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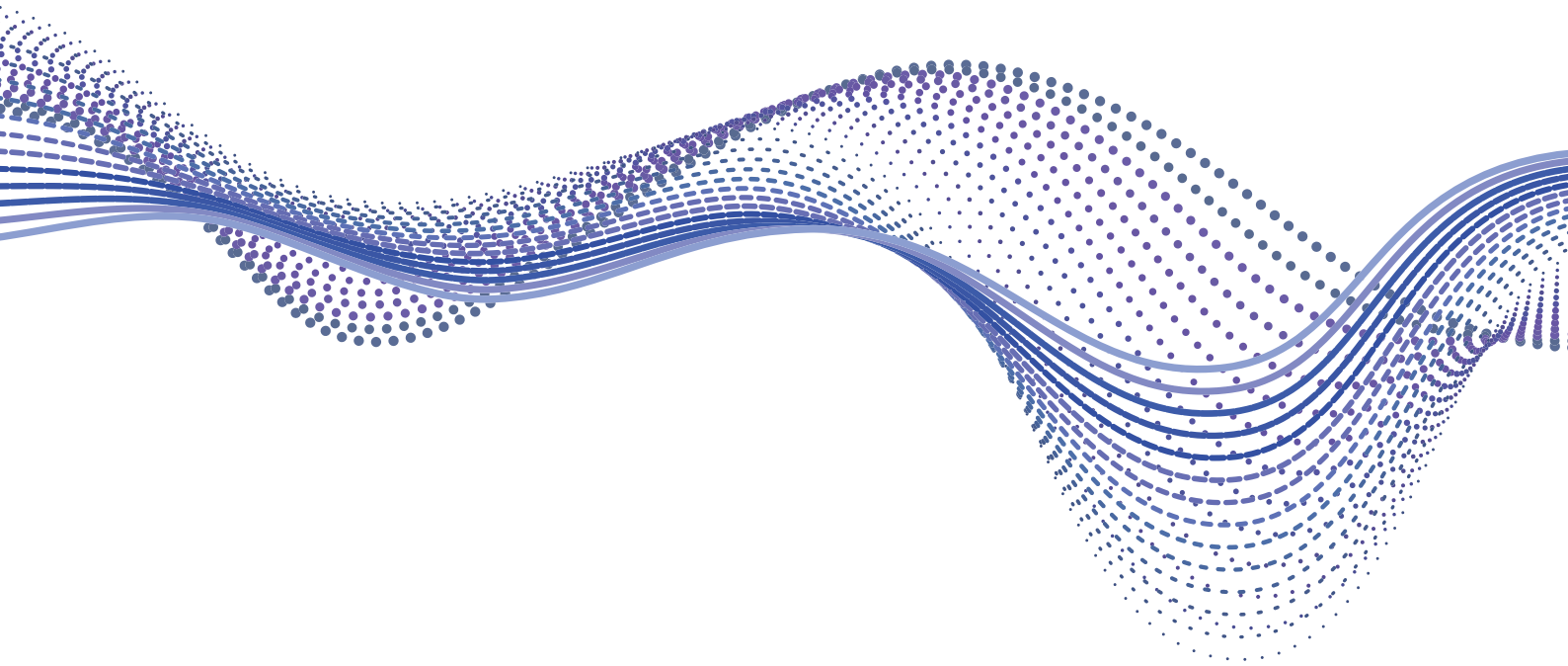
Code of Practice for the **Design and Operation of Assistive Listening Systems**



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FOREWORD

This Code of Practice has been produced by an independent team of UK audio and assistive listening experts to provide guidance for the design and operation of assistive listening systems, regardless of their technology and method of operation. Although some guidance is available in existing standards such as IEC 60118-4 (Hearing loop systems) and IEC 61603-3 (infra-red systems) many newer technologies have little guidance regarding their required performance. However, from the user's perspective, the needs and requirements are essentially the same for the successful operation of any Assistive Listening System, regardless of the technology used to deliver the signal.

This Code of Practice not only provides basic guidance concerning the audio performance but also introduces best practice considerations with respect to the design, operation, maintenance and accessibility of such systems, aspects that have not all received an appropriate level of attention to date but are extremely important for the successful use and operation of any ALS.

INTRODUCTION

Assistive listening is the direct transmission of the audible local sound to an end-user device, delivered in a way that improves the intelligibility and clarity for the user compared to indiscriminately amplifying the ambient sound and room reverberation together with the wanted speech signal. It is explicitly to deliver the desired audible sound, wherever the end-user is, within that room, area or at a specific service point in a manner that provides a genuine benefit.

Assistive listening systems (ALS) can significantly increase speech intelligibility and reduce listening effort by either by-passing the acoustic space or by bringing an appropriate pick-up microphone into close proximity with a talker or desired sound source. In noisy environments this can increase the signal to noise ratio for the listener by as much as 15-20 dB and overcome the detrimental effects of room reverberation as compared to the normal listening situation.

An ALS is beneficial when the listener is either located at some distance from a talker or the source of sound and / or when the background noise level is such as to be clearly audible – for example:

- A talker using a raised voice when they are more than 3m from a Hearing Aid or Cochlear Implant user or where the ambient noise level exceeds 40 dBA.
- A talker using normal, conversational voice levels in large spaces at distances greater than 2m and/ or when the noise level exceeds 45 dBA.

Assistive Listening systems have also been found to be beneficial for listeners with normal hearing but listening in a less than ideal acoustic conditions such as in lecture theatres and classrooms.

Code of Practice for the Design and Operation of Assistive Listening Systems

1 Scope

This document sets out the recommendations for the provision of ALS in places where there is a benefit for hearing-aid, CI, or other hearing device users compared to listening to the acoustically provided audio at that location.

This document applies to all, area coverage or service point ALS used for communication, entertainment, or educational purposes in public, private or domestic installations and public transport.

This document does not apply to any other audio transmission, for example audio translations, audio description, or audio-streams, such as from a multi-screen environment, where the sound is not audible, but may provide useful, ancillary information for such systems and should be applied as far as possible.

Personal listening / intelligibility enhancement devices are also included within the scope but in a separate clause as they constitute a special case and incorporate some unique features and requirements.

This document does not apply to hearing aids and devices themselves.

Prerequisites when considering how these requirements apply to any system:

- what the users of the system are likely to listen to, and hence the signal sources that are to be reproduced,
- the location area(s) to be covered,
- whether the audio information needs to be confidential (e.g. a court).
- what device or devices the listener will use to access the desired audio signal.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60118-4: Electroacoustics – Hearing aids: Induction-loop systems for hearing aid purposes – System performance requirements

IEC 60118-17: Electroacoustics – Hearing aids – Assistive listening system for hearing aid users based on 2.4 GHz audio streaming

IEC 60268-8 Sound system equipment: automatic gain control devices

IEC 60268-16: Objective rating of speech intelligibility by speech transmission index

IEC TR 63079: Code of practice for hearing-loop systems (HLS)

IEC 62489-1: Electroacoustics – Audio-frequency induction loop systems for assisted hearing: Methods of measuring and specifying the performance of system components.

3 Informative references

The following documents provide information that may be helpful with regard to the design, measurement and performance of ALS but are not requirements. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ADA standard 219 American Disabilities Act (2010) section 219

ANSI 12.60 Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools

BB93: acoustic design for schools - performance standards. UK Department of Education

BS 8300: Design of an accessible and inclusive built environment.

BS 5839-8 Fire detection and fire alarm systems. Part 8: Design, installation, commissioning and maintenance of voice alarm systems – code of practice.

BS 7827 Designing, specifying, maintaining and operating emergency sound systems for sports grounds, large public buildings, and venues — Code of Practice

EBU Tech 3326:2014: *Audio contribution over IP – Requirements for Interoperability*

EN 17210: Accessibility and usability of the built environment

ETSI EN 300 328: Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz band; Harmonised Standard for access to radio spectrum.

ETSI EN 300 440: Short Range Devices (SRD); Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.

ETSI EN 301 489-1: Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU.

ETSI EN 300 422-4 Wireless Microphones; Audio PMSE up to 3 GHz; Part 4: Assistive Listening Devices including personal sound amplifiers and inductive systems up to 3 GHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU.

ETSI EN 303 348: Audio frequency induction loop drivers up to 45 amperes in the frequency range 10 Hz to 9 kHz; Harmonised Standard for access to radio spectrum

IEC 60107: Methods of measurement on receivers for television broadcast transmissions - Part 1: General considerations - Measurements at radio and video frequencies

IEC 60118-0: Electroacoustics – Hearing aids: Measurement of the performance characteristics of hearing aids

IEC 60118-16:2022 Electroacoustics - Hearing aids - Part 16: Definition and verification of hearing aid features.

IEC 60118-7 Electroacoustics – Hearing aids – Part 7: Measurement of the performance characteristics of hearing aids for production, supply, and delivery quality assurance purposes

IEC 60315-1 Methods of measurement on radio receivers for various classes of emission. Part 1: General considerations and methods of measurement, including audio-frequency measurements.

IEC 61603-1: Transmission of audio and/or video and related signals using infra-red radiation - Part 1: General

EC 61603-2: Transmission of audio and/or video and related signals using infra-red radiation – Part 2: Transmission systems for audio wide band and related signals.

IEC 61603-3: Transmission of audio and/or video and related Signals using infra-red radiation - Part 3: Transmission systems for audio signals for conference and similar systems

IEC 61938: Multimedia systems - Guide to the recommended characteristics of analogue interfaces to achieve interoperability.

IEC 62489-2: Electroacoustics – Audio-frequency induction loop systems for assisted hearing: Methods for calculating and measuring the low-frequency magnetic field emissions from the loop for assessing conformity with guidelines of limits for human exposure.

IEC 62777: Quality evaluation method for the sound field of directional loudspeaker array system

IEC 63087-1: Active assisted living (AAL), wearable electronic devices and technologies, accessibility, and user Interfaces

IEC TR 63479-1, Infotainment Services for Public Vehicles (PVIS) – Part 1: General

IEC TR 63481: Accessibility goals and needs with an exemplar of use with a household voice control system.

IEEE 802.11: IEEE Standard for Information Technology -- Telecommunications and information exchange between systems local and metropolitan area networks -- Specific requirements - Part 11: Wireless local area network (LAN) medium access control (MAC) and physical layer (PHY) specifications

IHME: GDB Compare - Global Burden of Disease (GBD) Study – Data for world's health levels and trends from 1990 to 2019 - https://vizhub.healthdata.org/gbd-compare/

ISO/IEC 29138-1:2018: Information technology — User interface accessibility — Part 1: User accessibility needs.

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply. ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/

- ISO Online browsing platform: available at http://www.iso.org/obp

4.1 accessibility

degree to which an ALS product (e.g., device, service, and environment) is available for the intended users.

4.2 AFFL – above finished floor level

4.3 AFILS – Audio Frequency Induction Loop System

system including amplifier(s), microphones and/or other signal sources, in which magnetic fields are created by the flow of audio-frequency current in a conductor arranged in the form of one or more loops or a coil or solenoid.

Note: often called a hearing loop.

4.4 Assistive Listening Device (ALD)

a device that can directly access an ALS – e.g. Hearing Aid, Cochlear Implant, Hearable, Mobile phone, ALS receiver or personal listener.

4.5 assistive listening system (ALS)

a device or system that enables people with hearing loss to access the sound being transmitted by a Public Address (PA), Paging, Sound Reinforcement, or dedicated microphone system.

Note:– Assistive listening systems may also be used by listeners who are not hard of hearing to improve the clarity and intelligibility received speech.

Note: a personal listener may connect to an assistive listening system.

4.6 audio over Wi-Fi™

a system that enables wireless transmission of audio via a Wi-Fi™ network, allowing the user's own device (smartphone or tablet) to act as the receiver.

4.7 Auracast™

a proprietary audio transmission system using Bluetooth® LE available from Bluetooth® core Specification v5.3 onwards that enables several separate audio streams to be simultaneously transmitted to multiple compatible listening devices at distances of typically up to 50m depending on the local conditions and transmitter power. To allow as many receivers as possible to access an audio stream within the reception range Auracast™ does not use a traditional two-way Bluetooth® 'Connected link', instead relying on the stream source operating as a 'Broadcast' transmitter and advertising it's availability with a range of quality and access options.

4.8 automatic gain control (AGC)

a means (other than peak clipping) by which the gain is automatically controlled as a function of the level of the signal being amplified with the objective of providing a stable output signal level.

4.9 Bluetooth / Bluetooth Classic

a low power radio system that can continuously stream data over 79 channels in the 2.4 GHz unlicensed industrial, scientific, and medical (ISM) frequency band.

4.10 Bluetooth Low Energy (BLE)

a Bluetooth® system designed for very low power operation, transmitting data over 40 channels in the 2.4 GHz unlicensed ISM frequency band.

Note – BLE remains in sleep mode except when a connection is initiated. Power consumption is lower and data rates are higher than Classic Bluetooth, but connection is not continuous.

4.11 BYOD

Bring your own device – the scenario in which a user provides their own means to access an ALS.

4.12 C50 – Clarity

a measure of the direct to reverberant ratio whereby the sound energy arriving within the first 50ms after the arrival of the direct sound is divided by the late sound energy arriving after 50ms.

Note: C50 provides a measure of the ratio of useful sound energy to later arriving and reverberant energy that is considered to inhibit the intelligibility of speech.

4.13 Critical Distance (Dc)

The distance from a sound source, in a room or enclosed space, were the Direct and Reverberant sound energies become equal.

4.14 Cochlear Implant (CI)

a cochlear implant is a small electronic medical device that electrically stimulates the cochlear nerve to provide a sensation of sound.

Note 1: CIs comprise two parts, the implant and a control / processing device that is worn behind the ear in a similar manner to a hearing aid.

Note 2: CI processing devices are generally fitted with a T-coil and so can be used with hearing loops and neck-loops

4.15 competent person

person with the relevant current training and experience, and with access to the requisite tools, equipment, and information, and capable of carrying out a defined task.

Note 1: A list of recommended organisations for assessing a person's competence is provided in Annex F

4.16 EHIMA European Hearing Instrument Manufacturers Association

4.17 ear hook

a small inductive device in the form of a hook that sits behind the ear and is placed adjacent to a hearing device in order to inductively transmit an audio signal to the device's telecoil.

4.18 electromagnetic interference (EMI)

interference that is caused by one electrical or electronic device to another by the electromagnetic fields generated by its operation.

4.19 emergency sound system (ECS)

a sound system specifically intended to broadcast emergency announcements and messages.

Note: such systems generally incorporate fault and status monitoring and are required to meet associated national or international standards.

4.20 FM/ Radio assistive listening system

an assistive listening transmission system based on radio technology.

Note – FM/radio assistive listening receivers may be connected to a neck-loop so that the signal may be received by a compatible hearing aid or cochlear implant.

4.21 hearable

a type of personal listener, usually in the form of personal earbuds or earphones that contain both a pickup microphone and loudspeaker in each unit together with complex speech and noise suppression processing to provide sound amplification.

Note: hearables are often termed ‘over the counter’, non-prescription hearing aid devices.

4.22 hearing aid (HA)

portable instrument intended to assist the hearing of persons with impaired hearing, usually consisting of a microphone, amplifier and earphone or bone vibrator.

Note: A hearing aid is a medical device selected and fitted by an appropriately trained and competent hearing care professional.

4.23 hearing device (HD)

a user device which can directly access an ALS – e.g., Hearing Aid, Cochlear Implant, Hearable, Mobile phone, ALS receiver, or personal listener etc.

4.24 hearing loop

an audio frequency induction loop (AFILS) assistive listening technology.

Note: A loop or loops of cable or copper tape are typically installed at floor level in a room or area to be covered to create an electromagnetic field that can be picked up by a hearing aid, cochlea implant or listening device employing a suitable pick up or telecoil. The loop is fed from either a dedicated pick-up microphone or from the output of a sound system.

4.25 hearing loss

the reduction in hearing acuity

Note 1: Hearing loss is a common problem caused by noise, aging, disease, trauma, and heredity.

Note 2: Four different levels of hearing loss have been defined: Mild (25-45dB loss), Moderate (40-75dB loss), Severe (75-90dB loss) and Profound (>90dB loss)

4.26 infrared (IR) assistive listening system

an assistive listening transmission system based on infrared technology.

Note: IR systems are often used in environments where it is desired to contain the signal within the confines of a room.

Note: IR assistive listening receivers may incorporate a neck-loop so that the signal may be received by a compatible hearing aid or cochlea implant.

4.27 IHME Institute of Health Merics and Evaluation

4.28 ISTS International speech test signal

ISTS was developed by EHIMA to create reproducible measurement conditions for the purpose of analysing the processing of speech by a hearing aid and associated equipment. ISTS is a

standard test signal which features all or most relevant properties of natural speech e.g. the modulation spectrum, the fundamental frequency and its harmonics.

Note The ISTS is based on natural recordings but is largely non-intelligible because of segmentation and remixing. The signal comprises real speech from multiple talkers but presented in a manner such as to have no meaning nor gaps between words.

4.29 loop receiver

a device fitted with a telecoil / T-coil allowing it to pick up signals from a hearing loop.

4.30 latency

the discrepancy in time between when an audio signal enters a system or electronic device and when it emerges.

Note – Potential causes of latency in an audio system include analogue-to-digital conversion, buffering, digital signal processing, transmission time, digital-to-analogue conversion, and the speed of sound in the transmission medium.

4.31 Long Term Average Speech Level (LTASL)

the unweighted speech signal level averaged over a period of at least 30 seconds

Note This may be measured either as an Leq value or by means of a r.m.s. meter with suitably long integration time

4.32 neckloop

a device that allows a personal listener or ALS receiver to be used with a hearing aid that is fitted with a telecoil.

Note 1: A neckloop must provide a signal compliant to IEC 60118-4 when measured as specified in IEC 62489-1

Note 2: Neck-loops are usually passive devices and often dedicated to a particular receiver, although active types and non-product specific types are also available.

4.33 product

piece of equipment, possibly comprising several objects that work together, that is typically acquired by a member of the general public as a single purchase.

EXAMPLE 1 a television receiver

EXAMPLE 2 a radio headphone kit, comprising headphones, transmitter and power supply.

4.34 personal listener

a system for relaying an acoustic input signal to an acoustic output transducer, for listening purposes. A system will at least comprise a microphone, an amplifier and earphones or headphones.

Note 1: Additional items can be included, such as a neck-loop for use with hearing aids, or a magnetic pick-up coil for use with hearing-loop systems.

Note 2: The sound picked up by a personal listener may also be transmitted directly to a hearing aid via Bluetooth or other, defined, radio-based system.

4.35 recruitment

the rapid and abnormal growth of perceived loudness of sounds for those with a hearing impairment and which is frequency-dependent in nature.

4.36 remote (extension) microphone

a microphone, specifically intended to pick up the wanted sound to enable it to be broadcast to an assistive listening system, personal listener, or hearing device.

Note 1: for speech applications the microphone needs to be located close to the talker to minimise the pick-up noise and reverberation.

Note 2: remote microphones may be active devices and incorporate speech processing technology, such as acoustic noise cancellation, to enhance the intelligibility of the speech signal.

4.37 signal to noise ratio (SNR)

the ratio between the desired information signal or the power of a signal and the undesired signal or the power of the background noise.

4.38 soundfield system

a dedicated sound system, usually employing distributed or directional loudspeakers, to provide an amplified speech signal to hard of hearing listeners.

Note: Soundfield systems are most frequently used in school and classroom applications.

4.39 speech transmission index (STI)

an objective, electroacoustic method of assessing the potential intelligibility of a communication, sound, or assistive listening system.

4.40 talkbox

loudspeaker mounted in an enclosure designed to exhibit directivity and radiation patterns similar to those of the average human head and produce a calibrated frequency response for reproduced test signals.

4.41 telecoil (T-coil)

a small induction pickup coil used to receive an audio signal from a Hearing Loop or portable loop device.

Note 1: T coils can be found inside most behind the ear, in the ear and open fit hearing aids.

Note 2: Not all hearing aids incorporate a T-coil and those that do may need to have their T-coil specifically activated.

4.42 VACIE

voice alarm, control and indicating equipment

4.43 venue

any building, space or facility that contains an assistive listening system.

4.44 voice alarm (VA) system

a sound distribution or public address system specifically intended to broadcast emergency announcements and messages that meets the requirements of national or international Fire Alarm standards and codes of practice.

Note: such systems are mandated to incorporate fault and status monitoring and be configured from equipment that meets specific build and performance regulations

5 Objectives of an ALS as required by the end user

Where the distance between a hearing device user and a person talking to them exceeds approximately 2 m, the effects of room reverberation and background noise make it exceedingly difficult for the user to understand what is being said to them. Even within this distance other factors can degrade intelligibility.

To overcome this problem an ALS can be employed to bridge the acoustic gap between talker and listener and deliver the sound directly to the user's ear or hearing device.

5.1 Service Provision – End user requirements for equipment, audio quality, latency and system interconnection

To provide practical benefit, the ALS must be readily accessible and usable by the intended listener. The venue management or operator should be able to demonstrate that an acceptable level of performance is achieved.

For hearing aid users, the optimal experience is obtained by the hearing aid being compatible with the ALS signal and picking up the transmission directly as this enables their prescribed frequency response compensation to be employed and does not require the need for an additional intermediary device.

Where this is not possible, an intermediary device will be required, and venues need to provide appropriate devices for use by the HA user. Currently these often take the form of a receiver with a neck-loop or Bluetooth transmitter which then transmits the signal to the hearing aid.

However, as new technologies advance; other forms of directly compatible solutions are likely to become available. It is essential that the intermediary devices do not adversely increase the latency of the system (see clause 5.3 regarding echo & latency). It must also be ensured that the ALS delivers the correct signal level to the hearing aid. (e.g., such as to drive the hearing aid or hearable to an equivalent SPL of 70dB LTASL). Assistive Listening Systems that do not provide a corrected hearing loss response or do not enable the user to employ their own hearing aids should be avoided, although in the case of mild hearing loss such systems can be useful.

For listeners with either little or mild hearing loss, and who therefore do not use a prescription hearing aid, a wider range of options exists including a variety of 'over the counter' devices or 'Hearables'.

Cochlear Implant (CI) users' requirements are potentially even more critical than those of HA users due to the limited number of device channels and consequential signal resolution that is available.

A venue claiming to provide ALS facilities should provide:

– an adequate number of receivers for people who wish to use the system or whose hearing aids are incompatible with the ALS technology.
– receivers that work for the duration required.
– the ALS should be easy for users to access, and any limitations on access to the ALS should be clearly indicated to users.
– the ALS should provide adequate quality of reception in the three-dimensional space for which coverage is claimed.
– users' privacy and confidentiality should be maintained where and whenever they expect it.
– clear signage should be used to indicate spaces where the ALS service is acceptable and where it is not.

– regular maintenance should be performed on the ALS to ensure it is always available when required by users.

5.2 Signal Sources – End user requirements for AV Interconnection, Microphone Placement and Usage

An ALS should reproduce signals from all the sound sources a user would expect to hear at the venue.

5.3 Audio Provision – End user requirements for quality & latency

The user should experience no noticeable delay between the sound delivered by the ALS and acoustic sound from the same source arriving from other audible locations (e.g., loudspeakers), and there should be no noticeable lead or lag in the sound delivered by the ALS and associated visual display (AV synchronisation e.g., lip-sync issues). Detailed recommendations are set out in clause 9.

5.4 Awareness, Education and Handling of Complaints – End user requirements

A venue with an ALS should ensure its staff know an ALS is installed, how users should access it, and are made aware of the needs of hearing-impaired people. This should be achieved through appropriate education, training and refresher training.

A clearly understood and, preferably, documented process should exist for receiving and managing complaints from HA users and this process should be advertised to HA users.

6 System Design

6.1 Introduction

Prior to the detailed design of an assistive listening system, the suitability, type, format and the operational and installation requirements of the system need to be carefully considered and discussed with the client or purchaser. Where the building or area already exists a detailed site survey should be carried out.

Issues to consider include:

- The purpose of the system
- Audio inputs that are available or that may need to be added to capture the required sound sources.
- The intended audience / users of the system
- How users are expecting to access the system
    - How will users connect to the service?
    - What device compatibility will users expect with their hearing devices?
    - What percentage of audience will require access?
- Whether the intended ALS is to connect to an existing or associated sound system or to be stand alone
- Whether there is a need for additional equipment or transmission technology format conversion
- Where the system is to be installed
- The required coverage area
- Signal delay and latency
- Transmission equipment location and security

- Power supply and mains power provision
- Cable routes and connections
- Acoustic conditions of the room or space (including background and operational noise levels)
- Background noise (electrical, magnetic & RF)
- Special climatic or hazardous conditions or issues
- Access limitations and privacy
- Room or building type and construction materials
- Potential sources of interference to the signal
- Transmission equipment maintenance
- Receiver equipment maintenance and hygiene (for systems where the user does not use their own device)
- Specific standards and codes of practice that need to be followed or adopted

For large area or complex systems, a document addressing the above items should be drawn up and provided to the purchaser in the form of a design certificate. (This will not normally be necessary for one to one, domestic and simple systems). Based on consideration of the requirements and site conditions, the technology thought to be most appropriate can then be recommended. A sample Design Checklist is provided in appendix B.2.

6.2 Purpose and use of the system

The purpose and use of the system should be agreed and defined. For example, is it to be used as an ancillary system to a sound reinforcement / PA system or as a stand-alone system to pick up wanted speech. Is the system to provide large area coverage or act one to one transmission? Is it expected that the system will primarily be used by the deaf and hard of hearing or act as a general boost to intelligibility. It is useful to know if there is likely to be a particular age group that will use the system e.g., a school or college students or the elderly. Equally it should be ascertained whether it is intended that the users will be supplied with receivers or that they will bring their own devices, bearing in mind potential issues that this may produce such as device compatibility, maintenance and hygiene.

6.3 Site Survey

A detailed site survey can resolve many potential design issues including background noise levels, potential EMI or RF interference, acoustic conditions, suitable equipment locations, cable routes and power supplies. The construction of the building should also be investigated to understand any potential impact which may affect system type selection or performance. Specific design values and requirements can be found in clauses 8 and 9.

6.4 Coverage

The area to be covered should be clearly defined and agreed. If necessary, a sketch or diagram of the area should be made. Where it is felt that an entire area cannot be covered this should be stated and agreed or other technologies considered if suitable coverage cannot be achieved. Several prediction programs exist to predict the coverage of various types of transmission system, and it is useful to provide a visual representation or plot to illustrate the expected coverage.

6.5 Access limitations and Privacy

Where access to the ALS service is to be limited (for example, to manage access to chargeable services, or prevent people in one cinema screen hearing the overspill of the soundtrack from an adjacent cinema screen), the operational characteristics of available ALS technologies

together with the physical location of users should be considered early in the design stage so that an optimum solution is found.

Note 1: For Hearing Loops, it is often possible to mitigate overspill laterally in a building, where it is intended or anticipated that multiple systems may be used simultaneously, or a certain level of privacy is required. Vertical overspill is more difficult to mitigate through design but may be possible depending on distance between systems and building construction. Vertical as well as horizontal transmission and overspill should be considered with predictions or tests carried out to ascertain the potential level and viability of the overspill.

If privacy is important, this should be ascertained before design commences and measures taken within the design and choice of ALS to ensure that transmissions are inaccessible or inaudible in adjoining or nearby areas.

Note 2: For systems that support access restrictions such as encryption, a suitable method of controlling access must be determined at the design stage. Depending on the level of security required and whether the system is accessible with dedicated receivers only or users' own devices, this may include regular changes to access keys and a plan for disseminating those keys only to those who should have access.

6.6 Signal delay and latency

The effects of delay to the ALS audio signal can be disturbing for the user and may adversely affect the potential intelligibility and acceptability of the system. Three different aspects need to be considered:

1. Where the ALS system is used in conjunction with a video display of the talker (or film/video with dialogue).
2. Where the acoustic signal, for example from a sound system loudspeaker or directly from a presenter, and the received ALS signal are not synchronised, due to latency within the ALS. This can cause the audio signals to not arrive at the listener's ears at same time which can be highly disturbing and can be a particular issue where 'open fit' hearing devices are employed.
3. In large areas where the acoustic signal is delayed in arrival for listeners further away from the sound source, in which case delaying the ALS to align with the acoustic audio, or separating the ALS into different zones or channels with appropriate delays may need to be accommodated in the design.

Further information is provided in clause 9.8.

7 Service Provision – Provision of Receivers, Coverage, Privacy, Confidentiality, Access Restrictions, Signage and Maintenance

7.1 General

Systems that allow direct access to end users with their own hearing devices should be prioritised where reasonably practicable. This primarily refers to hearing aids and cochlear implants but may include other devices such as hearing device accessories, personal listeners or mobile devices which are able to receive the assistive listening feed.

However, users cannot be expected to both provide a working compatible Hearing Device and possess the skills to be able to connect it to and use it with an unfamiliar system Therefore, to ensure that all potential users may benefit from an ALS provision, there will always be a need for an ALS system to have venue-provided receivers, at least to a minimum limit.

7.2 Access for users with compatible Hearing Devices - BYOD

7.2.1 Venue Provision

To ensure access to any assistive listening system for users with compatible Hearing Devices, venues should provide clearly accessible information on the type of system, compatible devices and how to access the system. This should follow the guidance on signage in Clause 7.6.

In addition to any objective commissioning of the system, it should have also been subjectively tested with at least one device of the type which end users may be expected to use.

Compliance with the recommendations of this part of the code of practice can be demonstrated by satisfying these 3 criteria:

- Any provision must be open and accessible to all stakeholders.
- Provision of signage in accordance with Clause 7.6.
- Each service has demonstrated that satisfactory performance with representative and compatible Hearing Devices, as per Clause 7.1.2, is in accordance with Clause 9

7.2.2 Device Compatibility

To determine that user-provided Hearing Devices are genuinely compatible with the ALS, either the ALS must be demonstrated to meet an appropriate technology specific standard, or a representative sample of potential compatible hearing devices should be shown to perform with the ALS to the requirements of this code of practice. Manufacturers should be able to confirm the extent of compatibility of various devices to the venue.

For User access with non-venue provided compatible Hearing Devices these additional considerations are required:

i) Where device age, operating system or features and functionality may affect use of the ALS, then the extent of this impact should be determined and, where feasible, a number of representative samples used to demonstrate compatibility with the ALS.

Note 1: Where these tests show that device variations significantly affect adherence to any parts of this code of practice, specifically Clause 9, then this should be communicated as part of the signage and staff training. This may include explicitly specifying limits for devices deemed to be compatible with the system.

Note 2: Tests may be carried out with a representative device where it is not practical to test directly with a hearing aid or cochlear implant, for example a dedicated receiver or a consumer device using the same reception technology as a compatible hearing device. In this case a benchmark test should have been undertaken to measure any discrepancies between the hearing device and representative test device, such that any differences can be taken account of during testing.

ii) Verification of system performance with end user devices must take into account the complete end to end signal chain.

Note: For example, if mobile devices are able to connect directly to the ALS then these should also be tested with a representative range of output connections, such as a neck-loop, wired headphones and a Bluetooth connection to headphones or a hearing device. Each of these scenarios should adhere with the requirements of Clause 9.

iii) Where there are separate broadcasts or channels, all possible audio streams must have been tested with representative receivers.

Note: For example, high quality and standard quality broadcasts targeting different receiver types or channels for different audio content such as multiple languages or voice description.

iv) Witness testing involving end users with hearing loss utilising their own compatible devices is encouraged where practical and feedback should be documented.

Note: Any testing should be representative of the percentage user base of technology in the field.

v) Backward compatibility – any provision must protect from obsolescence as far as possible.

Note: Telecoils have been a valid solution for over 40 years. As such there will be a significant user base in existence. Any new technology, which is direct to User devices, must allow for backwards compatibility to ensure both user devices and installed systems are not rendered obsolete or impaired by subsequent developments in standards.

7.3 Access for users without compatible Hearing Devices & provision of receivers

7.3.1 Provision of receivers

7.3.1.1 Venue Provision

Venues should provide at least a minimum level of access to receivers either self-service or upon request which are compatible with the assistive listening provision in any ALS listening area.

Any receiver provision should be capable of delivering audio quality and end-to-end latency (see clause 9) in line with the hearing-aid solution and the needs of the application.

Any venue-provided receivers should protect users and avoid excessive sound levels to ensure no risk of acoustic shock. See IEC 62489-1:2010+A2:2018 clause 10.3 for further information.

7.3.1.2 Device Provision

The capacity of a listening area should be defined by number of seats, if fixed seating, or the maximum number of people in the typical venue usage and layout. Coverage requirements with respect to the total Listening Area are discussed in clause 7.3.

The default provision for receiver provision should be based on the demographic which may be expected to require Hearing Assistance. Institute of Health Metrics and Evaluation (IHME) GBD figures show that globally approximately 20% of the population have at least mild hearing loss, although the exact percentage for any venue / listening area will vary based on various factors including country, region and expected user age.

Table 1 – IHME Global Burden of Disease (GBD) Study – Data showing extent of users who experience mild hearing loss or worse.

Demographic	Age	Population (million)	Number with at least mild Hearing Loss (million)	Percentage with at least mild hearing loss	Rounded Percentage
Education Age	0-24	2,922	144	4.94%	5%
Working Age	15-69	5,226	1,152	22.04%	20%
Retirement Age	70-95+	464	350	75.49%	75%
All	0-95+	7,441	1,571	21.11%	20%

Where the demographic of the users is known, adjustments can be made.

Additionally, it is entirely reasonable that the number of receivers a venue needs to provide can also be reduced if it can be demonstrated that a proportion of its users are both likely to provide their own compatible devices and are willing and able to use them for this purpose.

To achieve this, any ALS provision should be assessed to determine the proportion of potentially available compatible devices which can be expected to be provided by a venue's end-user base. To evaluate this, the following points should be considered as factors which may affect availability of end user devices:

- ALS technology deployed – Loop, Auracast, & Wi-Fi solutions can potentially be accessed directly by users, other technologies providing a closed loop system do not.
- What potential end user devices are certified to an international standard by the manufacturers, or independently certified by a third party.
- Proportion of all current user devices in the relevant population with this certification
- Adjustment for ownership of these devices in the venue's target demographic.

- Adjustment for proportion expected to have their device in a working state.
- Adjustment for proportion expected to be capable and willing to use their device – this includes providing their own wired headphones or neckloop where the receiving device is a smartphone or similar.

Note: Latency of Bluetooth Classic wireless headphones is unacceptable for ALS solutions due the additional latency provided by the extra transmission.

Consideration of these factors should result in a set of data that the venue can use to provide as part of its specification, device population data that needs to be made available by manufacturers or via a third party, Table 2 provides a set of guidelines on how to make adjustments to the receiver provision for venue requirements based on some default assumptions about expected usage for scenarios where that data does not exist.

Table 2 – Adjustment to receiver provision depending on expected venue user profile

Adjustment Factor	Loop	Auracast	Wi-Fi	Other closed system (IR, RF etc)
User Compatibility [a]	1/2 [c]	1/2 [c]	1/2	No Adjustment
Demographic dependant [b]	2/5	2/5	2/5	No Adjustment
	Note a: Depending on Country / Region / Location of the venue. Note b: Increased likelihood for users to provide compatible devices based on user demographic / audience profile. E.g. University campus attendees are more likely to have mobile phones, provide wired headphones and are prepared to download an app. Note c: Proportion may change over time as user provided devices evolve with availability of different technologies.			

Once the factors that affect user available devices are considered, the quantity for venue provided receivers can be determined. This will either be:

i) The default level of receivers, the minimum where there are no end user devices expected e.g. for an infrared system, or

ii) Reduced based on the factors detailed in Table 2 down to the absolute minimum level of receivers, where the venue can show a high proportion of end users are able to provide their own device.

Any ALS system should provide a level of receivers to suit the expected audience, reduced by a function of the proportion of end users expected to provide and use their own device as defined in Table 2.

Compliance with the recommendations of this part of the code of practice can be demonstrated by the provision of receivers in line with Table 3.

Table 3 – Venue Provision of Receivers for Assistive Listening Systems

Capacity of the Listening Area	Default Number of Required Receivers	Minimum Number of Required Receivers	Minimum Number of Required Receivers which should be compatible with hearing-aids[a]
50 or less	20% or 2 (whichever is greater)	2	2
51 to 200	10 + 1 per 5 seats over 50 seats[b]	2 + 1 per 25 seats over 50 seats[b]	1 in 4 receivers[b]
201 to 500	40 + 1 per 5 seats over 200 seats[b]	8 + 1 per 25 seats over 200 seats[b]	1 in 4 receivers[b]
501 to 1000	100 + 1 per 5 seats over 50 seats[b]	20 + 1 per 25 seats over 50 seats[b]	1 in 4 receivers[b]

1001 to 2000	200 + 1 per 5 seats over 50 seats[b]	35 + 1 per 25 seats over 50 seats[b]	1 in 4 receivers[b]
2001 and over	400 + 1 per 5 seats over 50 seats[b]	55 + 1 per 25 seats over 50 seats[b]	1 in 4 receivers[b]
Note a: Compatible hearing-aid receivers must be able to transmit the signal directly to the hearing aid without use of the hearing aid microphone (e.g. via neck-loop) – advances in hearing-aid technology may mandate that the types of provision required will change over time. The level of provision should account for and mirror user-base adoption as far as possible during any transition. Note b: Or fraction thereof.			

Exceptions:

- Where a building contains more than one Listening Area and the assembly areas required to provide assistive listening system are under one management, the total number of required receivers should be permitted to be calculated according to the total number of seats in the assembly areas in the building, provided that all receivers are usable with all systems.
- Where the seats in the Listening area are served by a system which can transmit directly to compatible hearing-aids, the number of receivers required by Table 3 to be hearing-aid compatible can be reduced based on the percentage of compatible users expected to be serviced by the system provided.
- Where an ALS is installed in a transient listening environment and can transmit directly to compatible hearing-aids, no receiver requirement should apply.

7.3.1.3 Battery Life

The expectation is that a user will be able to listen for the duration required. This depends on application – typical values are:

- House of worship – 2 hours
- Cinema – 4 hours
- Conference – 8 hours

It should be noted that some of the older Bluetooth formats (Classic before BLE Audio v5.3) can appreciably increase the power consumption of a hearing device and so reduce its useable battery run time significantly.

Compliance with the recommendations of this part of the code of practice can be demonstrated by a battery life of the above durations.

7.4 Coverage

7.4.1 Venue Provision

A permanently installed ALS should be included in any space with a fixed amplification (audio) system. Any space regularly used for meetings, lectures, classes, performances, spectator sports or films should be considered to have an ALS system installed.

All service or reception points should have ALS installed.

Priority should be given to installation of ALS in any spaces with high levels of acoustic noise and / or reverberation.

Any transient environment, where users of the system are likely to only be within coverage of the ALS for a brief period (such as concourses, waiting areas, service points, intercoms, etc.) should be covered by an ALS that can broadcast directly to hearing aids and should not require the dispensing of dedicated receivers.

Coverage of an ALS is defined as the space where the ALS performance meets the recommendations of this part of the code of practice and complies with any relevant standards applicable to the specific transmission technology as outlined in Annex C Table 4. As such, any locations which do not satisfy all performance requirements of these guidelines should not be classed as part of the Coverage area.

Coverage should take into account listening height, which is defined as 1.2 m AFFL for a seated listener or standing child, or 1.7 m AFFL for a standing adult listener. A venue with only seated use may define coverage based solely on 1.2 m AFFL. Whenever the venue has standing height use the coverage must be defined for both 1.2 m and 1.7 m heights to accommodate a full range of heights including both standing, child, and wheelchair users.

Note: In schools and establishments where children may need to regularly need to use and access the ALS, lower seated and standing heights will need to be considered and catered for.

Coverage is determined by testing at a number of points which are representative of different parts of the listening area and different heights where applicable. Satisfactory reception at these points should be identified on a floorplan of the venue and provided by installers to the venue as part of any system documentation.

7.4.2 Area Coverage Systems

Where reasonably practicable, area coverage ALS should cover the entire listening area of the room or venue.

As a minimum the ALS should cover 50% of the listening area, or 50% of seats where the venue has fixed seating. This coverage requirement applies individually to each area or type of seating, for example in a theatre the stalls should have at least 50% of seats covered and each balcony should have at least 50% of seats covered.

All designated accessible areas such as wheelchair positions should be covered.

Where signal coverage may be affected by changes in condition when the venue is in use (for instance blocking line-of-sight transmission, absorption of transmission signals or presence of interfering signals, caused by either people or equipment within the environment) the coverage should be reconfirmed when the venue is in a state representative of normal usage.

In any case, where full coverage of the listening area is not achieved, the signage as per clause 7 should include clear indication of areas of coverage and, when booking seats, potential attendees should be made aware of the coverage and any potential limitations.

7.4.3 Soundfield systems

Soundfield systems are a special type of area coverage system normally associated with, though not necessarily limited to school classrooms. Their objective is to amplify the level of the natural voice and improve the signal to noise ratio. This is achieved by broadcasting the speech over a number of dedicated loudspeakers within the room, with the aim of providing an even distribution of sound. A gain of 6-10 dB is usually targeted in order for the system to be considered effective. The teacher or instructor wears a radio (or infrared) based microphone to transmit their voice to the amplification system, though this signal is often also simultaneously transmitted directly to the students via their personal hearing devices or associated receivers. It is important that the sound system provides a high level of speech intelligibility with values in excess of 0.6 STI being targeted in order to provide effective improvement and to comply with the recommendations of room acoustic standards and codes of practice for classrooms such BB93, ANSI S12.60 and AS/NZ2107-2000. Inputs from AV systems and other devices such as laptop computers are also desirable and should be provided where practical. If the soundfield

system also provides a signal that is transmitted directly to a hearing device, then this signal should comply with the higher requirements for this type of signal.

Note: Clauses 8 and 9 provide further details concerning the interfacing and the electroacoustic performance of the ALS.

7.4.4 One to One - Intercom, Refuge and Service Point Systems

One-to-one, or small ALS (for example service counters, help points or intercoms) coverage should be determined by the expected listening position in relation to the device or service point they are interacting with.

Coverage should allow for some latitude within the listening position, a distance of at least 150 mm either side of the designated listening position should be included within the coverage.

All one-to-one ALS should account for mixed listening heights, from 1.2 m to 1.7 m AFFL, to accommodate standing users, children and wheelchair users.

Where there are multiple service points, all service points should be covered with individual ALS if reasonably practicable.

As a minimum at least one service point in each location should be covered and all designated accessible service points should be covered (note overspill and confidentiality requirements of clause 6.5. Service points with ALS capability should be clearly indicated by signage (clause 7.6).

In any case where one or more service points are not covered, the signage as per clause 7.6 should include clear indication of which service points are covered by the ALS.

7.4.5 Portable & Temporary Systems

Portable systems should be oriented as specified by the manufacturer and provide the same coverage and quality of service as Intercom, Refuge and Service Point Systems.

Unless the talker is normally within 1 m of the microphone integrated in the portable unit, a separate microphone should be connected and positioned close to the talker to ensure the best signal-to-noise ratio for the listener.

Batteries in portable systems should be charged regularly and checked prior to each use. Staff using portable systems should be trained in their use.

Temporary systems should be installed to provide the same coverage volume and quality of service as installed area coverage systems. Care should be taken to protect users from trips and falls due to wires and cable and to protect cables from damage. Microphone use and placement and provision of signal sources should meet the recommendations of clause 8.1.3.

Places where adequate coverage or quality of service is not possible must be clearly indicated to hearing-impaired users, for example by the signage recommended in clause 7.6.

Where reasonably practical, and especially in cases such as service points where the audio source and coverage area are known and remain fixed, a permanently installed, mains powered system should be employed by preference over a portable or temporary system.

7.4.6 Domestic Systems

Domestic systems may provide coverage for a room or for an individual seat or seats.

A domestic ALS should meet the coverage and service quality recommendations for area coverage systems but for a smaller coverage space. The intended use, whether for seated listeners or otherwise, should be taken into consideration and the coverage space optimized for that use case. The recommendations for input signals will be as clause 8.1. Signage (clause 7.6) is not usually appropriate in a domestic setting.

7.5 Personal Systems

7.5.1 General

There are several different types of personal listening device. Some are intended to work directly with a hearing aid or CI, others may be standalone. They can comprise a handheld microphone or device that is worn either by the user or the talker or may employ a remote microphone. These latter types of microphone can often be quite sophisticated and frequently include automatic voice detection, noise suppression and adaptive processing. They may be used domestically or in public venues and meeting rooms. The objective of a personal listener is to extend the range of a conventional hearing aid to beyond its typical limit of approximately 2m.

Personal listeners can be used by:

- People with mild to moderate hearing loss who do not consider that they need hearing-aids.
- People with greater hearing loss who have a hearing aid or cochlear implant with their hearing instrument being connected by means of a neck-loop or direct injection of the signal into their device, for example via Bluetooth or other radio-based system.
- People listening to alternative audio channels such as language translations etc.

Provision of personal listeners may only be deemed a suitable ALS when considering a small, closed group of users who have all been consulted, are satisfied that the devices meet their needs and are compatible with their existing hearing devices if applicable. In any case, where members of the public may utilise the space or there may be users with hearing loss who have not identified themselves, a fixed area-coverage ALS must be provided.

The intelligibility of the wanted speech may be enhanced in a number of ways which can give rise to a non-linear characteristic both in the frequency and time domains and is therefore likely to invalidate conventional electroacoustic performance testing. The frequency response of the device may also not be ‘flat’ but deliberately adjusted to exhibit a peaked or rising high frequency response. Therefore, the frequency response requirements of clause 9.2 should not be applied, however, it is important that such devices do not introduce an unacceptable latency into the system resulting in an end-to-end delay exceeding 40ms. Some products enable a number of devices to be grouped together enabling multiple microphones and receivers to be employed.

7.5.2 Types of personal listener, hearables and remote wireless microphones

a) Simple domestic type

This type is typically used for improving the audibility of television sound or other audio device. A microphone is positioned near to the loudspeaker of the television set for example and connected by a cable to the personal listener device to which normal earbuds or headphones are connected. The personal listener may be powered by batteries or from the mains supply. This format can only provide general amplification, though some form of basic frequency adjustment may also be available.

b) Hand-carried or wearable – simple format

This type usually consists of a device with microphone, small amplifier, and a socket for plugging in earbuds or headphones. The microphone may be built-in, or a connection may be

provided to enable a remote microphone to be plugged in, enabling the microphone to be located as close to the desired source of sound as possible. The personal listener may, optionally incorporate a magnetic pick-up coil (T-coil) thereby enabling listeners to take advantage of hearing-loop systems, in auditoria and similar spaces and at counters and helpdesks. Some smart phones also provide the facility to use their built-in microphones and processing to pick up wanted speech and relay this to the listener via earbuds or headphones.

c) Wearable (non-prescription)

These devices, also often termed ‘hearables’, are usually in the form of self-contained earbuds that have integral microphones and processing to pick up and enhance the pick-up of speech. Active noise cancelling is also often incorporated into the device. Some hearables have separate microphone systems that are also worn by the user.

d) Hand-carried, wearable or static operation – radio transmission format

This, more sophisticated, type of device is wireless based and connects to the user’s hearing aid either directly via proprietary radio system, Bluetooth or indirectly by means of a neck-loop and receiver. The microphone is usually designed so that it can either be worn or placed on a table to pick up conversation or possibly put in front of a television or radio loudspeaker etc. However, many systems also incorporate a means of directly connecting an audio device to the transmitter and so enabling a completely ‘wireless’ means of enhanced listening. The microphones associated with such systems generally incorporate speech enhancement processing and acoustic noise suppression. The microphone can generally be placed at some distance (several metres) from the listener in order to pick up the desired sound.

e) Static personal listeners for meeting rooms and similar applications

In meetings, the listener may be located at some distance from the person speaking. Whilst it may be suitable to employ a remote microphone as described above, some forms of personal listener are available that are specifically intended for meeting room applications. These provide a remote, wirelessly operated microphone, specifically intended for tabletop use that may also incorporate selectable microphones, steerable beamforming or automatic voice detection in order to optimise speech pick-up. Noise suppression and speech enhancement processing are also generally incorporated. Connection to the user’s hearing aid is either by radio or Bluetooth transmission and may or may not require the use of a neck-loop and receiver.

f) Hearables

Hearables are an additional type of personal listener and usually take the form of personal earbuds or earphones that each contain both the pickup microphone and loudspeaker in each unit. The devices usually incorporate complex signal processing and noise suppression features in order to detect and enhance the intelligibility of the wanted speech. Most hearables also enable audio signals to be streamed to them directly via Bluetooth®. This solution will need to employ the more recent Low Energy configuration as detailed in Bluetooth® Core Specification v5.3 or higher if it is likely to satisfy audio latency goals for live speech applications.

7.5.3 Use of Neck-loops with personal listening systems

Where a neck-loop is required to connect the personal listener to a hearing aid or CI it should meet the field strength and frequency response performance characteristics set out in IEC 60118-4 and IEC 62489-1.

7.5.4 Confirmation testing to demonstrate that end user objectives have been met.

Due to the potential non-linear behaviour of many of these listening devices, the only practical way to field test them is to carry out an operational check and listening test.

The operational test should be such as to demonstrate that the device / system connects and functions in the way expected and provides intelligible speech of an acceptable audio quality.

The speech intelligibility and audio quality can be tested using a real talker or by playing a high quality recording of speech into the room or system microphone via a Talkbox or test loudspeaker.

Note: The adjusted frequency balance of personal listening devices, whilst potentially of benefit to the deaf and hard of hearing, might be considered to be poor by those with normal hearing or with a mild hearing loss. As such, hearing impaired persons are recommended for these evaluations.

7.6 Privacy, Confidentiality and Access Restrictions

7.6.1 Venue Provision

For any ALS, the possibility exists that signals from adjacent systems could be received by users outside the intended listening area. Where more than one system is deployed near another and depending on the type of ALS used, this can simply result in interference which reduces the intelligibility and so needs to be managed in that regard. In some applications however, this could also lead to issues of privacy, confidentially or a breach of access restriction e.g., Film Certification, and so needs to be managed accordingly.

The required reduction or control of access to different ALS between adjacent rooms and spaces depends on the application. Privacy / confidentiality may be required in some commercial settings, for law courts and medical facilities etc. Some technologies are less prone to overspill than others and the nature and construction of the building can have a significant effect.

Note: IR systems limit coverage to within the boundary of opaque walls and are frequently used when the coverage area needs to be contained within a room.

For openly accessible, audio frequency transmissions a reduction of at least 50 dB in signal level can be expected to be needed in applications with requirements for privacy but the exact levels depend on technology used for the ALS system as well as use case and building basis. For spaces with no specific privacy requirement a reduction of at least 32 dB in signal level should be achieved at the edge of the defined listening area of the adjacent system.

For systems capable of broadcasting on separate channels, a separate channel should be used for each system within range of another. Where privacy or confidentiality is required the audio content on that channel should be encrypted with a suitable method employed to provide access only to the intended users.

Regardless of privacy requirements, ALS broadcasts should be limited in range outside of the intended coverage area where practical.

At service counters and similar locations, where privacy is an issue, there is little point in exceeding the inherent acoustic isolation and so a reduction in ALS signals between adjacent positions of 15-20 dB may be adequate. It is however important that both connection to (and disconnection from) the correct ALS is intuitive, managed and restricted to avoid undesirable eavesdropping.

At service counters and similar locations, where privacy is not an issue, it may only be desirable to improve on the inherent acoustic isolation between adjacent positions to increase SNR and intelligibility, and so the use of an ALS should be encouraged in all cases where there is a significant level of acoustic noise.

Signage (see clause 7.7) should be used to alert users where appropriate.

Compliance with the recommendations of this part of the code of practice can be demonstrated using a suitable receiver at appropriate positions and by observing signage.

7.7 Signage and Instruction

Clear signage should indicate the type or technology of ALS available together with clear instructions on accessing it with hearing devices or with venue-supplied receivers. Trained staff should be available to users on request to assist with accessing the ALS.

Note: For training see Clause 9 – Awareness, Education & Handling of Complaints

7.7.1 Venue Provision

Areas covered by an ALS should be clearly indicated at visible positions by means of permanently installed signage. In addition, details of any installed ALS should be provided on the venue's website so that potential attendees and users can prepare before visiting.

Note: further details of website information provision can be found in Appendix E

The signage for all ALS should be based on the symbol in figure 1 and the symbol should be a minimum size of 100 mm x 100 mm.

Figure 1 – Sign for display in premises to indicate that a HA compatible ALS is installed.

The signage should be white printing on a blue background (Pantone 661 or 662). If other colours are used, they must contrast visually from their surroundings and meet a suitable level of contrast between printing and background. A difference of at least 70% Light Reflectance Value (LRV) between printing and background is recommended.

The signage should identify the type of ALS used and provide any instructions needed to access the ALS. For example, if a receiver-based system is provided, the signage should instruct users where they can access receivers, or if necessary, identify any actions, settings, channel names or security parameters needed to access the transmission. Any customisations as applicable depending on ALS transmission type: e.g., for hearing loop systems, the sign should include a letter "T" in the bottom right as defined in IEC TR 63079.

See Annex D for details regarding signage for different technologies.

Signs should be positioned as a minimum -

1. At all entrances to an area covered by an ALS
2. In at least one prominent position within each coverage area
3. On any service points, help points, intercoms or other similar devices with integrated ALS.
4. At the location where receivers can be obtained (where applicable)

If the ALS does not cover the entire listening area, then this should be clearly indicated by the signage. This should be either a coverage map provided alongside all occurrences of the signage, or localised signs used to specifically identify areas of coverage or non-coverage (see figure 7.2)

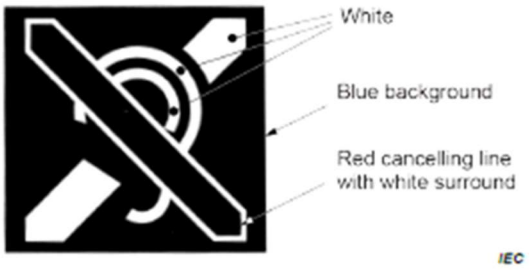

Figure 2 – Sign to show seating areas where ALS reception is not satisfactory.

Compliance with the recommendations of this part of the code of practice can be demonstrated by observing signage.

7.8 Monitoring & Maintenance

7.8.1 Venue Provision

Many ALS faults are not obviously apparent until a person with hearing loss attempts to use the system, so it is critical that systems are tested on a regular basis to ensure reliable operation when required.

The ALS should be supplied with a test listening device so that the output of the ALS can be checked and auditioned. This may either be a portable device or permanently fixed monitor.

Routine testing should, as a minimum, include listening to the ALS via a listening device, such as a portable receiver with headphones. The audio signal used for routine testing should be as close as possible to the audio signal used when the system is in normal use, in both content and source. For example, when live speech is the primary audio source for the ALS, the routine tests should include a person talking (or a talk-box) at a normal distance from the microphones.

The person carrying out the test should be familiar with the sound of the correctly operating ALS and should be able to determine that suitable level and quality of audio is received.

Frequency of testing will depend on the nature of the venue and number of ALS installed but should be at least as frequent as the test schedule for any other audio systems and no longer than monthly intervals or weekly where the system is in regular use.

Where the venue with ALS is used for events or performances the system should be tested before each event. Testing should also be regularly carried out during events as the presence of an audience and audience activity can often cause RF and optical signal levels to vary.

1. Routine testing should be recorded in a system logbook and where applicable, the status monitoring records should be reviewed.
2. A routine listening test should be performed to identify any obvious faults.
3. Repeat any commissioning tests required for the specific type of ALS to ensure it still conforms to relevant performance standards and meets the performance documented in the original and commissioning certification.
4. Wherever possible the ALS should be incorporated into any active status monitoring systems employed by the venue. This may take the form of analogue relay contacts or

network protocols but should, as a minimum, allow alerts to be received if the ALS system has lost power or developed a fault.

The above inspection should also be carried out if building works or reconfiguration of an area has taken place that could have affected the operation or performance of the system. If the ALS uses a permanently installed sound system as its primary audio source, then its performance must be checked after any modifications or changes to the sound system have been made or where the system has been used and operated by a third party. Similarly, benchmark testing should be carried out on appointment of any new maintenance organisation.

Any areas of non-conformance identified during the inspection should be reported to the venue operator and recommendations made for remedial action.

8 Signal Sources – AV Interconnection, Microphone Placement and Usage

8.1 Signal Sources

8.1.1 General

The prime technical objective of an ALS is to improve the intelligibility for the user by improving the signal to noise ratio and direct-to-reverberant sound ratio. As such, the choice of the audio source and the selection and positioning of any microphones are of paramount importance.

It is important that all ALS provide a consistent level of transmission to ensure compatibility with other installations of the same type and provide predictable performance with different programme signals e.g. speech or music and for different microphones and talkers. Listeners with hearing loss particularly benefit from a system incorporating AGC as speech and other programme signals are maintained at a stable level. This results in less cognitive effort being required as it enables the signal to be heard at an optimal level and without becoming too loud due to effects of recruitment.

As such, the ALS should incorporate an effective AGC (Automatic Gain Control) by providing a capture range of at least 20-30 dB and overall limiter to ensure that the maximum programme level is controlled such that spurious or unintended signal peaks are limited to prevent distortion, discomfort, damage to hearing, or malfunction of equipment in the receiving device.

As some form of AGC / dynamic range control is usually deployed in a hearing-aid, an effective AGC for an ALS should not change the subjective quality of the programme signal and therefore should be implemented as defined in Annex A of IEC 62489-1. This AGC should hold the audio output level substantially constant for input levels above a given threshold by using an attack time constant in the order of milliseconds, and a release time-constant of 1 s or greater.

A “Compression” style AGC is not desirable for an ALS as this may depress speech signals in noisy situations and may work against any such processing employed for an individual user in the hearing-aid.

Although the relationship between the maximum and average signal levels is fixed, different ALS technologies are not consistent in the dynamic range they provide. In most cases the average speech level should be in the region of -18 to -25 dBfs (dB relative to full scale or maximum signal). For analogue systems, the headroom should be at least 12 to 15 dB.

8.1.2 Local AV sources

It is important that all audio sources in the room are reproduced by the ALS, this includes any content from existing sound reinforcement systems, AV such as PC audio or any media playback and both the near and far end of video conferencing.

In many cases this may be as simple as connecting an auxiliary output of the AV system to one of the inputs of the ALS, however in some cases a separate audio mix may be required, for instance to prioritise speech over other content, ensure a flat frequency response is delivered without room equalisation applied or to provide a summed mono feed for single channel ALS.

8.1.3 Use and Siting of Microphone Sources

To optimise intelligibility, the microphone should be as close to the talker's mouth as possible, for example by use of a headset microphone, lavalier (tie clip) or gooseneck lectern microphone.

Where a sound system is not installed it will be necessary to provide one or more microphones and a mixer specifically for the ALS. Such microphones should be chosen and sited with a view to obtaining as much direct sound from the original sources as possible and balanced to provide uniform loudness. Directional microphones normally give better results than omnidirectional types; but highly directional microphones require considerable skill and experience to achieve consistent pick up of the wanted sound. If several microphones are needed, they should be controlled by an automatic mixer if a skilled operator is not available.

Microphones should be located to have a clear "view" of the source they are intended to cover, and should be located away from air conditioning grilles, fans, strong air currents or other potential sources of acoustic noise pick-up, for example some types of lighting, and video projectors.

Microphones, except wireless microphones, requiring internal batteries should not be used, because of the inconvenience of replacing them and the impairment of reliability of the system consequent on failure to replace them before their end of life.

If there is no fixed position for a talker in the space, the use of wireless microphones, temporary wired microphones, or possibly automatic beam steered microphones should be considered, together with suitable audio processing and automatic mixing to optimise the speech signal and to minimize unwanted pick up of noise and reverberation. Where questions or comments from an audience are to be relayed via the ALS, strategically positioned stand microphones or hand-held radio microphones, managed by staff should be used.

It is essential that the signal delivered to hearing aid users is as free as possible from reverberation and noise and other forms of degradation. The maximum effective pick-up range of a microphone is dependent upon many factors including: microphone directivity, the volume, reverberation time and the critical distance (Dc) of the room as well as the presence and distribution of sound reflecting surfaces close to the microphone and the ambient noise level. Microphones should be placed in front of or possibly directly above a talker but not behind them. In rooms that are subject to traffic noise or high levels of low frequency sound, it is often desirable to apply a high pass filter or other, more complex filtering, to the microphone output to reduce the pick-up of the noise – particularly when it excites room resonances and reverberation.

Further information may be found in IEC TR 63079:2017+A2:2020 clause 10.4.3.

8.1.4 ALS – Use of ambience microphone(s) and confidence signal

It is desirable that an ALS user knows that the system is operating prior to its use of relaying audio program or sound from an event. This can most readily be accomplished by the provision of an 'ambient sound' microphone. This can pick up pre-event audience hubbub or other background sounds or music prior to the start of the event, so enabling the ALS user to be confident that the system is working. Such a microphone system can also pick up associated unamplified music or other sounds that the ALS listener may not otherwise hear. Alternatively, a confidence signal may be used. This may be in the form of a pre-recorded announcement identifying the type or channel of ALS. The ambience signal must be automatically muted or dimmed when the main sound (performance or emergency message) signal is broadcast so that

it does not reduce its clarity or intelligibility, although some residual sound can make listening to an ALS less isolating.

8.2 Integration of ALS with Sound Reinforcement Public Address and Emergency Communication (VA) Systems

It is often possible and indeed desirable to derive the ALS signal from a permanently installed or temporary sound reinforcement system, as for these systems to be effective, their associated microphones are generally positioned close to the talker(s). In such a case the ALS signal can be derived from a line level output (e.g., 0dBu,) of the mixer or signal router. Preferably, the ALS should have its own dedicated output channel. Whilst it is also possible to derive the signal from a loudspeaker distribution system, e.g., via a suitable matching transformer, this method should be avoided as the signal may be equalised, delayed or otherwise processed to optimise the loudspeaker performance but which may be detrimental for the ALS listener when heard out of context.

When deriving the ALS signal from a sound reinforcement (SR) or PA system, it should be confirmed that any adjustment of the output of the main PA/SR system does not affect the signal being fed to the ALS and that the ALS signal is not subject to equalisation or compensation for the loudspeakers or the loudspeaker-room characteristic. A dedicated, controllable output, protected against inadvertent adjustment should be provided.

It must be ensured that the output from the PA/SR system feeding the ALS is controlled and set to match that of the specified ALS input so that the output signal from the ALS is optimal. The ALS should incorporate an effective AGC as defined earlier in this clause.

It should be difficult to inadvertently disconnect, switch off, or to fade down the feed to the ALS.

8.3 Interconnection With a Voice Alarm or Emergency Communication System

Where the ALS is used as a supplementary alarm device to reproduce messages or signals from a voice alarm or emergency communication system, provision should be made to silence or override all other input signal inputs to the ALS for the duration of the emergency message. (Additional equipment may be required in order to achieve this). It must be ensured that the output from the voice alarm or emergency communication system feeding the ALS is controlled and set so that the ALS output is optimal. The ALS should incorporate an effective AGC as defined in clause 8.1.

The signal transmitted to the hearing device must be zoned in a similar manner to the loudspeaker system covering the same area so that the acoustic and electronic signals are consistent and do not conflict.

The feed to the ALS should be protected against being inadvertently switched off or adjusted in level once it has been commissioned and optimally set.

The VA/EC system should provide both an audio signal and a control connection (usually a switched DC voltage) to the ALS. The ALS should incorporate automatic surveillance monitoring with a fault condition being automatically reported to the VACIE or communication system. It should also provide an indication to the Voice Alarm / Emergency Communication system that it is successfully transmitting the emergency audio signal. Consideration should also be given to providing a secondary power supply for the ALS to ensure its continued operation in the event of the failure of its primary power supply.

Note: Further information concerning the operation of an ALS with a fire alarm or emergency sound system can be found in BS5839-8 :2023 and BS 7827; 2019).

9 Audio Provision – Quality & Latency

9.1 Intelligibility

Hearing impaired listeners, even with prescription hearing aids, will not hear as well as those with normal hearing. It is therefore essential that the speech signal the Assistive Listening System transmits/relays to the listener is of good quality and exhibits the potential for high intelligibility. This means that the transmitted signal must be adequately free from noise, distortion, reverberation and echo, as well as providing sufficient bandwidth and frequency response to ensure that the speech content is fully preserved.

The location and type of microphone employed to relay the desired speech is of critical importance as it affects the pick-up of room noise, reverberation and acoustic reflections that can seriously impair intelligibility and mar the ‘ease of listing’ for the listener.

Objectively, the potential intelligibility of a system can be assessed by measuring the STI (Speech Transmission Index). For hearing impaired listeners, an STI value of at least 0.70 is normally the minimum acceptable value. (This is tested using an electroacoustic ‘talker’ (Mouth simulator or Talkbox) located at the normal talker position and measuring the received signal at the output of the hearing device (hearing aid, hearable or test receiver).

9.2 Bandwidth and Frequency Response

To provide high intelligibility, a bandwidth of at least 6–7 kHz is required. The bandwidth and frequency response achieved will depend on the transmission format but as a minimum should achieve a response within the range ± 3dB from 100Hz to 5 kHz with respect to the response at 1 kHz.

Note 1: Although traditional telephony is restricted to the range 300 Hz to 3.3 kHz and can provide reasonable speech intelligibility, the truncated high frequency limit can lead to word confusions and requires greater cognitive effort by the listener. Whilst hearing loops have a specified limit of 5 kHz, this, combined with a lower frequency limit of 100Hz ensures sufficient intelligibility for assistive listening purposes provided that the high frequency roll off is not too abrupt.

Note 2: Hearing loops are subject to an upper passband limit of 9kHz in order to comply with radio frequency spectrum regulatory requirements. (Further information can be found in ETSI EN 303 348 V1.2.0).

In general, solutions should be provided to cover as much of the range of human hearing as possible to maximise sound quality and allow for specific user customisation to be carried out during the final audio delivery to the listener. Depending on the application & use case a satisfactory solution can be delivered according to the following guidelines:

- Full bandwidth 20 Hz to above 20 kHz – if solution is not compromised (44.1 / 48 kHz sample rate)
- Adult hearing limited 40 Hz to 15 kHz – typical adult upper hearing limit (32 kHz sample rate)
- Hearing Assistance - High Quality 50 Hz to 11 kHz – (24 kHz sample rate)
- Hearing Assistance - Standard Quality 100 Hz to at least 5 kHz – (16 kHz sample rate)

Note 1: In all applications microphone inputs may be provided with the option to roll off the low frequency response below 250Hz reducing noise pick up and correcting microphone proximity effect. Rather than being a shortcoming, this improves the input signal quality, SNR & promotes speech intelligibility.

Note 2: Personal listeners and speech enhancement devices may exhibit a more restricted low frequency response and deliberately enhance the higher speech frequency range designed to optimise speech intelligibility.

9.3 Signal to Noise Ratio (SNR)

The signal to noise ratio of the received speech signal comprises two subcomponents which are additive in their effect:

The electronic noise and associated SNR and, the pickup of acoustic noise within the room or space and hence the acoustic SNR.

Generally, electronic noise should not pose a problem. However, there are potential issues that can affect and reduce the signal to noise ratio depending on the system type used e.g.:

- The gain structure of the system – particularly when the ALS is interfaced with a PA or sound reinforcement system, as such interfaces can also lead to the electronic pick up of hum and buzz and distortion if incorrectly set.
- Electromagnetic interference during transmission – no system is perfectly immune and depends on the system type: Sunlight, for example, can affect Infra-red systems, Radio Frequency Interference can compromise range, impact audio continuity, or simply cause artifacts in most RF solutions, and direct interference with hearing loop systems through an undesirable increase in the ambient magnetic field noise from radiated mains power hum/buzz.

Electronic background noise can be both disturbing, annoying, and fatiguing or be of such a level to directly reduce speech intelligibility.

In general terms, the level of ambient electronic noise should be at least 20 dB (‘A’ weighted) below the normal (required) long-term average speech signal level of the ALS system.

9.4 Acoustic Noise

Acoustic noise may be generated by both technical services within a building, such as air conditioning or equipment noise and the noise generated by occupants of the space. Equipment noise can usually be determined by testing when the building or room is unoccupied. Any such noise should be at least 20 dB (‘A’ weighted) below the normal speech level when measured at the ALS or sound system microphone used to relay the speech to the ALS. Whilst these SNRs should ensure the ambient noise has minimal effect of intelligibility, higher values are desirable for high-quality listening. Typically, a signal to noise ratio of at least 30 – 40 dB is required to ensure good audio quality and 40 – 50 dB (A weighted) for high quality listening.

Occupancy noise is often more difficult to determine as it can be highly variable (e.g. people coughing in an auditorium, talking or being noisy, e.g. children). The closer the pick-up microphone is to the talker(s) or performer, then the better the potential SNR. Where a dedicated remote microphone is employed to pick up the speech (e.g. auditorium show relay microphones or meeting room microphones) then they must be located away from potential noise sources such as air conditioning grilles or other technical and mechanical equipment.

Typically, in meeting rooms or similar rooms, the pick-up microphones will generally need to be located within a maximum of 2 m from the person talking (assuming a cardioid response) or 1 m if an omni directional microphone is used. Some types of ‘steered beam’ and voice tracking microphones can also be effective but all have their limitations and must be fully evaluated to ensure compliance before an ALS is handed over or brought into operational use. Highly directional ‘rifle’ or ‘gun’ microphones may successfully be used at greater distances in auditoria or similar applications. Beamforming and speech tracking microphones are becoming more common, being employed either as ceiling or table mounted units and may (depending on their characteristics) potentially increase the maximum pickup distance – though very careful set up and testing is required.

Where multiple microphones are employed, for example in a meeting room or where there is not a sound system operator, an auto-mixer to control and minimise the number of open microphones that may pick up extraneous noise and reverberation should be provided and carefully set up to optimise the operational signal to noise ratio of the system.

In noisy environments, such as counter systems in shops, ticket offices or information desks, it is essential that the operational signal to noise ratio and potential intelligibility are verified. As

these ALS are used for short periods of time, a lower SNR may be tolerated but needs to be agreed with all parties concerned. For example, the SNR may be relaxed to 10 dB with respect to the long-term average speech level (LTASL) or a noise level (A weighted) that is 22 dB below the maximum speech rms level. However, it should be recognised that this reduction in SNR may adversely affect intelligibility.

9.5 Reverberation

Reverberation and echo can also degrade intelligibility, though their effects are a little more difficult to assess. As with the case for signal to noise ratio, the closer the microphone is to the talker, the higher the potential intelligibility, with the pick-up distances given above also being applicable. Technically, the microphone should be within less than 0.5 of the room's Critical Distance (Dc), though this guide is subject to the effect of local sound reflections, microphone directivity and the particular application. For optimal performance, the distance should be reduced to 0.3 Dc equivalent. Objectively, the potential effect of reverberation on speech intelligibility can be evaluated by measuring the C50 of the system whilst the combined effect of reverberation and noise can be assessed by measuring the STI (Speech Transmission Index) of the system.

9.6 Distortion

In practice, provided that the gain structure of the ALS (and if applicable that also of any associated PA or Sound Reinforcement system) is set correctly, then distortion is rarely a problem. If distortion is audible, then this indicates either a fault within the equipment or incorrect setting of the gain structure. Electronic distortion should be ≤0.5% THD or ≤1.0% THD+N.

9.7 Continuity

Depending on system type, it is possible for audio delivery to be interrupted either by location or movement in the space where the system is provided. Any dropouts or glitches etc should be kept to a minimum such that service usage is not noticeably compromised. The nature of any degradation in performance will differ depending on the method used to provide the ALS, and as such any measure of acceptability should be based on the type of system being applied. In the absence of a suitable measure of acceptability, the primary objective is that the intelligibility of a system is maintained.

Any location or zone in which the service is compromised below the point of usability (as per the technology specific standards or where intelligibility is compromised) should be identified, documented, and deemed to not be part of the area covered by the ALS.

9.8 Audio Latency end-to-end

Echoes can be extremely disturbing and disruptive to intelligibility and can be caused by strong acoustic reflections occurring approximately 50 - 60 ms after the initial sound or when the ALS signal is heard via two different paths or channels. An example of the latter is where the sound is heard acoustically via a loudspeaker system and electronically via the ALS. Digital processing within the ALS can create additional processing delays (latency) to the received signal. Equally, some sound systems in large spaces, such as cathedrals, auditoria or arenas may employ loudspeakers fed with signals that are intentionally 'delayed' so as to provide appropriate acoustic alignment. Whatever the cause of the timing discrepancy, it is recommended that the time difference between audible speech signals of similar sound level should, if possible, be 30 ms or less, with a limit of acceptability being 40 ms. (Where the ALS is being used to relay music, percussive sounds may require a lower limit to be acceptable, though otherwise, a slightly longer delay is usually acceptable for most other music). The permissible delay and latency values relate to the end-to-end total for the signal chain and received ALS signal. In practice, it is rare for the received acoustic and ALS signals to be of equal level and even a few dB difference in sound level can reduce the perception of there being an audible discrepancy.

Where the ALS system is used in conjunction with a video display of the talker (or film/video with dialogue) any timing delay between the visual and audio signals should preferably be less than 40 ms and no more than 50 ms in order to facilitate lip-reading and minimise potential conflict or disturbance between the received signals.

To achieve the necessary synchronisation in large venues, several separate ALS coverage zones may be required, with each transmitting a customised (delayed) signal to produce the necessary alignment.

It should be noted that some ALS technologies inherently exhibit latencies of 50ms or greater which is additional to other delays or latencies within the system. Some types of radio microphones for example may exhibit latencies of up to 20ms and digital signal processing may add a further 5-10 ms. The latency of the ALS user's hearing device should also be included which is often in the region of 5-12 ms. It is quite possible therefore for an ALS system, with a notional latency of 50ms, to actually exhibit an end-to-end latency of 65-70 ms. which is likely to be unacceptable.

10 Awareness, Education and Handling of Complaints

Upon handover of any ALS the venue operator should be provided with training and information relevant to the use of the system.

An operation and maintenance manual should be provided and include 'as fitted' drawings of any system components and wiring, handbooks for each piece of equipment, instructions for operation of the system and coverage maps, commissioning reports and certificates of conformity as applicable. The commissioned level and control settings of all ALS equipment should be provided.

The venue operator should be given an opportunity to witness a demonstration of the system in use and listen through a suitable receiver.

Appropriate education, training and refresher training should be provided for customer-facing staff to help them understand the needs of hearing-impaired people, that an ALS is installed, what type of technology it is, and how users should access it.

At least one representative of the venue should be trained on how to perform the routine tests detailed in clause 7.7 and provided with any equipment necessary to facilitate these tests.

A documented process should be created for receiving and managing complaints from hearing device users, and this should be communicated to customer-facing staff and advertised to HD users. The process should be designed to ensure the user's complaint is resolved in the quickest possible way.

Where HA devices are dispensed to users (e.g., hearing aids by audiologists) the dispenser should advocate for ALS technology and ensure the users are made aware of all the possible ALS technologies compatible with the HA device and how to access them with that device.

11 System Compliance, Testing and Certification

It is essential that after a system has been installed it is tested to ensure that it is functioning correctly and is fit for purpose. The recommended way of ensuring this is for the installer or system specifier to carry out a series of specified performance tests. These should compromise both subjective and objective appraisals.

Complex and area coverage systems should be tested as described in clause 11 and Annex A. Simple, one-to-one systems, due to the similarity and nature of their design (depending on the technology and installation) may only need to be tested subjectively with an appropriate listening device to ensure that speech is clear, intelligible, not muffled, and free from noise and interference.

Subjective testing should essentially follow the same format for any of the ALS technologies but objective testing, although following a core series of tests, will vary depending on the technology employed. A sample test report / certificate is provided in Annex B.

Following the subjective tests, if there is uncertainty that a particular installation meets the recommendations of this Code of Practice, then the objective measurements listed in Annex A should be performed to assess the installation's performance.

Whether the compliance testing is by subjective appraisal only or also with objective tests, a certificate of compliance is to be produced and supplied to the venue management. A sample test report / certificate is provided in Annex B

11.1 General

All assessments and measurements should be taken with the receiver at the normal use height and position, and with consideration of any impacts on transmission of the space being fully occupied, such as absorption or blocking of the signal. For ALS that transmit directly to hearing aids, measurements should be made at listening height, i.e. 1.2m for seated or 1.7m for standing users. In cases where the system may be used by both standing and seated listeners, then the assessment should be carried out for both positions and the results separately recorded for both listening heights. For ALS that will use receivers other than hearing aids the tests should reflect the intended use, for example with the receiver in a pocket, on a belt clip or on a lanyard in seated and/or standing use.

Note: This is particularly important where hearing loops or infra-red systems are employed. For Hearing Loops, take care to ensure that the field strength meter or loop listener is held with the telecoil vertical (i.e. measuring the vertical magnetic field). For infra-red systems, it can be important for the transmitter to have 'line of sight' to the receiver, so tests should be representative of anything that may block infra-red transmission to the receiver in its normal use position.

11.2 Room and equipment layout

Draw a plan of the room or space, including dimensions and ceiling height, together with the locations of the transmitting equipment and microphone(s).

When taking measurements, conduct a 'walk about' and assess the performance of the ALS throughout the area. Note any locations where the performance (subjectively or objectively) does not meet the requirements.

The test conditions for measurements relating to specific technologies are listed in clauses A.1 to A.8.

In some rooms and spaces, for example theatres or council chambers, coverage areas may be at different heights or in separated areas. These should be noted on the sketch, or the sketch drawn such as to clearly show these separate areas (e.g., theatre balconies).

The assessment positions (objective measurement and subjective evaluation) should be marked on the plan and individually identified by either a designatory number or letter. It is usually helpful to mark the proposed test positions onto the plan before commencing the test so that a good distribution of assessment points can be arranged.

The number of positions will vary depending upon the size and shape of the room.

For example:

- A conference/meeting room may be characterised by as little as 4 positions.
- An auditorium (stalls, balcony, side balconies etc.). may require 10 or more positions, to adequately assess the performance in each seating area.
- Larger venues such as stadiums and arenas will require several measurement positions in each seating block or designated coverage area.
- For domestic systems, an assessment should be carried out at each normal use position.
- Any areas where performance is expected to be less uniform, or where inconsistencies are identified during testing, should have a greater density of test points added to accurately identify the extents of coverage.
- At service points 4 test positions are normally required (2 at 1.7m and 2 at 1.2m) to ensure that adequate coverage of the area where a customer may be located has been achieved.

11.3 Subjective Assessment

With the system set to its normal operating configuration, speech should be played over the system. Firstly, a good quality speech recording is injected into the system, for example via an A/V input. Using either a test listening device of known performance, or a venue supplied listening device, the quality and relative level of the speech is assessed at the previously established designated test positions. With additional positions being added if required.

With the test speech playing over the ALS, check that the speech is free from audible distortion, is intelligible and has an adequate (natural) frequency response/balance. The signal should also be free from disturbing noise. If any of these requirements are not met, an objective test should be carried out to determine the cause of the problem.

Once it has been established that the ALS is basically working, it should be tested with a sound source representative of normal use. Systems that will be reproducing live speech should be auditioned with a talker using a system microphone whilst speaking at a normal level and at a normal user position / distance from the microphone. Where this is not possible, a calibrated Talkbox can be employed and set up at the talker position. Again, the received speech signal should be highly intelligible and free from noise and distortion. Any aberrations should be noted. With live speech, the audible delay of the system can also be checked. There should be no discernible delay or echo between the acoustic sound in the room or space and the signal received via the ALS. Similarly, there should be no noticeable mis-synchronisation between a video picture and the received audio signal (Lip sync). Equally there should be no mis-synchronisation between the mouth movements of a live talker and the corresponding ALS audio signal. If there is an apparent discrepancy between the received audio and visual information, the latency of the system should be measured and assessed objectively.

The ambient noise level in the room or space should also be subjectively rated. For example: quiet, noise audible but not interfering, objectionable or loud and whether it is constant or impulsive in nature.

Any areas where the ALS signal should not be received should also be checked, for example due to privacy concerns, crosstalk with other ALS or interference with other equipment.

It is useful to get the views of a hearing aid user or hard of hearing listener as their perception of the system and its intelligibility may be different to a listener with normal hearing or a listener with mild hearing loss.

Details of subjective testing are outlined in Annex B.1 f)

11.4 Objective Assessment

11.4.1 Ambient noise level – Acoustic (Room noise)

For ALS utilising live microphones, the ambient acoustic noise should be measured at each microphone pickup position.

Ideally, the acoustic noise level should be made under normal operating conditions. If this is not possible, the noise level should be measured, and separate measurements made for normal operation. (Operational conditions may increase the noise level due to building occupancy or different operating conditions of equipment e.g., air conditioning, cooling, or heating etc.).

The noise level should be measured using a calibrated type 1 or type 2 sound level meter, set to 'A' weighting and 'Slow' integration time. Alternatively, the LAeq (Equivalent A weighted noise level) can be measured. Where the character of the noise varies or is impulsive, the maximum 'Fast' levels should also be noted. Where the ambient noise level exceeds 40-45 dBA this should be highlighted as it may affect the performance of the ALS.

The acoustic signal to noise ratio of the transmitted/received audio signal should be measured to ensure that system microphones are correctly positioned and sited away from potential noise sources such as ventilation grilles and air conditioning or other potentially noisy equipment. The ingress of traffic noise or noise from other external sources may also affect the room ambient noise level and hence SNR.

The SNR can be measured using a calibrated Talkbox located at a normal speaking position and broadcasting, either a reference speech signal or speech shaped test signal such as the STIPA test signal, and measuring the ALS levels, with and without the speech being present, with the microphone channel open and set to its normal operating gain and level. The signal to noise ratios set out in clause 11.4.2 provide a useful guide.

11.4.2 Electrical noise level

11.4.2.1 Electronic noise

Usually, the self-noise of ALS should be inaudible unless it is faulty, or the gain structure has not been correctly set up. However, radio frequency or electromagnetic interference can result in spurious noise being audible in hearing loop receiving devices, including HAs and CIs, which can be prone to picking up magnetic noise from mains power cabling, some forms of lighting and power transformers.

The electronic noise level (A weighted) of an ALS should be at least 45-50 dB below the normal operating level. Where it exceeds this and particularly where it exceeds a relative level of -20 dB relative to the long-term average speech reference level, the cause of the noise should be investigated and remedied if possible. In certain cases, such as at service points or information desks, a residual noise level of up to -12 dB re LTAS reference level may be permitted for short periods as the noise is more distracting or annoying rather than being a significant hindrance to intelligibility. It can be useful to measure the 1/3 octave spectrum of the noise in order to assist with determining its cause and mitigation.

Note: signal to noise and residual noise levels are normally expressed with respect to the long-term average speech reference level but may also be cited relative the maximum r.m.s. level as in the case of hearing loops described by IEC 60118-4. The equivalent values for hearing loops are -32 dB or -22 dB for short periods.

11.4.2.2 Magnetic noise

Any ALS that allows for reception of a magnetic field subjects the receiving device (primarily a telecoil in a hearing aid or cochlea implant) to the pick-up of magnetic noise. This applies whether the magnetic field is the primary mode of transmission such as with a hearing loop or when using intermediary devices such as receivers with neckloops regardless of the primary

transmission technology. Where these systems are employed, tests should be carried out throughout the coverage area to ensure that users will not be subject to undesirable pick up of magnetic noise or other interference. The coverage area should be tested to conform with background noise requirements of IEC 60118-4.

Note: magnetic interference may indicate the presence of an electrical fault not otherwise detected by conventional test equipment and may indicate unsafe conditions.

11.4.3 Coverage

As different ALS technologies employ different transmission topologies, signal formats and levels, no one universal coverage test method can be specified. To establish the extent of the coverage from any given system, it should be tested according to the method detailed in the appropriate system standard should one exist.

Where a performance standard is not available, the system should be tested for coverage using a receiver device of known quality and representative sensitivity, and a threshold of acceptance should be clearly established. Subjectively this may be where the signal level noticeably drops, or the signal becomes noisy and / or distorted. These points should then be plotted and clearly identified on a floor plan.

Note: Details of ALS topologies and associated standards can be found in Annex C.

11.4.4 Frequency response

The frequency response of the transmitted ALS signal will depend on the technology and application, with the relay of music generally requiring a wider frequency response than speech.

As a minimum, a ‘Voice Only’ speech system should be provided as defined in Clause 9.2.

Note: With the exception of hearing loops, it is not normally necessary to measure and confirm the frequency response of the electronic / RF audio transmission as this is unlikely to deviate from the manufacturer’s specification.

11.4.5 Latency

Measuring the latency of an installed ALS on site may not always be straightforward and depends on the type and nature of the installation and to some extent the location and accessibility of the equipment. The latency of the complete ALS can be ascertained by measuring the impulse response of the system. This can be achieved by employing a Talkbox or talker simulator loudspeaker (with known latency characteristics) to acoustically input the test signal into an ALS microphone and measuring the associated delay via a suitable receiver.

The impulse response timing can be derived in a number of ways – for example by employing an exponential sine sweep or MLS (maximal length sequence) test signal or by measuring the transfer function of the system using a live program signal (e.g., ISTS or natural speech) and measuring the correlation between the input signal and that received by the test receiver. Alternatively, it may be directly measured using an impulsive signal provided that the system operates within its linear region.

When connected to a sound system, the inherent latency of the system due to associated digital signal processing will increase the overall latency and received delay.

Depending on the complexity of the sound system, processing and type of microphones employed, latencies of up to 20ms can occur. This secondary latency is additional to the inherent latency of the ALS and so latencies of over 70ms can easily result. It is therefore essential that the latency of the system is assessed from end to end.

Note: It should be noted that the latency of a Wi-Fi system can vary with network traffic and loading and so may fluctuate, even over short periods of time. It is therefore essential that the latency is measured with the associated

IT network operating under normal or expected traffic conditions. Additionally, network settings may need to be changed to facilitate minimum latency including implementing QOS on the network.

11.4.6 Objective Speech Intelligibility (STI)

Where a doubt exists as to the potential intelligibility of an Assistive Listening System, an objective assessment of the intelligibility should be carried out and the results recorded. The most straightforward approach is to measure the Speech Transmission Index (STI) of the system. This can be achieved by locating a calibrated Talkbox at a normal talker position and using the standardised STIPA signal with the Talkbox output set to be 63 dB LAeq at 1m (normal speech level) or 68 dB LAeq at 1m for an elevated (teaching) voice level. The output of the ALS is then measured using a suitable listening device or probe or alternatively via the output from a hearing aid. A value of ≥ 0.70 STI has been found to produce acceptable intelligibility, although ideally, a value of ≥ 0.75 STI is desirable. The STI measurement technique automatically considers both the level of the ambient noise and room reverberation. STI measurements will not normally take into account latency issues exhibited by the system.

Note: further information concerning intelligibility testing can be found in BSEN 60268-16

An alternative method of objectively establishing the intelligibility of an ALS is to conduct a word or sentence intelligibility test. Although such testing needs to be conducted and evaluated by an experienced specialist it may be the only way to objectively assess the intelligibility of some of the more advanced types of ALS.

11.4.7 Access limitations and privacy

In cases where the client has requested confidentiality, access to the ALS may need to be assessed.

Note: For hearing loops whilst this can be checked subjectively, a calibrated measurement of the signal levels is usually required.

11.5 Signage

The compliance assessment should also include a visual check of the ALS signage provided. Where the ALS only covers part of the usable space, the signage needs to clearly identify this.

Annex A (Informative) Technology Specific Measures and Parameters

A.1 General

Complex and area coverage systems should be tested as described in clause 11 and further explained in this Annex A. Simple one-to-one systems due to the similarity and nature of their design (depending on the technology and installation) may only need to be tested subjectively with an appropriate listening device to ensure that speech is clear, intelligible, not muffled, and free from noise and interference.

Following subjective tests, if there is uncertainty that a particular installation meets the recommendations of this Code of Practice, then the objective measurements listed in this Annex should be performed to assess the installation's performance.

A.2 Hearing Loops (AFILS)

Hearing loops, whilst a relatively simple technology that allows direct connection with a hearing aid, can be affected by several specific issues. These include background electromagnetic noise and interference – particularly from local mains wiring and some types of electronic / electrical equipment. The structure of the building, particularly if of steel construction or if it contains significant steelwork or reinforced concrete (rebar) can significantly affect the frequency response and overall signal strength produced by the loop. Similarly loops that must be run adjacent to pipework or in ceilings of steel or aluminium construction can exhibit a nonlinear frequency response. Aluminium based computer flooring can be particularly troublesome. It is therefore important to measure the frequency response, output level and coverage of these systems. Overspill to adjacent areas must also be carefully considered. IEC TR 63079 and IEC 60118-4 provide detailed performance and measurement requirements for AFILS-based Assistive Listening systems.

The following measurements should normally be made.

- Frequency response / bandwidth [See Notes A.2.1 & A.2.2]
- Magnetic field strength
- SNR – Relative (combined acoustic / electronic*) background noise level
- Coverage
- Subjective assessment

The following measurements could also be made.

- Latency
- Intelligibility (STI)

* Note: it may be preferable to measure these parameters separately in order to identify potential issues.

A.2.1 Measurement Note 1

Signal level and frequency response of an encoded / modulated communications system depends on the specific implementation of the that transmission topology. Provided that an audio input signal of suitable level is supplied to the system it is unlikely that the resultant performance in respect to signal level and frequency response will differ from the manufacturer's specification and as such would not normally need to be measured.

A.2.2 Measurement Note 2

The frequency response of the acoustic signal picked up by a system microphone, however, may vary but may only need to be measured if the subjective assessment suggests that the response is poor and speech clarity and intelligibility are affected.

A.3 Auracast™ (Bluetooth Low Energy) Systems

At the time of publication of this Code of Practice, Auracast™ is not yet fully defined and there are no installed systems. The maximum range of the transmission depends on the RF power emission and siting of the antennas as well as sensitivity and positioning of receivers. Room occupancy may also affect the transmission.

Note - This section will be updated as further details of the Auracast™ system and characteristics become available.

The following measurements should normally be made.

- Frequency response / bandwidth See Notes A.2.1 & A.2.2
- Audio signal level See Notes A.2.1
- SNR – Relative (combined acoustic / electronic) background noise level
- Coverage (Signal Strength / Packet Loss)
- Latency (potential digital processing times)
- Network performance
- Interference from other RF transmissions
- Subjective assessment

The following measurement could also be made.

- Intelligibility (STI)

A.4 Wi-Fi™ systems

Wi-Fi™ audio transmission and performance can be dependent upon network traffic and capacity as well as RF signal strength. Latency can also be affected and can be an issue with some systems or where smartphones are used as the receiving device.

The following measurements should normally be made.

- Frequency response / bandwidth See Notes A.2.1 & A.2.2
- Audio signal level See Notes A.2.1
- SNR – Relative (combined acoustic / electronic) background noise level
- Coverage (Signal Strength / Packet Loss)
- Latency (potential digital processing times)
- Network performance
- Interference from other RF transmissions
- Subjective assessment

The following measurement could also be made.

- Intelligibility (STI)

A.5 FM systems

The range and coverage of FM radio signal transmissions depend on the permissible RF power emission and siting of the antennae. Room occupancy may also affect the transmission.

The following measurements should normally be made.

- Frequency response / bandwidth See Notes A.2.1 & A.2.2
- Audio signal level See Notes A.2.1
- SNR – Relative (combined acoustic / electronic) background noise level
- Coverage
- Interference from other RF transmissions
- Subjective assessment

The following measurements could also be made.

- Latency
- Intelligibility (STI)

A.6 Infrared Systems

Infrared systems provide line of sight communication and can be affected by sunlight and certain forms of lighting. Great care needs to be taken to ensure that the line-of-sight transmission is maintained when audiences and spectators are present.

The following measurements should normally be made.

- Frequency response / bandwidth See Notes A.2.1 & A.2.2
- Audio signal level See Notes A.2.1
- SNR – Relative (combined acoustic / electronic) background noise level
- Coverage
- Interference from other RF transmissions
- Latency
- Subjective assessment

The following measurements could also be made.

- Intelligibility (STI)

A.7 Neckloops

A neckloop is a small hearing loop, often about 230 mm diameter, worn as a "necklace" by a hearing-aid user. The neckloop may be fed, via a cable typically up to 1 m long, from an ALS receiver, personal music player, a mobile phone or similar device, or a larger piece of audio equipment. A neckloop may be electrically passive, i.e., comprise only wire and maybe a transformer, or active, including an amplifier or impedance converter and a power source such as a battery.

A neckloop operates in similar way to a Hearing Loop (see clause A.1) and so its operation can be affected by background electromagnetic noise and interference.

The design and construction of neckloops varies considerably, and it is important that they can provide both an adequate magnetic signal and frequency response to enable the performance requirements of IEC 60118-4 to be met – particularly when provided in conjunction with an ALS receiver. IEC 60118-4 provides detailed performance requirements and IEC 62489-1 provide the measurement requirements for neckloops.

The following product measurements should normally be made and provided.

- Frequency response / bandwidth See Notes A.2.1 & A.2.2
- Magnetic field strength for a given drive voltage or max drive of associated ALS device.
- Impedance

When used in a venue and there is a doubt as the performance of the device, in addition to the above measurement data, the following measurements should also be made.

- SNR – Relative (combined acoustic / electronic / magnetic*) background noise level
- Operational signal to noise ratio (i.e., typical operating level to background noise)
- Subjective assessment in the area(s) where the neckloop is intended for use.

The following measurements could also be made.

- Intelligibility (STI)
- Latency

* Magnetic noise needs to be measured in the area(s) where the neckloop is intended for use.

A.8 Personal Listeners and Hearables

These are generally individual or pairs of standalone devices, but some types can be wirelessly combined to form a localised arrangement that enables a group of listeners and talkers to share the composite audio signal. This category of device can often exhibit highly non-linear behaviour both in the frequency and time domains and incorporate noise cancelling or speech enhancement processing which often precludes the use of traditional test methods and signals. Some devices deliberately tailor their frequency response to enhance the higher speech frequencies resulting in an unbalanced but intelligible sound quality. The integral signal processing often increases the residual latency and values up to 45-50 ms are not uncommon. As these devices are not restricted to be used in just one environment or set of conditions, the local noise and acoustic environment will vary, as will therefore, to some extent the performance of the device.

Given the above characteristics, a detailed list of recommended objective performance measurements is difficult to formulate, but the following parameters can be extracted and verified if required and should also be provided by the manufacturer. For field testing, a subjective evaluation, as described in 11.3, may be the best approach.

- Frequency response / bandwidth See Notes A.2.1 & A.2.2
- Latency
- Range (distance) of operation
- Speech and noise maximum operational amplitude ranges
- Maximum acoustic output (SPL) or audio signal voltage
- Directionality
- Residual noise
- Room ambient noise level (during the assessment)
- Operational signal to noise ratio (i.e. typical operating level to background noise)

- Subjective assessment

Note 1: there is a difference in determining the performance of the device under laboratory and operational user conditions.

Note 2: Remote microphones may connect directly to a hearing device via a radio or Bluetooth transmission or via a suitable receiver and neckloop.

A.9 Soundfield systems

Soundfield systems essentially comprise two separate parts, the in-room sound amplification and the transmitted radio or infrared signal, which is also usually simultaneously transmitted directly to the listeners. The latter signal can be treated as an ALS signal and so clauses A4, A5 or A6 can be applied to assess this component. The sound amplification part should be evaluated separately.

The following measurements would normally be expected to be made.

- **The sound level**

The sound level produced by the loudspeaker system when in its normal operating condition should be measured and logged. From this the acoustic gain of the system can be established, with an expectation of 6 to10 dB amplification of the unaided voice level being achieved. Measurements are most effectively made using a Talkbox to substitute for the human talker although live speech could also be used if necessary.

- **Frequency response / bandwidth**
- The spatially averaged frequency response of the sound field, produced by the loudspeaker system should be measured. This should vary by no more than ± 4 dB over the range 200Hz to 4 kHz when measured with a resolution of 1/3 octave when the test signal is directly injected into the audio input.
- **Ambient acoustic noise level**

The ambient noise level should be measured with the room in an unoccupied condition but with air conditioning/ventilation equipment and other classroom equipment operating.

- **Coverage**

The coverage provided by the loudspeaker system should be measured using either a 4kHz octave band noise-based test signal or by measuring the variation of the 4 kHz octave band level using a pink noise test signal.

- **Interference from other RF transmissions**

The audio output of the system should be auditioned to ensure it is not audibly distorted or subject to interference.

- **Latency**

The latency of the system can be checked subjectively to ensure that there is no noticeable delay occurring between the live acoustic signal and (1) the soundfield signal and (2) the transmitted RF or IR signal and (3) where applicable between audio and visual signals. The latency can also be measured objectively. However, site conditions are unlikely to significantly affect this and so should be provided by the manufacturer of the system.

- **Subjective assessment**

A detailed subjective assessment should be carried out. In particular the level, intelligibly and clarity of speech broadcast over the system should be assessed.

- **Intelligibility (STI)**

Where practical, the STI of the soundfield system should be measured to ensure that it is providing useful and adequate enhancement.

Annex B **Model Certificates and Checklists**
(Informative)

B.1 ALS - Test Report and Certificate of Compliance

The objective is to certify the extent to which an ALS provision complies with the recommendations of this Code of Practice and to document any deviations from them.

Assistive Listening System - Certificate of Compliance

Test Report

Date:					
Client/Project:					
Project Reference:					
System location:					
Usage height:	Seated 1.2 m ☐		Standing 1.7 m ☐	Other…… ☐	
System type:	Hearing Loop ☐	Auracast™ ☐	Infra-red ☐	Radio / VHF ☐	Wi-Fi™ ☐
Performance validated against:	IEC 60118-4 ☐	IEC 60118-17 (pending) ☐	IEC 61603 ☐	N/A	N/A

a) Room / space & Equipment Layout

Draw sketch plan of room with dimensions (L, W, H) showing equipment locations, microphones and other associated equipment. Show locations of ALS equipment, microphones (marked with letters, directional type and orientation), hearing loops or antennae. Also mark and number the coverage test positions.

Sketch plan with test positions & mics etc

b) Acoustic Noise - Ambient level

The objective is to determine if the ambient noise level may potentially interfere with intelligibility or result in undesirable SNR.

Measured the A-weighted ambient noise levels at each mic position and record the results.

Position	Mic Details	Noise level (dBA)*	Comment / Conditions
A			
B			
C			
D	Ambient in centre of coverage area		
* Note: Intelligibility may be an issue > 45 dBA, < 40 dBA is desirable			

c) ALS Coverage

The objective is to determine the extent of acceptable coverage.

If ALS can be verified by a technology specific standard reference this should be used to evaluate the performance of the system and summarise the results.

If no technology specific standard method exists, then test according to the following method and record the results:

Apply 1 kHz test sinewave and establish the extent of ALS coverage.

Position	Inside / Outside Area	Pass / Fail	Comment
1			
2			
3			
4			
5			
6			
7			

d) Frequency Response

The objective is to determine if acceptable frequency response for the application is provided.

If ALS can be verified by a technology specific standard reference this should be used to evaluate the performance of the system and summarise the results.

If no technology specific standard method exists, then test according to the following method and record the results and appended these to the test report or certificate.

Apply pink noise or a multi-frequency tone to the ALS. Confirm the frequency response meets the requirements for the application. Mark any areas of non-conformance on the plan. Both the electronic and electroacoustic (microphone to receiver) response should be measured in order to determine which part(s) of the signal chain is compliant.

ALS Requirements	Range (± 3 dB)	Pass / Fail / N/A	comment
Full Bandwidth ☐	20 Hz to 20 kHz		
Adult Limited ☐	40 Hz to 15 kHz		
Hearing Assistance High Quality ☐	50 Hz to 11 kHz		
Hearing Assistance Standard Quality ☐	100 Hz to ≥ 5 kHz		

e) Signal to Noise Ratio - SNR

The objective is to determine if an acceptable Signal to Noise Ratio for the application is provided.

If ALS can be verified by a technology specific standard reference this should be used to evaluate the performance of the system and summarise the results.

If no technology specific standard method exists, then test according to the following method and record the results and appended these to the test report or certificate.

With the ALS operating, mute / terminate all inputs and compare A-weighted noise level to the long-term average level of speech.

ALS Requirements	SNR Target Level	Pass / Fail / N/A	comment
High Quality ☐	> 45 dB		For loops, noise level to be less than - 47 dB with respect to 400 mA/m
Limited Quality ☐	> 20 dB		For loops, noise level to be less than - 32 dB with respect to 400 mA/m
Minimum Quality ☐	> 12 dB*		For loops, noise level to be less than - 22 dB with respect to 400 mA/m*
	* For service points or where ALS will only be used for very brief period. Not acceptable for area coverage systems		

f) Subjective test

The objective is to determine if acceptable audio quality for the application is provided.

To achieve this, test at least three positions according to the following method and record the results and appended these to the test report or certificate:

Apply a speech signal – preferably using a person at a normal talking position and distance from the microphone and speaking at a typical level and ensure any AGC is activated appropriately. Alternatively use a calibrated Talkbox with reference speech segment. If the ALS is not intended to reproduce live speech apply a representative program audio signal.

Check the system is performing as expected for the given technology and then listen with the relevant receiving device or headphones to the audio quality.

Verify that the speech is intelligible, has good clarity, and is free from noise and distortion throughout the coverage area and as detailed below.

Evaluation of Quality	Pass / Fail			Comment
	Position 1	Position 2	Position 3	
Speech intelligible				
Speech clarity				
Speech quality / spectral balance				
Freedom from noise				
Freedom from distortion				
Disturbing echo / reverberation				
Latency / Delay / video sync				

g) Latency / Delay

The objective is to determine if acceptable latency for the application is provided.

Depending on requirements, test according to the following method and record the results:

With a live speech signal or representative program audio input into the loop check that either.

i) There is no perceptible audible delay between the live acoustic sound (either that of the talker or that heard via the sound system) and that heard via the ALS

ii) That the audio is in sync with the talker's lip movements, or

iii) If a video screen is used, ensure that the video picture synchronises with the audio signal heard via the ALS.

In particularly large spaces, this test should be repeated at varying distances from the sound source

Note: Hard of hearing listeners can be more sensitive to lip sync discrepancies than assessors having only minimal or mild hearing loss.

Latency / Delay	Pass / Fail	Latency (ms)	Comment
Freedom from disturbing delay			

h) Speech intelligibility (STI)

The objective is to determine if acceptable performance for the application is provided by other tests in this report.

If necessary or in the case of a dispute, test according to this method and record the results:

Measure the STI of the combined microphone / ALS system. A calibrated talk box will be required. The system should be measured in its normal operating configuration, with room equipment operating. An STI value ≥ 0.70 should be achieved.

Speech Intelligibility	STI / N/A	Assessment
From Microphone A		
From Microphone B		
From Microphone C		
From A/V system		

i) Access Limitations / Privacy

The objective is to determine if suitable access limitations for the application are provided.

In cases where the client has requested confidentiality or multiple systems, the extent to which the ALS is accessible both inside & outside the coverage area may need to be established.

Evaluate if the scenarios in which access should be allowed are applied and managed correctly.

If the ALS needs to be verified by a technology specific standard reference this should also be used to evaluate the performance of the system and summarise the results.

Access Restriction	Pass / Fail	Comment
Physical location ☐		
Secure passcode ☐		
Service encryption ☐		
Access code refresh ☐		

j) Accessibility & Signage

The objective is to determine if appropriate access to the ALS is provided for this application.

Confirm that clear signage is provided informing users of the presence and type of the ALS, how to access it, and that if it only covers part of the space the relevant area is clearly identified.

Access Needs	Pass / Fail	Comment
Suitable Accessibility Provided ☐		
Appropriate Receiver Provision ☐		
Coverage limitations identified ☐		
Appropriate Signage ☐		
Support & maintenance ☐		
Complaints Process ☐		

ALS Certificate of Compliance

The following ALS installation meets accessibility needs of the application and complies with the recommendations of the Code of practice for Assistive Listening Systems (ALS) subject to noted remedial works.

Client / Site / Venue	
Project Reference:	
Room / location	
Date of Test / Verification	
Listening height	
ALS Type	
ALS Equipment	
Microphones	
Other Inputs	
Test equipment + calibration dates	
Test certificate number *	

I / we being the competent person(s) responsible (as indicated by my/our signatures below) for the commissioning of the ALS, particulars of which are set below, CERTIFY that the said installation for which I/we have been responsible complies to the best of my/our knowledge and belief with the recommendations of this document except for the variations, if any, stated in this certificate.

Assessor (name)	
Assessor (signature)	
For and on behalf of:	
Address:	

The extent of liability of the signatory is limited to the system described below:

Extent of system covered by the certificate:	
Variations from the recommendations of the CoP:	

The following work should be completed before/after (delete as applicable) the system becomes operational

***** Attach any referenced ALS test report to this certificate of compliance.

B.2 ALS Design Checklists

This appendix summaries the design process provided in Clause 6 with a Checklist Template and two design examples.

B.2.1 Design Checklist - Template

Assistive Listening System – Design Checklist

ALS design checklist **Date**	**Project**:
Address	
Contact(s)	

Design Consideration	System Application	Comments
Purpose of System		
Who will use the system?		
Access to system		
Connection to sound system		
Area(s) to be covered		
Coverage		
Operational requirements		
Maximum latency permissible/ expected		
Access Limitation / Privacy		
System Latency		

Equipment location		
Power		
Building / room construction		
Potential signal interference		
Receiver access		
Receiver maintenance		
Equipment maintenance		
System monitoring		
Signal Distribution		
Ambience Microphone		
Other		

Summary	
Recommendation	
Notes	

B.2.2 Example 1 - Design for Theatre – Auditorium and Foyer

ALS design checklist **Date**	**Project**: Theatre Auditorium & Foyer
Address	
Contact(s)	

Design Consideration	System Application	Comments
Purpose of System	Add ALS facility to existing sound system	
Who will use the system?	Patrons / General public	
Access to system	Automatic via own hearing devices & issued receivers	Minimum action by staff and users required
Connection to sound system	Required	Dedicated output from existing mixer
Area(s) to be covered	Main auditorium & Foyer	
Coverage	(1) Auditorium - main seating area (2) Foyer – central area	Perimeter coverage not required
Operation	Areas to operate separately or combined	As sound system operation
Access Limitation / Privacy	Overspill between areas is acceptable	Acceptable due to proposed method of operation
System Latency	Maximum latency should be ≤40 ms to minimise audible disturbance and facilitate lip reading	
Equipment location	Existing control room	Space in existing rack
Power	Use sound system power	
Building construction	Reinforced concrete floor with carpet	Expect additional metal loss if hearing loop employed
Potential signal interference	• Lighting system EMI • Existing radio and Wi-Fi	Survey shows no significant issues. BGNL auditorium < -42 dB (-39 dB with lighting /

	equipment & installations	other systems), Foyer -33 dB, & -30 dB adjacent to counter. Low level buzz in foyer audible, agreed to be acceptable
Receiver access	From reception desk	
Receiver maintenance	Sound crew /management	Check equipment for operation / damage on regular basis (weekly or as found necessary). Hygiene clean after each use
Equipment maintenance	Sound crew	Check system operation on
System monitoring	Permanent, illuminated monitor in Foyer and Auditorium to indicate system is on / working. Portable listener to check coverage / sound quality	By sound crew /management
Signal distribution	From existing mixer to ALS equipment in existing sound system rack or to remote equipment cabinet if necessary	If AFILS employed used twisted conductor feed cable to loop and route away from mic lines. Ensure mic lines and low-level signal cables are balanced.
Ambience Microphone	Ambience mic required for each area to provide pick up of unamplified acoustic source and to provide confidence signal	System to automatically mute or dim ambience microphone when signal from main sound system is present
Other		

Summary	Client requirement is for simple to use / minimum maintenance system. Survey indicates that hearing loop is feasible as are Wi-Fi or Infrared systems, but these require intermediate receivers. Reinforced concrete floor may cause some additional loss of signal that will require attention.
Recommendation	Given user requirements and site conditions a hearing loop for each area is recommended. Design to note potential metal loss due to construction. Loop system to meet performance requirements of IEC 60118-4
Notes	Test loop may be required to optimally size loop amplifier

B.2.3 Example 2 - Design for college seminar rooms and classrooms project

ALS design checklist **Date**	**Project**: College seminar rooms and classrooms
Address	
Contact(s)	

Design Consideration	System Application	Comments
Purpose of System	Add ALS facility to each seminar / classroom (20)	Link to existing room sound / AV system where applicable
Who will use the system?	Students	Public may also use main lecture theatre
Access to system	Ideally automatic via own devices & issued receivers	Multiple simultaneous audio streams will be required so channel selection required
Connection to sound system	Required	Dedicated o/p from existing room system & connect to Voice Alarm system
Area(s) to be covered	Seminar / classrooms and main lecture theatre	
Coverage	All seats	
Operation	Each room to provide dedicated feed from existing sound reinforcement system	*Survey note* – Room XXX does not have a sound system so dedicated ALS microphone & AV input required
Access Limitation / Privacy	Overspill between room systems to be minimised in order to avoid disturbance / reduction in intelligibility	Adjacent room signals/channels to provide minimum 40 dB attenuation. Note some rooms on floor above - vertical signal separation as well as lateral therefore required
Equipment location	Locally with existing sound / AV system where required	
Power	Use local sound system power	
Building construction	Reinforced concrete floors with carpet tiles, plasterboard / sheetrock partition walls Outer walls reinforced concrete Ceilings - ceiling tile lay in grid	
Potential signal interference	Lighting systems EMI Existing Wi-Fi equipment & installations	

Receiver access	From reception desk if needed	Students could bring own devices if compatible
Receiver maintenance	AV department	Check equipment for operation / damage on regular basis (weekly or as found necessary). Hygiene clean after each use
Equipment maintenance	AV department	Check system on weekly basis
System monitoring	Remote monitoring from AV department office required	Plus local monitoring via system receiver / smart phone
Signal distribution	Via existing IT network	Note potential for system latency when network is busy. Consider separate network
Ambience Microphone	Should be considered for each room not only to demonstrate that the system is operating but primarily to pick up questions and dialogue from other students. Ambience and dialogue mics required for main lecture theatre.	System to automatically mute or dim ambience microphones when signal from main sound system is present
Other		

Summary	Client requirement is for simple to use / minimum maintenance system requiring minimal intervention from staff with multiple, simultaneous audio streams. System to provide relay of fire alarm (VA system) announcements.
Recommendation	Given user requirements, user base, site conditions and overspill requirements, hearing loops are not considered to be a viable option. Provided the increased latency times can be proved to be acceptable, a multichannel Wi-Fi System is recommended with students using their Smart phones or provided receivers to access the system. If latency is not acceptable, then an IR system with dispensed receivers is advised. The ALS can be fed from the existing, local sound systems with exception or Room XXX which will require dedicated ALS microphone and audio input.
Notes	IT Network traffic may give rise to latency issues. Detailed investigation required. Separate Wi-Fi system or modification to existing to be considered. ALS microphone for room XXX requires careful consideration. Directional ceiling microphone may be the most practical, offering lowest maintenance and operator intervention but needs to be selected and positioned with care to provide good audio quality and high intelligibility sound pick up. ALS connection instructions to be provided and displayed in each room

Annex C (Informative) Common Assistive Listening System topologies

Table 4 gives a non-exclusive list of such systems, but the list is intended to be updated as new systems qualify for inclusion.

Table 4 – Assistive Listening Systems Topologies

Type of system	Applicable Standards	Notes
Hearing-loop system	IEC 60118-4 - Performance IEC 62489-1 - Equipment IEC TR 63079 – Code of Practice EN 303 348 (RED)	Studied by IEC TC29. Include methods of measurement and performance requirements.
Personal listeners	IEC 63087-1*	Standard to include methods of measurement and performance requirements. Product includes microphone, amplifier, and earpieces. Can include input from any system type, and or output to telecoil or other method as applicable. “The standard is under revision.
Infra-red system	IEC 61603-1:1997 General IEC 61603-2 Audio wideband IEC 61603-3 Audio other Refers to: IEC 60914 (withdrawn)	Infra-red This was a TC 100 standard, but not dedicated to assistive listening. Includes infra-red headphones.
Radio system (VHF)	EN 301 489-1: EMC Others depending on application	Includes radio headphones.
Wi-Fi™ 2.4 & 5 GHz	IEEE 802.11 (Series) EN 301 489-1: EMC EN 300 328: (RED) 2.4 GHz EN 300 440: (RED) 1-40 GHz	
Bluetooth	From BT Core spec v5.3 & HAP v1.0 onwards. EN 301 489-1: EMC EN 300 328: (RED) 2.4 GHz EN 300 440: (RED) 1-40 GHz	IEC 60118-17 Application specific to support 2.4GHz direct to HA systems e.g., Auracast™ (under development)
Other Wireless system	EN 301 489-1: EMC Others depending on topology	Includes wireless headphones.
Audio vibration system		‘Body sonic’ is an example.
Soundfield system	IEC 62777	With directional loudspeaker or parametric sound system.

Annex D (Informative) Signage for different technologies

Apart from potential users of an ALS being informed about its presence by signage as per clauses 5.1 & 7.6 it is useful to also indicate the type of system in place. The following designs not only indicate the presence of an ALS but also its type. This ensures that users are appropriately informed, thus facilitating the accessibility of any service provision.

For venues where ALS are provided using more than one technology either multiple signs or a single sign containing multiple appropriate symbols may be provided if the extent of service provision is clear to the user and accessibility is not compromised.

D.1 Hearing Loops

Figure 3 – Sign for display in premises to indicate that a T-Coil compatible ALS (Hearing Loop) is installed.

D.2 Auracast™ (Bluetooth Low Energy) Systems

Figure 4 – Sign for display in premises to indicate that a Auracast™ compatible ALS is installed.

D.3 Wi-Fi™ Systems

Figure 5 – Sign for display in premises to indicate that a Wi-Fi™ compatible ALS is installed.

D.4 FM Systems

Figure 6 – Sign for display in premises to indicate that a FM compatible ALS is installed.

D.5 Infrared Systems

Figure 7 – Sign for display in premises to indicate that an Infrared compatible ALS is installed.

D.6 Soundfield Systems

Figure 8 – Sign for display in premises to indicate that a Soundfield ALS is installed.

Annex E (Informative) ALS information that should be provided on venue's website

To assist a visitor or potential user of a venue's ALS, the following information should be provided:

- Type or types of ALS in use at the venue
- How the ALS can be accessed (which hearing devices can be used and what are the requirements for users who bring their own devices)
- What equipment is available for loan (HA and non-HA users)
- Where the loan equipment can be obtained (preferably with a diagram or photograph of the location)
- Whether there is a test system to demonstrate that the loan equipment is working correctly. Details of areas where ALS coverage is provided, including a diagram or details if areas are not fully covered
- Contact information (phone/email) to obtain information in advance of visiting/attending the venue or an event.
- Who to contact in the event of a problem and their contact details
- Details of testing and system monitoring (e.g. permanent monitor or daily/weekly testing etc.)

Annex F (Informative) List of Recommended Organisations for Assessing a Person's Competence

Name of Organisation	Contact Details
Institute of Sound, Communications and Visual Engineers (ISCVE)	PO Box 3251, Gloucester, Gloucestershire, GL1 9FU, UK www.iscve.org.uk

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