Portable Audiometer Calibration System

Type 9729-W-011

... Easy, flexible and reliable

PRODUCT DATA

The Type 9729-W-011 Portable Audiometer Calibration System is an easy, flexible and reliable solution for automated calibration of audiometers to IEC and ANSI standards.

The system performs the tasks ranging from basic standard audiometer testing with fully automated procedures to advanced customized tests.

Audiometer certification is the primary focus, but the system is designed to accommodate the everyday needs of hospitals and clinics as well as those of calibration and metrology laboratories. Other fields of use are audiometer research & development and factory production testing.

The system is build around the powerful sound level meter and analyzer Type 2250. It utilizes the precision of this Class 1 measuring instrument and experience in calibration to provide simplicity of use.

The Type EN-2252 software with integrated database takes care of test procedure execution as well as all house-keeping data including client e-mail reminders for next calibration.

The calibration system is not limited to any specific brand or type of audiometer, but can calibrate any audiometer that complies with relevant ISO standards.

The interface with the variety of audiometers is secured by using Brüel & Kjær family of top-class couplers, such as 2cc Click-on Coupler Type 4946, the artificial ears Type 4152 or 4153 and the artificial mastoid Type 4930. The system can be configured for in-house calibration services or production tests as well as for use in the field, without compromising neither accuracy nor stability.

Uses and Features

Uses

- Calibrate any type of audiometer fulfilling IEC 60645 and ISO 389 series standards as well as ANSI/ASA S3.6 and S3.7.
- Calibrate Headphones, Inserts, HF phones, Bone Oscillators and Tympanometers
- Free field calibration (audiometry test room)

Features

- Calibration procedures based on international standards for air conductive and bone conductive transducers.
- Multiple test procedures.
- Semi- or fully automated procedures execution.
- Automatic correction for microphone and artificial mastoid sensitivity deviations.
- Data on operators, customers, audiometers, tests and test equipment is managed in one database.
- Data can be retrieved by a range of query parameters.
- Tracking of calibration equipment inventory and calibration date.
- Audiometer adjustment instructions
- Customized calibration reports
- Calibration reminder via e-mail.

Calibration..?

The basic aim of acoustic audiometer calibration is to define the audiometric zero for the chosen earphone. This can be performed using human volunteers or an artifical ear.

There are different types of audiometer output transducers:

1. Ear phones
2. Bone vibrator
3. Loud speaker (free-field)

Output transducers for audiometers cannot be replaced or changed without calibrating the whole equipment.

Calibration of the audiometer involves calibration of the audiometer proper, of ear phones, and of bone vibrators.

The calibration procedure and set-up for bone vibrators is the same as for earphones except for the basic measuring device.

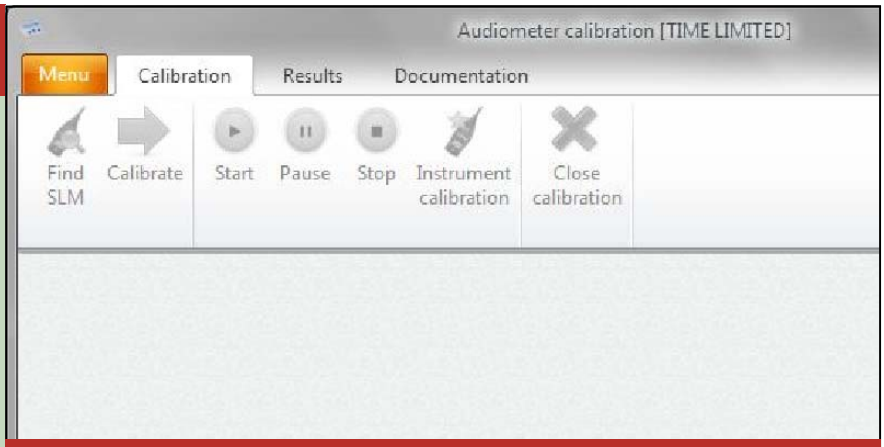


Figure 1.
Main menu of the EN-2252 software —a simple and intuitive user interface with all functionalities

Audiometer Calibration

The purpose of any calibration measurement is to check that the measurement equipment is measuring correctly. Regular testing and calibration of an audiometer is required to maintain maximum measurement accuracy.

For absolute acoustic calibration the audiometer should be calibrated using an artificial ear, a special measuring microphone designed for that purpose and a known sound pressure level.

Accurate and reliable measurements are fundamental to characterise and quantify hearing loss, and consequently for selection of hearing aids and for general health and safety monitoring. Prober calibration ensures that the measurements are consistent, no matter where the they are carried out.

The system calibrates audiometers using an ear simulator system. It includes an artificial ear for testing air-conduction hearing mechanisms. This device consist of a calibrated microphone with an associated coupling volume open on one side allowing application of headphones when testing.

For testing bone-conduction hearing mechanisms, an artificial mastoid is utilised. This device uses a series of rubber layers to couple the bone-vibrator to a force transducer. The device mimics the way in which sound is transferred through the mastoid part of the human temporal bone to which the bone-vibrators are applied when testing.

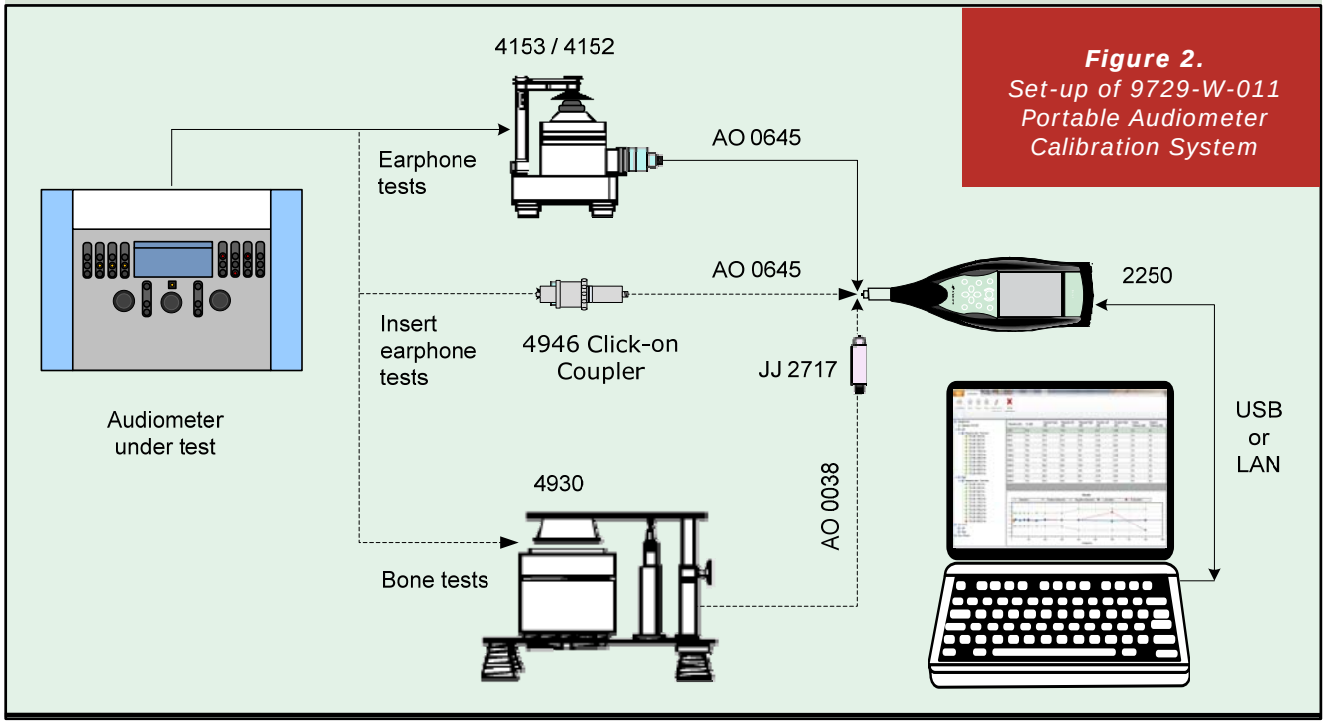


Figure 2.
Set-up of 9729-W-011 Portable Audiometer Calibration System

System Instrumentation

The calibration system is based on Hand-held Acoustic Analyzer Type 2250 and the Audiometer Calibration Software Type EN-XXXX.

Acoustic Analyzer

The 9729-W-011 Portable Audiometer Calibration System is based on the Type 2250 Hand-held Acoustic Analyzer. Type 2250 is a compact and robust hand-held instrument, which can host a number of software modules.

Sound Calibrator

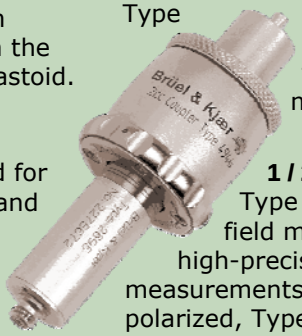
Sound Calibrator Type 4231 is a pocket-sized, battery operated class 1 sound source. The calibration frequency is 1000Hz (the reference frequency for the standardised international weighting networks) with a calibration pressure of 94 ±0.2 dB re 20 µPa is equal to 1 Pa or 1N/m2.

Artificial Mastoid

Artificial Mastoid Type 4930 is designed for the calibration of bone conduction hearing aids and bone vibrators used in audiometry. It mechanically simulates the human head, incorporating a built-in force transducer to monitor the output of the device to be calibrated. The artificial mastoid ensures longterm stability and accurate correspon-dence with the mechanical characteristics of the human mastoid.

Coupler

Type 4946 2 cc Click-on Coupler is intended for measurements on all types of headphones and hearing aids. The design is optimised for quick and easy use in the laboratory and the field. It fulfils the requirements of the ANSI S3.7 (1995) and IEC 60318-5 (2006) standards. A wide range of ear-mould simulators click on to the coupler body, making changing to different headphone or hearing-aid designs easy.



Artificial Ear

Artificial Ear Type 4153 fulfils the requirements of IEC 318 and has an acoustical impedance basically similar to that of the human ear and allows circum-aural earphones calibration. The acoustic coupler contains three volumes (*V*1 = 2.5cm3, *V*2 = 1.8cm3 and *V*3 = 7.5cm3) acoustically connected in parallel by means of a narrow annular slit and four parallel holes.
The Artificial Ear Type 4153 consist of an acoustic coupler, a main housing containing the sockets for the connection of a condenser microphone and a base plate with a mechanism for clamping the object being tested. The Artificial Ear is isolated from shock and vibration by means of three soft rubber feet.

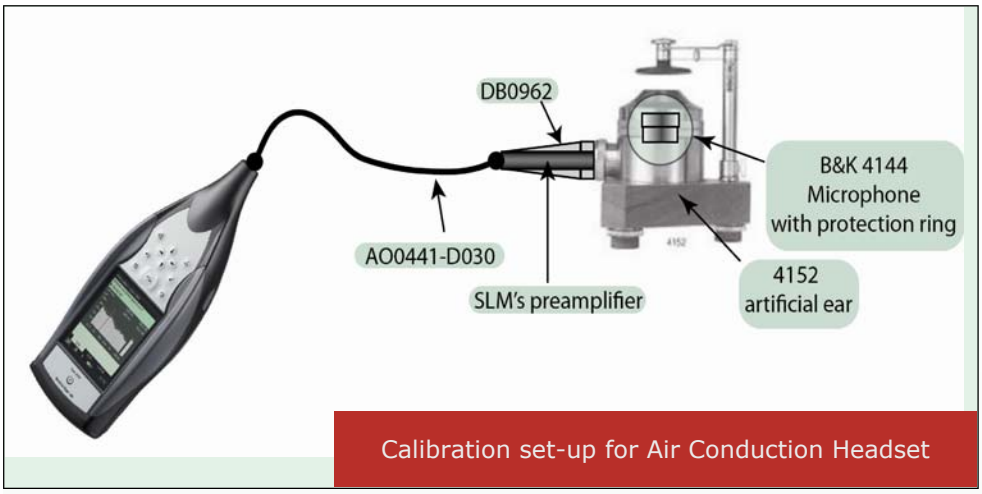
Artificial Ear Type 4152 has been designed for measurements in the audiometric and related fields. The primary function is the calibration of supra-aural earphones used in audio-metry in complaince with IEC 60318-2.

1" Microphone

Type 4144 is a 1" pressure-field microphone and the pressure frequency response is flat over a wide frequency range. Hence no correction is needed to the pressure response below 8 kHz. The use of pressure-field microphones is recommended where measurement of the local pressure is of interest, for instance for coupler measurements. The stability of Type 4144 combined with its low inherent noise and high sensitivity makes it the perfect choice for coupler measurements.

1/2" Microphone

Type 4192 is a ½" pressure-field microphone designed for high-precision coupler measurements. Being externally polarized, Type 4192 must be used with a classical preamplifier. Externally polarized microphones may be used at higher temperatures without severe changes in sensitivity.



Calibration set-up for Air Conduction Headset

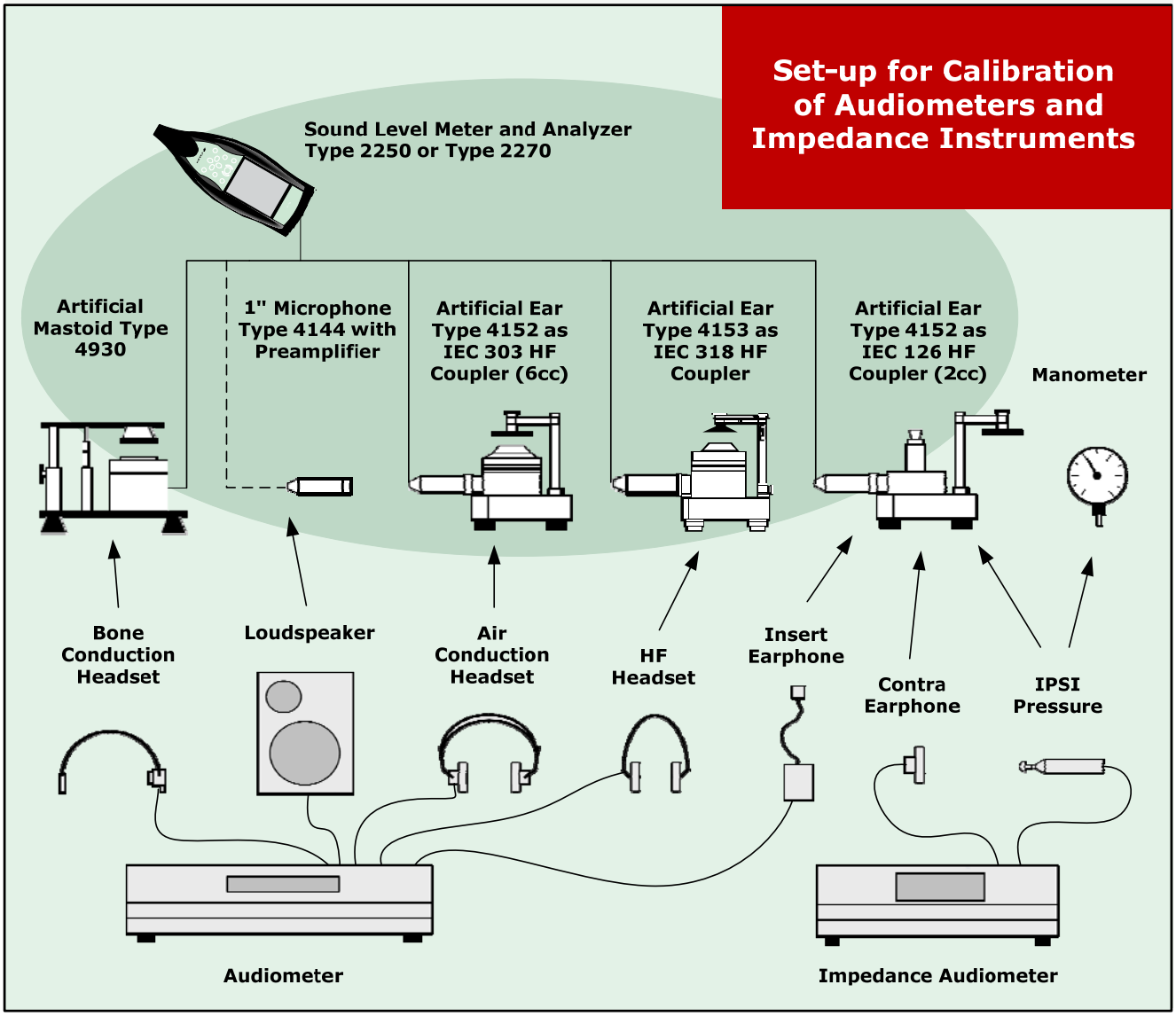
Coupling the earphone

Acoustic calibration consists of measuring the output of the earphones using a standardized microphone inside a standardized coupler called an Artificial Ear. As it is important to calibrate down to low hearing thresholds, Octave or One-Third Octave Band Filters are used to reject ambient noise picked up in the coupler. The Artificial Ear Type 4152 comes complete with both 6cc and 2cc coupler, pre-amplifier, micro-phone, and adaptor to 1 inch and ½ inch microphones. The unique ½ inch microphone adaptor design enables very easy and safe calibration of the coupler.

Simply unlock the adaptor and pull out the ½ inch microphone, with grid and preamplifier, and mount it in Sound Calibrator Type 4231 or any other Brüel & Kjær acoustic calibrator. When using a 1" microphone, the microphone protection grid must be mounted before calibration.

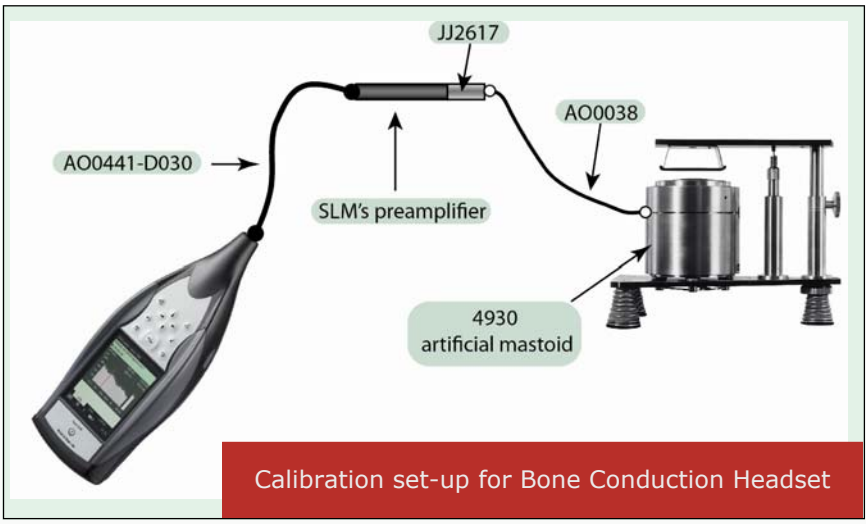
It is important to ensure that

Set-up for Calibration of Audiometers and Impedance Instruments



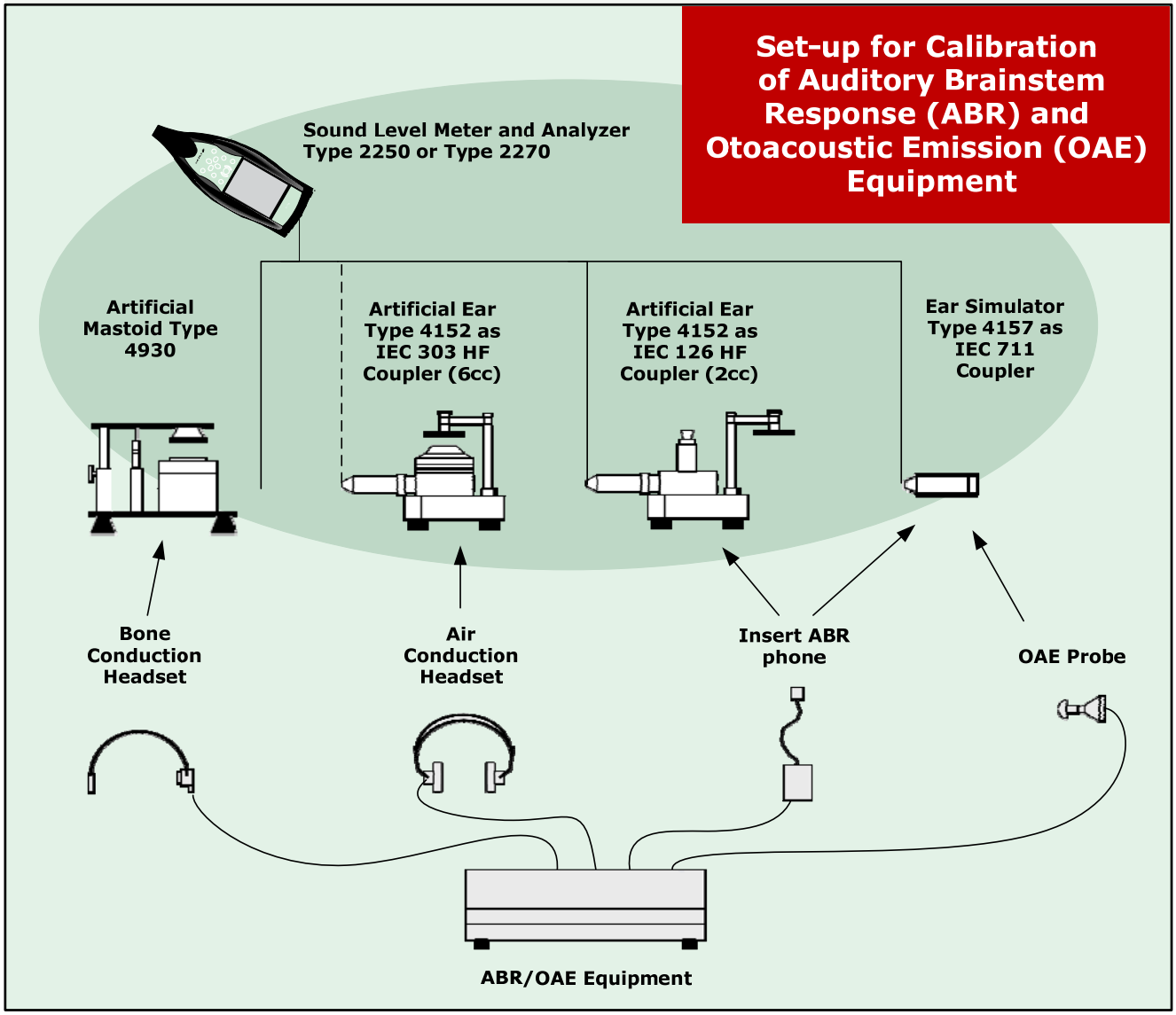
the earphone is well coupled to the sound level meter and that there are no leaks that would cause inaccurate sound pressure level readings. The earphone and weight should be placed on the coupler. The audiometer should be set to produce a continuous signal at 70 dB HTL at the lowest test frequency (125 Hz on clinical audiometers, 250 or 500 Hz on type 3 or 4 pure-tone airconduction audiometers).

The earphone is then adjusted on the coupler to produce the highest sound pressure level reading on the sound level meter. Then the earphone and weight are removed and the process is repeated. The same reading should be obtained. If so, the earphone should remain on the coupler for the rest of its calibration. If not, the earphone and weight should be removed and the process should be repeated until a sound pressure level reading is duplicated on successive placements and adjustments.



Calibration set-up for Bone Conduction Headset

Set-up for Calibration of Auditory Brainstem Response (ABR) and Otoacoustic Emission (OAE) Equipment



Easy, flexible, & reliable

The 9729-W-011 Portable Audiometer Calibration System:

- reduces typing errors by avoiding manual data entering
- reduces the time needed for audiometer calibration
- prevents errors caused by incorrect or ignored corrections for microphone or mastoid

The system includes a professional database for:

- Customers
- Audiometers
- Procedures
- Reports
- House keeping data
- Instrumentation
- Corrections and reference values

Audiometer Calibration in 9 simple Steps...

Step 1: System Set-up

The 9729-W-011 Portable Audiometer Calibration System comes in a robust and handy carrying case containing all instruments, cables and adaptors needed for testing and calibrating audiometers—all needed in addition is a PC and a USB or LAN connection.

The calibration system is set-up by connecting the relevant components and the instrument to be calibrated into a measurement chain. The audiometer under test is connected via LAN or USB interface.

The set-up is configured according to the options of the system (and optional accessories at hand) and to the tests to be performed (see figure 2 and 3).

From unpacking to reporting a basic calibration—including system calibration—only takes 10 minutes.

Step by step the calibration software guides the operator through the preparation procedure—all in an intuitive and logical order. During calibration only the audiometer is operated by the calibration technician—the 2250 is controlled from the software.

Step 2: Client Data

Data management is a critical part of the calibration process and a strong feature of the calibration software. Measurement data, reports, customer data, inventory data, audiometer data, procedures, corrections for headphones, vibrators, microphones, mastoids and operators are handled by a SQL database.

It is of major benefit to have all data stored in a well-defined and organised form, which facilitates retrieval, editing and updating. An additional safety feature is the regular software notification to produce a database back-up—in case of computer failure all data are preserved.

Prior to starting the actual calibration, the operator must enter customer information, select calibration procedure and specify the instruments used. Client and associated audiometer is selected from the database. If the customer does not already exist in the database, information is entered, in-

cluding audiometer and accessories data such as type, serial-number etc.

The acoustic analyzer is recognized by its serial number and even more importantly by installed software (Active Template). The most frequently used standardised headphones and vibrators are available in the database as default. Additional equipment can be added by the user and correction values entered as required.

Microphone and mastoid calibration corrections can be imported from a USB key or entered manually. An example of a correction graph is seen in figure 5.

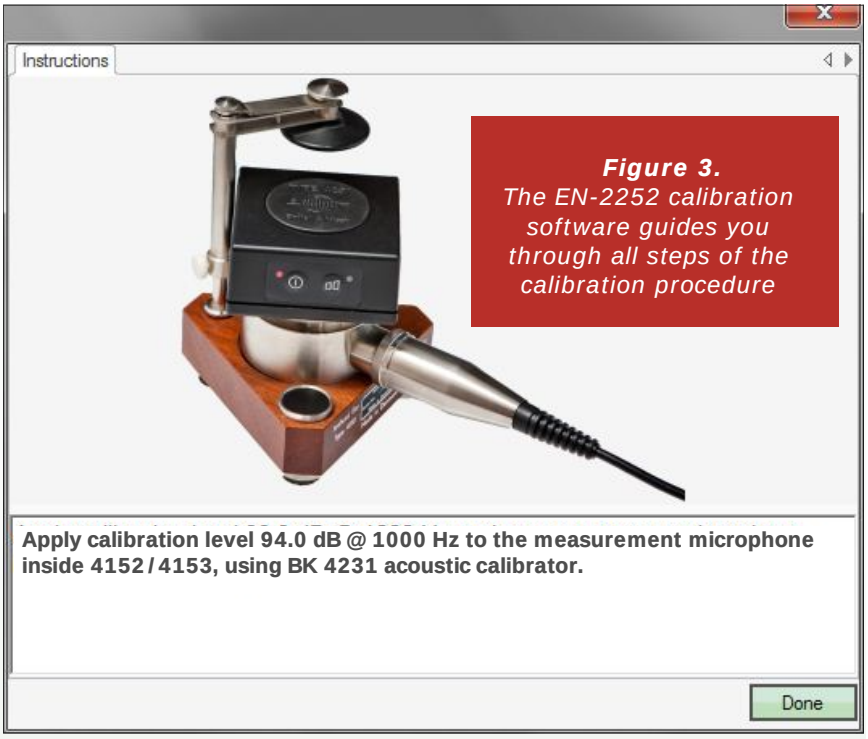


Figure 3.
The EN-2252 calibration software guides you through all steps of the calibration procedure

Step 3: Procedure

An audiometer calibration task incorporates several tests to be selected depending on the type of audiometer. All acoustic admittance instruments use a probe tone that must be calibrated for at least frequency, SPL and distortion.

The operator can select from a range of tests:

- Pure tone (Air and Bone conduction level)
- Masking level (Narrow band)
- Masking level (Broad band)
- Attenuator linearity
- Frequency
- Total Harmonic Distortion (THD)
- Narrow band cut-of frequencies and bandwidth
- Rise Time / Fall Time
- Free-field calibration
- Tympanometer calibration

One, more or all supported tests can be included in the calibration task. Several tests can be merged into one procedure (e.g. Pure tone first, Insert second and Mastoid third).

Each set of tests is user-defined—the operator can select the frequencies at which the tests are to be executed. All tests are compared to limit values defined by the user (in reference to standards in question).

Corrections for used transducer (microphone and/or mastoid) are automatically read from the database and taken into account for calculation of the expected result.

All calculations are performed by the calibration software and presented in a table as well as graphically to provide overview.

During pure tone level calibration, THD and frequency are simultaneously measured and calculated.

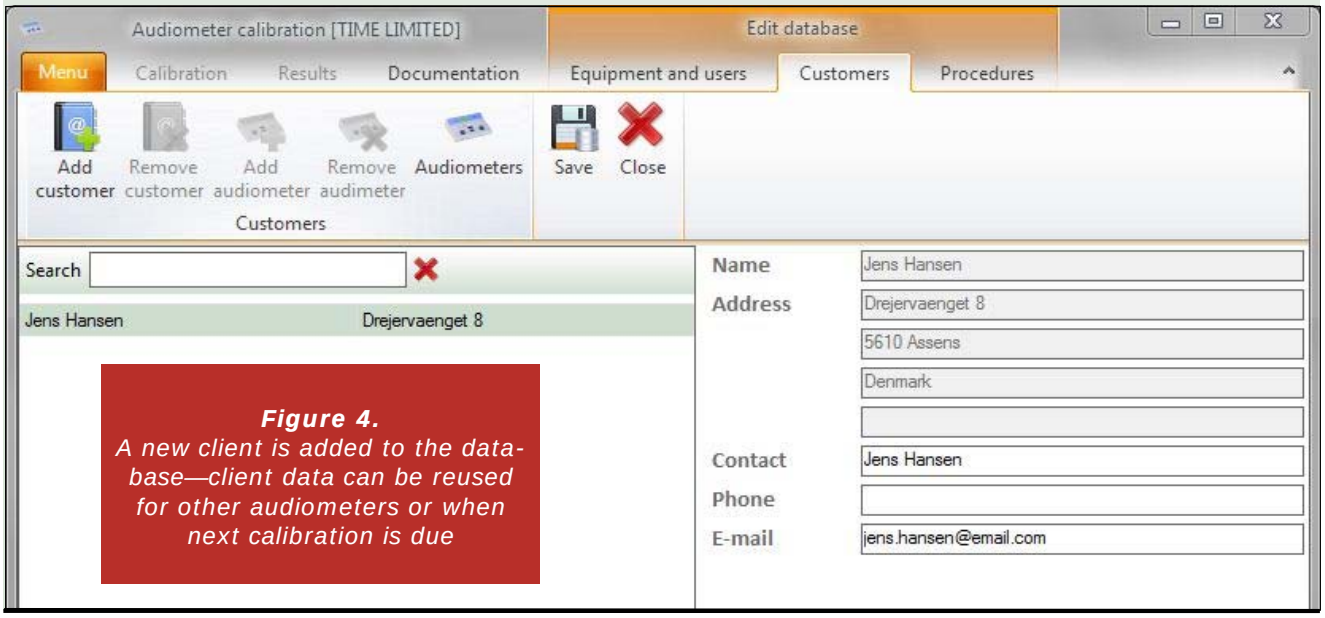


Figure 4.
A new client is added to the database—client data can be reused for other audiometers or when next calibration is due

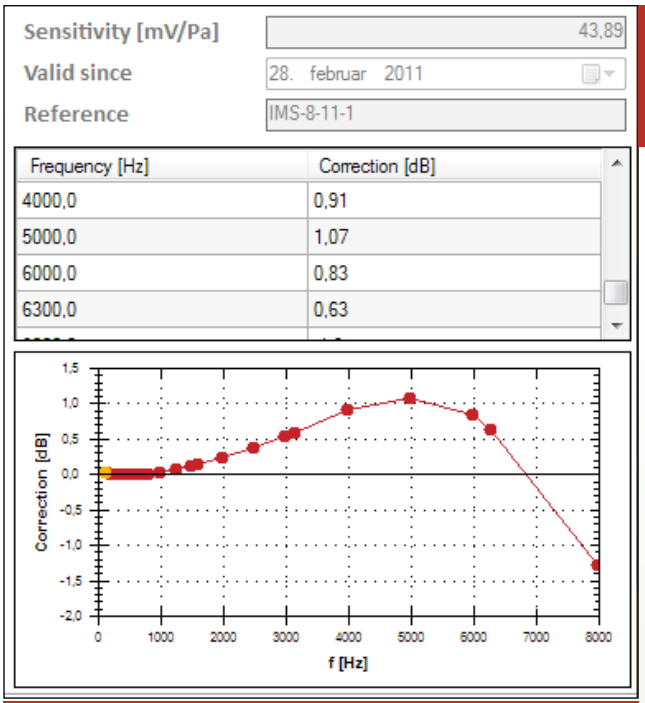


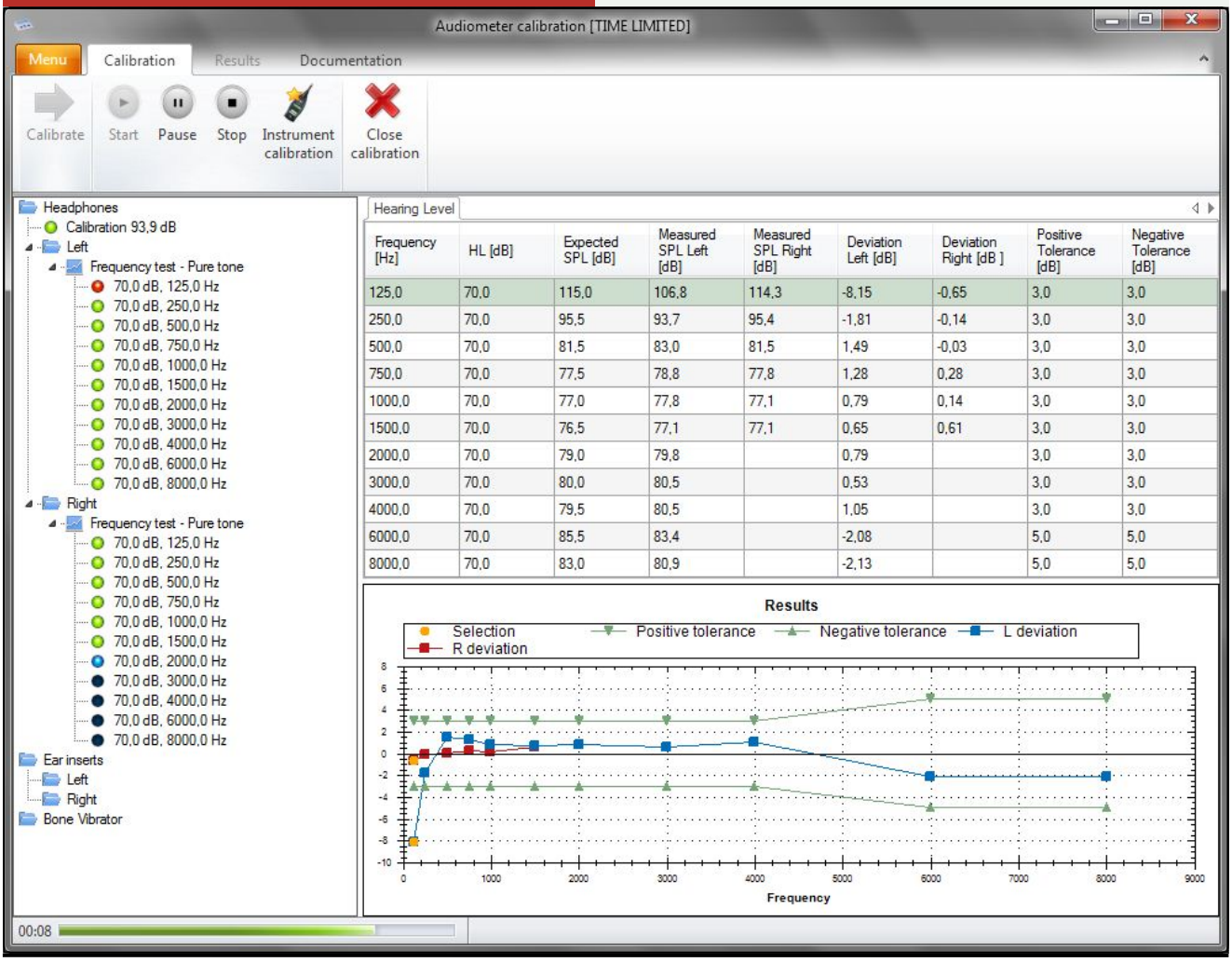
Figure 5.
Microphone calibration corrections example —Brüel & Kjær Type 4144

Step 4: Atmospheric Data
The environmental conditions of the calibration have to be documented. The levels of temperature, air humidity and air pressure are entered and will be included in the final calibration report. These data can be obtained from public sources.

Step 5: System Calibration
Traceability of measurement results is an integral part of the calibration procedure. Traceability is obtained by measurement chain calibration at the beginning of each audiometer calibration. Type 4231 is used as the reference sound source producing 94dB at 1kHz—the software automatically includes corrections for microphone and mastoid obtained from an independent calibration laboratory. The microphone chain sensitivity correction value is defined and saved for each completed calibration. The EN-2252 Software constantly monitors the validity of calibration equipment in use.

Calibration can start as soon as these conditions for correct calibration documentation are fulfilled.

Figure 6.
Audiometer calibration in progress - coloured dots indicate measurement status



Steps 6, 7 & 8: Calibration

When all relevant data are in the database, it is only a matter of selecting the calibration equipment and the audiometer to be tested, and calibration is started.

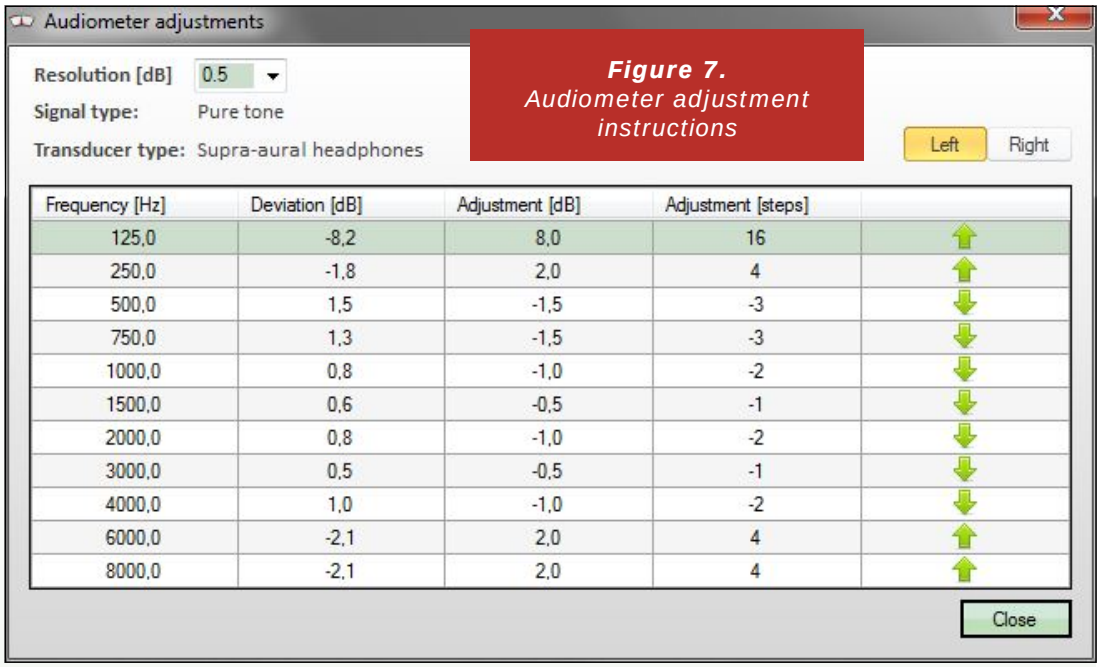
The calibration of an audiometer is performed in three steps:

1. *Calibration* - deviations are calculated: the difference between expected values and measured values.
2. *Adjustment* - the audiometer is adjusted to meet expected values.
3. *Recalibration* - the audiometer is calibrated once more to ensure the correctness of the adjustment.

Online guidance eases the calibration and prevents the operator from missing important steps or taking incorrect actions. Each time the operator needs to intervene while calibration is in progress, a window with clear and instructive information will appear.

Any deviation exceeding limit value displays an information window with the options to repeat or accept the result. Results which are out of tolerance limits get red light in front of the step in question. During semiautomatic calibration, only the audiometer is operated by calibration technician. Intervention with Type 2250 is not needed at all—it is controlled from the software.

The calibration software constantly monitors the calibration validity of client audiometers and automatically sends out a notice on expired calibrations at start-up or on request.



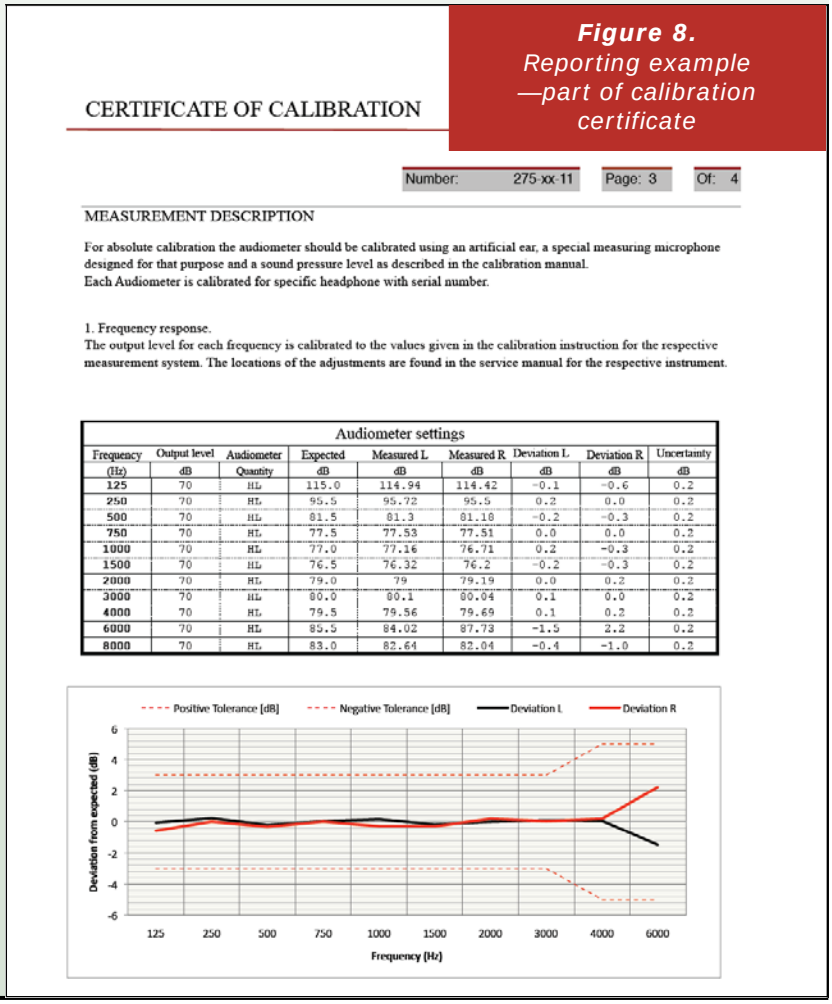
Frequency [Hz]	Deviation [dB]	Adjustment [dB]	Adjustment [steps]
125,0	-8,2	8,0	16
250,0	-1,8	2,0	4
500,0	1,5	-1,5	-3
750,0	1,3	-1,5	-3
1000,0	0,8	-1,0	-2
1500,0	0,6	-0,5	-1
2000,0	0,8	-1,0	-2
3000,0	0,5	-0,5	-1
4000,0	1,0	-1,0	-2
6000,0	-2,1	2,0	4
8000,0	-2,1	2,0	4

Figure 7. *Audiometer adjustment instructions*

Step 9: Reporting

Calibration results are saved in the database and available for creating report or just to be viewed on the screen. A query function provides capability to retrieve only the calibrations fulfilling specific criteria.

Selected calibrations can be examined on the screen or sent to Excel or Word using either a predefined or customer defined reporting template.


CERTIFICATE OF CALIBRATION

Number: 275-xx-11 Page: 3 Of: 4

MEASUREMENT DESCRIPTION

For absolute calibration the audiometer should be calibrated using an artificial ear, a special measuring microphone designed for that purpose and a sound pressure level as described in the calibration manual.
Each Audiometer is calibrated for specific headphone with serial number.

1. Frequency response.
The output level for each frequency is calibrated to the values given in the calibration instruction for the respective measurement system. The locations of the adjustments are found in the service manual for the respective instrument.

Audiometer settings

Frequency (Hz)	Output level dB	Audiometer Quantity	Expected dB	Measured L dB	Measured R dB	Deviation L dB	Deviation R dB	Uncertainty dB
125	70	HL	115.0	114.94	114.42	-0.1	-0.6	0.2
250	70	HL	95.5	95.72	95.5	0.2	0.0	0.2
500	70	HL	81.5	81.3	81.18	-0.2	-0.3	0.2
750	70	HL	77.5	77.53	77.51	0.0	0.0	0.2
1000	70	HL	77.0	77.16	76.71	0.2	-0.3	0.2
1500	70	HL	76.5	76.32	76.2	-0.2	-0.3	0.2
2000	70	HL	79.0	79	79.19	0.0	0.2	0.2
3000	70	HL	80.0	80.1	80.04	0.1	0.0	0.2
4000	70	HL	79.5	79.56	79.69	0.1	0.2	0.2
6000	70	HL	85.5	84.02	87.73	-1.5	2.2	0.2
8000	70	HL	83.0	82.64	82.04	-0.4	-1.0	0.2

Figure 8. *Reporting example —part of calibration certificate*

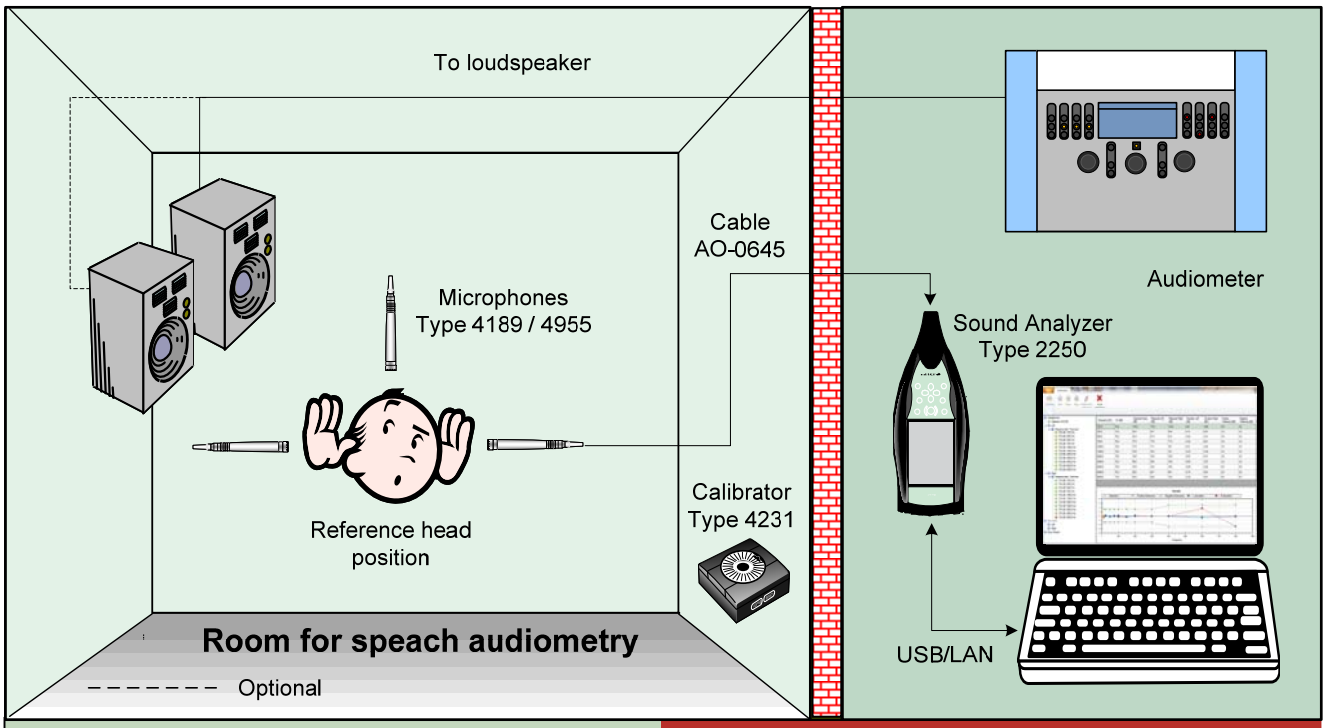


Figure 9.
System set-up for free-field audiometer calibration or audiometric test room / booth verification.

Free Field calibration

Pure tone audiometry deliver and important information related to the loss of human ear sensitivity. It is a good indicator for the candidates for hearing aid.

However, practice has proven that just increasing the hearing sensitivity is far from satisfactory as the reasons for hearing impairment can lie in different sections of the hearing chain. Therefore it is necessary to conduct another test which reveal not only what sound a person can detect, but more important how much this person can actually understand—a speech audiometric test.

When speech audiometry is conducted in a test room or booth using loudspeakers exact conditions for the test must be provided. It is important to check and calibrate the sound level at the reference point (the point where the head of the test person is), check and calibrate the homogeneity of the sound field around reference point, measure THD, linearity and frequency response of the audio system.

The loudspeaker should be head-height of the seated listener, and directed towards the reference point. In absence of the test subject the sound pressure levels 0.15 m above, below and to the left and right of the reference point should not vary by more than 1 dB from those predicted by the inverse square law.

Mesurements for free or quasi-free sound fields are specified by ISO 8253-2. The standard describes the characteristics of free-field and diffuse field characteristics and the procedures and conditions of use for sound field audiometry.

Tympanometers - Impedance audiometers

Impedance is measured by using a probe to present a sound of 226 Hz. into a cavity like the human ear. This produces different SPLs depending on the volume of the cavity of the ear. By measuring the SPL, the equivalent volume can be established, and by tracking the changes in SPL, the equivalent changes in the cavity can be identified

The tympanometer should be tested regularly as the probe is very fragile and possible impact on the transducer will affect measurements. The complete system has to be calibrated at least once a year.

The calibration is divided into two parts:

1. The instrument itself, which includes the air system
2. The software, which involves adjustments of different parameters via soft keys.

The EN-2252 software guides the operator through the specific tympanometer calibration process: probe calibration, compliance and reflex, manometer and Ipsilateral Pure Tone level. The calibration also includes the parameters that apply for Pure Tone Audiometers (linearity, frequency, THD etc).

The technical requirements for tympanometers are specified in IEC 60645-5 and for the acoustic part in IEC 60645-1. Calibration and test procedures are specified in IEC 1027 and ANSI S3.39 - 1987.

Standards:
EN-2252 Audiometer Calibration Software and Sound Analyzer Type 2250 conforms with the relevant parts of the following standards:

- IEC 60645-1:2001 Electroacoustics - Audiological equipment - Part 1: Pure-tone audiometers
- ANSI/ASA S3.6-2010 Specification for Audiometers
- ISO 389 Acoustics - Reference zero for the calibration of audiometric equipment
- IEC 60318-3 1998 Electroacoustics - Audiological equipment - Acoustic coupler for the calibration of supra-aural earphones used in audiometry
- ANSI S3.39-1987 (R 2007) Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance)

Calibration and test procedures are specified in:

- ISO 8253-1:2010 Acoustics - Audiometric test methods - Part 1: Pure-tone air and bone conduction audiometry
- ISO 8253-2:2009 Acoustics - Audiometric test methods - Part 2: Sound field audiometry with pure-tone and narrow-band test signals
- ISO 8253-3:1996 Acoustics - Audiometric test methods - Part 3: Speech audiometry
- IEC 60645-5:2004 Audiometric equipment - Part 5: Instruments for the measurement of aural acoustic impedance/admittance.
- ANSI/ASA S3.7-1995 (R 2008) Method for Coupler Calibration of Earphones

Calibration options:
The calibration options available with this Portable Audiomter Calibration System based on Brüel & Kjær Types 2250 or 2270 can cover:

- Pure tone (Air and Bone conduction level)
- Masking level - Narrow band (BZ-7230)
- Masking level - Broad band
- Attenuator linearity
- Frequency (BZ-7230)
- Total Harmonic Distortion (BZ-7230)
- Narrow band cut-of frequencies and bandwidth (BZ-7230)
- Rise Time / Fall Time
- Free-field calibration (BZ-7230)
- Tympanometer calibration (Manometer required)

ORDERING INFORMATION

9729-W-011 Calibration System using Supra-aural Earphones

- 2250-B - Hand Held Analyzer with Sound Level Meter and Frequency Analysis Software
- 4153 - Artificial Ear / Ear Simulator (IEC 60 318 coupler without microphone & preamplifier)
- 4192 - 1/2" Pressure-field Microphone, 3Hz to 20KHz, 200V Polarization
- AO-0645-D-100 - Cable, Microphone, circular-1B 7-pin (F) to circular-1B 10-pin (M), 10m (33.3ft),max.+90°C (194°F)
- 4231 - Sound Calibrator Class 1 and LS, 94 and 114 dB, 1 kHz
- BK-XXXX - Suitcase/transportation case
- EN-2252 - Audiometer Calibration Software
- 4946-Q-002 - 2CC Click-on Coupler for QC w/o microphone and preamplifier
- DB-3869 Ear Plug Simulator with Tube Stud for BTEs

9729-W-012 (9729-W-011 Calibration System with add-ons for Bone Vibrators)

- 4930 - Artificial Mastoid
- JJ-2617 - Input adaptor,1/2" microphone to microdot
- BZ-7230 - FFT Analysis Software
- AO-0038-D-005 - Cable super low-noise,10-32 UNF (M) to 10-32 UNF (M),0,5m (1,7ft),max.+250°C (482°F)

Optional

- 4152 - Artificial Ear / Ear Simulator (6cc coupler without microphone & preamplifier)
- 4144 - 1" Pressure- field Microphone, 3Hz to 10KH,200V Polarization
- Pressure meter
- Tube kit
- 4955 - ½" Low Noise Microphone system 5Hz to 20kHz, External Polarized
- ZE-0948 - USB Audio Interface

Portable Audiometer Calibration System

Type 9729-W-011

Benefits:

- Truly portable—easy to carry
- Easy to use—no special skills required
- Automated calibration and reporting
- On-line calibration instructions
- Automated correction of all instruments
- Traceable measurements and validity monitoring
- Easy data-handling—storage and retrieval
- Compliance to standards IEC 60645, 389 and 8253
- Full flexibility for professional use

SOUND AND VIBRATION - CONTACT BRÜEL & KJÆR

This product is for sale in Eastern and Central Europe, the Middle East and Africa.
For countries in other regions contact the local Brüel & Kjær office.

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Please, contact your local
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