# A DRAFT FOR ISI SPECIFICATIONS FOR ELECTRO-ACOUSTIC CHARACTERISTICS OF EAR-LEVEL HEARING AIDS

**A.K. Purwar**

**An Independent Project Submitted in part fulfillment**

**for the III Semester M.Sc. (Speech and Hearing)**

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# CERTIFICATE

This is to certify that the independent project entitled “A Draft for ISI Specifications for Electro – Acoustic Characteristics of Ear-level Hearing Aids” - is the bona fide work in part fulfillment for III Semester M.Sc., (Speech and Hearing), carrying 50 marks, of the Student with Register No. 1.

DIRECTOR,

All India Institute of Speech and Hearing
Mysore - 6.

# CERTIFICATE

This is to certify that the independent project entitled "A DRAFT FOR ISI SPECIFICATIONS FOR ELECTRO – ACOUSTIC CHARACTERISTICS OF EAR-LEVEL HEARING AIDS"- has been prepared under my guidance and supervision.

GUIDE

(Dr (Miss) Shailaja Nikam)

# DECLARATION

This independent project "A Draft for ISI Specifications for Electro – Acoustic Characteristics of Ear-level Hearing Aids" is the result of my own study under the guidance and supervision 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 other University for any other Diploma or Degree.

Mysore. REGISTER NO: 1.

Date:

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He thanks anyone and everyone who helped him.

INVESTIGATOR.

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# CHAPTER I

# INTRODUCTION

"Before anyone can effectively work with hearing aids it is necessary to understand how they work and how their performance is measured" – M.C. Pollak.

Perhaps the most significant advancement in hearing aids technology has been the development of the transistor. It's small size and versatility, coupled to the development of miniature transducers of high quality performance capabilities such as electrets microphone has permitted the miniaturization of hearing aid and this led to the development of ear-level hearing aids and yet provides the listener with a signal quality equal or superior to that of body worn aids.

A standard is simply a way of measuring performance and duplicating measures form one facility to another with consistent results.

Previous ISI document dealing with Electroacoustic characteristics of body worn hearing aids have not mentioned about methods of measuring electroacoustic characteristics of ear-level hearing aids. So this is the first attempt to develop ISI standards for ear-level hearing aids.

This standard is designed to test hearing aid in the absence of listeners and from aside from the use of the 2 c.c. coupler which presumably approximates the normal ear measures, real listeners have nothing to do with this standard.

Important considerations before obtaining performance data on hearing aids would be that tubing length, interval diameter and attachment between tubing and 2 c.c. coupler are same as those specified by hearing aid manufacturer.

If automatic chart recording is used rather than discrete frequency measurements, factors such as pen speed and paper speed should be checked to assure that they are the same as those used by the manufacturer.

The acoustic test procedures specified in the this standard are based on the free field technique in which the hearing aid is placed in plane progressive wave with the elbow of the ear-level hearing aid connected to a coupler by a plastic tube.

So the object of this standard is to insure the uniformity of methods of measuring electroacoustic performance characteristics of ear-level hearing aids acoustically coupled to the eardrum by means of ear insert.

# CHAPTER II

# SCOPE

This standard specified the method for measurements of performance characteristics of ear-level hearing aids (with or without induction coil pick up). Some of the characteristics mentioned, sets the tolerances to insure product uniformity and for compliance with the performance specified for the model and mark.

# CHAPTER III

# TERMINOLOGY

**Ambient Noise**

Ambient noise is the background noise in the test environment which may affect the test results.

**Amplification**

Amplification is the process by which a signal is applied to the input of the amplifier and appears at the output in increased strength. The amplification may be expressed as a direct ratio between the input and the output levels, but is more commonly described as a logarithmic ratio in terms of dB gain.

**Anechoic Chamber**

An anechoic chamber is a specially designed camber which is free of echoes because of its ability to absorb incident sound.

**Automatic Gain Control (AGC) Hearing Aids**

A hearing aid incorporating a means (other than peak clipping) by which the gain is automatically controlled as a function of the magnitude of the input signal is defined as an automatic gain control hearing aids.

**Coupler**

An artificial ear is a device used for the measurement of the earphones which present an acoustic impedance to the earphone equivalent to the impedance presented by the average human ear. It is equipped with a microphone for measurement of the sound pressure developed by the earphone.

**Ear-level Aids**

Also known as over the ear, behind the ear, at the ear, and post-auricular instruments; Ear-level hearing aids are those in which the microphone, amplifier and earphone are one integral unit. These hearing aids rest behind the pinna, with a plastic "elbow" fitting over the anterior edge of the ear connecting with a plastic tube leads to the concha.

**In-the-Ear Aids**

As those which snape directly into the ear mould and rest in the concha.

**Frequency Response**

The frequency response of a hearing aid is a measure of how efficiently the hearing aid passes various frequencies which are applied at input level. The frequency response characteristics may be measured by observing the output level of the hearing aid as a function of a constant input level across frequency.

**Frequency Response Curve**

A frequency response curve is a graphic representation of the way a device responds to various frequencies (of equal input amplitudes) which are applied to it.

**Frequency Range**

The frequency range of a hearing aid refers to the useful range of the frequency response. It is expressed by two numbers, one representing the low frequency limits of amplification and other the high frequency limit.

The frequency range is calculated by taking an average of 1000 Hz, 1600 Hz and 2500 Hz and substracting 20 dB from this level and drawing a line parallel to the abscissa at this reduced level. Where this line intersects the frequency response curve at lower and upper end of the curve, are taken as lower and upper limits of the frequency range.

**Full on Gain**

The full on gain is the acoustic gain of the hearing aid at a specified frequency when its gain control is set to maximum with a stated input sound pressure level (SPL).

**Harmonic Distortion**

Harmonic distortion is the unwanted introduction of harmonic components of a sine wave input signal which arises as a consequence of the nonlinear response of an amplifier or transducer.

**Hearing Aid Test Box**

The hearing aid test box consists of a miniature anechoic enclosure with a built in loudspeaker.

**Intermodulation Distortion**

It is characterized by the presence, at the output of an amplifier, of frequencies equal to the sums and differences of exact multiples of the input frequency components. The presence of intermodulation distortion is caused by non-linear amplifier response.

**Peak Clipping**

Peak Clipping refers to the process whereby a device such as an amplifier or transducer limits its output as the input signal is increased beyond a certain level. The output from an amplifier or transducer may be linearly related to the input signal upto a given level, but beyond this level the response becomes nonlinear. Any further increase in the input signal is not reproduced in the output waveform.

**Reference Test Gain**

When a gain control of a hearing aid is set to amplify a 60 dB SPL input signal to a level in the coupler that is 17 dB below the saturation sound pressure level of the hearing aid, this gain level is referred to as reference test gain and this gain control position is referred to as reference test gain control position.

**SSPL 90**

It is defined as the sound pressure level developed in 2 $cm^3$ earphone coupler when the input sound pressure level at the microphone sound entrance of the hearing aid in 90 dB re: 20µ pa, with the gain control of the hearing aid is set to full on position.

**Average SSPL 90**

It is defined as the average of the 1000 Hz, 1600 Hz and 2500 Hz frequencies values of SSPL 90.

**Test Space**

A test space which has high sound absorption, while unwanted stimuli, such as ambient noise or electrical or magnetic fields, shall remain at a low enough level that they do not affect the test results by more than 0.5 dB.

**Sound Source**

The sound source shall be able to deliver calibrated sound pressure levels between 50 dB and 90 dB re: 20µ pa at the position of the hearing aid sound entrance opening. The sound source, including the control microphone, will need to be able to maintain a stable sound presentation level at the hearing aid sound entrance opening within ± 1.5 dB between 200 to 2000 Hz and within ± 2.5 dB between 2500 Hz to 4000 Hz.

**Supply Voltage**

It is defined as the voltage measured at the battery terminals of the hearing aid with the hearing aid turned on, with the gain control at the reference test position and with no input test signal.

**Tone Control**

It is selector switch which change the relative strength of the low frequency or high frequency signals which passes through it.

**Total Harmonic Distortion**

It is the sum of all of the harmonics plus all of the noise being generated by the hearing aid and measuring equipment.

**Volume Control**

Or gain control which makes us possible to adjust the overall gain of a hearing aid to intermediate values.

# CHAPTER IV

# TEST EQUIPMENT

Electroacoustic measures are basically measurements of input-output functions. That is, they are concerned with how the output signal differs from the output signal. Therefore, a means is required of generating and specifying an input signal and of measuring the output from the hearing aid. The following instruments will be required –

**Hearing Aid Test Box**

The hearing aid shall be placed in an anechoic chamber – 'dead' room free from reverberation and vibration. More commonly measurements are made in a small insulated box containing a loudspeaker or "artificial voice" which generates the test signal over the frequency range of 200 to 5000 Hz.

The unwanted stimuli in the test space such as ambient noise or stray electrical or magnetic fields, shall be sufficiently low as not to affect the test results by more than 0.5 dB.

**Sound Source**

A continuously variable beat frequency oscillator is desirable for generation of pure tones. Provision shall also be made for generation of complex signal.

The sound source used shall be capable of maintaining a signal within ± 1.5dB between 200 to 2000Hz and within ± 2.5 dB between 2500 Hz to 4000Hz at the hearing aid microphone.

For frequency response measurements, the total harmonic distortion of the sound source shall not exceed 2%. For harmonic distortion measurements, the total harmonic distortion of the sound source shall not exceed 0.5%.

**Coupler**

A 2 $cm^3$ earphone coupler type HA 2 shall be used and the tubing length and diameter employed shall be stated.

Microphone is earphone coupler: The pressure frequency response of the microphone used in the earphone coupler along with its amplifier shall be uniform within ±1 dB over the frequency range of 200 Hz to 5000 Hz.

**Harmonic Analyzer**

A harmonic analyzer shall be used to measure distortion in the hearing aid. The principle is, it rejects the unwanted signals (fundamental frequency) and accomplishes frequency analysis of the distortion products.

**RMS Response**

Test equipment used for measuring sound pressure levels shall give readings, for nonsinusoidal signals required to be measured, within ±1 dB to the readings that would be obtained with true rms responding equipment.

**Additional Apparatus for Automatic Recording**

Additional Apparatus may be used

a) Equipment which is capable of maintaining at the entrance of hearing aid microphone the requisite sound pressure level automatically shall be within ± dB over the frequency range required; and

b) Automatic level recorder – The indicated frequency on a recorder chart shall be within ± 5%. The paper speed and the pen speed on a recorded shall not differ by more than 1 dB from the steady state value over the required frequency range.

**Standard Operating Conditions**

The standard operating condition shall be:

| | |
|---|---|
| Temperature | - $15^{o}$ c to $40^{o}$ c. |
| Relative Humidity | - 45% to 75% |
| Air pressure | - 86 to 106 Kpa (1 bar = $10^{5}$ pa) |

The atmospheric conditions at the time of the test shall be measured and recorded in the specification sheet.

**Reference Sound Pressure**

The reference sound pressure level with respect to which all sound pressure levels are specified is 20µ Pa.

**Magnetic Field Strength**

The magnetic field strength is expressed in A/m or mA/m.

**Mechanical Support**

The mechanical support shall be of such size and shape that it does not disturb the measurements of hearing aid over the specified range of frequency and it should not transmit the vibrations to the hearing aid under test.

The coupler shall be sufficiently distant from the hearing aid to avoid distortion of sound field.

All the measurements shall be carried out without using ear inserts or ear molds which is normally incorporated in coupler, unless specified by the manufacturer.

**Connection to the 2 $cm^3$ Coupler**

The elbow and tubing of behind – the ear instruments and tubing of spectacle type hearing aids shall be connected to 2 $cm^3$ coupler by means of a plastic tube, the tube may be of rigid or flexible material, having the same internal diameter as the nominal internal diameter of the flexible connecting tube of the acoustic outlet. The tube dimensions shall be 2.5 cm (0.984 inch) long ± 4%. and 0.193 cm (0.076 inch) diameter ± 2%. If the tube dimensions other than these are used then it shall be stated in the specification sheet.

The tubing shall not be connected directly to the behind the ear type of hearing aid if the aid is intended to be used with an elbow.

**Normal Operating Conditions**

The test space where the hearing aid is located during measurement, shall be an enclosure with high sound absorption. The sound pressure variation in the test space shall not exceed ± 1dB from 200 Hz to 5000 Hz.

Measurements shall be made with source and microphone placed in the space which is free from standing waves, stray, electric or magnetic field.

The total disturbing voltage due to ambient noise, stray, electric or magnetic fields shall be 20 dB below the output resulting from the applied signal or they should not affect test results by more than 0.5 dB.

The pressure at the microphone position due to reflections from surrounding objects, shall be 20 dB below the pressure of the sound waves arriving directly from the source.

The microphone of the hearing aid under test shall be located at a predetermined test point immediately adjacent to the control microphone.

**Supply Voltage**

The type of power source, the supply voltage and the internal impedance shall be stated. Either an actual battery of the type normally used or suitable power supply that simulate the voltage and the internal impedance of real batteries may be employed. The supply voltage shall be within ± 2% as specified by manufacturers.

**Basic Control Setting**

The gain control setting shall be chosen to produce maximum gain or output from a hearing aid.

The tone control setting shall be chosen to give broadest frequency response.

If this is not possible then the setting which gives the greatest output shall be selected.

For Automatic gain control instruments, the maximum compression setting shall be used.

The settings (if any) other than those most often used with the particular hearing aid shall chosen for measurement.

In general, the settings selected for measurement shall be specified in the test report.

**Graphic representation of Hearing Aid Characteristics**

All published curve either of gain response or output versus frequency by plotted on a grid having a linear dB ordinate scale and a logarithmic frequency abscissa scale with the length of one decade on the abscissa equal to the degree of 50 ± 20 dB on the ordinate.

**Frequency Accuracy**

The input frequency shall be within ± 2% of the indicated frequency. The indicated frequency on a recorder chart shall be accurate within 5% of the input frequency. The paper speed of the chart recorder and its pen response must be within 1 dB of any steady state value read across the frequency range from 200 Hz to 5000 Hz.

# CHAPTER V

# TEST PROCEDURE

The results obtained by the methods specified below expresses the performance under the condition of use. But these measured performance of hearing aid should not be taken as actual conditions of use. In evaluating the performance of a hearing aid on the individuals, these difference should be taken into account.

**(1) Hearing Aid Gain Characteristics**

The purpose of this test is to determine the characteristics of the gain control.

The hearing aid gain shall be measured with the gain control maintained at the full on setting. A sinusoidal input shall be used at a sound pressure level of 60 dB or 50dB if a lower input is needed to obtain linear input-output conditions. The 50 dB SPL level should always be used when measuring gain in automatic gain control aids.

**A full on gain curve** shall be obtained on a logarithmic graph paper for the frequency range of 200 Hz to 5000 Hz. Regardless of which setting is used, the specific input level shall be recorded.

**Full on gain** in then calculated as the difference between the input sound pressure level and the output coupler sound pressure level. Average full on gain is calculated at the average of the values at 1000 Hz, 1600 Hz and 2500 Hz. The average full on gain shall have a tolerance of within ± 5dB of the manufacture's specified value for the model.

The frequencies of 1000Hz , 1600Hz and 2500 Hz rather than 500 Hz, 1000 Hz and 2000 Hz were chosen for the computation of gain and saturation is an attempt to obtain a value that might be more meaningful in terms of user's application.

**(2) Gain Control Taper Characteristics**

The volume control shall be varied from just on position to the full on position in a systematic manner for varies equally spaced settings of the gain control. Thus giving true range of gain values at various volume control positions. This characteristic will give information about the change in gain of hearing aid with rotation of volume controls.

The acoustic gain in plotted as the difference in the output and input sound pressure level versus the percentage displacement of the gain control settings.

**(3) Saturation Sound Pressure Level**

The purpose of this test is to determine the maximum sound pressure that the aid is capable of producing using an

SPL of 90 dB as input to produce maximum output at full on gain control setting. This test gives information which is of great value when considering whether the maximum intensities available from the hearing aid may be dangerous to the ear.

**a) SSPL 90 Curve:**

Test procedure is:

1) turn the gain control to full on position
2) A sinusoidal input signal of 90 dB SPL at hearing aid microphone is presented over a frequency range of 200 Hz to 5000 Hz and above.
3) Finally, plot the maxima of coupler sound pressure levels against frequency on a graph sheet.
4) The maximum value of the SSPL 90 curve shall not exceed that specified by manufacturer.

**Note:** It may be necessary, when making measurements on hearing aid with adjustable peak clipping and automatic gain control. Repeat the measurements when compression is on and off and plot the curve, coupler SPL Vs frequency, in a similar fashion.

**(b) Average SSPL 90**

From SSPL 90 curve, a single numerical value for saturation can then be computed by determining the average of saturation values at 1000 Hz, 1600 Hz and 2500 Hz and this simple numerical value will be referred to as “average SSPL 90”.

Average SSPL 90 for any given instrument shall fall within ± 4 dB of the manufacturer’s specified value for that model.

**(4) Reference Test Gain**

The purpose of this manipulation is to determine the gain control setting which is closure to a typical “use” setting and is also expected to be more representative of the use gain for most hearing aids than is full on gain.

The intent of this particular gain setting is to drive an adjustment of the gain control relative to the output saturation capacity of the hearing aid for some of the subsequent harmonic distortion measurement and measurement of equivalent input noise level.

To adjust the gain control to reference test gain position, is determined by subtracting the 17 dB ± 1 dB from average SSPL 90 with the input sound pressure of 60 dB. If some hearing aid does not have sufficient gain to achieve this level, then the gain control is set to full on position for various measurements. For automatic gain control instruments, reference test gain is defined as the full on volume control position.

The reference test gain level shall be stated on the specification sheet.

The rationale for reference test gain position is that the long term average sound pressure level for speech at a distance of one meter approximates 60 dB re: 20 μ Pa. Additionally, speech peaks are typically considered to be approximately 12 dB above the average level. Using a 65 dB input and coupler output of 12 dB below saturation level, it can be assumed that the peaks should not exceed the saturation sound pressure level in that particular aid. The use of 60 dB input SPL and 17 dB gain reduction would result in essentially the same value but it will be easier to accomplish with a generally used test equipment. Also, the reference test gain position gives a more approximation of a probable use setting than any other setting.

**(5) Frequency Response Curve**

The procedure is:

1) Adjust the input sound pressure level to 60 dB.
2) Adjust the gain control setting to reference test gain position, if the hearing aid does not have sufficient gain to achieve this level then set the gain control to full on setting.
3) Vary the frequency of the sound source over the frequency response of 200 Hz to 5000 Hz keeping the input

sound pressure level constant at 60 dB.

4) From the continuous recording, sweeping rate shall be such that the indication does not differ by more than 1 dB from the steady state value at any frequency.

The tolerance for frequency response curve is calculated by determining the average of the 1000 Hz, 1600 Hz and 2500 Hz response levels. From this average subtract 20 dB and a line is drawn parallel to the abscissa at this reduced level. The lowest frequency at which this straight line intersects, the response curve is labeled '$f_1$'. The highest frequency at which this straight line intersects, the response curve is labeled '$f_2$'. The response curve is then broken into a low band and a high band.

The tolerance for low band ie., from f1 to 2000 Hz is ± 4 dB. The tolerance for high band ie., from 2000 Hz to 4000 Hz is ± 6 dB.

**(6) Frequency Range**

The frequency range is considered to be within f1 and f2 value.

**(7) Comprehensive Frequency Response**

A family of frequency response curves shall be obtained with a series of input sound pressure levels. This family of curves will indicate the input-output characteristics of the hearing aid.

Set the gain control to reference test gain or to full on position if the hearing aid does not have sufficient gain.

The measurement of coupler sound pressure levels shall be made over the frequency range 200 Hz to 5000 Hz with input sound pressure levels of 50 dB, 60 dB, 70 dB and 80 dB.

The frequency response shall be plotted as the coupler sound pressure level versus frequency with a separate curve for each of the free field sound pressure levels used.

**Note**: Comprehensive frequency response curves for automatic gain control aids may give an erroneous picture of frequency response when the AGC is in action, because the AGC will tend to keep the output level constant. So, to measure the frequency response of AGC hearing aids it will require the presentation of two tones simultaneously, that is, a constant tone of 2000 Hz at input SPL of 90 dB is used to maintain the AGC at a fixed level of activity while the frequency response is measurement by a 50 dB input sound pressure level over the frequency range 200 Hz to 5000 Hz.

**(8) Effects of tone control position on frequency response**

The purpose is to show the effect of tone control position on frequency response of the hearing aids.

The procedure is –

1) Set the hearing aid gain control position to reference test gain; if the gain of the hearing aid is low enough to set the hearing aid at reference test gain, set the hearing aid given to full on position.
2) Adjust the input sound pressure level to 60 dB.
3) The coupler sound pressure level shall be measured over the frequency range of 200 Hz to 5000 Hz by continuous recording or at a suitable set of fixed frequencies at each tone control positions.
4) The frequency response is plotted as the coupler sound pressure level versus frequency at constant input SPL with a curve for each tone control position.

**(9) Harmonic Distortion**

An ideal amplification system is one which among other characteristics reproduces the output signal, identical to the input signal. However, no such system usually exists. Neither microphone, amplifier or receiver is capable of producing a replica of input signal. The harmonics are generated when the aid distorts the signal it amplifies. The more harmonics, the more distortion at that frequency.

In harmonic distortion measurement one can either plot the IInd harmonic at a number of frequency or one can add all the harmonics at one frequency to calculate total harmonic distortion.

However, second harmonic alone can be misleading because as the input level increases so does the harmonic curve, especially the third harmonic. If only the second harmonic was measured for the hearing aid, other harmonics may pass unnoticed.

The distortion which is most often mentioned is the total harmonic distortion. Total harmonic distortion is the sum of all of the harmonics plus all of the noise being generated by the aid, the equipment and the measuring equipment.

Harmonic distortion shall be measured suing a wave analyzer, distortion bridge or filter set. The procedure involves filtering out the fundamental frequency from the output signal and measuring the intensity level of the remaining second or more harmonics and it is expressed into percentage harmonic distortion.

The procedure is:

1) Set the hearing aid gain to reference test gain position.
2) Harmonic distortion shall be measured at 500 Hz, 800 Hz and 1600 Hz.
3) The amount of total harmonic distortion shall not exceed the maximum stated value by the manufacturer.

   **Note:** Any one of these frequency may be omitted from the measurement scheme if the frequency response curve rises 12 dB or more between the distortion test frequency and its second harmonics. This is done because the hearing aids that have a stuply rising frequency response may cause an artifact in the distortion measurement which may be solely due to the shape of the frequency response curve.

**(10) Internal Noise**

Purpose – To determine the internal noise of the hearing aid in the absence of any signal input.

The procedure is –

1) Set the enclosure sound pressure level at 60 dB.
2) St the gain control at reference test gain position.
3) Measure the output of the coupler at 1000 Hz, 1600 Hz and 2500 Hz. Find the average of these frequencies and subtract 60 dB input level from this average level to get the average gain.
4) Now remove the input signal to the hearing aid in the sound chamber.
5) Again measure the output of the instrument without any input signal applied.
6) By subtracting this new output from average gain (as calculated in 3$^{rd}$ step) will give us the internal noise.

from the hearing aid.

The internal noise level shall not be grater than the maximum level specified by the manufacturer for that model.

**Note:** It shall be insured that the noise levels in the sound chamber and in the coupler are negligible by switching off the sound source. This method is not applicable for AGC hearing aids.

**(11) Induction Coil Sensitivity**

For those hearing aids constructed with a telephone or induction coil system. The controls shall be set for that operating mode. The gain control shall be turned full on and the hearing aid is placed in the magnetic field developed by a 1000 Hz 10 mA/m ± 5 % rms current and is oriented to produce greatest coupler output level and this sound pressure level is recorded.

The recorded sound pressure level shall be within ± 6 dB of manufacturer’s specified value for these test conditions.

**(12) Frequency Response using Induction Coil**

Purpose – To measure the frequency response of the hearing aid when induction coil or telephone system is on.

The test procedure shall be -

1) Place the hearing aid in the magnetic field developed by 10 mA/m ± 5% at 1000 Hz.
2) Adjust the gain control in the hearing aid to reference test gain position, if the hearing aid does not have sufficient gain to permit this, the gain control shall be set at maximum.
3) The frequency of the sound source shall be varied over the frequency range of 100 Hz to 10000 Hz keeping the magnetic field constant at 10 mA/m.

**Note**: If a significant degree of non-linearity occurs, in that condition input magnetic field strength or the gain of the hearing aid shall be reduced. When non-linearity does not occurs, a higher input magnetic field strength may be employed to obtain a better signal – to noise ratio. When this is done the test conditions shall be stated.

4) The frequency response shall be plotted as the coupler sound pressure level versus frequency at a constant magnetic input field strength.
5) The magnetic input field strength shall be stated.

**(13) Automatic Gain Control Input-Output Characteristics**

The input-output characteristics of AGC aids shall be measured using 2000 Hz pure tone when the input is varied from 50 dB to 90 dB SPL in steps small enough to determine the action of AGC circuit (usually in 10 dB steps). The compression control is set to maximum. Record the coupler output at each step.

The coupler output from the hearing aid is then plotted against the input sound pressure level on a grid having equal linear decibel scales on both the ordinate and abscissa. All the curves are then matched at the point corresponding to the 70 dB input SPL and the measured curves at the two input extremes shall not differ from the manufacturer's specified curve by more than ± 4 dB.

**(14) Dynamic Characteristics of Automatic Gain Control**

Dynamic AGC characteristics are to be measured at the frequency of 2000 Hz with a hearing aid gain control set full on and a square wave modulated pure tone used as the input signal. This input signal is alternated abruptly between the sound pressure level of 55 dB and 80 dB. The attack and release time is determined from an oscilloscope pattern. Attach time is defined as the time between the onset of the abrupt increase and the point where the level has stabilized to within 2 dB of the steady state value for the 80 dB input. Release time is defined as the interval between the abrupt drop from 80 dB to 55 dB and the point were the signal is within 2 dB of the steady state value for the 55 dB input sound pressure level.

The tolerance for the attack and release time shall be within ± 5 m.sc. or ± 5 per cent whichever is larger, of the value supplied by the manufacture for particular model.

**(15) Battery Current**

The battery current measurement shall be made with the instruments whose errors donot exceed 2% at the parts of the scale used for the measurement.

Set the gain control to reference test gain position. Battery current is measured with a 1000 Hz pure tone at a sound pressure level of 65 dB as input signal.

Battery current value shall not exceed the maximum value specified for that model.

**(16) Effect of Battery or Supply Voltage Variation on Acoustic gain**

Purpose – The battery or supply voltage variation on acoustic gain shall be tested as follows:

1. Set the hearing aid gain control to reference test gain position.
2. Adjust the frequency of the sound source to 1000 Hz.

3. Input signal to the hearing aid at a sound pressure level of 60 dB.
4. With these settings vary the supply voltage (from 1.5 Volts to 1.0 Volt) and measure the variations in coupler sound pressure level for various values of supply voltages.
5. The deviation of the acoustic gain from the gain under normal supply voltage shall be plotted as a function of supply voltage.

Note: It may also be of interest to measure the influence of supply voltage on maximum acoustic gain or saturation sound pressure level in the coupler.

**(17) Effects of Varying Battery or Supply Voltage on Harmonic Distortion**

The purpose of this measurement is to determine the effects on harmonic distortion of variation in battery or supply voltage.

Repeat the procedure described in section 9 to measure the total harmonic distortion, but measure only at 1000 Hz by varying the supply voltage from 1.5 volts to 1.0 volt.

The variation in total harmonic distortion shall be within the specified values by the manufacturer for that model.

**(18) Effects on Acoustic Gain of Variation of Internal Resistance of Battery or Supply**

The purpose is to determine the effects of variation of internal resistance of battery or supply on acoustic gain.

The test procedure shall be –

1. Adjust the frequency of the sound source to 1000 Hz.

2. Set the gain control to reference test gain position and set input sound pressure level at 60 dB. Measure the changes in coupler sound pressure level for various values of the internal resistance of supply within the resistance range from the resistance of new battery to 100 ohms and keeping the supply voltages at the normal values when measured across the hearing aid terminals.

3. Plot on the graph paper the deviation of the acoustic gain from the gain at the normal value of the internal resistance of the supply against the supply internal resistance.

# CHAPTER VI

# GENERAL REQUIREMENTS FOR EAR-LEVEL-HEARING AIDS

**(1) Design of Hearing Aid**

The hearing aid shall be so designed:

1. To avoid undesirable feedback. The feedback can result from poor acoustic isolation of the receiver, the microphone or both, this permits the sound to radiate through the hearing aid case of the ear-level-hearing aids and be picked up by the microphone. This situation usually occurs only under high gain conditions. So proper insulation shall be provided to isolate the receiver from microphone.

2. The case of the hearing aid shall be strong, light and durable; and it shall be made of such material so as to withstand shocks, drops, and other mechanical damages likely to occur in normal life.

3. The microphone shall be mounted and housed to minimize –
   a) Mechanical transfer of housing noise to the microphone.
   b) The microphone shall be mounted in the hearing aid to partially eliminate the unwanted sound generated behind the ear.
4. That under normal conditions of use the hearing

aid shall not be damaged by inserting the battery with reversed polarity.

5. That the voltage and currents of all components shall not exceed the manufacturer's rating for these equipment.
6. To keep the distortion in hearing aid as low as possible.
7. To minimize interference resulting from the proximity of the hearing aid to the source of electrical interference.
8. To minimize the effect of moisture on hearing aid components since it causes corrosion and shortening of electrical connections.
9. To minimize the effect of body perspiration.
10. To provide reasonable protection form the dust.
11. To provide wind noise protection.
12. To withstand the wide range of temperature variations.

**(2) Housing**

1. The hearing aid including the battery shall be contained in a compact light weight housing.
2. The housing shall be so designed that the replacement of battery does not require the use of tools.
3. The insulation shall be provided to decrease

the vibration transmission.

4. The design of the housing shall be such that it is possible to open the housing for maintenance purposes without damaging or defecting the housing or hearing aid components contained therein.
5. The various controls, sound outlets of the hook (behind the ear type aids) and nozzle (spectacle type aids) shall be provided on the housing so as not to interfere with the wearing, operation or functioning of the hearing aid in normal use.
6. A proper connection of elbow or nozzle to the hearing aid receiver shall be provided to avoid any kind of feedback.

**(3) Coupling**

1. Ear level hearing aids with the internal receiver requires some means of delivering the amplified signal to the ear. For this purpose, a plastic tubing shall be used to couple the elbow or nozzle of the ear level aid to earmold. The tubing carries the sound from the receiver outlet through the earmold.

The coupling device shall be made of rigid material, having the same internal diameter as the nominal internal diameter of the flexible connecting tube.

The elbow and nub of the hearing aid shall always fit tightly into a plastic tube transmuting the output signal to the earmold to avoid any direct leakage of the acoustic signal.

A variance from the standard length and inner diameter of tubing shall be provided in order to control the frequency characteristics of the output signal. Thus, the tubing diameter shall be used as a means of shifting emphasis from higher to lower frequency or voice-versa. The use of smaller tubing can also be employed as a means of reducing average saturation output and gain. The option of changing the tubing length is generally not possible, since a certain length of tubing is required to reach from hearing aid to the earmold tip.

If a wider plastic tube (2.5 mm) or a narrow tube (1.0 mm) is used an ear adopter shall be required to connect the hearing aid elbow to the earmold.

Thus, each hearing aid shall be provided with an acoustic outlet attachment (elbow and tubing for behind the ear instruments or nozzle and tubing for spectacle type of instruments).

A minimum of three ear hook or elbow configurations of different sizes (small, medium and large size) shall be made available to fit the instrument to the individual's ear.

2. Spectacle type hearing aids shall be supplied

with an active temple and dummy temple for monaural fitting and both active temples for binaural fittings. The active temple shall includes microphone, amplifier and a receiver.

3. Each temple shall be provided with an interchangeable extension tip or temple tep adapter so that the hearing aid can be individually fitting to different lengths.
4. Manufacturer shall specify the area where the bending of the temple can be attempted for tight fitting of the spectacles on the individual.

**(4) Battery Compartment**

1. The battery compartment shall be made in such a way to protect the hearing aid components from chemical discharge from the battery.
2. Battery contacts shall be of corrossion resistant material.
3. Battery compartment shall be clearly marked to indicate +ve or –ve polarity for battery insertion.

**(5) Battery Data**

1. Unless otherwise specified the hearing aid shall be so designed as to be capable of operating from a battery voltage of preferably 1.4 volts.
2. The battery should preferably confirm to the

size specified by the manufacturer.

3. Average battery life shall be specified in the specified sheet.
4. If the battery other than that recommended by manufacturer is used in measurements, the change in maximum output, gain or battery life shall be specified and the type of battery used.

**(6) Controls and their Markings**

The controls shall be easily manipulable either by hand (eg: gain control) or by screw driver (eg: tone control). The controls shall be raised from the surface of the hearing aid for easy to feel and adjust. With a view of providing uniformity in marking used on hearing aid, and in order to facilitate easy identification, markings of control settings on hearing aid specified.

The markings shall be made of easily readable characters and aim shall be made for easy identification of various control settings. One should try to avoid the markings of setting by use of colour coding eg: by using dots of different colours shall be avoided.

**1) Battery 'On-Off' Switch:**

The battery is designed to supply the current or voltage to the hearing aid and the circuit may be activated by an on/off switch on the hearing aid or by proper insertion of the battery in ear level aids. However, in many cases, the battery switch may be combined with other function switches eg: the battery switch is combined with tone control or gain control switch.

The markings shall be as follows:

| Function | on | off |
| --- | --- | --- |
| Marking | ‘ I ’ | ‘ O’ |

**Note**: the marking of the ‘on’ position is used only when the hearing aid is provided with separate batter switch.

**2) Gain Control:**

Most of the hearing aids have a volume control or gain control that allows the user to adjust the output level from minimum. The volume control shall be made in such a way as to provide linear growth in gain because most of the hearing aids may not have some additional amplification by rotating the gain control beyond 50% setting. The volume control shall be raised from the outside surface of the instrument and it shall be provided with deeply serrated vertically mounted wheel which is easy to feel and adjust.

The settings of the gain control (or volume control) shall be indicated by numbers on the control knob in such a way that higher number indicates a high gain. Incases where restricted space does not allow the use of numbers, in that case three colored codes shall be used for each one-quarter increment to show the degree or rotation.

| | | |
|---|---|---|
| Yellow color | - | Low intensity |
| Green color | - | Moderate intensity |
| Red color | - | High intensity |

A raised notch on hearing aid housing shall be provided for convenient calibration of control position.

**3) Input Selector:**

The markings shall be as follows:

| Function | Microphone | Pick up Coil |
|---|---|---|
| Marking | ‘M’ | ‘T’ |

If the battery on/off switch is attached to the input selectors. Then marking for ‘off’ position ‘O’ only shall be added to these functions like O-M-T.

Note: If a position where both microphone and pick up coil are connected together, this shall be marked by ‘MT’.

**4) Tone Control Switch:**

The tone control is a filter network designed to alter relative strength of high frequency and low frequency energy passing through it and can be located internally or externally in the circuit.

Tone control shall be located on the outside or inside surface of the case. A switch or screw shall be provided to adjust the tone control setting.

The tone control shall have three settings and shall be marked as followed:

| **Function** | **Marking** |
|---|---|
| Low frequency emphasis | 'L' |
| High frequency emphasis | 'H' |
| Normal or No emphasis | 'N' |

When the tone control points at 'N' (normal), the instrument shall be set at its broader frequency response. When control points at 'H' (high frequency emphasis or Low frequency suppression), the low frequency shall be reduced in strength or attenuated more than the high frequency and thus a relation high frequency emphasis shall be obtained. When the switch points at 'L' (low frequency emphasis or high frequency suppression), the high frequency strength shall be reduced or attenuated more than the low and thus low frequency emphasis shall be obtained.

**5) Telephone Pick up Switch:**

Many hearing aids provides with a special circuit to enhance its use with a telephone. This circuit shall be activated by a switch marked on the case as 'Tel'. It shall be mounted on the upper surface of the case with other input selector switches ‘O-M’. This switch shall allow the user to substitute the telephone pick up for the microphone as the input to the aid. With the microphone out of the circuit, noise from the local environment will be excluded and only the telephone signal shall be amplified.

**6) Automatic Gain Control Switch:**

(a) The threshold of compression shall be fixed at some particular level and shall remain at that level at any setting of the volume control. That is, it shall not amplify beyond that limit no matter how high the volume control has been adjusted. In this way the user will be protected from the effect of sudden impulse signals being amplified beyond the threshold of discomfort. The automatic gain control limits shall be specified.

(b) The input compression circuit shall be designed in such a way to prevent transient over shoot from rising more than 2 to 3 dB during the attack period. So, the user will be further protected from sudden, rapid, transient changes in signal level which might reach the ear during the attack period.

The markings shall be as follows:

| Function | Marking |
| --- | --- |
| No limiting | None |
| Automatic Volume Control or Automatic gain Control | AV or AG |
| Peak Clipping | PC |

**7) Output Limiting Control:**

Continuously adjustable gain/saturation sound pressure level control shall be provided which may be located on the inside or outside surface of the case. The control for adjusting the gain/SSPL shall be indicated by numbers in such a way that a higher number indicates a higher output. The range of adjustment shall be specified. The control shall be calibrated directly in dB (HL) for easy presetting.

**(7) Physical Dimensions and Weight**

(1) Dimensions:

The maximum permissible dimensions for ear level (behind the ear type) hearing aids shall be as follows:

| | |
| --- | --- |
| Length | 50.0 mm |
| Width | 20.0 mm |
| Thickness | 10.0 mm |

**(2) Weight:**

The weight of the hearing aid without battery but with ear hook shall not exceed 10 gm.

**(8) Climatic and Mechanical Durability Requirements**

The hearing aid shall be so designed as to be capable of withstanding the climatic and mechanical tests and satisfy the electroacoustic characteristics (as specified in this draft) after these climatic and mechanical tests.

**(1) Damp heat (Cycling)**

The hearing aid shall be subjected to two cycles of damp heat (cycling) test; the duration of the recovery period shall be 24 hours, after which the hearing aids shall be subjected to the relevant performance tests.

**(2) Dry Heat:**

The hearing aid shall be subjected to the dry heat test of temperature range 10 to $40^{o}$c. This would be somewhat equivalent to the difference between our winter extreme and summer extreme temperatures. The duration of recovery period shall be 2 hours, after which the hearing aid shall be subjected to the relevant performance tests.

**(3) Drop:**

The hearing aid shall be subjected to the drop test. The height of fall shall be 1.5 meter and the number of drops shall be 6. After the test, the hearing aid shall be subjected to the relevant performance tests, Minor cracks or dents which donot affect the performance of the hearing aid should not be taken as criteria of failure for this test.

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