



American National Standard Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids

C63[®]

Accredited Standards Committee C63[®]—Electromagnetic Compatibility

Accredited by the
American National Standards Institute

ANSI C63.19-2019
(Revision of ANSI C63.19-2011)

STANDARDS

American National Standard Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids

Accredited Standards Committee C63®—Electromagnetic Compatibility
accredited by the
American National Standards Institute

Secretariat
Institute of Electrical and Electronics Engineers, Inc.

Approved 19 August 2019
American National Standards Institute

C63®

Abstract: Uniform methods of measurement for compatibility between hearing aids and wireless communications devices are set forth.

Keywords: American National Standard, ANSI C63.19, electromagnetic compatibility, HAC, hearing aid, hearing aid compatibility, measurement methods, operational compatibility, wireless communications device

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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PDF: ISBN 978-1-5044-6241-9 STD23936
Print: ISBN 978-1-5044-5599-2 STDPD23583

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Introduction

This introduction is not a part of ANSI C63.19-2019, American National Standard—Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids.

In the fall of 1995, the Federal Communications Commission (FCC) initiated a Steering Committee to initiate a summit on Hearing Aid Compatibility and Accessibility with Digital Wireless Telecommunications. The goal of the summit was to formalize and continue discussions among the three key affected interests in this issue: organizations representing people with hearing loss, hearing aid manufacturers, and the digital wireless telephone industry. The ultimate purpose of the summit was to find a resolution of the interference problem that was acceptable to the industries involved.

A summit meeting was held on January 3–4, 1996, in Washington, DC. At this summit meeting, three working groups were formed to pursue issue resolution. Subsequently, the Long-Term Solutions User and Bystander Interference Group reached a consensus that a standards project was needed to document the consensus definition of and method of measurement for hearing aid compatibility with wireless telecommunications. Subsequently ANSI C63[®] was petitioned to undertake the joint standards projects documenting the methods of measurement and defining the limits for hearing aid compatibility with wireless telecommunications.

At its April 1996 meeting, ANSI C63[®] established a task group under its subcommittee on medical devices (SC 8). The charge to this task group (TG C63.19) was to develop such standards in cooperation with representatives of organizations representing people with hearing loss, hearing aid manufacturers, the digital wireless telephone industry, and other interested parties. ANSI C63.19-2001 was the result of that committee's efforts.

The FCC adopted this standard to provide the technical requirements for its Report and Order FCC 03-168 [B41] establishing mandatory requirements for wireless hearing aid compatibility on July 10, 2003.¹ Following the adoption by the FCC and for several reasons, including technical changes in wireless communications devices and hearing aids and new understanding coming from experience gained in working with the 2001 version of this standard, a new revision effort was started. The result of this revision effort culminated in the production of ANSI C63.19-2006.

During the final approval process for the ANSI C63.19-2006 version, several issues were raised. The working group and ANSI ASC C63[®] decided to open an amendment project to deal with these issues. The successful completion of that effort resulted in the publication of ANSI C63.19-2007.

After the publication of C63.19-2007 (ANSI approved March 29, 2007), the FCC issued Report and Order 07-72 [B42] (see also FCC DA 07-4151 [B43]), allocating new wireless services to a frequency band in the 700 MHz range. As part of that rulemaking, the Commission requested that the C63[®] committee revise the standard to support the application of HAC requirements to the 700 MHz band. The committee agreed to address this 700 MHz band and also decided to extend the upper frequency range to 6 GHz, taking into account newer technologies that are also covered by similar regulations.

The working group and ANSI ASC C63[®] decided to open an amendment project to deal with these issues. The successful completion of that effort resulted in the publication of the 2011 version of the standard.

In 2015, a project was authorized to prepare a new revision of ANSI C63.19 addressing the following issues:

- a) Growing importance of VoIP and VoLTE for telephony services
- b) Hearing aid user satisfaction with HAC
- c) Adequacy of volume control

¹ The numbers in square brackets correspond to those of the bibliography in Annex J.

- d) Adequacy of T-Coil reception
- e) Harmonization with corresponding IEC 60118-13
- f) Cover new technologies, particularly at TVWS devices and cellular at 600 MHz, 3.5 GHz, and 5.0 GHz, which may include extending the lower boundary of the frequency range covered
- g) Use of software defined radio (SDR) and other new instrumentation in HAC measurements
- h) Simultaneous transmissions, particularly in smartphones

The outcome of this project was this version of the standard.

Acknowledgments

The Accredited Standards Committee on Electromagnetic Compatibility, C63[®], thanks the IEEE and Edwin L. Bronaugh (author) for granting permission to use *Helmholtz Coils for Calibration of Probes and Sensors: Limits of Magnetic Field Accuracy and Uniformity*, from the 1995 IEEE Symposium on EMC, Atlanta, GA, in Annex G of this standard.

Permission is granted by PCTEST to make available US Patent 9277331 (Inventors: Justin Chao, Stephen Liu, Andrew Harwell, Randy Ortanez) for this standard. The patent is considered essential for performing T-Coil testing on VoIP communication services.

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American National Standard Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids

1. Overview

1.1 Scope

This standard applies to both wireless communications devices (WDs) and hearing aids. It sets forth uniform methods of measurement and parametric requirements for the electromagnetic and operational compatibility of hearing aids and WDs, including cellular phones, personal communications service (PCS), and voice-over-Internet-protocol (VoIP) devices, operating in the range of 614 MHz to 6 GHz.² TIA-1083, *Telecommunications Communications Products Handset Magnetic Measurement Procedures and Performance Requirements* [B87],³ has become the recognized standard for measurement procedures and performance requirements for handset-generated audio band magnetic noise of wireline communications devices, including cordless telephones (cordless handsets with wireline-connected base units). Ongoing communications between the TIA TR-41.3.14 accessibility working group⁴ and ANSI C63.19 working group have been maintained with the objective of harmonizing the two standards to the maximum extent possible.

This standard is intended to apply to all types of hearing aids with acoustic output, including, as examples, behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), completely-in-the-canal (CIC) types, and receiver-in-the-canal (RIC). Test methods are provided for acoustic (microphone input) mode and tele-coil (T-Coil) hearing aid modes of operation.

Users of this standard are cautioned to maintain the field strength called for in various places in the document within the limits for radio-frequency (RF) safety specified in IEEE Std C95.1™ [B65].

1.2 Purpose

The purpose of this standard is to provide tests and establish requirements for hearing aids and for WDs that allow a hearing aid user to effectively use a WD when both the hearing aid and WD meet the requirements of this standard. The various parameters required in order to demonstrate compatibility are measured. The design

² This version of ANSI C63.19 provides detailed procedures up to 3 GHz, although the scope has been expanded up to 6 GHz. The guidance provided goes as far as well-researched methods are available and covers the primary bands relative to this topic.

³ The numbers in brackets correspond to those of the bibliography in Annex J.

⁴ TIA-1083 is administered by TIA Engineering Committee TR-41 Performance and Accessibility for Communications Products (<http://standards.tiaonline.org/all-standards/committees/tr-41>).

of the standard is such that when a hearing aid and a WD achieve the specified requirements, as measured by the methodology of this standard, the user of a hearing aid can effectively use a WD.

In order to provide for the usability of a hearing aid with a WD, several factors are coordinated, as follows:

- The field strength emitted by a WD must not exceed the RF immunity of the hearing aid.
- The T-Coil baseband H-field transmission of the WD must be compatible with the T-Coil mode of the hearing aid.
- The magnetic noise from the WD in the T-Coil band must not degrade the reception quality to unacceptable levels.

Both the WD's RF and audio-band emissions are measured. Hence, the following measurements are made for the WDs:

- a) RF amplitude modulation characteristics and power level or, optionally, near-field E-field emissions
- b) T-Coil mode, magnetic signal strength in the audio band
- c) T-Coil mode, magnetic noise in the audio band
- d) T-Coil mode, magnetic signal frequency response in the audio band

Corresponding to these quantities, the hearing aid is measured for the following:

- 1) RF immunity in microphone mode
- 2) RF immunity in T-Coil mode

This standard describes preferred test methods and test facilities. If alternative test methods or facilities are employed, every effort shall be made to establish correlation with the preferred ones. Any deviation from the preferred test methods, as specified in this standard, shall be fully described in the test report.

1.3 Word usage

In this document, the word *shall* is used to indicate a mandatory requirement. The word *should* is used to indicate a recommendation. The word *may* is used to indicate a permissible action, which is at the discretion of the test engineer. The word *can* is used for statements of possibility and capability.

1.4 Organization and use of this standard

These technical requirements specify the measurement methods and qualification levels to ensure hearing aid operational compatibility with WDs.

To ensure hearing aid and WD compatibility, it is essential that uniform measurement methods be specified for hearing aid RF immunity and WD RF emissions. In addition, in order to provide for T-Coil mode, the WD T-Coil signal must be evaluated for signal strength, intended/unintended signal ratio, and the frequency response of the signal in the audio band.

There are several factors impacting hearing aid performance when used in the presence of a WD. The hearing aid can be exposed to near-field illumination (when the hearing aid user uses a WD) or far-field illumination (when the radiating element is at a distance from the hearing aid user). Different styles of hearing aids (for example, BTE, ITE, ITC, and CIC) are positioned differently with respect to the WD. WDs can operate at different frequencies and utilize different transmission schemes.

Hearing aids can operate in an acoustic coupling mode or a T-Coil coupling mode. In acoustic mode, hearing aids use a microphone to pick up acoustic sound waves generated by the WD. In T-Coil mode, the microphone output is disabled (or attenuated) and a baseband (audio frequency) H-field signal, generated

by the WD becomes the signal source. During T-Coil operation, the baseband H-field generated by the WD is intended to be the primary coupling mechanism to the hearing aid. The WD also can produce unintended baseband H-fields (the result of circulating currents). Such H-fields produce noise, if detected during T-Coil operation, or can introduce interference in hearing aid circuits, even in the acoustic mode.

The WD generates an electromagnetic field as the main communication means with the public telephone network. However, it is possible for this field to interfere with the hearing aid's proper operation. Interference is produced as a result of pickup and demodulation within the hearing aid circuitry. The goals are to limit the WD's interfering RF field and to provide hearing aids with a minimum amount of electromagnetic immunity such that RF field levels in direct proximity to the hearing aid (with the WD in normal position, when the hearing aid user holds the WD at the ear) are manageable and do not interfere with basic hearing aid functionality.

The following table provides an overview of each clause in this standard, highlighting the technical requirements in each clause:

Clause number	Title	Description
1	Overview	Describes the scope and purpose of the standard.
2	Normative reference	Lists references used in this standard.
3	Definitions, acronyms, and abbreviations	Defines terms, acronyms, and abbreviations used in this standard.
4	WD RF interference potential	This clause includes a WD RF emissions test. Prescribes the measurements correlated to the RF field strength in the near field generated by a WD in the region potentially occupied by a hearing aid.
5	Hearing aid RF immunity test	Prescribes the measurement method to be used in determining the immunity level of a hearing aid to radiated electromagnetic fields originating from a WD.
6	WD T-Coil signal test	Specifies the WD T-Coil signal measurement. Three quantities are measured: the magnetic audio frequency response, and the desired and undesired audio frequency H-field levels.
7	Volume control	Requires that a WD meet the requirements of ANSI/TIA-5050-2018, <i>Telecommunications – Communications Products – Receive Volume Control Requirements for Wireless (Mobile) Devices</i> .
8	Calibration requirements and measurement uncertainty	Describes basic requirements for instrumentation calibration. Provides guidance for estimating the uncertainty and reproducibility of measurements made in accordance with this standard.
9	Test report	Specifies the minimum content of the test report and is similar to the test report specifications of ANSI C63.4-2014.

Figure 1.1 depicts the organization and use of this standard. Both the WD and hearing aid have mandatory tests, in Clause 4 through Clause 6. These provide for both microphone and T-Coil modes of operation. The appropriate test is performed for each device. To claim compliance with this standard, a device must meet the requirements specified for either a hearing aid or WD, as appropriate.

Clause 7 specifies the volume control requirement for a WD.

Clause 8 describes the uncertainties involved in these measurements and instrument calibration procedures to minimize the measurement uncertainty.

Clause 9 provides guidance on preparation of the test report. The test report shall be delivered to the relevant authority requiring the testing.

ORGANIZATION AND USE OF THIS STANDARD

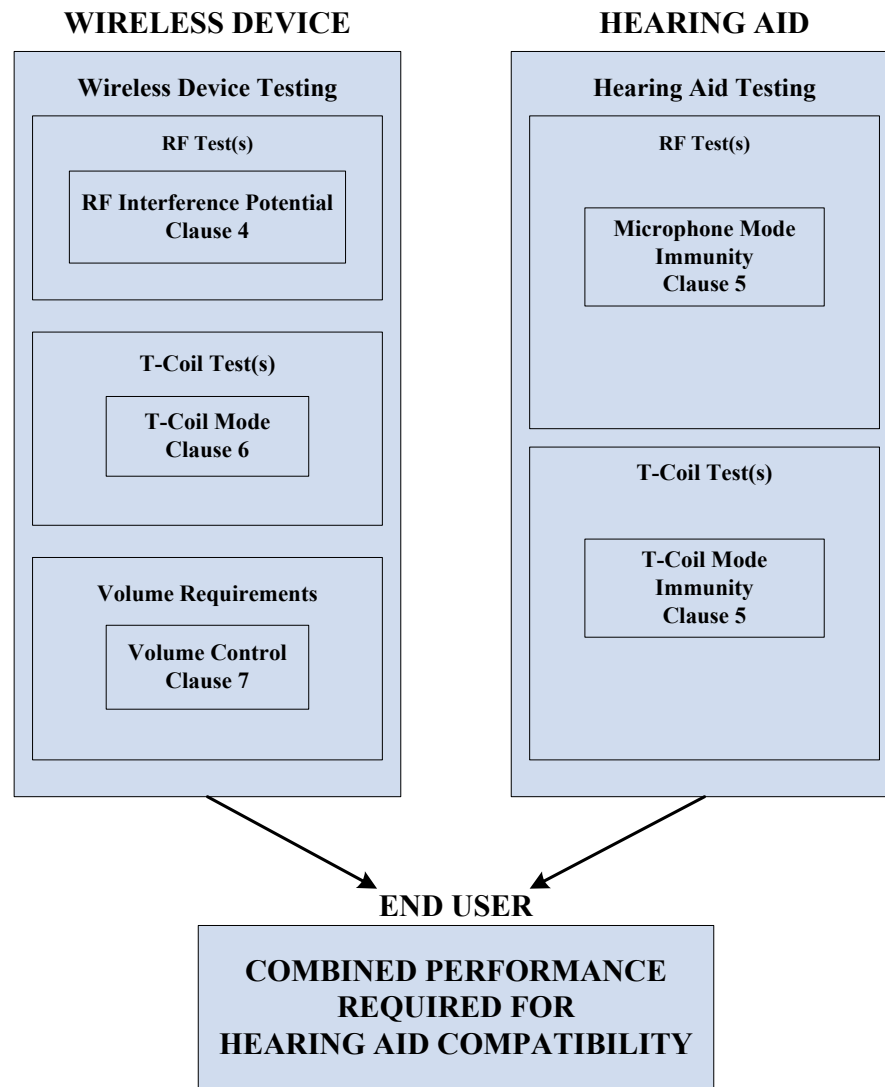


Figure 1.1—Organization of this standard

To be in compliance with this standard, a device must meet all normative requirements that apply to it. The requirements for a WD are primarily in Clause 4, Clause 6, and Clause 7. The requirements for a hearing aid are primarily in Clause 5. There are requirements, such as the reporting requirements in Clause 8, that apply to all devices.

This standard also contains several annexes with additional information about the measurements (Annex A and Annex B), instrumentation (Annex D), calibration of instruments (Annex C, Annex E, and Annex G), and uncertainty of the measurements (Annex F).

This standard is intended to provide a measure of the compatibility between hearing aid devices and WD products. The requirements in this standard are based on testing with hearing aid devices in the laboratory and in actual use. However, there is a wide range of human perceptions of normal communications with WD or even wired communications. Thus, even when compatibility between a particular hearing aid and WD is indicated by these tests, it cannot be guaranteed that the vocal output of the WD will be intelligible and any interference not annoying to all users at all times.

2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

In the event of a conflict between the text of this document and the normative references to other documents cited herein, the text of this standard takes precedence.

ANSI/ASA S3.22-2014, American National Standard Specification of Hearing Aid Characteristics.⁵

ANSI C63.4-2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.⁶

ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

ANSI C63.14-2014, American National Standard Dictionary of Electromagnetic Compatibility (EMC) including Electromagnetic Environmental Effects (E3).

ANSI C63.26-2015, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.

ANSI/TIA-5050-2018, Telecommunications – Communications Products – Receive Volume Control Requirements for Wireless (Mobile) Devices.⁷

IEC 60118-0:2015, Electroacoustics – Hearing aids – Part 0: Measurement of the performance characteristics of hearing aids.⁸

IEC 60118-13:2016, Ed. 2.0, Electroacoustics – Hearing aids – Part 13: Electromagnetic compatibility (EMC).

IEC 61000-4-3:2006, Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test.

IEC 61000-4-20:2010, Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides.

IEEE Std 269™-2010, IEEE Standard Methods for Measuring Transmission Performance of Analog and Digital Telephone Sets, Handsets, and Headsets.^{9,10}

IEEE Std 1027™-1996, IEEE Standard Method for Measurement of the Magnetic Field in the Vicinity of a Telephone Receiver.

IEEE Std 1309™-2013, IEEE Standard for Calibration of Electromagnetic Field Sensors and Probes (Excluding Antennas) from 9 kHz to 40 GHz.

ISO 3:1973, Preferred numbers – Series of preferred numbers.¹¹

⁵ ASA publications are available from the Acoustical Society of America (<https://acousticalsociety.org/>).

⁶ C63® publications are available from the Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>) and the American National Standards Institute (<http://www.ansi.org/>).

⁷ TIA publications are available from the Telecommunications Industry Association (<http://www.tiaonline.org/>).

⁸ IEC publications are available from the International Electrotechnical Commission (<http://www.iec.ch/>) and the American National Standards Institute (<http://www.ansi.org/>).

⁹ The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

¹⁰ IEEE publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>).

ISO 266:1975, Acoustics – Preferred frequencies for measurement.

NIS 81: Edition 1, May 1994, The Treatment of Uncertainty in EMC Measurements.¹²

NIS 3003: Edition 8, May 1995, The Expression of Uncertainty and Confidence in Measurement for Calibrations.

NIST Technical Note 1297, Sept. 1994, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results.¹³

SAE J551/1:2005, Performance Levels and Methods of Measurements of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz).¹⁴

TIA/EIA-136 Series, 800 MHz TDMA Cellular Standards.¹⁵

TIA-2000 Series, CDMA 2000 Series.¹⁶

3. Definitions, acronyms, and abbreviations

3.1 Definitions

The definitions given in ANSI C63.14-2014¹⁷ and IEEE 100 [B60] apply throughout this standard, unless otherwise noted in this subclause. Particular product standards or applicable regulation definition take precedence. Definition sources (if applicable) are enclosed in brackets or parentheses following the definition.

anechoic enclosure: An enclosure whose internal walls have low reflection characteristics. (ANSI C63.14-2014)

NOTE—This implies that all six surfaces of the enclosure have low-reflection characteristics for incident waves. For audio use, the anechoic enclosure is not necessarily a metallic enclosure; for RF applications, the anechoic enclosure is a shielded (against RF ingress or egress) metallic enclosure. Both types of enclosures use absorbing material (suited to the frequency range of use) to implement the low-reflection characteristics desired.¹⁸

audio band: The audio frequency range. *See also:* **audio frequency**.

audio coupling mode: Transmission of a signal between two pieces of equipment using sound.

audio frequency: Any frequency corresponding to a normally audible sound wave. (IEEE 100 [B60])

NOTE 1—Audio frequencies range roughly from 15 Hz to 20 kHz. This standard generally addresses audio frequencies from 50 Hz to 10 kHz.

NOTE 2—This term is frequently shortened to audio and used as a modifier to indicate a device or system intended to operate at audio frequencies, for example, an audio amplifier.

¹¹ ISO publications are available from the International Organization for Standardization (<http://www.iso.ch/>) and the American National Standards Institute (<http://www.ansi.org/>).

¹² NIS standards are published by NAMAS (UKAS) and can be ordered from UKAS, National Physical Laboratory, Teddington, Middlesex, TW11 0LW, U.K. (tel. 011-81-943-7140, FAX 011-81-943-7134).

¹³ NIST publications are available from the National Institute of Standards and Technology (<http://www.nist.gov/>).

¹⁴ SAE publications are available from the Society of Automotive Engineers (<http://www.sae.org/>).

¹⁵ TIA/EIA publications are available from the Telecommunications Industry Association (<http://www.tiaonline.org/>).

¹⁶ TIA publications are available from the Telecommunications Industry Association (<http://www.tiaonline.org/>).

¹⁷ Information on references can be found in Clause 2.

¹⁸ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

band: Frequency range between two defined limits. (IEEE 100 [B60])

bandwidth: The range of frequencies within which performance, with respect to some characteristic, falls within specific limits. (IEEE 100 [B60])

compatibility: The ability of a WD and a hearing aid to work together; specifically with regard to radio-frequency interference and magnetic signal levels, frequency response, and signal-to-noise levels.

conducted power: Power applied to the terminals of the antenna, measured by the appropriate procedure for the equipment under test in ANSI C63.10-2013 or ANSI C63.26-2015.

dBm0: Power level in dBm, relative to a reference point called the zero-transmission level point, or 0 TLP (transmission level point).

digital wireless telephone: An RF-based wireless telephone utilizing digital transmission formats over an air interface.

NOTE—Generally these are devices regulated under Parts 15, 22, 24, 27, and 90 of the Rules of the Federal Communications Commission.

directional coupler: A transmission coupling device for separately (ideally) sampling (through a known coupling loss for measuring purposes) either the forward (incident) or the backward (reflected) wave in a transmission line. (IEEE 100 [B60])

far-field region: That region of the field of an antenna where the angular field distribution is essentially independent of the distance from a specified point in the antenna region.

NOTE 1—For a half-wavelength dipole, the reference point is usually taken as the center of the antenna, but may be anywhere on the surface of the antenna.

NOTE 2—For a half-wavelength dipole, the far-field region is considered to exist at distances much greater than $\lambda/2\pi$, where λ is the wavelength. For a half-wavelength dipole, this distance is at the geometric center of the transition region between the near-field and far-field regions.

NOTE 3—The distance 3λ is considered to lie in the far-field region. (IEEE 100 [B60])

forward power: That power supplied by the output of an amplifier (or generator) traveling towards a load. (SAE J551/1:2006)

gigahertz transverse electromagnetic chamber (GTEM): *See:* wideband TEM (WB TEM) cell.

hearing aid: A professionally dispensed, wearable, air-conduction, sound amplifying device that is intended to compensate impaired hearing.

input-referenced ambient noise (IRAN): The equivalent acoustic input sound pressure level that would produce the acoustic noise output observed from a hearing aid.

NOTE—IRAN is determined by subtracting the acoustic gain in decibels from the acoustic noise output.

input-referenced interference level (IRIL): The equivalent acoustic input sound pressure level (typically at 1 kHz) that would produce the same acoustic output in a hearing aid as that produced by an RF interference source.

NOTE—IRIL is determined by subtracting the acoustic gain in decibels from the acoustic interference output.

intentional radiator: A device that intentionally generates and emits RF energy by radiation or induction. (FCC 47 CFR 15.3(o) [B26])

measurement reference point: Generally, the center of the earpiece receiver speaker openings.

NOTE—The physical location is sometimes offset from the earpiece center, i.e., if a secondary induction source is used.

modulation interference factor (MIF): For a modulated signal, the difference, in decibels, found by subtracting the signal's steady-state level, in decibels, from its RF audio interference level, in decibels.¹⁹

near-field region: That part of space between the antenna and the far-field region. (IEEE 100 [B60]: (AP) 145-1993)

NOTE 1—The near field includes the quasi-static and induction fields varying as r^{-3} and r^{-2} , respectively, but does not include the radiation field varying as r^{-1} (IEEE 100 [B60]: (PE/T&D) 1260-1996).

NOTE 2—For a half-wavelength dipole, the near-field region is considered to exist at distances much less than $\lambda/2\pi$, where λ is the wavelength.

NOTE 3—For a very short dipole, or equivalent radiator, the outer boundary is commonly taken to exist at a distance of $\lambda/2\pi$ from the antenna surface. (IEEE 100 [B60]: (AP) 145-1993)

net power: Forward power minus reflected power at the same location on a transmission line. (SAE J551/1:2006)

personal communications service device: Intentional radiators operating in the frequency band specified by the applicable regulating agency that provide a wide array of mobile and ancillary fixed communication services to individuals and businesses. (Adapted from FCC 47 CFR 15.303(g) [B26])

reflected power: That power traveling towards the amplifier (or generator) reflected by a load caused by impedance mismatch between the transmission line and load. (SAE J551/1:2006)

RF audio interference level: The level of an unmodulated RF carrier that, when modulated by 80% 1 kHz sine wave AM, produces the same output from a weighted square-law detector as does the modulated RF signal under test when measured with the same weighted square-law detector.

NOTE—The term “level” is to be interpreted as “rms amplitude” or “average power level,” whichever is appropriate.

shielded enclosure: A mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and the external environment. (ANSI C63.14-2014)

sound pressure level (SPL): The sound pressure level, in decibels, of a sound is 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure. (IEEE 100 [B60])

NOTE—For this standard, the reference level shall be 20 μ Pa.

tele-coil (T-Coil): An inductive coil used in some hearing aids to allow reception of an audio band magnetic field signal, instead of an acoustic signal.

NOTE—The magnetic or inductive mode of reception is commonly used in conjunction with telephones, auditorium loop systems, and other systems that provide the required magnetic field output.

transverse electromagnetic (TEM) cell: A measuring device that is designed to utilize the TEM mode over the frequency range of interest.

NOTE—Common examples are the two-port TEM cell (also known as the Crawford Cell) and the wideband TEM cell. (ANSI C63.4-2014)

¹⁹ The term “level” is to be interpreted as “rms amplitude” or “average power level,” whichever is appropriate.

wavelength (λ): Of a monochromatic wave, the distance between two points of corresponding phase of two consecutive cycles in the direction of the wave normal. (IEEE 100 [B60])

wideband TEM (WB TEM) cell: A TEM cell that has been altered to extend the usable frequency range. Often this is achieved by replacing one port of a two-port TEM cell with a wideband load. One example is commonly called a GTEM (gigahertz transverse electromagnetic). (ANSI C63.4-2014)

wireless communications device (WD): A communications device using RF energy.

NOTE—These devices are used in wireless communications networks such as cellular or personal communication service.

3.2 Acronyms and abbreviations

2G	2nd generation (cellular)
3G	3rd generation (cellular)
3GPP	3rd Generation Partnership Project
ABM	audio band magnetic
AM	amplitude modulation
AMPS	advanced mobile phone system
ANSI	American National Standards Institute
BTE	behind the ear (hearing aid)
CDMA	code division multiple access
CFR	Code of Federal Regulations
CIC	completely in the canal (hearing aid)
CMRS	Commercial Mobile Radio Service
CW	carrier wave
DAI	digital audio interface
dB	decibel
dBc	decibels below carrier
dB SPL	decibels referenced to a sound pressure level of 20 μ Pa
dBm	decibels (dB) with reference to one milliwatt (mW)
DL	down-link
EHIMA	European Hearing Instrument Manufacturers Association
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EUT	equipment under test
f	frequency

FDD	frequency division duplex
FFT	fast Fourier transform
GSM	Global System for Mobile communication
GTEM	gigahertz transverse electromagnetic
iDEN ^{®20, 21}	integrated digital enhanced network
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	internet protocol
IRAN	input-referenced ambient noise
IRIL	input-referenced interference level
ISO	International Organization for Standardization
ITC	in the canal (hearing aid)
ITE	in the ear (hearing aid)
ITU	International Telecommunication Union
kHz	kilohertz
LTE	Long Term Evolution
max	maximum
MHz	megahertz
MIF	modulation interference factor
OATS	open area test site
ORIL	output-referenced interference level
o.d.	outside diameter
OSPL	output sound pressure level
P	transmit power or forward power (watts)
PCM	pulse code modulation
PCS	personal communications services
QAM	quadrature amplitude modulation
QPSK	quadrature phase shift keying
RB	resource block
RBW	resolution bandwidth

²⁰ The following information is given for the convenience of users of this standard and does not constitute an endorsement by the IEEE of these products.

²¹ iDEN is a registered trademark of Motorola, Incorporated.

RF	radio frequency
RF _{AIL}	RF audio interference level
RF _{AIPL}	RF audio interference power level
RLR	receive loudness rating
rms	root mean square
RIC	receiver in canal (hearing aid)
SPL	sound pressure level
T-Coil	tele-coil
TDD	time division duplex
TDMA	time division multiple access
TEM	transverse electromagnetic
TMFS	telephone magnetic field simulator
UKAS	United Kingdom Accreditation Service
UL	up-link
UMTS	Universal Mobile Telecommunications System
UTRA	universal terrestrial radio access
VoIMS	voice over IP multimedia subsystem
VoIP	voice-over-Internet-protocol
VoLTE	voice over LTE
VoWiFi	Voice over Wi-Fi®
VSWR	voltage standing wave ratio
WB TEM	wideband transverse electromagnetic
WCDMA	wideband code division multiple access
WD	wireless communications device
WLAN	wireless local area network

4. Evaluation of WD RF interference potential

4.1 Introduction

This clause provides guidance on measuring the potential for WD RF emissions to cause annoying audio-frequency interference in a hearing aid. Clause 5 specifies the companion measurement, for immunity of a hearing aid to RF interference.

WDs can operate at a variety of RF frequency ranges, but this standard is restricted to the range of 614 MHz to 6 GHz. This range contains the most widely used frequency bands in which WDs typically transmit while held to the user's ear.

Generally, it is considered sufficient to measure a particular pulsed RF WD at the frequencies at which the WD is capable of transmission as part of its normal operation, as specified by the manufacturer. However, the evaluation need not be limited to those frequencies if there is a basis for concluding that the WD can be expected to normally operate at other frequencies.

For the purposes of this standard, the term “pulsed” refers to the use of a non-continuous RF envelope or carrier.

This clause includes guidance on evaluating the RF interference potential of an air interface technology. This evaluation analyzes the potential of an air interface technology, which includes its modulated waveform and operating characteristics, to produce hearing aid interference.

As is stated in the Scope (1.1) and Organization and use (1.4) subclauses of this standard, the topic of interest is “interference to hearing aids.” To that end, the purpose of the measurements in this clause is to measure the quantity of the RF signal most closely correlated with the intensity of interference to hearing aids, termed the RF audio interference level.²²

The following discussion is given to clearly and succinctly describe the physical quantity to be measured. This quantity, the RF audio interference level, is defined by the following characteristics. Conceptually, this definition is intended to correlate to the user perception of interference received through an idealized hearing aid and is characterized by the following attributes (as depicted in Figure 4.1):

- The full signal bandwidth is presented to a wideband square-law detector, which demodulates the RF signal. When reproducing this function, which is a characteristic of RF interference, the sensing elements and the detector shall have a bandwidth greater than or equal to the emission bandwidth. After the square-law detector, the RF signal will be in the baseband.²³
- The post-detection recovered audio signal shall be filtered by the spectral and temporal filters specified in D.4 and D.5.

The output from the spectral and temporal filters has been designed to be proportional to the interference as heard by hearing aid users. The level of an unmodulated RF carrier that, when modulated by 80% 1 kHz sine wave AM produces that same output from the spectral and temporal filters, is termed the RF audio interference level.²⁴ The RF audio interference level is used in determining the hearing aid compatibility of the WD being tested.²⁵

A WD's interference potential is a function of both the WD's average in-use near-field field strength and of the signal's audio-frequency amplitude modulation characteristics. The portion of the interference potential attributable to the modulation characteristic can be evaluated independently of any particular WD. This evaluation of this interference potential relative to a signal's average field strength is described in D.7 and is termed its Modulation Interference Factor (MIF). The MIF may be determined through analysis and simulation, allowing evaluation of an RF technology's RF interference potential in advance of actual product development.

²² The term “level” is to be interpreted as “rms amplitude” or “average power level,” whichever is appropriate.

²³ After the square law detector, the signal is the recovered audio interference that would be received by a hearing aid.

²⁴ The term “level” is to be interpreted as “rms amplitude” or “average power level,” whichever is appropriate.

²⁵ Human hearing is characterized by several characteristics of the signal, including its spectral and temporal components. The spectral and temporal weighting filters, in D.4 and D.5, are designed to capture and weight the components of the signal for assessment of its RF audio interference potential to hearing aid users.

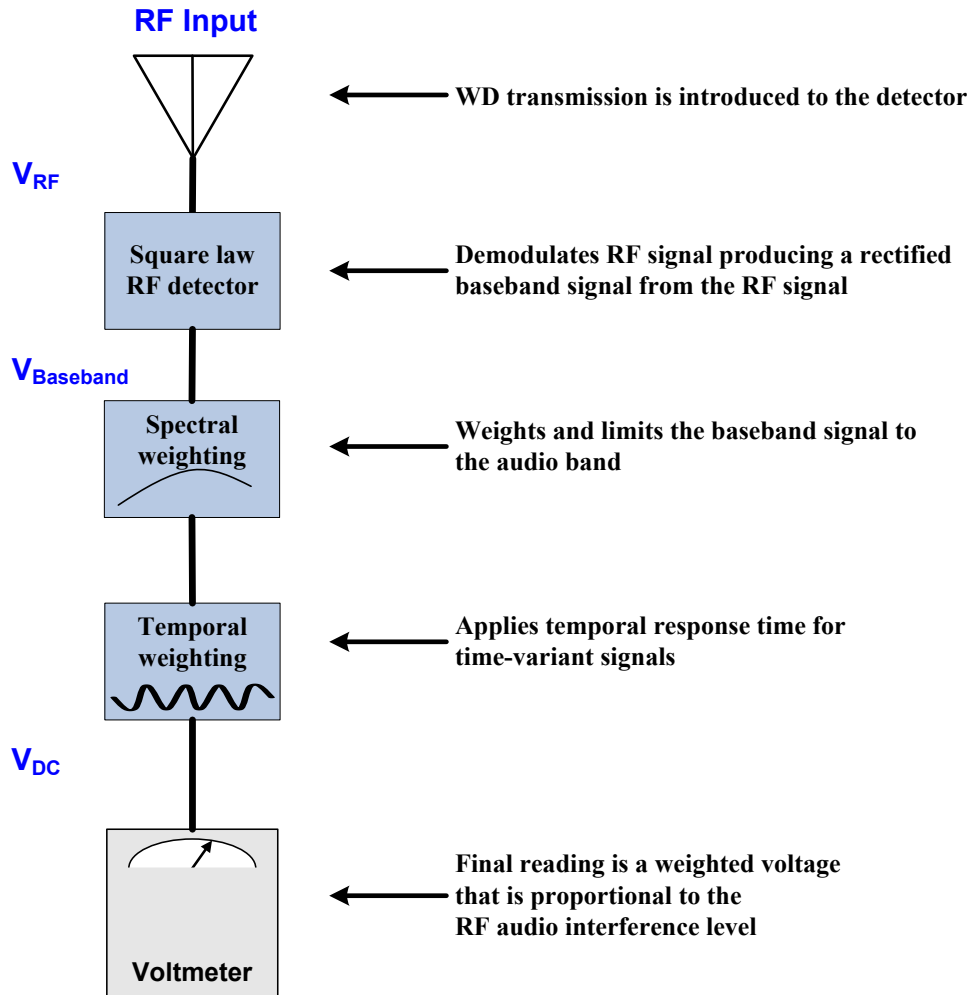


Figure 4.1—Measuring the RF audio frequency interference level

The MIF characterizes the audio frequency interference potential of a modulated RF signal, independent of its average level. It is defined in terms of the long-term average of the square-law detector's output to the weighting filter output. The MIF in decibels is expressed by Equation (1) as follows:

$$10 * \log_{10}(\text{weighting filter output} / (1.154 \times \text{rms average output})) \quad (1)$$

The factor 1.154 in the formula normalizes the result to that obtained for an RF carrier with 80% 1 kHz sine wave amplitude modulation.

Alternatively, qualification may be achieved more conservatively by evaluation of the peak power or field strength, based on an assumption of a possible worst-case associated MIF.

4.2 Evaluation of interference potential

An analysis shall be performed, following the guidance of 4.1, of the RF air interface technology being evaluated. Factors that will affect the RF interference potential shall be evaluated, and the worst-case operating mode shall be identified and used in the evaluation. Any factor that can affect the RF interference potential shall be evaluated. Examples of such factors are those that will change the RF signal envelope,

such as discontinuous transmission due to data load, power management, or configuration options of the RF air interface technology.

The primary method for establishing the RF interference potential of a WD is based on conducted power to the antenna. This may be based either on evaluation of the RF audio frequency interference power level for the worst-case operating mode or, more conservatively, on a simple measurement of the peak conducted power, averaged over intervals $\leq 50 \mu\text{s}$.²⁶ The peak power measurement alone may be sufficient to qualify a WD operating mode. For a mode that does not qualify in this manner, evaluation of the RF audio interference power level may allow qualification, in the case of a low-to-moderate MIF.

A secondary method for establishing the RF interference potential of a WD transmitter, which could be more suitable when its strongest near-field is concentrated away from the WD's acoustic output, is to evaluate the RF audio frequency interference level by direct measurement of the near-field E-field emissions near the measurement reference point (acoustic output). E-field strength is measured, isotropically or using a D-Dot probe, over a 50 mm^2 measurement area, in the measurement plane as specified in A.2. Evaluation is based on the simple average of the measurements over the measurement area. This average measurement may be evaluated according to its RF audio frequency interference level, as described in 4.5.

Alternatively, and more conservatively, the peak E-field strength of the measurement area-averaged measurement, averaged over intervals $\leq 50 \mu\text{s}$, may be used to evaluate the interference potential.

The result of any of these methods shall be compared to its respective test limit as specified in 4.7. A WD may be considered acceptable through qualification by any one of these methods.

All methods require that the combination of power and modulation characteristic that is representative of the worst-case operating mode (highest interference potential) likely to be encountered in normal voice mode operation be identified and used when determining compliance with this standard. Transmitting modes and conditions that are transient in nature, likely to occur less than 1% of the time, on average, in the network, may be excluded from consideration. Hence, unique transmit modes that occur only during call set-up or tear-down, or during hand-over between base stations, may be excluded. Only transmit modes that occur during conversational speech with the WD held in a talking position at the ear should be considered. The transmit modes to be tested shall be clearly identified in the test report.

The typical test procedure would begin with the simplest test for each operating mode, proceeding to the more time-consuming tests only if qualification had not yet been achieved.

- a) Measure peak conducted power; compare to the associated qualification level.
- b) Measure RF audio interference power level (RF_{AIPL}) (see 4.4); compare to the associated qualification level.
- c) Measure peak E-field strength, averaged over the designated scan area (see 4.5.3.2.4); compare to the associated qualification level.
- d) Measure RF audio interference level (RF_{AIL}), averaged over the designated scan area (see 4.5.3); compare to the associated qualification level.

In practice, it is often found that Step a) is sufficient to qualify most or all operating modes for RF emissions, without further testing.

²⁶ The peak power averaging time was determined by the inverse of 20 kHz, the top of the audio frequency band. A full cycle at 20 kHz is $50 \mu\text{s}$.

4.3 Test equipment and facilities

4.3.1 General

This subclause provides a list of the test equipment required to perform this test. Portions of this standard place requirements on the test facilities and are discussed in this subclause, as well as in C.1.

A careful review shall be made of the factors affecting measurement uncertainty, as described in Clause 8 and Annex F. Efforts made to reduce the measurement uncertainty improve the stability and reproducibility of the measurement.

The test equipment used shall meet the applicable specifications of Annex D.

4.3.2 Test equipment for conducted methods

- a) Square-law detector
- b) Spectral weighting filter
- c) Temporal weighting filter
- d) DC voltmeter
- e) WD support fixture
- f) RF enclosure, if applicable

4.3.3 Test equipment for the near-field scan method

This subclause provides a list of the test equipment required to perform the near-field scan test. The test equipment used shall meet the applicable specifications of Annex D.

- a) E-field, near-field probe
- b) Probe positioning system
- c) Square-law detector
- d) Spectral weighting filter
- e) Temporal weighting filter
- f) DC voltmeter
- g) WD support fixture
- h) Reference dipole antenna as described in D.11.
- i) RF enclosure, if applicable

4.4 Measured RF audio interference power level

There are two methods for establishing the RF audio interference power level (RF_{AIPL}) of a WD:

- Direct measurement, by applying the conducted power of the WD to a square law detector meeting the frequency response requirements of D.3, followed by spectral and temporal weighting according to D.5 and D.6, calibrated to yield the same results as the indirect method.
- Indirect measurement, where the waveform-specific modulation interference factor (MIF), as specified in D.7, is measured separately and added to the measured average conducted power, in dBm. The MIF is independent of overall signal level (within the constraints of the transmission protocol) and may be measured using either a conducted input or an air interface.

4.5 Measured near-field RF audio interference level

4.5.1 Near-field measurement system

The near-field measurement system shall include a small (relative to the wavelength)²⁷ E-field probe suitable for measuring the field strength of the RF field. For the direct measurement method, the RF signal from a probe is delivered to a square law detector that delivers the recovered audio. The post-detection signal from the probe and detector shall have a modulation frequency response of at least 50 Hz to 10 kHz, ± 1 dB. The output from the detector is passed through the spectral and temporal weighting filters. The final measurement is the average output voltage from the weighting filters. (See Figure 4.1.)

The probes shall meet the requirements given in D.13 for the E-field.

The use of an automated movement system, such as robotic arms or three-axis positioners, is preferred because it can provide superior probe placement accuracy and placement repeatability. The placement accuracy and repeatability of the system used shall be determined and included in the measurement uncertainty calculation. Alternatively, manual placement systems may be used. It is recommended that a placement fixture be used with manual systems to assist in accurate probe placement. Such a fixture should be constructed of expanded foam or other RF-transparent materials.

The probe shall be held in such a way as to not significantly influence the readings. For manual measurements, the use of an extension handle, made of low dielectric material, allows the body of the operator to remain sufficiently distant from the test area. In addition, such a probe handle can also serve to assist in maintaining the required 15 mm separation distance (see 4.5.3.2) from the center point of the probe element(s) to the reference plane for the WD under test.

4.5.2 WD setup and use

Because the presence of wires or conductors in the close vicinity of the WD will disturb the RF fields, the WD should be operated solely under its own power source, with no external connections unless specifically required by the manufacturer for normal operation. It is assumed that the user of a WD will operate the device in a manner that is consistent with the recommendations of the manufacturer for maximum efficiency of the WD.

Some WDs have more than one antenna position, for example stowed and deployed. In such cases, it is only necessary to test the WD in the condition of maximum antenna efficiency, as specified by the manufacturer. This is considered to be the recommended or specified operation by the manufacturer for the WD. If the fields were found to be higher at another antenna position, the results would be of little concern as the user of the WD would simply have to move the antenna to the more efficient position to reduce the field strength at the hearing aid. However, in cases where compliance is only achieved in specific configurations, it is very important that the consumer be properly informed. Therefore, when compliance is only achieved in specific antenna position(s) or other user configuration instructions are required, these conditions shall be reported in the user documentation, label on the device, or other locations where the compliance with this standard is communicated to the user.

4.5.3 Near-field test procedure

4.5.3.1 General

In actual use, the wearer of a hearing aid would place the WD in a position that gives the best acoustic coupling from the WD to the hearing aid. In other words, the WD would be located so that the user could best hear the WD desired acoustic or T-Coil output. This would be with the output transducer (receiver or

²⁷ A dimension ≤ 0.1 of the smallest wavelength, highest frequency, is normally considered small with respect to a wavelength. This consideration was used to develop the probe specifications in D.13.

T-Coil signal source) of the WD in close proximity to the microphone or T-Coil receiver of the hearing aid. For the purposes of this standard, the measurements are made in these areas of the WD.

A measurement area is specified over which the RF field strength will be measured. The measurement area is 50 mm by 50 mm. The measurement area is centered on the audio frequency acoustic output of the WD. The measurement area is in a reference plane specified in A.1. The plane of the area is located parallel to the reference plane and 15 mm from it, outwards from the phone. The measurement area is located in the measurement plane.

The E-field probe is to be used to measure the field strength at the array of points, spaced ≤ 10 mm apart in the 50 mm by 50 mm measurement area. The result will be the average over the 50 mm by 50 mm area.

The field probe is carefully moved through the measurement area and the field strength noted at each measurement point. In order to accurately scan the entire 50 mm by 50 mm measurement area, the center of the probe shall be moved through this area. Accordingly, the total area covered by the outside edge of the probe shall be the 50 mm by 50 mm measurement area, increased by half (1/2) the probe diameter on all sides.

The distance from the WD reference plane to the center point of the probe element(s) shall be 15 mm. The WD reference plane is a plane parallel with the front “face” of the WD and containing the highest point on its contour in the area of the phone that normally rests against the user’s ear. The probe element is that portion of the probe that is designed to receive and sense the field being measured. The physical body of the probe housing shall not be used when setting this 15 mm distance, because this would place the sensing elements at an indeterminate distance from the reference plane. See Figure A.2.

The field probe used, and associated instrument chain, shall be described in the test report.

If a probe and instrumentation chain with a response of < 10 kHz (see 4.5.1) is used, the indirect method (see 4.5.3.2.34.5.3.2.3) shall be employed.

If a single-axis field probe is used, it is necessary to rotate the probe to obtain the measurement results. Two methods may be used for this. In the preferred method, the probe shall be rotated in three dimensions for maximum alignment and the reading at maximum field alignment used. An alternative method is to rotate the probe about its geometric center so as to obtain measurements in all three mutually orthogonal orientations. The maximum field shall be the vector sum of all three individual mutually orthogonal measurements.

If a D-Dot probe is used, the measures taken to reasonably ensure that the area-average E-field has been adequately represented shall be documented in the test report.

Annex E provides test preparation procedures, including supporting the device, reducing reflections, validating the measurement system, and configuring the WD.

In summary, the scan shall adhere to the following requirements:

- The center of the probe shall scan to the edges of the measurement area. Accordingly, the total area covered by the outside edge of the probe shall be the 50 mm by 50 mm area, increased by half (1/2) the probe diameter on all sides.
- The center point of the probe measurement element(s) shall be held 15 mm from the WD reference plane. The probe element is that portion of the probe that is designed to receive and sense the field being measured. The physical body of the probe housing shall not be used when setting this 15 mm distance, because this would place the sensing element(s) at an indeterminate distance from the reference plane.
- A step size of ≤ 10 mm shall be used.

4.5.3.2 Detailed near-field test procedure

4.5.3.2.1 Pre-test procedure

The following steps shall be performed before the WD near-field emissions test is performed (see Figure 4.2). However, these steps need not be performed before every test. They shall be performed periodically, consistent with good laboratory practice and as required, for example, before testing types of WDs not assessed previously at a laboratory.

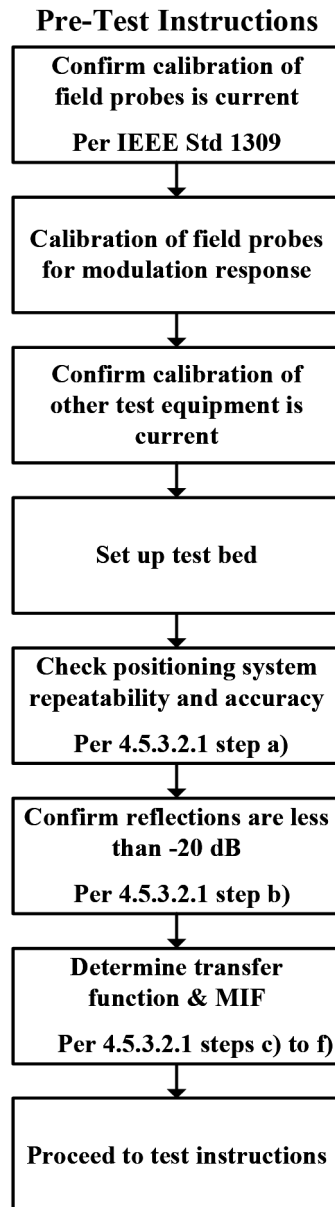


Figure 4.2—WD near-field emissions pre-test flowchart

Steps a) and b) check the probe positioning system for repeatability, accuracy, and to confirm that reflective objects are not influencing the measurement. The rest of the procedure characterizes the output of a probe and measurement system, compliant with the requirements of 4.3, determining the transfer function of the probe from the RF field presented to it to the resulting weighted output level, over the range of expected frequencies and field strengths to be tested. This characterization is performed starting at Step c).

- a) Check for probe positioning system repeatability and accuracy.
- b) Confirm that the influence of reflective objects is less than -20 dB of the intended signal. This may be done by performing the same measurements on the same WD using multiple WD positions and orientations. The readings shall not differ, due to reflections, by more than ± 0.8 dB.²⁸

For the direct method, perform the following steps:

- c) Apply a known field strength and frequency to the probe.
- d) Modulate the field with 1 kHz 80% AM and read the output of the measurement system, after the weighting filters.
- e) The transfer function of the measurement system is the level of the square root of the output reading, R , divided by the level of the unmodulated carrier, in volts per meter. This takes into account the probe factor, which transfers volts per meter to volts presented to the detector, the square law relationship created by the detector, and the effect of the weighting filters on the modulated carrier. Expressed as Equation (2), the transfer function is:

$$TF = R^{1/2} / FS \quad (2)$$

where

TF is the transfer function
FS is the field strength of the unmodulated carrier (V/m)
R is the output reading

Sufficient measurements shall be performed so as to fully characterize the measurement system for the range of field strengths and frequencies to be measured.

For the indirect method, perform the following step:

- f) Determine the Modulation Interference Factor (in decibels) for the specific modulation characteristic to be tested using the procedure of D.7.

4.5.3.2.2 Test procedure: Direct measurement—alternative

The following methods are example step-by-step test procedures. Other comparable procedures may be used. Either manual or automatic test procedures may be used. The automated test procedure is preferred.

²⁸ A common practice is to move the EUT $1/4$ wavelength relative to the structure, repositioning the measurement probe, so as to keep the same relative spacing between the EUT and measurement probe. Changing the relative orientation of the probe and EUT to the structure can also be a helpful test. If the readings change significantly, the cause could be reflections from nearby structures.

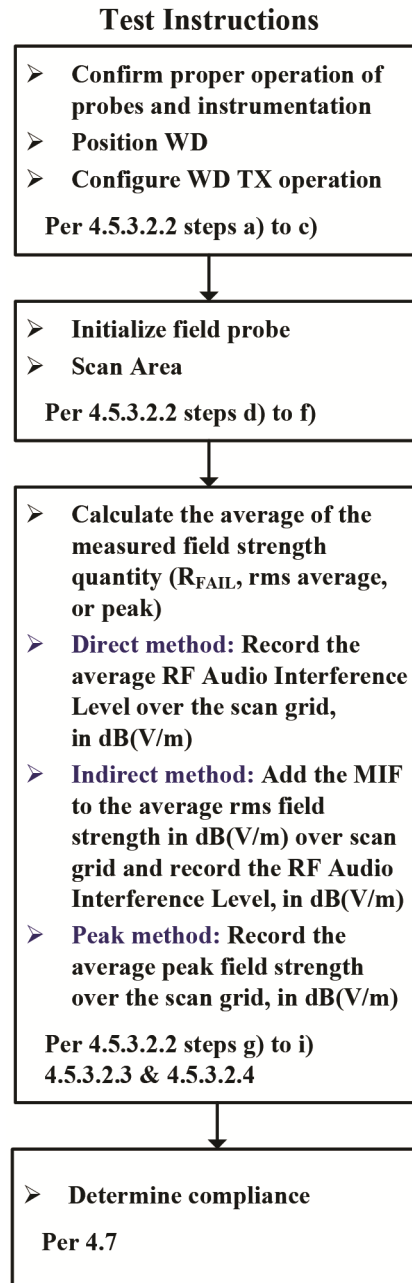


Figure 4.3—WD near-field emission scan flowchart

The following steps, included in the depiction of Figure 4.3, shall be followed when using this test procedure:

- a) Confirm proper operation of the field probe, probe measurement system, spectral and temporal weighting filters, and the positioning system.
- b) Position the WD in its intended test position. A gauge block, depicted in A.1.2, can simplify this positioning.
- c) Set the WD to transmit a fixed and repeatable combination of signal power and modulation characteristic that is representative of the worst case (highest interference potential) encountered in normal use. Transiently occurring start-up, changeover, or termination conditions, or other

operation likely to occur less than 1% of the time during normal operation, may be excluded from consideration.²⁹

- d) The measurement area shall be centered on the acoustic output or the T-Coil mode measurement reference point, as appropriate. Locate the field probe at the initial test position in the 50 mm by 50 mm measurement area, which is contained in the measurement plane, described in 4.5.2 and illustrated in Figure A.1. If the field alignment method is used, align the probe for maximum field reception.
- e) Record the reading at the output of the measurement system.
- f) Scan the entire 50 mm by 50 mm measurement area in equally spaced step sizes and record the reading at each measurement point. The step size shall meet the specification for step size in 4.5.3.
- g) Calculate the average of the measurements taken in Step f).³⁰
- h) Convert the average value found in Step g) to RF audio interference level, in volts per meter, by taking the square root of the reading and then dividing it by the measurement system transfer function, as established in 4.5.3.2.1 pre-test procedure. Convert the result to dB(V/m) by taking the base-10 logarithm and multiplying it by 20. Expressed as a formula:

$$\text{RF audio interference level in dB(V/M)} = 20 \times \log(R_{\text{ave}}^{1/2} / \text{TF}) \quad (3)$$

where

R_{ave} is the average reading

- i) Compare this RF audio interference level to the limits in 4.7 and record the result.

4.5.3.2.3 Test procedure: Indirect measurement—preferred

The measurement procedure using a probe and instrumentation chain with a response of <10 kHz (see 4.5.1) is identical to the direct measurement method of 4.5.3.2.2: however, because of the bandwidth limitations, it cannot include the direct use of the spectral and temporal weighting functions. The output of such measurement systems must be readings of steady state rms field strength in dB(V/m).

Replacing Step h) of 4.5.3.2.2: The RF audio interference level in dB(V/m) is obtained by adding the Modulation Interference Factor (in decibels) to the average steady state rms field strength reading over the measurement area, in dB(V/m), from Step g). Use this result to determine the WD's compliance per 4.7.

4.5.3.2.4 Test procedure: Peak field strength

There are two methods for establishing the peak near-field field strength of a WD:

- Direct measurement using a fast (>10 kHz response) probe, limited to a 10 kHz detection bandwidth.
- Indirect measurement, where a consistent relationship is found through a separate measurement between the peak field strength and the steady state rms field strength and this difference added to the measured average steady-state rms field strength over the measurement area.

By either method, the desired result is the average peak value over the measurement area.

²⁹ Normally the amount of time a display remains on is a customer defined option. When this is true the display should not be illuminated during the test.

³⁰ Probe anisotropy may add significantly to the measurement uncertainty. This factor may be minimized by first moving the probe to the location of maximum measurement and then rotating the probe to align it for the maximum reading at that position. This rotation around the axis or shaft of the probe is recommended in order to minimize uncertainty due to anisotropy in the probe.

4.6 Multiple simultaneous transmitters

WDs capable of operating multiple transmitters shall be subject to emissions requirements for all such transmitters expected to be operated when the WD is in voice mode operation positioned at a user's ear.

Each qualified transmitter is tested individually using the method of Clause 4. Other WD transmitters shall be temporarily disabled or reduced in power level such that their average antenna input power is at least 6 dB lower than the average antenna input power of the transmitter under test. The transmitter under test is set to the fixed and repeatable combination of power and modulation characteristic that is representative of the worst case (highest interference potential) likely to be encountered while the WD is experiencing normal voice mode operation.

The limiting measurement for device qualification is the highest RF audio interference potential measured for any of the WD transmitters. If the highest interference measurement is from a transmitter that is not required for normal voice mode operation, a secondary rating may be given that applies when that transmitter is disabled.

4.7 WD emission requirements

The WD's conducted power must be at or below either the stated RF_{AIPL} (Table 4.1) or the stated peak power level (Table 4.2), or the average near-field emissions over the measurement area must be at or below the stated RF_{AIL} (Table 4.3), or the stated peak field strength (Table 4.4). The WD may demonstrate compliance by meeting any of these four requirements, but it must do so in each of its operating bands at its established worst-case normal speech-mode operating condition.

Table 4.1—Wireless device RF audio interference power level

Frequency range (MHz)	RF_{AIPL} (dBm)
<960	29
960–2000	26
>2000	25

Table 4.2—Wireless device RF peak power level

Frequency range (MHz)	$RF_{Peak\ Power}$ (dBm)
< 960	35
960–2000	32
>2000	31

Table 4.3—Wireless device RF audio interference level

Frequency range (MHz)	RF_{AIL} [dB(V/m)]
≤ 960	39
960–2000	36
>2000	35

Table 4.4—Wireless device RF peak near-field level

Frequency range (MHz)	RF _{peak} [dB(V/m)]
≤960	45
960–2000	42
>2000	41

5. Hearing aid RF immunity test

5.1 Introduction

This clause prescribes the measurement method to be used in determining a hearing aid's immunity to radiated electromagnetic fields originating from a WD. This clause can also be used for other listening devices intended for use with WDs. Because the positional relationship of the WD's field and its polarization relative to the hearing aid is not predictable or limited to a small range of possibilities, the goal of the test is the determination of the RF immunity at the worst-case hearing aid orientation relative to the applied field strength. While this approach has the potential to overestimate the interference in actual use, it does establish an upper bound and will exhibit more predictive consistency overall than would an arbitrary single orientation or a more limited range of orientations.

5.2 Performance criteria for hearing aids

This subclause specifies the requirements for the acceptable performance of a hearing aid. When the tests described in this standard are performed and the results meet the requirements of this subclause, the hearing aid is in compliance with this standard. It is expected that the hearing aid user can effectively use a compliant WD held in a talking position at the ear.

Hearing aids shall demonstrate immunity to the RF illumination levels specified in Table 5.1 for all modes relevant for use with a WD. Modes intended for use with a WD include microphone mode and T-Coil mode. Some hearing aids are equipped with a direct RF link to the WD. This standard does not test hearing aids while operating in a mode using a direct RF link.

Hearing aid phone mode(s) shall be tested according to Table 5.1. For each of the six test positions specified in 5.3.8, if the hearing aid operating mode does not change and the IRIL (Input-Referenced-Interference Level) remains ≤55 dB SPL for all frequencies and field strengths, then the hearing aid shall be considered compliant to the requirements of this standard.

Table 5.1—Hearing aid RF test field strengths

Frequency range (MHz)	Field strength	
	V/m	dB(V/m)
650–960	60	35.6
1400–2000	40	32.0
2000–2700	30	29.5

5.3 Test procedure

This subclause describes the test facility, test equipment and test methods to be used for these measurements.

5.3.1 General test conditions

This subclause lists the test equipment and provides the general test conditions that should be used when performing the test described in this subclause. Any deviation from the recommendations contained in this subclause shall be identified in the test report.

5.3.2 Ambient conditions

Ambient conditions shall meet the requirements of 8.2.

5.3.3 Power supply voltage

A fresh or fully recharged battery of the type specified by the hearing aid manufacturer shall be installed in the hearing aid just prior to the immunity test.

5.3.4 Test equipment

This subclause lists the test equipment needed to perform the immunity tests, using the generic test equipment setup diagram shown in Figure 5.1. The test equipment used shall meet the applicable specifications of Annex D.

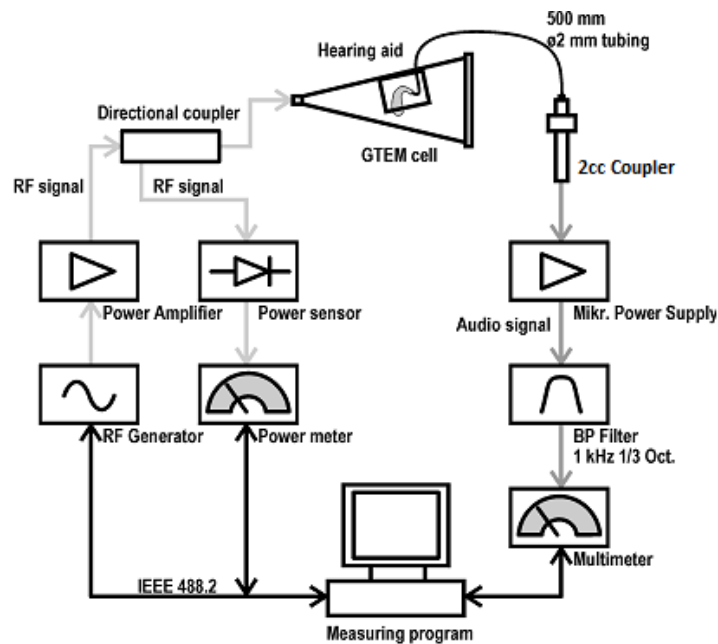


Figure 5.1—Test setup for hearing aid immunity measurements

Confirm that there is not RF interference to the instrumentation being used. This is done by performing the test without a hearing aid in place and confirming no 1 kHz audio output is measured above the noise floor.

The RF field strength presented to the EUT shall be validated either by measuring the field strength using RF field probes or by having the relationship between power into the WB TEM cell to field strength at the EUT calibrated.

5.3.5 Hearing aid settings

The hearing aid gain control shall be adjusted to a linear gain region. The other controls shall be set to the basic settings, with adaptive features disabled. This can be accomplished by setting the device to RTS as defined in ANSI S3.22-2014 and IEC 60118-0:2015. Test settings used during testing shall be specified and included in the test report.

5.3.6 Determination of gain

For the determination of gain, use the same acoustic coupler and tubing as used for the output-referenced interference level (ORIL) measurement (see below). The measurement setup for determination of gain can be in accordance with ANSI S3.22-2014 or IEC 60118-0:2015. The setup shall be specified in the test report.

$$\text{Gain (dB)} = \text{Output (dB)} - \text{Input (dB)} \quad (4)$$

The input-output response curve of a hearing aid in microphone mode is determined by applying a sinusoidal 1 kHz signal with a sound pressure level swept from 30 dB SPL to 80 dB SPL at the microphone reference point of the hearing aid, then measuring the respective acoustic sound pressure level at its output. Gain is determined from this input-output response curve at a 55 dB input level.

The input-output response curve of a hearing aid in induction pick-up coil mode is determined by applying a sinusoidal 1 kHz signal with a magnetic field strength level relative to 1 A/m, 0 dB(A/m) in decibels, swept from -60 dB(A/m) to -10 dB(A/m) at the induction pick-up coil reference point of the hearing aid, then measuring the respective acoustic sound pressure level at its output. Gain is determined from this input-output response curve at a -35 dB(A/m) input level (which is equivalent to the acoustic sound pressure level of 55 dB).

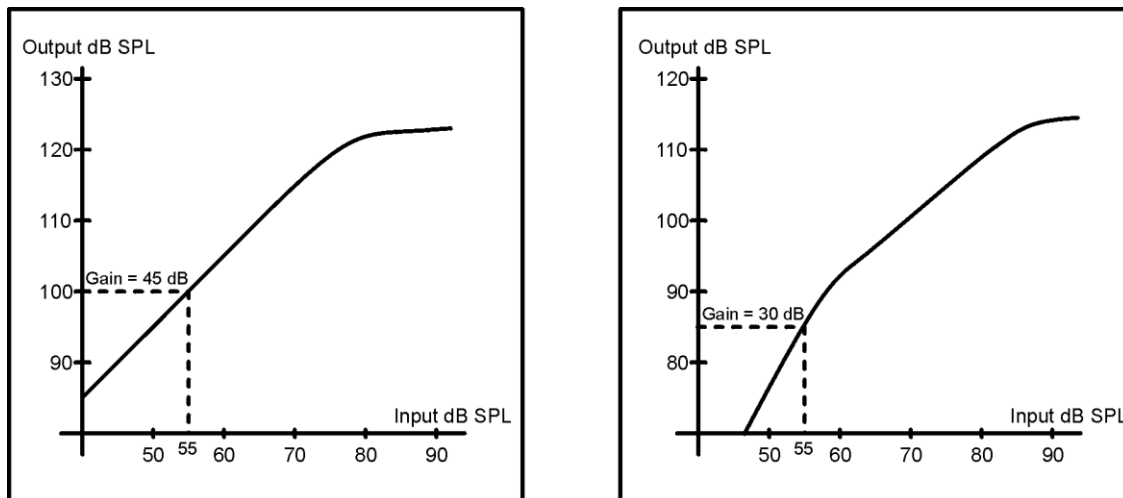


Figure 5.2—Examples of input-output response curves at 1 kHz and the determination of output SPL at an input level of 55 dB SPL

5.3.7 Hearing aid output coupling during immunity test

The hearing aid shall be placed in the RF field.

Other than the hearing aid, no objects that could distort the RF-field, should be present in the test volume. In order to remove the metallic coupler from the test volume, the normal tubing between the hearing aid and the coupler shall be replaced by tubing of 2 mm bore and with a length typically between 50 mm and 1 m.

For in-the-ear hearing aids, the outlet from the receiver shall be coupled to the tubing by a suitable adaptor. This adaptor and the length of the tubing are not critical, because the hearing aid gain is determined in each individual test configuration.

The generic test equipment setup diagram is shown in Figure 5.1.