subjective calibration passes as long as the requirements of SANS 10154-1 Annexure A[3] have been adhered to.

A booth and audiometer set up in a fixed site clinic

"The reason a booth should be used is that the exposure to ambient noise can be better controlled if the client is sitting in a booth."

Points for mobile testing

- The equipment must be set up as far away as possible from any noise source i.e. generators, compressors, mills, etc.
- The operator should carefully listen for any possible external noise disturbances that may adversely affect testing.
- Perform a biological calibration, as described earlier in this article, before actual audiometry testing commences and upon completion.
- An OSCAR is recommended for this purpose as it will not be affected by onset of cold or flu or a possible temporary threshold shift as seen in a human subject.

Record keeping

All records need to be kept for a period of 40 years.[4] It is essential that the records be kept in case of dispute. It is also the authors' recommendation that a copy of the calibration records be given to the client with the audiometry results to facilitate verification of calibration status.

Things to remember

1. Calibration is not affected by changing headphone cables. However, never inter-change headphones between booths (multiple testing systems). Do not swap headphones between audiometers without calibrating the audiometer with the new headphones before testing.
2. The headphones are calibrated to a specific audiometer and cannot be exchanged without re-calibrating with the new headphones again.
3. The transducers have a unique serial number which must be recorded on the calibration certificate.
4. Patient response buttons can be interchanged without affecting the calibration.

Indications of faulty calibration

Generally the audiometer and transducers are reliable, the most common faults are with broken headphone cables and broken/faulty patient response buttons. Table 2 presents some common problems that may be experienced and a possible cause and solution for each. These faults and solutions have been identified by the authors and are based on their experience in audiometry. Some practical tips to prevent downtime with your audiometer are:

- many of the faults can be avoided by installing a Uninterrupted Power Supply (UPS); and
- keeping a spare headphone cable and patient response button will reduce downtime due to broken cables and these are inexpensive items.

Conclusion

The quality of the audiogram will be influenced by the calibration of the equipment. In order to make effective use of available resources it is important to ensure that all testing meets minimum standards and complies with the applicable SANS standards. In this way, a situation will be created where the audiogram recorded is a true reflection of hearing acuity where the client has been cooperative.

Table 2. Some common faults, possible causes and solutions.

Fault	Possible cause	Possible solution
Display screen does not light up.	No electricity supply.	Check equipment is plugged in to a working wall socket. Audiometer fuse may have blown, get supplier or qualified electrician / technician to check and replace fuse.
The tone is very soft.	The interconnecting cables (between audiometer and booth) may have dust or condensate (common at coastal and high humidity areas) between the contacts.	Carefully withdraw and re-insert one cable at a time – perform several times per cable. If problem still persists, clean the plug with an alcohol swab or contact cleaner.
	The headphone cable may be broken or damaged.	Replace the faulty cable with a new cable. When replacing cables do not over-tighten the small screws as it is almost impossible to remove a broken screw in the transducer (speaker).
There are sounds heard in the headphones when no signal is presented.	Possible fault on the audiometer tone generator.	Contact the audiometer supplier for assistance.
The tone is intermittent.	The headphone cable may be broken or damaged.	Replace the faulty cable with a new cable. When replacing the cable do not over-tighten the small screws.
There is no response from the patient.	The patient response button may be faulty.	Replace the faulty response button with a new response button.
	The patient response interconnecting cable (between audiometer and booth) may be faulty.	Replace the faulty cable or contact the audiometer supplier.

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