Assistive Listening Systems

a guide for architects

and consultants

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Assistive Listening Systems

A Guide for Architects and Consultants

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1.0 Public Facilities Need Assistive Listening Systems

Even with the best sound system, most public facilities are unable to accommodate the needs of the patron who has a hearing impairment. A hearing aid does of course provide some assistance, however, the further the listener is from the sound source, the greater will be the level of both background noise and reverberation. Even the most professionally fitted hearing aid cannot be expected to overcome these effects without some assistance.

Increasing the gain of a hearing aid does increase the level of the sound source to the hearing impaired person. But doing so also increases the level of the background noise, so the clarity of the sound source appears no better, and the wearer of the hearing aid may experience some discomfort due to the increased volume.

Reverberation may occur in a concert hall, lecture theatre, airport departure hall, or in fact any area which is devoid of soft furnishings such as carpeting that dampen sound echoes. As an example of the problems caused by reverberation, members of the community with normal hearing are often confused by messages relayed over the sound system in an airport or railway station. So it is easy to understand the further degrees of difficulty that a person with a hearing impairment must suffer.

A person with a hearing impairment is entitled to the same degree of access to public venues as a person with normal hearing. Any establishment which is open to the public, and provides a sound system for use by persons with normal hearing, should also provide some form of Assistive Listening System for those members of the community who require it. Demands for the provision of such systems from those members of the community who have a hearing impairment is increasing, and there exists the possibility of action under the auspices of the Human Rights Act.

There is a further consideration regarding the installation of an Assistive Listening System, a commercial one. The percentage of the population who have a hearing impairment (currently around 10%) is increasing, and is predicted to continue doing so. Those people will still wish to visit the cinema, theatre, or museum for their own pleasure, and so will tend to favour those establishments catering for their particular needs, avoiding those that ignore or pay only lip service to them. This trend has already been noted in other countries, prompting some major companies to take effective remedial action.

2.0 Types of Assistive Listening Systems

In general terms, an Assistive Listening System is a wireless link directly between the sound source and the hearing impaired person. The direct link to the listener eliminates the effects of background noise and reverberation, thus not only providing some amplification, but also improving clarity.

Essentially, there are three types of systems used to provide hearing assistance in public places.

2.1 Electromagnetic Loop Systems

Probably the most widely known and used form of Assistive Listening System, the loop system emits a low frequency electromagnetic signal rather than an auditory one. This signal is detected by the Telecoil in a hearing aid, and subsequently processed back into sound waves which the wearer of the aid can hear.

2.2 Infrared Communication Systems

An Infrared Communication System emits an invisible infrared rather than an auditory signal. The infrared signal is detected and processed by a receiver worn by the hearing impaired person, additional and external to the hearing aid.

2.3 FM Radio Communication Systems

An FM Radio Communication System emits a high frequency radio signal, rather than an auditory one. The signal is detected and processed by a receiver worn by the hearing impaired person, additional and external to the hearing aid.

Each type of system has different characteristics, permitting coverage of all normal applications. These characteristics are summarised following a description of the different systems.

Regardless of the type of Assistive Listening System used, there must be minimum signal distortion, and a high signal to noise ratio.

3.0 Electromagnetic Loop Systems

3.1 The Basic System

The basic components of a loop system include:

- a wire loop installed around the perimeter of the area where coverage is to be provided
- a loop amplifier connected to the sound source, possibly a microphone or tape deck depending on the particular application.

In situations where the speaker wishes to be mobile within the coverage area, a wireless microphone may be used in conjunction with the system.

3.2 Technical Considerations

The loop amplifier must be capable of driving into a low impedance load, have low distortion (better than 1%) on the output signal, and have automatic level control so that the hearing impaired person does not constantly have to adjust the volume of their hearing aid. For larger systems, there should be independent input and output level controls. Tone controls are desirable. In order that an electromagnetic field of sufficient strength is generated by the system, the amplifier must be capable of delivering a continuous current of 100 mA per metre length of loop for a circular loop, and 112 mA per metre for the longest side of a rectangular loop. The peak current the amplifier must be capable of delivering, is at least three times the normal continuous current. Overall, the signal to noise ratio in the system should be better than 40 dB, with good frequency response between 100 and 5000 Hz.

It should be noted here that the only amplifiers likely to fulfil all these needs are those designed specifically for loop systems. Normal PA or domestic amplifiers seldom in practice prove to be adequate.

The loop wire is usually an insulated copper wire, the cross sectional area is adequate to allow it to safely carry the peak current that may flow through the system. Ideally, the loop wire should be installed when the area to be covered is either being constructed, or perhaps refurbished. This allows for optimum positioning of the wire, so that it is not run close, or parallel to, power wiring. This minimises the effects of "mains hum", which can be severe and cause considerable problems. It is also important that the wire is not installed along piping, or behind metallic coatings such as used for insulation. These will effectively act as a shield, reducing the amplitude of the signal detected by the hearing impaired person. A good height to run the loop wire is around 3 metres above floor level.

Generally, there will be equal emission of the electromagnetic signal in all directions from the loop wire, although there are methods of loop design that can be employed to minimise this effect.

3.3 Factors Affecting the Quality of a Loop System

The overall quality of the completed loop system can be no better than the components used, or the care taken over installation. The following factors can greatly affect the performance:

1. The quality of the microphones used.
2. The ability of the amplifier to meet current, distortion, frequency response and signal to noise requirements.
3. Interference from external sources such as fluorescent lamps, high tension wires, computers, and some electrical appliances.
4. Positioning of the loop wire.
5. The performance of the hearing impaired person's hearing aid.

3.4 Special Loop Systems

One variation of the loop system merits further mention. This is the Counter Communication System, a small system which provides the hearing impaired person with individual access to such places as information desks, hotel reception desks, bank tellers; all places where the level of background noise may be such that the hearing impaired person has difficulty communicating effectively. The Counter Communication System operates under the same principles as the larger systems, but the loop design is somewhat different, and being small in size is more straightforward to install.

3.5 Pros and Cons of Loop Systems

The main advantages of loop systems are that they are generally accessible to anyone who wears a hearing aid equipped with a Telecoil (the majority of behind the ear hearing aids and many larger in the ear hearing aids), and that the material purchase cost may be lower for smaller and medium sized systems.

Loop systems are generally not accessible to people who do not have a hearing aid with a Telecoil. However there are loop receivers available which can be used to provide access to those members of the community who are not equipped with a hearing aid fitted with a Telecoil.

The main disadvantages of loop systems are that they can mainly be used only in a stand-alone situation, as systems used adjacent to each other in either the horizontal or vertical plane would cause cross talk. They may be prone to external electrical interference, and there is no confidentiality apart from possibly when using a Counter Communication System.

4.0 Infrared Communication Systems

4.1 The Basic System

An Infrared Communication System basically consists of three components: a base station connected to the sound source; an emitter which transmits the infrared signal; and a receiver which detects and processes the infrared signal. The receiver may be connected directly or indirectly to the hearing aid of the wearer. A separate receiver is required for each person using the system.

For those applications where the speaker wishes to be mobile within the coverage area, it is possible to link an infrared system with a wireless microphone.

4.2 Technical Considerations

Essentially, the only wiring necessary is between the base station and the emitter, generally a length of standard 50 ohm coaxial cable. The base station would normally be located close to the sound source, which, as with loop systems, may be a microphone, or a standard line input, dependant on the application.

The receiver is a small, pocket sized unit, powered by two AA sized cells which may be rechargeable. Direct connection to the hearing aid is normally by means of a Direct Audio Input cord, plugging into both the receiver and the hearing aid. Indirect connection to the hearing aid would generally be accomplished by means of a neck loop which emits a low level electromagnetic signal picked up by the telecoil in a hearing aid. The electromagnetic signal is so weak that only the wearer of the neck loop can detect it.

Infrared receivers can also be used with a standard or attenuated headset, similar to “walkman” style headsets.

Infrared emissions are in the form of a broad beam, which may be around 50 ft wide, extending around 100 ft from the emitter. A single emitter is generally capable of providing coverage to most public areas, but in certain cases it may be advantageous to use two emitters. Infrared emissions are in the form of invisible light and they will not pass through solid objects. If there is any obstruction, such as a pillar, there will be a dead spot immediately behind the object where no signal will be detected. The use of two emitters sited appropriately will eliminate this problem. These emitters can be daisy chained together from a single base station, without any detrimental effect on the quality of the transmitted signal.

4.3 Factors Affecting the Quality of an Infrared System

The overall quality of the installed Infrared Communication System is very dependant on the components used, and on the positioning of the emitter. The following factors should be noted as affecting the performance of such a system:

1 The quality of the microphones used.

2 The positioning of the emitter(s).

3 The condition of batteries in the receiver.

4 The condition of headsets, cords, and neck loops.

5 The performance of the hearing impaired person’s hearing aid.

6 The strength of the ambient sunlight.

4.4 Pros and Cons of Infrared Communication Systems

The inability of an infrared signal to pass through solid objects is one of its major advantages. An Infrared Communication System allows for total confidentiality, the signal will not pass outside the confines of a room. This may be an important factor to government departments, courtrooms, and so forth. A further advantage is its portability. The components are light and easily transportable, and there is little need for permanent wiring, making installation and dismantling of a system a very simple and quick matter. Infrared Communication Systems are also very resistant to external interference.

In addition to those hearing impaired persons who use a hearing aid, there are many that for one reason or another do not. These people can also obtain some assistance from an infrared system, by using the receiver with a headset. The infrared system can provide coverage without having to provide any additional equipment.

The main disadvantage of the Infrared Communication System is the need to purchase and manage several receivers. This entails some management of the system, ensuring that receivers are kept in good order, batteries are properly charged and changed as required, and that receivers are issued and collected as required.

A further disadvantage is related to the infrared system emitting light. In very strong light which contains an infrared component, the signal from the emitter may be blanked out. This is seldom a cause for concern inside buildings, including those with a large expanse of window. But it does mean that the system cannot be used outdoors.

5.0 FM Radio Communication Systems

5.1 The Basic System

An FM Radio Communication System basically consists of two components: a radio transmitter which may either be stationery (for larger systems) or mobile; and a personal receiver which detects and processes the radio signal into a form audible to the wearer. The receiver may be directly or indirectly connected to the wearer's hearing aid.

5.2 Technical Considerations

FM Radio Communication Systems require little in the way of installation. Mobile systems require no installation, while the transmitter for a larger system would normally be located close to the sound source, which may be a microphone or a standard line input as with other Assistive Listening Systems.

Mobile transmitters have an antenna as an integral part of the microphone. Large area systems have an external antenna, the choice of which is affected by the size of the area in which coverage is to be provided. The larger and more efficient the antenna, the greater the coverage area. With a large area system, and a well designed antenna, it ought to be possible to cover an area with a radius of some 300 metres.

The receiver is a small, pocket sized unit, powered by two AA sized cells which may be rechargeable. Direct connection to the hearing aid is normally by means of a Direct Audio Input cord, plugging into both the receiver and the hearing aid. Indirect connection to the hearing aid would generally be accomplished by means of a neck loop which emits a low level electromagnetic signal picked up by the telecoil in a hearing aid. This electromagnetic signal is so weak that only the wearer of the neck loop can detect it.

FM radio receivers can also be used with a standard or attenuated headset, similar to "walkman" style headsets.

FM Radio Communication Systems may be fitted with any of a range of frequencies designated for use with such systems by the Ministry of Economic Development under the Radio Communications Act 1989. This service also grants approval for specific equipment to be used. It is important to realise that not all systems currently on the market have been approved for use in this country, and may cause interference to users of legitimate systems. It is illegal to use non approved systems, and to do so runs the risk of confiscation of the equipment, along with prosecution.

FM Radio Communication Systems used in close proximity to each other must be used on different channels in order to eliminate interference.

FM radio emissions have a circular pattern, extending outwards from the antenna.

While these emissions can be shielded to a greater or lesser degree by metallic objects, they will in practice penetrate walls, so that the signal will be accessible to anyone who has an FM receiver on the appropriate channel, thus confidentiality is limited.

Finally, care should be taken that external electrical noise in the environment (possibly caused by heavy electrical machines or power lines) is not excessive as it may cause interference to the FM signal, and also that the antenna is mounted in a vertical plane.

5.3 Factors Affecting the Quality of an FM System

As with the other types of Assistive Listening System, the overall quality of the installed FM Radio Communication System is dependant on the components used, and in the case of a fixed system, the antenna installation. The following factors may affect the performance of the system:

1. The quality of the microphones used.
2. The antenna location and orientation.
3. The condition of the batteries in the receiver or mobile microphone.
4. The condition of headsets, cords, and neck loops.
5. The amount of spurious electrical noise in the environment.
6. The performance of the hearing impaired person's hearing aid.

5.4 Pros and Cons of FM Radio Communication Systems

An FM Radio Communication System can be used to great advantage when portability is required, without the need for total confidentiality. These systems have fewer component parts than infrared systems, so are even easier to install. They may also be used out of doors, and can provide coverage over a wide area.

As with Infrared Communication Systems, those persons with a hearing impairment who do not wear a hearing aid can gain some benefit from an FM system, by wearing the receiver with a headset.

The disadvantage of FM systems is the need to purchase and manage several receivers. This entails some management of the system ensuring that receivers are kept in good order, batteries are properly charged and changed as required, and that receivers are issued and collected appropriately.

6.0 Assistive Listening Systems Comparison

6.1 Electromagnetic Loop Systems

- ☺ Accessible to most hearing aid wearers
- ☺ Most hearing impaired persons are familiar with loop systems
- ☺ Cost effective solution for many stand-alone, fixed installations
- ☹ May be complicated, messy, and expensive to actually install
- ☹ Not readily portable
- ☹ Not suited to multiple installations in close proximity
- ☹ Limited confidentiality
- ☹ Prone to electrical interference if inadequate care taken over installation

6.2 Infrared Communication Systems

- ☺ Easy to install
- ☺ Easily portable
- ☺ Complete confidentiality
- ☺ People without hearing aids can use receivers
- ☺ Not susceptible to electrical interference
- ☹ Relatively high cost for smaller installations
- ☹ Receivers needed for each hearing impaired person
- ☹ Prone to interference from very strong direct sunlight
- ☹ Needs some management of receivers

6.3 FM Radio Communication Systems

- ☺ Extremely easy to install
- ☺ Portable
- ☺ Large area coverage
- ☺ May be mobile
- ☺ Multiple channels available
- ☺ People without hearing aids can use receivers
- ☺ Can be used outdoors
- ☺ Generally not prone to electrical interference
- ☹ Relatively high costs for smaller installations
- ☹ Receivers needed for each hearing impaired person
- ☹ Needs some management of receivers
- ☹ Limited confidentiality, but better than with loop systems
- ☹ Initial equipment cost may be relatively high, dependant on application

7.0 Assistive Listening Systems – Typical Applications

The following table is provided to illustrate the type of system normally used for specific applications. It must be remembered that every individual application is different, so all factors which may affect the installation should be taken into account before deciding which system would be best suited.

VENUE	CONSIDERATIONS	SYSTEM
Banks	Teller/Interview Rooms	Counter Communication System
Hotels	Reception Desks	Counter Communication System
Theatre	Ticket Office	Counter Communication System
Churches	Large area coverage, many people	Loop System, Infrared, or FM
Rest Homes	Coverage for many people	Loop System
Lecture Theatres	System choice depends on particular application	Loop System, Infrared, or FM
Cinema	Single Screen	Loop System
Cinema	Multi Screen	Infrared or FM
Museums	Auditory Description, Translation	FM
Courtrooms	Confidentiality Required	Infrared
Convention Centres	Depends on number of convention rooms and proximity	Loop System, Infrared or FM
Airport Halls	Improve Acoustics	Standard Loop
Outdoors	Outdoor concerts in parks etc	FM

Oticon would be happy to provide assistance and advice regarding system selection on request.

8.0 Microphones

With so many types of microphone available, it is impossible to specify exactly which should be used until full details of each application are known.

Many people appreciate that a good quality amplifier is needed, but try to keep the price of their system down by purchasing a low cost microphone. This is false economy, as the system can only be as good as its worst component, and most degradation of the signal will occur at the point it is picked up. It is better to make the most of the sound source by utilising the most appropriate high quality microphone, which has a frequency response covering the entire audible range, and has a high signal to noise ratio. This should also be borne in mind if connecting an Assistive Listening System to some form of sound system.

In situations where microphones are used, the microphone cable should be of a good shielded type and it should not be run close, or parallel to the loop wire in order to avoid problems with feedback.

For many Assistive Listening System applications, there are three specialised types of microphone:

8.1 Wireless Microphones

Recommended where freedom of movement by the speaker is desirable. Relatively expensive, but very effective.

8.2 Boundary Layer Microphones

Recommended where hands-off operation is desired. Also allows for some freedom of movement. Mounted in ceilings etc. May cause problems with reverberation if not installed with care.

8.3 Conference Microphones

Again, for use in a hands-off type operation, normally utilised in a round the table situation. Placed in the centre of the table, it picks up all sounds from around the table. Effective range varies with model, but is generally around a 15 to 20 feet radius. Conference Microphones may be useful in other applications as well.

9.0 The Building Act and The Hearing Impaired

The following summarises New Zealand Legislation as of August 1998 concerning provision of facilities for the hearing impaired in public buildings. For full details please consult the original Acts and standards, or a building inspector of your Local Authority. If doubtful about any legal obligation or liability consult a solicitor familiar with the Building Act. In cases of dispute, the Building Industry Authority in Wellington has the final word.

The Building Act 1991

Clause G5 Interior Environment

Objective

G5.1 The objective of this provision is to:

(a) Safeguard people from illness caused by low air temperature

(b) Safeguard people from injury or loss of amenity caused by inadequate activity space

(c) Safeguard people from injury caused by unsafe installations and

(d) Ensure that people with disabilities are able to carry out normal activities and processes within buildings

Limits on application

Objective G5.1 (d) shall apply to those buildings to which section 25 of the Disabled Persons Community Welfare Act 1975 applies.

Functional Requirement

G5.2.1 Buildings shall be constructed to provide:

(a) An adequate, controlled interior temperature

(b) Adequate activity space for the intended use, and

(c) Accessible spaces and facilities

Limits on application

Requirement G5.2.1 (c) shall apply only to Communal Residential, Communal Non-residential and Commercial buildings.

Performance

G5.3.4 Where reception counters or desks are provided for public use, at least one counter or desk shall be accessible

G5.3.5 Buildings shall be provided with listening systems which enable enhanced hearing by people with hearing aids.

G5.3.6 Enhanced listening systems shall be identified by signs complying with Clause F8 "Signs".

Limits on application

Performance G5.3.4 applies only to Communal Residential, Communal Non-residential and Commercial buildings.

Performance G5.3.5 applies only to:

(a) Communal Non-residential assembly spaces occupied by more than 250 people, and

(b) Any theatre, cinema, or public hall, and

(c) Assembly spaces in old people's homes occupied by more than 20 people.

S47A - Access and Facilities for persons with disabilities to and within buildings

(1) In cases where provision is being made for the construction or alteration of any building to which the public are to be admitted, whether on payment or otherwise, reasonable and adequate provision by way of access, parking provisions, and sanitary conveniences, shall be made for persons with disabilities who may be expected to visit or work in that building and carry out normal activities and processes in that building.

(2) Notwithstanding the provisions of subsection (1) of this section, in respect of alteration of any existing building or premises, the Building Industry Authority may at any time by determination under Part III of this Act provide for a waiver or modification from all or any of the requirements of this section if, having regard to all the circumstances, the Building Industry Authority determines that it is reasonable to grant the waiver or modification.

(3) Any provision that is made to meet the requirements of disabled persons in accordance with New Zealand Standard Specification No 4121 (being the code of practice for design for access and use of buildings by persons with disabilities) and any amendments thereof (whether made before or after the commencement of this subsection) or in accordance with any standard specification that is in substitution therefore, shall, in respect of matters subject to this Act, be deemed to be one of the documents establishing compliance with the building code for the purposes of section 49 of this Act.

(4) The provisions of this section shall apply to, but shall not be limited to, buildings, and parts of buildings, (including driveways, access ways, and passages within and between complexes and developments and associated landscaping, if any) that are intended to be used for or associated with one or more of the following purposes:

(a) Land, sea and air passenger transport terminals and facilities and interchanges, whether wholly on land or otherwise;

(b) Public toilets wherever situated;

(c) Banks;

(d) Childcare centre and kindergartens;

(e) Day-care centres and facilities;

(f) Commercial buildings and premises for business and professional purposes, including computer centres;

(g) Central, regional, and local government offices and facilities;

(h) Courthouses;

(i) Police stations;

(j) Hotels, motels, halls of residence, holiday cabins, groups of pensioner flats, boarding houses, guest houses, and other premises providing accommodation for the public;

(k) Hospitals, whether public or private, nursing homes, and old people's homes;

(l) Medical and dental surgeries, and medical and paramedical and other primary health care centres;

(m) Educational institutions, including public and private primary, intermediate and secondary schools, universities, polytechnics and other tertiary institutions;

(n) Libraries, museums, art galleries and other cultural institutions;

(o) Churches, chapels, and other places of worship;

(p) Places of assembly, including auditoriums, theatres, cinemas, halls, sports stadiums, conference facilities, clubrooms, recreation centres, and swimming baths;

(q) Shops, shopping centres, and shopping malls;

(r) Restaurants, bars, cafeterias, and catering facilities;

(s) Showrooms and action rooms;

(t) Public laundries;

(u) Petrol and service stations;

(v) Funeral parlours;

(w) Television and radio stations;

(x) Car parks, parking buildings, and parking facilities;

(y) Factories and industrial buildings where more than 10 persons are employed;

(z) Other buildings, premises, or facilities to which the public are to be admitted, whether on payment or otherwise

(5) Where any provision required by this section is made at a building in compliance therewith, a notice or sign that indicates in accordance with the international access symbol that provision is made for the needs of persons with disabilities shall be displayed outside the building or so as to be visible from outside it.

(6) For the purposes of this section, the term "person with a disability" means any person who suffers from physical or mental disability to such a degree that he or she is seriously limited in the extent to which he or she can engage in the activities, pursuits, and processes of everyday life.

D47A.05 – People for whom provision is to be made

The previous s25 Disabled Persons Community Welfare Act 1975 did not refer to "persons with disabilities" but to "disabled persons". When s25 was in effect transformed into s47A BA91, the terms "disabled persons" became "persons with disabilities".

Subsection (6) ascribes to the term "persons with disabilities" a definition identical to the definition of "disabled person" in s2 Disabled Persons Community Welfare Act 1975.

It should be noted in particular that the term "persons with disabilities" is not limited to wheelchair users. The term also included people with hearing and sight disabilities, with mobility disabilities which do not confine them to a wheelchair, and so on.

Subsection (1) required provision to be made for "persons with disabilities who may be expected to visit or work in that building and carry out normal activities and processes in that building". In several of its determinations, the Authority has taken the view, as it said in determination 97/009, that:

(a) The provisions of the building code for access and facilities for use by people with disabilities apply to a building as a whole but do not apply to a building or to any part or portion of a building in which people with disabilities, solely because of their disabilities, cannot work, and which, for some specific reason, will not be visited by people with disabilities.

(b) It is important not to underestimate the extent to which people with disabilities are capable of

overcoming those disabilities. The clear intention of the Building Act and the Disabled Persons Community Welfare Act is that buildings must not be constructed in such as way as to prevent people with disabilities from undertaking work which they are capable of undertaking or from visiting buildings which they are capable of visiting.

For example, people confined to wheelchairs are unlikely, solely because of their disabilities, to be able to work in a slaughterhouse and therefore cannot be expected to do so; therefore subs (1) would not require provision to be made.

D47A.06 - Reasonable and adequate provision

Subsection (1) specifically requires reasonable and adequate provision for people with disabilities to be made in respect of "access, parking provisions, and sanitary conveniences". However, for buildings to which the section applies, the building code required additional provisions to be made for people with disabilities in respect of such matters as laundering, interior environment (heating, space, listening systems), electricity, and water supply. In several of its determinations, see for example Determination 94/005, the Authority has taken the view that if people with disabilities may be expected to visit or work in a building then provisions is to be made to enable them to carry out normal processes in that building. That will include the provision of manoeuvring space for wheelchairs, fixtures such as desks and counters at appropriate heights, and so on.

New Zealand Standard 4121: 1985

216.4 Listening System - 216.4.1

Where a sound amplification system is provided, a listening system shall be installed to cover the total area of the room. A sign indicating that a listening system, is installed shall be provided in accordance with fig. 23 at the main door (or doors) to the room.

216.5 Induction Loop - 216.5.1

An acceptable type of listening system is an audio frequency induction loop system. The value of magnetic field strength recommended is 0.1 ampere/meter for an input signal of normal speech level. This magnetic field strength shall be chosen so that:

(a) It is high enough to produce an acceptable signal-to-noise ratio over ambient electromagnetic noise from power installations, etc

(b) It is not so high as to cause overloading of the hearing aid.

NOTE - The design, supervision, and installation of listening systems should be undertaken by suitably qualified persons.

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