AN AUDIO VISUAL SCRIPT ON CALIBRATION OF AN AUDIOMETER

Reg. No. M.9209

An independent project submitted as part fulfilment for the first year M.Sc (Speech & Hearing) to the University of Mysore

All India Institute of Speech and Hearing
MYSORE - 570 006
MAY 1993

Dedicated to
My dearest
Chikkappa
Dr. M. Shivakumar

CERTIFICATE

This is to certify that the Independent Project entitled ***"AN AUDIO VISUAL SCRIPT ON CALIBRATION OF AN AUDIOMETER"*** *is abonafide work, done in part fulfilment for the First Year Degree of Master of Science (Speech and Hearing), of the student with Reg. No. M. 9209*

MYSORE
MA Y 1993

Dr. (Miss) S.NIKAM
DIRECTOR
All India Institute of
Speech and Hearing
Mysore - 570 006

CERTIFICATE

This is to certify that the independent Project entitled "AN AUDIO VISUAL SCRIPT ON CALIBRATION OF AN AUDIOMETER" has been prepared under my supervision and guidance.

MYSORE
MAY 1993

Dr. (Miss) S.NIKAM
GUIDE

DECLARATION

This is to certify that the Independent Project entitled **"AN AUDIO VISUAL SCRIPT ON CALIBRATION OF AN AUDIOMETER"** is the result of my own study under the guidance of **Dr. (MISS). S. NIKAM.** Professor and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

MYSORE
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Introduction

As we are moving towards the 21st century, Science is progressing with new techniques. New branches are arising with new techniques with sophisticated instruments. Audiology is one of the branch among this. This is the branch which deals with the study of auditory process and it is an expanding field of applied science. Scientific experiment clinical research and many other endeavors contribute to its growth. This is newly developing in all the areas like clinical training and research. Audiologist mainly deals with the evaluation of hearing and rehabilitation of hearing disordered person. In clinical work, to arrive at diagnosis he has to use two types of testing methods - subjective and objective. Objective testing method plays very significant role in Audiology. Measurement made by objective method has significant advantage over other methods. An instrument is that by means of which are can quantify and measure a particular kind of data. There is a vast range of instrument in the field of audiological science. As days are passing more and more instrument are being made available which helps audiologists to increase their knowledge regarding the auditory system. With the help of a new instruments, the field of audiology is marching towards the path of progress by leaps and bounds. While today's instruments are often much more complex, much accurate and more reliable then the device of part.

Use of calibrated equipment is a prerequisite for an accurate audiological evaluation. Failure to calibrate the instrument at approximate intervals may be major cause of unreliable test results. Calibration of the equipment though an extremely important issue is often the most neglected one in India. There are many clinics in India where equipment bought several years ago may not be calibrated even once. Most organizations do not have facilities of their own and depend on supplies or other organization for this purpose. But even when calibration of the audiometer is reported to, often there is little au/areness about the standard norms which the equipment is calibrated.

"Regardless of whether the audiometer is new or has been in use for sometime, it is the responsibility of the user to check its calibration, personally atleast to arrange for the regular calibration of equipment by outside sources"

Wlilber (1985)

The present study highlights the important aspects of calibration and the procedure for calibration. This project is just an audio visual script which can be further converted into video with audio cassette.

Calibration of an audiometer

1.1 Definition of Calibration

"To determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter or other device, or the correct value for each setting of **a** control knob". (Mc Graw Hill Dictionary of Scientific & Technical terms - II Edition)

A calibrated audiometer is simply one which

(1) emits the signal at the level and frequency it claims to be producing,
(2) delivers the signal only to the place (i.e. a specific earphone it is directed,
(3) produces the signal free from contamination by extraneous noise or unwanted by products of the test signal.

1.2 Importance of calibration:

Use of calibrated equipment is a pre requisite for an accurate audiological evaluation. Failure to calibrate the instrument in an appropriate intervals may be major cause of poor results.

Checking calibration is necessary to be sure that an audiometer produces a puretone at the specified level and frequency, that the signal is present only in the transducer it is direct and that the signal is free from distortion or unwanted noise interference.

By keeping the audiometer calibrated, the audiologist can report his findings with great confidence. He can ascertain that, the instrument meets the national/international standards or norms. He can also establish reference values for his own equipment to detect any change that may over time.

1.3 How frequently should the audiometer be calibrated?

ASHA ('78) recommended the following schedule for the calibration of audiometer

- A daily listening check to detect any gross deviation.
- A monthly detailed timely check to include examinations of cross talk in earphones, signal distortion and abnormal noise.
- A quarterly electro acoustic calibration of solid state (transistorized) audiometers. This include the measurement of o/p SPL of puretones masking noise and speech signals in both earphone and in sound fields.

The measurement should be carried out once in a month in the case of non solid state instruments.

- An annual electro acaustic evaluation which includes the following

a) Measurement of output SPL for puretones
b) Frequency calibration for puretones
c) Determination of attenuator linearity
d) Measurement of harmonic distortion for puretones
e) Rise-decay time for puretones
f) Measurement of signal to noise ratio for all outputs
g) evaluation of special test functions

Often, the listening checks are called subjective calibration procedures, while the electrostatic measurements are reffered as 'objective calibration process'.

Calibration Procedure:

Before calibrating the audiometer, check for the following

1) The working voltage is within permissible limits
2) All the jacks, cords and plugs are in place and there are no loose connection
3) There is no visible damage on the audiometer, its control and its accessories. These include switches, knobs, dials, earphones, earcushions, BC vibrator, headbands, jacks, cords, sockets, etc., Damage if any should be rectified before checking the calibration.
4) The earphone and the vibrator are of type that match the audiometer (the type specified by the manufacturer).
5) The head bands have adequate tensions. This may be checked using a spring balance.
6) The instrument is not delivering any electrical shock.

Daily listening checks:

Check the audiometer as it is routinely used. For instance, in a two room situation, do not bring the earphone from the test room and plug them directly into the audiometer because by doing so, defects in the cords or in the panel transferring the signal through walls, may go undetected. The following steps may be taken into determine if the instrument is in calibration.

1) Switch on, allow warm up time according to instruction manual supplied by the manufacturer.

2) Make sure that the switches/knobs are fixed firmly and that they are easily operable. They should not produce any clicks when changing the intensity and frequency.

3) Check if the indicator function properly.

4) Look for defects in the patient signal light eg. it fails to glow when the patient response switch is pressed.

5) Determine if the threshold levels are correct for (a) AC (b) BC at all frequencies as evaluated subjectively. These may be determined with a subject whose thresholds are previously measured and are available for reference.

6) Higher level listing check should reveal that the signal generated are appropriate and free of distortion on AC, BC and masking noise (including insert receiver) and loudness balance and other functions.

7) Should listen to the signal with the attenuation dial rotated from maximum to minimum. Sometime a break in the using of the attenuator may cause lack of attenuation below certain level.

8) Ensure that the operation of the attenuator brings about a variation in the signal level, which is linear over the intensity range specified by the manufacturer and that it does not produce any audible clicks.

9) Check if the speech material presented through mic/tape i/p is heard over the earphone without distortion. Asertain if the level of the signal varies if the dial reading changed. Present all signals with the uv meter peaking zero

10) Inherent noise or hum generated by the audiometer should not be audible when checked at the position, where the patient is to be seated.

11) Reset all control to normal operating positions before the evaluation of patient is begun.

Monthly listening checks:

In addition to the daily listening checks it is necessary to rule out the presence of abnormal noise, signal distortion and cross talk in the earphone by listening for them at least once a month.

Procedure:

1. Set the attenuator to maximum output. Turn the signal off and listen for possible hums or other amplifier noise.

2. At maximum output level, turn the signal on and off using the interrupter. Make sure that the signal is free of distortion and that there is no audible click when the interrupter is operated.

3. Rule out the presence of the test signal in the non test earphone. This must be clear at all audiometer frequencies.

Cross-talk:

To check cross talk, keep the signal level at 60dB. Detach the test earphone and keep it away from the head. Listen to the non test earphone for the presence of the signal.

If cross talk is observed, it could be because of shortening in the jack panel which carries the signal from the control room to the test room or defect in the audiometery circuitory.

Have the wiring checked to rule out the former. If the problem persists, the audiometer must be repaired before further use. Temporarily however, the non-test earphone may be disconnected while testing.

Such listening checks although subjective serve to elicit reliable results and to carryout electro acaurtric evaluation periodically, to ascertain the integrity of the instrument.

Parameter to be calibrated

- Intensity
- Frequency
- Time

Especially frequency and time parameter may be checked u/hen the audiometer is first acquired and at yearly intervals thereafter. Intensity should however be checked monthly or quarterly. For use in research, calibration should be done much more frequently weekly/daily. In addition to these regular checks. calibration must be checked whenever Clinician notices sometning unusual.

Correction of frequency and time components or unstable intensity variation should be done by the manufacturer or a qualified electronic technician, whereas the stable intensity variation can be corrected by adjusting the presents or making a correction chart for this purpose which should be used whenever intensity readings are taken.

Audiometer calibration:

Accuracy in audiometry is based upon 3 important requisite, a tester, a controlled acoustic test envirnoment and accurate test equipment. Too much of attention is given to first two conditions. Where as little or no attention is given to ecalibration and maintanance of equipment, ther are numerous resons form audiometer to lose its precision such as dropping earphone, overheating and exposure to dust and heat.

Let us examine the nature of inacccurate calibration and the possible source of error in the signal which audiometer produces.

1. Frequency: most audiometer have little difficult in reaching ASA$\pm$5% sepecified tolerance for frequency. For eg. on the basis of current standard this means that an audiometer can reduce signal from 950 to 1050 Hz. When set at 1KHz or when set 4KHz. Lower the frequency the less tolerable varies in cycles per seconds. Even though these tolerance are established are should strive to maintain an accurate frequency o/p as possible.

2. Harmonics: Eventhough all we using pretones in the basic measurement of hearing, it is possible to have harmonics of the fundamental present in the earphone. The ASA specifications call for the fundamental to be atleast 25dB to 30dB above the SPL of any harmonics.

3. **Intensity:** The intensity o/p can be generally too strong or too weak. The ASA standard allows for a ±4dB variance in intensity over the full range from -10 to maximum o/p at the test frequency of 2000HZ lowr and ±5dB at the test frequencies above 2000Hz. ISO & ANSI allows ±3dB variance in intensity over the full range. ASA also specifies +5dB variation in any 5dB step throughout the intensity range. Therefore it is important to know whether the audiometer is producing the intensity it claims to be producing on the dial or it is producing more or less than this reading. Eg. If one audiometer is 10 to 15dB weak, every person tested on it will show a greater hearing loss than he would have on an accurate audiometer. This leads to misdiagnosis of case and rehabilitation of case. An audiometer that is too strong, can present problems similar to this kind but in opposite direction. The screening audiometer that is too strong will pass cases that should not have passed. A strong audiometer is a real hazard in an identification audiometry program.

The second problem with intensity in non linearity when an audiometer fails to attenuate uniformly below lOdB. Eg: Anyone with actual threshold of O or 5 dB will report hearing a tone when the dial is set at -lOdB.

4. Tone interruption:

According to ASA (1951) it should rise to its peak with in 100 to 500 milliseconds and go of in the same peeriod of time. Actually it is undiserable to have a rise decay more than 200 milliseconds. The audiometer should not present an usually long rise and decay time and there should be an absence of overheat in the tone. The precaution of the signal presentaion can be very critical for accuracy in audiometry. A slow rise time may fail to elicit maximum on effect of the auditory machanism and result in a poorer threshold than in fact is present, on the other hand, over shoot may result in establishment of better thresholds than present.

5. Total harmonic distortion:

The o/p of the audiometer sent to distortion analyzer which provides a readout corresponding to the total harmonic disortion of the signal. There are two basic parts to a disortion analyzer, a voltmenter and a band rejection filter, when the distortion analyzer is set to a desired measurement signal frequency the centre frequency of the band rejection filter is set to the same frequency. Thus this frequency maximally rejected by the filter leaving only the distortion product. Since total harmonic distortion is the ratio. between the intensity at the signal frequency and the intensity at all other frequency the distortion analyzer must be able to measure the intensity both at the signal frequency at all other frequencies. This is done by having a voltmenter in the analyzer measure the intensity both before and after the band reject filter and then taking the ratio of these two values. Total harmonic distrotion should always be measured with the signla inteensity near the top of the dynamic range of the instrument or sufficiently 'above any noice floor (idealy 60dB) to avoid contamination of the measurement by noise.

Rise/Fall time measurement:

Distortion is the generation of the signal is one way of generating unwanted signal components. Inappropriate switching of the signla can also careate undesirable signals. In this case the difficulty arise, because signal enargy at frequencies in addition to the dignal frequency are generated if the signal is switched on too abrutly. For audiometer purpose too abruptly translates into a rise/fall time <10ms. The more repidly the signal is tuned on the more the signal spectrum at onset resembles that of a click. If the test is attempting to measure threshold at a single frequency, it is clearly indesirable to have signal energy at other frequencies.

This problem can be eliminated by turning the signla on slowly this is done by switches in audiometer. The standard is very conservative in this area and requires a rise/fall time >30ms. The instrument required is audiometer and storage oscilloscope. The rise/fall time is a temporal measurement easier and more accurate, recommended that the measurement be made witha high intensity signal (>90HL) from the audiometer. The rise/fall time should not change with frequency either but this can be checked ralatively easily.

The o/p from the audiometer is routed to the osciloscope and the amplitude display is adjusted to place the waveform simmetrically in the vertical dimentsion around the central graticule line. The waveform display should be as large as possible vertically, while still keeping the maximum and minimum portions of the waveform on the screen. The waveform must be displayed so that the change in waveform amplitude from 10% to 90% at onset or termination is visible. Tn the case of waveform termination, this is reelatively easy. The oscilloscope is placed in storage and single sweep modes and with a little experimentation it is possible to catch the termation of the waveform catching the onset of the wveform is more difficult and requires adjusting the trigger level so that the waveform triggers appropriately. The oscilloscope should be in storage and signle sweep modes. The calibration is made by determinating the time it takes for the waveform to change from 10% to 90% of waveform amplitude. The time base on the oscilloscope must be set to sufficient resolution to make an accurate measurement.

Warble tone calibration:

It is a frequency modulated tone with a modulation width from 3 to 10% and a modulation rate from 2 to 8Hz. An FM tone is a tone.whose frequency (not intensity) is varied over a specified range at a specified rate.

FM Signal: period of the waveform changes over time, but the intensity does not change. This fluctuation in frequency reduces the standing wave problem, because the frequency is never at the resonent frequency of the chamber long enough to generate stationary standing waves.

As long as the modulation width is small ie. <10% of the test frequency, the intensity can be calibrated with an active band filter. The best instrument for making their instrument is a modulation metre. Good meters will permit measuremtn of both amplitude modulated AM/FM signals (but these are very expensive).

Procedure:

For both modulation width is to store the waveform using a single sweep with sufficient time resolution to measure the periods. The lowest possible warble tone centre frequency should be used to aid in visualization. The longest and shortest periods displayed are measured. After this has been done for several sweeps, approx. 10 to 15, there will have been a reasonable sample of waveform periods to permit estimation of the modulation width.

The procedure for the modulation rate is to make the time resolution poor enough so that the period oscillation from longest to shortest is displayed. This will require some adjustment and visualization. The storage and single sweep modes are employed for the measurement. The time resolutions that are necessary for each measurement can be estimated from the specification for the warble tone. eg. if center frequency of the warble tone is 250Hz, the modulation width is 10% and modulation rate is 5Hz. The periods should vary between approx. 3.6 and 4.4 ms with the interval between the shortest and logest period being 200ms. Thus the time resolution setting for the modulation width measurement should be 1 or 2 ms/division and for the modulation rate measurement the setting should be 20 to 50 ohms. In general a ratio of about 1 to 4 is needed for accuracy.

Biological Calibration Audiometer:

It is used for bone vibrators and for pure tone calibration. As the name implies it involves using biological instrument to do the calibration. Bequse they are the most available biological instrument and of their extensive sensory apparatus humans can be very reliable and accurate.

Procedure: Select normal hearing person with no middle ear problem (even common cold also). The audiometer is set up just as it would be for regular BC testing. The bone vibrator in attached to the individual with known hg and the intensity at threshold as a function of frequency is noted. The resulting table represents the calibrated values for the bone vibratior. The calibration should first be done when the bone vibrator is new.

Earphone Calibration:

There are two methods 1. Real Ear
2. Artificial Ear

Real Ear: One simply tested the hearing of a group of normal hearing person, averaged the results and checked to see that the average hg of this group was at zero on the dial for each frequency. Although this is theoritically fleasible with a larrge .population sample, it is not a recommended procedure. In order to do the procedure properly the sample should consist of at least 25 young (18-25 yrs.) otologically normal hearing adults. The equipment used should allow the examiner to measure thresholds atleast -10 to -20dB to account for those subject who will have more sensitivity.

Another type of real earphone calibration procedure consists of comparing the o/p of known earphone with that of an unknown earphone.

Artificial ear / coupler methods: is most commonly used. The artificial ear consists of a condensor microphone and 6-cc coupler. The 6cc coupler was originally chosen, because it was thought that the enclosed volume was approximately the same as the volume under an earphone for a human ear. The procedure for using an artificail ear is simple. The earphone is placed on the coupler, a 500 gm weight is placed on the top of the earphone. The o/p is read in voltage and then transformed to dB. After the earphone is placed on the coupler, a low frequency tone is introduced and the earphone is readjusted on the coupler until the highest o/p intensity is reach. This helps assure best placement on the coupler. The o/p from the earphone may then be compared to the expected values at each frequency.

Bone vibrator calibration:

There are two methods 1. Real Ear

2. Artificial Ear

Real ear: The original technique for checking bone vibration was a real ear procedure. (American medical association 1951). This method assumes that air and bone conduction thresholds are equivalent for human. Therefore if 6 to 10 normal hearing subject are tested for both AC and BC with an audiometer whose air conduction system is in proper calibration. BC correction for the audiometer can be determined by using the difference between AC and BC.

Artificial mehtod:

The prefered procedure for calibrating bone vibrations involve the use of an artificial head bond or artificaial mastoid. Artifical mastoid were proposed as early as 1939 by Hawley both earphone and bone vibratior calibration, it is important to check distortion as well as overall intensity through the transducer. Distortion may be measured directly with (1) a distrotion meter (connected to the o/p from the artifical method) 1 or (2) a frequency analyzer. An oscilloscope provides a visual picture of the distortion wave, but it is difficult to determine the exact percentage of distortion this way. Allowable distortion values for bone vibrators is 6 to 12%.

Different standards gives different values of RETSPL. Here the important standards like ANSI, ISO & IS documents regarding RETSPL values are given.

Indian Standard IS:11449-1895 "Specification for mechanical coupler for measurementon Bone Vibrators"

Calibration:

Sensitivity level: The mechanical coupler shall be calibrated by the manufacture at 23°C±1°C in terms of its sensitivity level at the frequencies listed as follows:

Frequency	Mechanical impedence level (Reference 1NSM-1)	Tolerance
Hz	dB	dB
125	48.9	±2.0
160	47.4	±2.0
200	45.8	±2.0
250	44.3	±2.0
315	42.9	±2.0
400	41.3	±2.0
500	39.9	±2.0
630	38.5	±2.0
750	37.4	±2.0
800	37.0	±2.0
1000	35.5	±2.0
1250	34.0	±2.5
1500	32.4	±2.5
1600	31.9	±2.5
2000	29.8	±2.5
2500	27.8	±2.5
3000	27.2	±2.5
3150	27.3	±2.5
4000	29.5	±2.5

5000	32.6	+2.5
6000	34.4	+2.5
6300	34.6	+2.5
8000	35.1	+2.5

These frequencies are used in audiometry but are not included in the preferred even specified in IS:2264-1963.

Indian Standard: IS:11024-1984 specification for standard reference zero for the calibration of puretone. Bone conduction audiometers and guidelines for its practical application.

Specification:

Reference equivalent therehold force levels are as follows. They are derived from determinations of the threshold of hearing by bone conduction of otologically normal persons.

Frequency	RETEL (refl N)
Hz	dB
250	67.0
315	64.0
400	61.0
500	58.0
630	52.5
750	48.5
800	47.0
100	42.5
1250+	39.0
1500	36.5*
1600+	35.5
2000	31.0
2500	29.5
3000	30.0
3150	31.5
4000	35.0
5000	40.0*
6000	40.0*
6300	40.0*
8000	40.0*

+ Values for there frequencies are interpolated.

* Values for there frequencies are derived from the results in one country only.

ISO (1964)	Specification for TDH-39
125HZ	45.0
250Hz	25.5
500Hz	11.5
750HZ	8.0
1KHz	7.0
1.5KHz	6.5
2KHz	9.0
3KHz	10.0
4KHz	9.5
6KHZ	15.5
8KHz	13.0

ANSI (1969) threshold values for TDH-39 earphones in MX-41/AR cushions and TDH-49 earphone in MX-41/AR cushions.

Frequency (Hz)	TDH-39	TDH-49
125	45.0	47.5
250	25.5	26.5
500	11.5	13.5
750	8.0	8.5
1000	7.0	7.5
1500	6.5	7.5
2000	9.0	11.0
3000	10.0	9.5
4000	9.5	10.5
6000	15.5	13.5
8000	13.0	13.0

AN AUDIO VISUAL SCRIPT

For the calibration of an audiometer different equipment is used with different combination. Depending upon the purpose the instrumentation will be varied. ie. if the purpose is to measure the ouput SPL or if it measures the frequency response of earpone or frequency calibration of pure tone, the instrument will be varied.

But care must be taken to see that these instruments should be matched with each other. The impedence matching of the equipment is a must for the calibration. If the impedence mismatching occurs in between the instruments then the results will not be valued.

Different companies manufactures instruments in India and also in abroad. The main companies are Bruel and Kjaer and Quest electronics, Starkey, Lucas GSI, Harrison, Bio acustic analyzer, Phonic, Maico, Beltone and Rikon. All these companies manufactures different equipments.

I Calibration of Audiometer output SPL:

VISUAL	AUDIO
Audiometers and other equipment required for Calibration	The purpose of calibrating the audiometer output SPL is to check if the output is accurate or not. To do this, the output of the audiometer in question is measured at all frequencies available on the audiometer with the attenuator fixed at the same level. We now take you over the procedure step-by-step.

Show the microphone being screwed on the SLM	The first step in calibration is to check the sound level meter. To do this the microphone is screwed onto the sound level meter. Now be careful not to screw on the microphone too tightly. Otherwise it will not be possible to unscrew it after the job is done.
Picture of SLM connected to microphone using an adaptor will be shown.	A suitable adopter needs to be used if the microphone cannot be connected directly with SLM.
Picture showing the piston phone in 'on' postion and then chang-ing it to the 'batt' position.	To check its accuracy the pistone phone should be switched it to 'on' position. Then change it to 'batt' portion. A change in the pitch of the sound indicates that the piston phone is in calibration.
Picture showing the batteries being changed in pistonphone.	If the pitch does not change replace the piston phone batteries and check again.
Picture of SLM in 'batt' positionwith the needle in white position.	Check the batteries in the SLM by turning the switch to 'batt'. The needle should rest in white position of the battery indicting scale. If it does not change the battery.
Picture of SLM with weighting network in 'C' and meter switch at 'fast' response and attenuator at 120dB will be shown.	Now set the weighting net work to C and set the meter switch to 'fast' response and attenuator, to 120 dB.
Picture of piston phone which is screwed on to SLM will be shown.	Place the piston phone over the microphone which is connected to the SLM.
Picture of SLM in 'on' position and with the meter reading of 124dB.	Now switched on the SLM, the reading on SLM should be 124dB.

Picture of adjustment of gain will be shown	If not adjust the 'gain adjustment' till the reading shows 124dB.
Picture showing the SLM in 'off postion	Turn off the piston phone and the SLM. Remove the microphone.

Phase IT: Mounting the microphone and the earphone on the artificial ear:

Picture of artificial ear conntected with microphone will be shown.	Unscrew the coupler from artificial ear. Unscrew the protection grid from the microphone without touching the diaphragm connect the microphone to the socket inside the artificial ear. Replace the coupler on the artificial ear.
Picture of earphone which is placed on the coupler with earphone performation facing the coupler cavity will be shown.	Remove the earphone to be calibrated from its head band. Place it on the coupler so that the earphone performation faces the coupler cavity.
Picture of earphone on coupler which is adjusted with the clamp will be shown.	Unscrew the adjustment clamp on the artificial ear slightly, and adjust the weight on the earphone to 0.5kg or as per the specification provided by the manufacturer.
Picture of SLM connected to artificial ear will be shown	Connect the artificial ear .

Phase III Measurement of output SPL

Picture of an audiometer in 'on' position with its attenuator at 60dB, frequency dial at 250Hz will be shown.	Switch 'on' the audiometer. Set the attenuator to 60dB and frequency dial at 250Hz. (If the audiometer is being checked is calibrated according according to ISO standard)
Picture of earphone which is connected to artificial ear will be shown.	Set the output selector to 'Right' or 'Left' depending upon the earphone placed on the artificial ear.

Picture of SLM with active filter set will be shown

The octave filter set is connected to SLM. Set it to the required frequency ie. same frequency as that selected on the audiometer.

Picture of SLM in 'on' position with 'slow' response 'external filter' and attenuater at 60dB will be shown

Switch on the SLM and set it to 'slow' response and to 'external filter', Set the attenuator on SLM to 60dB. If the needle deflects to either extreme, vary the attenuator setting suitably so that the needle deflects to the centre of the meter. Note down the combined reading from the attenuator and the meter.
Repeat the same procedure for each of the test frequency. Remember to change the frequency setting on the octave filter set the test frequency is varied.

Phase IV Preparing the correction chart

Picture showing the correction chart as follows

Freq. Rt. Lt. Bone

Compute the expected SPL by adding the values recommended by the standard to which the audiometer is being calibrated. The difference between the expected value and the value obtained should exceed 3dB at frequency from 250 to 4kHz. But 5dB at 6 and 8KHz. [IS:9098-1979]. Write correction chart as shown in the video.

Phase V Linearity Check:

Picture showing an audiometer with intensity at 120dB and frequency at 1KHz .

The procedure is similar as to that of as described in Phase 3. But here the intensity should be at maxmimum level frequency dial should be set at 1kHz, note down the reading on SLM. Then decrease the intensity in 5dB steps and note down the readings in SLM. If the reading on SLM changes correspondingly as the intensity on the audiometer is changed, it indicates that intensity variation is linear.

II Calibration of audiometer o/p intensity in a bone condition

VISUAL	AUDIO
Audiometer and other equipment required for calibration	The purpose of calibrating the audiometer o/p SPL is to check if the o/p is accurate or not through BC. To do this the output of the audiometer in question is measured at all frequencies available on the audiometer with the attenuator at specified intensity level.

Phase I

Pictures showing the procedures of calibration of SLM	The calibration of SLM is similar to as explained earlier.

Phase II - Mounting of bone conduction vibrator on the artificial mastoid and connecting artificial material to SLM.

Picture of BC vibrator placed on artificial mastoid will be shown	Now detach the BC vibratior from the head band and place it on the artificial mastoid. Note the level with the help of level indicator.
Picture of artificial mastoid with the spring balance will be shown	Remove BC vibrator from the head band, with the help of spring balance, check the weight on the clamp of the artificial mastoid and readjust the level of the clamp with reference to the level indicator.
Picture of SLM with an adoptor will be shown	Connect adoptor to SLM.
Picture showing SLM with adoptor which is connected to artificial mastoid.	Remove the spring balance and level indicator. Plug in the o/p jack of the artifical mastoid which is connected to SLM.
Picture showing the SLM is being connected to octave filter set	Connect the octave filter set to SLM.

Phase III Measurement of output SPL

VISUAL .	**AUDIO**
Picture showing audio-meter wich is connected to BC vibrator with artificial mastoid with octave filter set.	This is the setting for the measurement of output SPL. Here BC vibrator is connected to audiometer. BC vibrator is placed on artifical mastoid which is connecteed to a SLM octave filter set.
Picture of audiometer in 'on' position with intensity dial and frequency dial at set specified level. Output selector to 'bone'.	Switch on the audiometer and set the intensity dial at 40dB and frequency dial at 250Hz. Set the attenuator as per the specificiation of standards which is calibrated. Set the output selector to 'Bone'. Set the octave filter set the required frequency.
Picture showing SLM with 'slow' response and external filter setting.	Switch on the SLM and set it to the 'slow' response and to external filter.
Picture of an audiometer with tone interrupter in 'on' position.	Set the tone switch on the audiometer so that the signal is continuously 'on'.
Picture of SLM with 60dB with needle in the central area of the meter	Set the attenuator on the SLM to 6OdB. If the needle deflects to either extremes, change the attenuator setting suitably so that the needle deflects to the central area of the meter. Note down the combined reading from the attenuator and the meter. Repeat the procedure for each of the test frequencies. Adjust the frequecy setting on the octave filter set to correspond with the test frequency.

III Frequency Calibration of puretone

VISUAL	**AUDIO**
Picture of audiometer which is connected to digital counter	Here purpose is to check calibration of the puretone to find out whether any deviation is present from that of dial reading. These are the instruments required to obrtain the frequency calibration of pure tone.
Picture showing an ear-phone jack being conected into the socket	Remove one of the earphone from the output socket. Insert a space earphone jack into socket.
Picture of the spare jack connected to the i/p terminal of the frequency counter.	Connect the spare jack to the input terminals of the frequency counter with a wire.
Picture of an audio-meter in 'on' position with frequency at 250Hz and o/p intensity at maximum and tone switch at continuously on.	Switch on the audiometer and the frequncy counter. Set the audio-meter frequency dial to 125Hz and o/p intensity to maximum and tone switch to continuously 'on' position.
Picture showing an audiometer being connected to frequency with counter with the function switch in 'freq' position.	Turn the function selector to 'freq' and note down the reading on the frequency counter. Adjust the sensitivity of the counter to obtain a suitable value. Compute the deviation of the frequency generated by the audiometer from the expected frequency. Repeat the same procedure for the other set frequencies.

IV Frequency response of earphone

VISUAL	AUDIO
Picture of earphone audio frequency analyzer condensor microphone GLR. Recording paper.	These are the instruments required to measure the frequency response of earphone. Note: [These are the instruments used earlier. Due to its difficulty, now computerized equipments are used. Now audio teest station is used instead of BFO and AF analyzer].
Picture showing the coupler	Unscrew the coupler from the artificial ear.
Picture showing a condensor microphone is being connected with artificial ear.	Screw on the condensor microphone to the artificial ear and replace the coupler.
Show the earphone being connected to BFO	Connect the earphone cord to o/p terminals of BFO
Show the earphone on artificial ear which is further connected to AF analyzer.	Place the earphone on the artificial ear such that the perforation face the microphone. Connect the artifical ear to condensor microphone input of the audio frequency analyzer.
Picture showing the frequency is being connected to GLR	Connect the output terminal of audio frequency analyzer to the i/p socket of GLR. The recording paper must be properly loaded on the GLR.
Picture of BFO in 'on' position with 'Auto sweep' and earphone with a same impedence of GLR will be shown.	Switch on the instrument and set the BFO to 'Auto sweep' from 50Hz. Set the impedence of the BFO to match with that of earphone.

Picture showing the GLR with its needle on 50Hz	The needle of the GLR must be on the 50H2. Then mark on the reading paper. Select a paper drive that permits a synchronization of paper speed with BFO sweep.
Picture of BFO with off position and GLR in on position	Turn on the BFO and simultaneously switch on the motor drive of the GLR. Repeat the procedure with the other earphones.
Chart showing the frequency response which is almost flat at all frequency with a small peak between 4 to 6 KHz. Also charts showing frequency response which is not flat will be shown	The frequency response characterstic should be almost flat at all frequency with a small peak between 4 to 6KHz.

V. Calibration of the speech audiometer mic input

Picture showing an audiometer in 'on' position and somebody showing the attenuator at 70dB.	Switch on the audiometer, make the appropriate adjustments to present the signal through microphone. Select the left or right earphone and set the o/p select corresponding to left or right set the intensity level at 70dB.
Picture of a mic being connected to audiometer which is further connected to SLM	PresentlkHz tone speech noice or the vowel 'a' and set the V-U gain so that the needle peaks at '0'. Note down the reading on SLM on linear response. If the reading deviates more than ±3dB from the expected value so, then internal calibration is required.

VI Calibration of tape input

VISUAL	AUDIO
Picture of an audiometer in 'on' position and tape recorder	Record the puretone of frequency 250, 500, 1kHz and 2kHz on a magnetic tape. Play the above tape on the recorder to be coupler with audiometer. Measure the SPL of each tone using a set up similar to those used for calibration of o/p terminal via AC. Compare the levels of the tones with reference to that of the 1kHz signal. If the difference in the level are 4dB, there is no mismatch between taperecorder o/p and audiometer 1/p.

Calibration of loud speaker output SPL

Picture showing the connection of micro-phone to SLM	Connect the suitable microphone to SLM
Picture showing the SLM with is 1 meter away from the loud speaker	SLM is kept 1 meter in front of the face of the loudspeaker taking care to account for the angle of incidence of the signal from the speaker to the characteristic of the measuring microphone. Keep the attenuator setting as specified by the standards to which the instrument is calibrated. Note down the reading on SLM. If the reading deviates from the standard specification then internal calibration is required.

VII. Frequency response of loud speaker

Picture of a GLR which is connected to oscillator with a micro-phone will be shown	These are the instruments required to measure the frequency response curve of a loud speaker.
Picture showing oscillator connected to the loud speaker	The o/p from the oscillator is directly fed into the loudspeaker.

Picture of a condensor microphone placed lmm away from the loud-speaker	A condenser microphone is placed lmm in front of the face of the loudspeaker taing care to account for the angle of incidence of the signal from the speaker to the characteristic of the measuring microphone. The signla from microphone is fed through the GLR. A complete frequency response curve can be obtained quite accurately and rapidly in these manner.

IX. Calibration of volume unit meter

Picture of an audiometer and oscillator, voltmeter	These are the instruments required to calibrate the volume unit meter.
Picture of an oscillator connected to voltmeter	A puretone should be fed from an oscillator through an electronic switch to the i/p of the audiometer.
Picture of VU meter deflecting	By activating the electronic switch to produce rapidly interrupted signal one can watch the deflection of VU meter. But care must also be taken to check the response time of the needle on VU meter.

There are some other instruments used to calibrate the audiometer. These are new instruments which are computerized. They are easy to use and gives accurate, precise measurements, so it is important that the audiologist should be available in the market. Some instruments are listed here.

Biological calibration of audiometer

VISUAL	AUDIO
Picture of a BA201 Bio acoustic stimulator	This is a high quality measuring devise used to fulfill the requirements of daily biological tests of audiometer. This can be used with manual, automatic or microprocessor audiometer.
Picture of BA201-25 bioacoustic stimulator	It is similar to BA-201. But it measures background noise in five octave bands.

Picture of a AM-2000 set up	This is manufacture by quest electronics. This system performsaccurate acoustical calibration of all types of audiometers and this replaces the biological calibration. This performs monthly, yearly, exhaustive audiometric calibration. This gives precise measurement of a decible level, linearity, rise and fall tim, pulse width.
Picture of AA-175 audiometer analyzer with SLM	This is a microprocessor controlled analyzer that verifies audiometer calibration and performance. This requires SLM. It calculates decible level, linearity, harmonic distortion rise and fall time.
Picture of a AA-188 audiometer analyzer	It is similar to AA-175. But it does not require SLM to operate it.

CONCLUSION

It is important to calibrate the audiometer. Calibrated audiometer is a prerequisite to an audiologist. At the time of purchasing the instrument the audiologist must also know where the calibration is going to be done and if a speech and hearing centre is not have facility to calibrate, it must atleast have an access to a centre where the calibration can be done. It is prefer for speech and hearing centre to have its own calibrating equipment to ensure the optimum level.

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