



American National Standard for Validation Methods for Radiated Emission Test Sites, 30 MHz to 1 GHz

C63[®]

USEMCSC C63[®] Committee on Electromagnetic Compatibility –
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ANSI/USEMCSC C63.25.2-2024

STANDARDS

American National Standard for Validation Methods for Radiated Emission Test Sites, 30 MHz to 1 GHz

USEMCSC C63® Committee on Electromagnetic Compatibility

Accredited by the

American National Standards Institute

Secretariat

Institute of Electrical and Electronics Engineers, Inc.

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Abstract: ANSI/USEMCSC C63.25.2 is a stand-alone standard for site validation measurements of radiated emission test sites from 30 MHz to 1 GHz. The site validation techniques covered are the site comparison method and the delta normalized site attenuation method. In addition, the traditional normalized site attenuation method is retained for continuity. This standard incorporates Annex D of ANSI C63.4-2014 and ANSI C63.14a-2017 as well as necessary information from ANSI C63.5-2017 related strictly to site validation requirements (for example, antennas allowed to be used, geometry-specific correction factors for biconical dipoles used in normalized site attenuation measurements). This standard can be referenced by other ANSI/USEMCSC C63 standards where site validation requirements are necessary.

Keywords: ANSI C63.25.2, antennas, normalized site attenuation, site validation

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³ Available at: <https://standards.ieee.org/standard/index.html>.

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⁵ Available at: <https://www.ansi.org/american-national-standards/ans-introduction/essential-requirements>.

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Introduction

This introduction is not part of ANSI/USEMCSC C63.25.2-2024, American National Standard for Validation Methods for Radiated Emission Test Sites, 30 MHz to 1 GHz.

After years of site validation (SV) measurement procedures being contained in the ANSI C63.4-2014 [B1] and its amendment, ANSI C63.14a-2017 [B2], the USEMCSC C63 Committee decided to create a separate standard, specific for SV procedures.⁶ Therefore, product standards that require SV, for example, ANSI C63.4-2014 and ANSI C63.4a-2017, ANSI C63.10-2020 [B4], ANSI C63.26-2015 [B7], can be updated to refer to a specific source. This also has the advantage that if changes are needed to SV procedures, a product standard would not have to wait for a change to ANSI C63.4-2014 [B1] and ANSI C63.14a-2017 [B2].

In addition to the traditional normalized site attenuation (TNSA) method, two additional methods of validating the site are included in this standard. The site comparison method (SCM) is a procedure where a set of measurements of site attenuation (SA) are performed at a reference test site [which is an antenna calibration site (ACS)] and then the same antennas are used to measure the SA at the site under validation (SUV); the difference of these values can be directly compared to the SV criterion (± 4 dB). The second additional method is the delta NSA (DNSA) method, where standard biconical antennas are used after obtaining their free-space antenna factors; this method then compares the measured NSA values with numerically computed theoretical NSA values.

This standard provides more flexibility than the previous solutions in ANSI C63.4-2014 [B1] and ANSI C63.14a-2017 [B2], because the user has the option to select between three techniques, when the conditions of the method can be satisfied.

⁶ The numbers in brackets correspond to those of the bibliography in Annex I.

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American National Standard for Validation Methods for Radiated Emission Test Sites, 30 MHz to 1 GHz

1. Overview

1.1 Scope and purpose

The purpose of this standard is to specify validation methods of test sites used for radiated emissions measurements in the frequency range 30 MHz to 1 GHz as required by ANSI/USEMCSC C63 standards. The site validation (SV) requirements specified in this standard are applicable to standard test sites (see 4.2) as well as alternative test sites (see 4.3).

1.2 Word usage

The word *shall* indicates mandatory requirements strictly to be followed to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{7,8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

The word *might* is used to express a chance or possibility that something will happen or exist in the future.

1.3 Additional word usage conventions

Notes in this document are informative and are not part of the requirements. Notes are used in the text for emphasis or to offer informative suggestions about the technical content of the standard, and these notes provide additional information to assist the reader with a particular passage but do not include mandatory requirements.

⁷ The use of the word *must* is deprecated when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁸ The use of the word *will* is deprecated when stating mandatory requirements; *will* is only used in statements of fact.

Footnotes in text are included only for information, clarification, and/or as an aid applicable to the use of the standard, but mandatory requirements are not included in text footnotes.

In this standard, figures are normative only if identified by inclusion of the word “normative” in the figure caption. In general, the text takes precedence over the figures because the text is complete, and the figures are illustrative of a typical application of the text.

Notes to tables and figures are informative; however, footnotes (i.e., superscript notation) to tables and figures are normative, as are numbered paragraphs between a figure and its caption.

The word *shall* when used in an informative annex indicates a mandatory requirement for the use of that annex (i.e., while the annex is not normative, if the user chooses to use it, then the mandatory requirements stated therein using the word *shall* indicate requirements that have to be met to satisfy this standard). The use of that annex makes all *shall* statements therein conditionally normative, i.e., if the annex is selected for use, then each *shall* statement in that annex becomes normative for the application of this standard.

1.4 Dimensional tolerances

Tolerances for spatial dimensional requirements specified in this standard are given in the tables of the normative Annex C and shall be used to provide the required tolerance.

Wherever non-spatial parameters are stated in this standard (e.g., a “50 Ω ” system), they are not normally accompanied by a normative tolerance requirement.

To aid in knowing when tolerances are to be used, a parenthetical statement follows those dimensions in the text. The wording simply says, e.g., “(see Table C.1)” to lead the user to the applicable tolerance.

Tolerances for non-spatial parameters should be consistent with good engineering practice.

NOTE—Nominal dimensions are those dimensions that are stated without a specified tolerance. By definition, nominal dimensions should have tolerances that are consistent with good engineering practice. In particular, tolerances selected by users should be at least an order of magnitude lesser in comparison to the dimensional requirements themselves.⁹

2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used; therefore, each referenced document is cited in the text and its relationship to this standard 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. However, for undated references, unless otherwise stated by the regulatory authority or purchasing agency, a transition period of two years applies, starting from the date a new edition of such a reference is published, within which either the previous or the new edition shall apply.

Where a dated reference to a specific clause, subclause, table, figure, or annex of another document is made within this standard, it is acceptable to use a more recent edition of the referenced document provided identical text exists in both editions of that document for the referenced clause, subclause, table, figure, or annex.

NOTE—In-text references, within ANSI C63.25.2, to a specific clause, subclause, table, figure, or annex of another document are dated even if the corresponding document is listed as an undated normative reference below.

⁹ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

ANSI C63.5-2017, American National Standard for Electromagnetic Compatibility—Radiated Emission Measurements in Electromagnetic Interference (EMI) Control—Calibration of Antennas (9 kHz to 40 GHz).¹⁰

CISPR 16-1-5:2016, Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration sites and reference test sites for 5 MHz to 18 GHz (Edition 2.1; Consolidated Reprint).¹¹

CISPR 16-1-6:2017, Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-6: Radio disturbance and immunity measuring apparatus – EMC antenna calibration (Edition 1.1; Consolidated Reprint).

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this standard, the following terms and definitions apply. The *IEEE Standards Dictionary Online*¹² and ANSI C63.14 [B6]¹³ should be consulted for terms not defined in this subclause.

NOTE—All the definitions in this subclause are written such that they can replace the corresponding term in its context within this standard. Therefore, the text of a definition does not start with an article (e.g., “the,” “a”) nor end with a period.

antenna calibration site (ACS): Site that satisfies either ANSI C63.5-2017 Annex J or the CALTS requirements defined in CISPR 16-1-5:2016.

antenna factor: Ratio of the electric field strength E in the polarization direction of the antenna to the voltage induced across the load connected to the antenna terminals V_o and expressed in decibel form $[20 \log (E/V_o)]$. (modified from ANSI C63.5-2017)

NOTE 1—The antenna factor has a logarithmic unit of dB(1/m) and a linear unit of 1/m.

NOTE 2—In contrast, ANSI C63.5-2017 includes the text of the previous note in the definition text.

antenna pair: Two antennas that cover the same frequency range, are of the same type and have impedance and physical dimensions that are nominally identical.

NOTE—Ideally, the two antennas should be from the same manufacturer, have the same model number and have the same build standard. If the antennas are not identical, then additional unknown uncertainties can be introduced.

calibration test site (CALTS): Site with a metallic ground plane and tightly specified site insertion loss in horizontal electric field polarization that is used for calibrating antennas.

line impedance stabilization network (LISN): Network inserted in the power supply conductor of the equipment under test (EUT) that provides, in a given frequency range, a specified load impedance for each current-carrying conductor for the measurement of conducted emission voltages.

¹⁰ ANSI C63 publications are available from the United States EMC Standards Corporation through The Institute of Electrical and Electronics Engineers (<https://standards.ieee.org/>) and the American National Standards Institute (<https://www.ansi.org/>).

¹¹ CISPR documents are available from the International Special Committee on Radio Interference through the International Electrotechnical Commission (<https://www.iec.ch/>) and the American National Standards Institute (<https://www.ansi.org/>).

¹² *IEEE Standards Dictionary Online* subscription is available at <https://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

¹³ The numbers in brackets correspond to those of the bibliography in Annex I.

NOTE 1—A LISN is used to isolate the EUT from the supply mains in that frequency range and couples the EUT emissions to the measuring instrument.

NOTE 2—A LISN unit can contain one or more individual LISN circuits.

NOTE 3—Within IEC CISPR standards, LISNs are called artificial mains networks (AMNs).

measurement axis: Principal axis for SV that is a line passing through the projection on the ground plane of the center of the test volume and of the measurement (receive) antenna's reference point, with the latter placed at the location used for measurements on EUTs.

NOTE—The measurement axis is illustrated in Figure 1 (while performing EUT measurements) and in Figure 2 (while performing site validation).

measurement distance: Horizontal separation distance between the projections on the ground plane of reference points of the transmit antenna and the receive antenna, which are specified in 4.2 of ANSI C63.5-2017.

NOTE 1—See Table C.1 for allowed tolerance on the measurement distance value.

NOTE 2—This is equal to the distance between the receive antenna and the EUT boundary used during EUT measurements.

NOTE 3—See Figure 1 of ANSI C63.5-2017.

measurement geometry: Specific configuration of the antenna pair either along the measurement axis or with the transmit antenna at an offset from this axis, with both antennas at the measurement distance (R) from each other, in the same polarization, and with the transmit antenna at a specific height.

NOTE 1—Offsets from the centerline are required on alternative test sites (4.3), see Figure 8.

NOTE 2—During SV measurements, the transmitting antenna is set to a specific height and the receiving antenna is scanned in height over a given range.

nominal: Conventionally stated value of a quantity or dimension, but which does not necessarily correspond exactly to the actual value.

NOTE—The allowable tolerances for values above and below the nominal value need not be symmetric (see Annex C).

nominally identical: Devices that are identical within the variation that can be expected to arise as a result of quantity production techniques.

NOTE 1—This definition is per U.S. Code of Federal Regulations Title 47 §2.908.

NOTE 2—The phrase “nominally identical” is often applied specifically to the parameters that describe the key properties of devices. For example, two log-periodic dipole array (LPDA) antennas can differ in the types of metals used in manufacturing, but if they have nominally identical key dimensions, nominally identical mainbeam gains, and nominally identical antenna patterns, they are considered to be “nominally identical” antennas.

normalized site attenuation (NSA): Site attenuation divided by the free-space antenna factors (all in linear units) of the transmit antenna and the receive antenna, and corrected by the geometry-specific correction factors, if available. (modified from ANSI C63.5-2017) *See also:* **site attenuation**.

NOTE 1—NSA values are usually stated in decibel units.

NOTE 2—In contrast, the definition in Clause 3 of ANSI C63.5-2017 is: “Site attenuation (SA) divided by the free-space antenna factors (all in linear units) of the transmit antenna and the receive antenna, and corrected by the geometry-specific correction factors (GSCF) if available. Results can be stated in decibel units.”

NOTE 3—See ANSI C63.5-2017 for details about applicable antenna factors and other parameters.

site attenuation: Minimum relative insertion loss measured between two polarization-matched antennas located on a test site when one antenna is moved vertically over a specified height range.

standard biconical antenna: Antenna of dimensions that are within the ranges specified in Figure F.1.

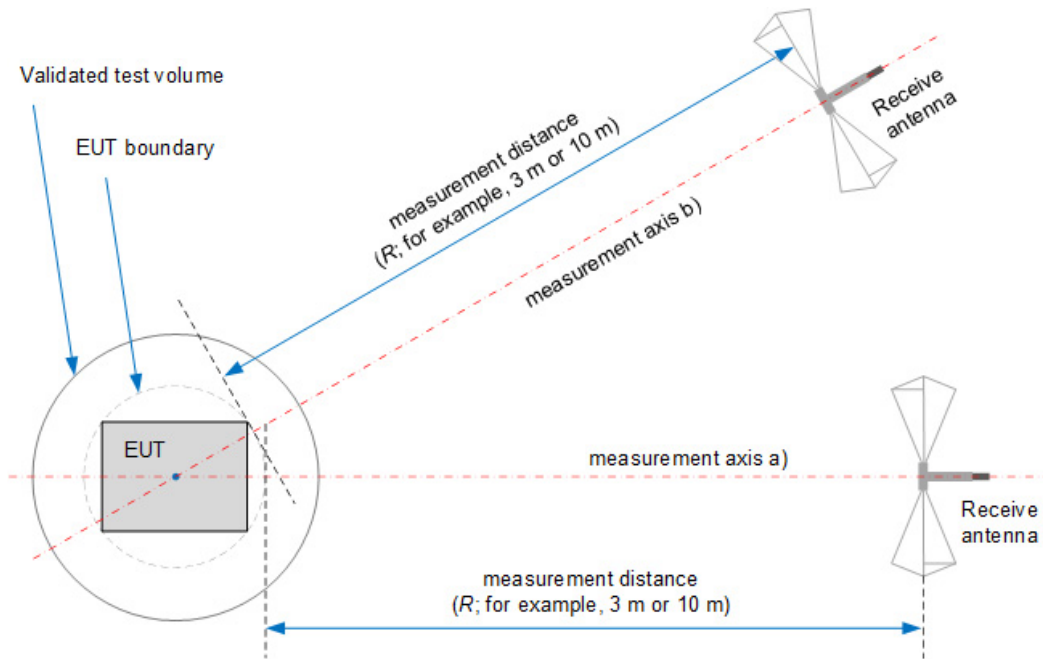
NOTE—Most commercial biconical antennas satisfy the requirement because they are based on the specifications listed in MIL-STD 461-1969 [B20].

test site: Location meeting appropriate validation criteria, if identified, to perform EMC measurements on the EUT.

3.2 Acronyms and abbreviations

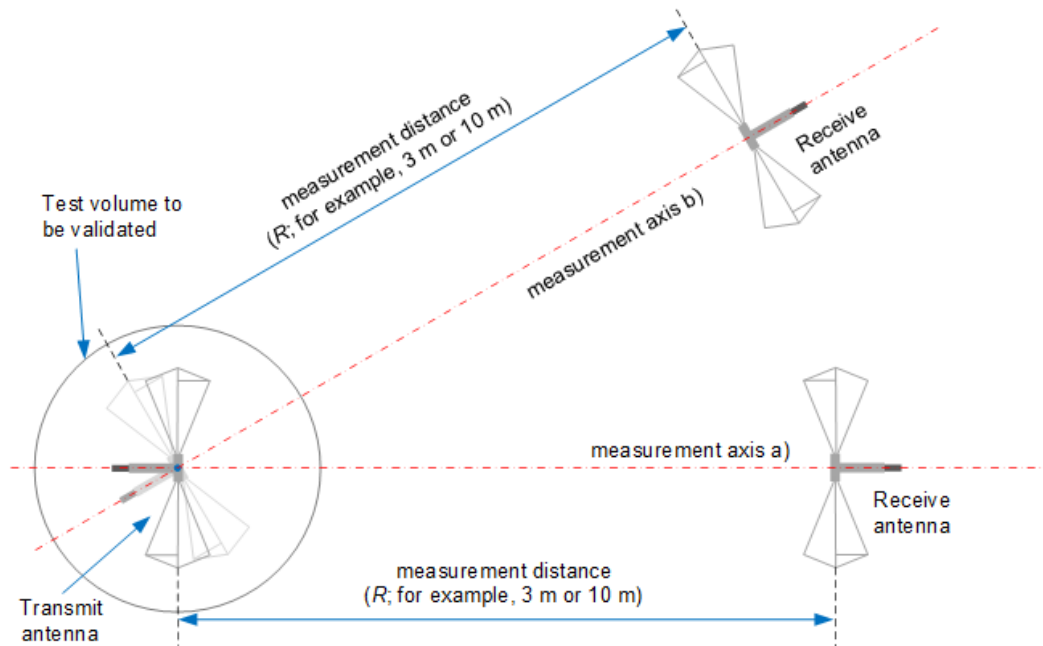
ACS	antenna calibration site
AF	antenna factor
CALTS	calibration antenna test site
DNSA	delta NSA
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EUT	equipment under test
FSAF	free-space antenna factor
GSCF	geometry-specific correction factor
LISN	Line Impedance Stabilization Network
LPDA	log-periodic dipole array
MSA	measured site attenuation
NEC	Numerical Electromagnetic Code
NFSAF	near-free-space antenna factor
NSA	normalized site attenuation
OATS	open-area test site
RF	radio frequency
SCM	site comparison method
SI	international system of units
SSM	standard site method
SUV	site under validation
SV	site validation
TNSA	traditional NSA
VSWR	voltage standing wave ratio

3.3 Figures for Clause 3



NOTE—Two different measurement axes are shown: a) and b). Measurements on EUTs might necessitate multiple measurement axes, e.g., when the test site uses more than one antenna.

Figure 1—Measurement axis for EUT measurements



NOTE—Two different SV main axes (centerlines) are shown: a) and b). These are the same as the measurement axes used for EUT tests, with the same separation distance (see Figure 1).

Figure 2—Measurement axis for site validation

4. Test facilities

4.1 Introduction

The measurement method for radiated emissions in the frequency range 30 MHz to 1 GHz requires the presence of a conducting ground plane, which provides repeatable and reproducible reflections of the emissions radiated by the EUT that are received by the measurement antenna. This method also requires that indirect reflections (i.e., reflections involving objects that are around the test site, such as the walls and ceiling of a semi-anechoic chamber) are minimized. For controlling the level of these indirect reflections, a validation process is required. The goal of the SV measurement is to compare the site attenuation values measured on a site under validation (SUV) to those measured on an antenna calibration site (ACS) or those calculated.

The conducting ground plane can be a metal sheet on an open field (with or without a weather protective cover), be part of a screened room, the floor of an indoor room or some other structure. Based on these characteristics, the SUV is classified as a standard test site (4.2) or an alternative site (4.3). These two different types of facilities have different validation processes.

NOTE—Product standards (such as ANSI C63.4-2014 [B1] and ANSI C63.14a-2017 [B2] or ANSI C63.10-2020 [B5]) either require a minimum obstruction-free area around the test site or require that during measurements on EUTs there are no additional or different obstructions than were present during the SV measurements within an area around the test site defined by an ellipse, such as illustrated in Figure 1 of ANSI C63.7-2015 [B4].

4.2 Standard test site

A standard test site consists of a conductive metal plane that covers the ground on an open, flat, level area that is clear of overhead wires, overhead building supports and other reflecting structures, except for the metallic ground plane, and is sufficiently large to permit measuring antenna placement at the specified distance from the EUT. This is commonly called an open-area test site (OATS).

A single-position SV, where the transmit antenna is positioned at the center of the turntable, is suitable only for standard test sites (see 8.1.7).

NOTE 1—Standard test sites do not need to satisfy the volumetric SV measurements as required by alternative test sites (see 4.3).

NOTE 2—Clause 3 of ANSI C63.7-2015 [B4] specifies a standard test site as an “open-area test site (OATS) that does not incorporate weather-protection (or other) structures above the surface of its ground plane.” ANSI C63.7-2015 [B4] also provides additional guidance on the desired characteristics, construction, and deterioration possibilities of a standard site.

4.3 Alternative test sites

Radiated emission measurements can also be made at certain types of alternative test sites. Alternative test sites could include the following:

- Metal test chambers with RF absorber materials added to reduce resonances and reflections
- Semi-anechoic chambers
- Office or factory buildings large enough for reflections to not disrupt the field at the point of measurements
- Weather-protected standard test site regardless of whether the weather-protection structure covers only a portion of (for example, the turntable area) or the entire standard test site

All such alternative sites shall comply with the volumetric SV requirements of 8.1.6 over the volume occupied by the EUT or the EUT arrangement to be accepted as an alternative test site. This is required because a single position SV measurement is insufficient to pick up possible reflections from the construction materials or the RF absorbing materials covering the walls and ceiling of a test site or weather-protection coverings for an OATS.

5. Overview of site validation methods

5.1 General

There are three different SV methods specified in this standard: site comparison method (SCM) (see 5.2), delta normalized site attenuation (DNSA) method (see 5.3), and the traditional normalized site attenuation (NSA) method (TNSA) (see 5.4). The SUV shall be validated by measurements using one of the three methods (given in 5.2, 5.3, or 5.4) as appropriate.

NOTE—The SCM is the simplest process; users are encouraged to use this method. The TNSA method was included to aid transition. Annex G demonstrates the equivalency between the SCM and the TNSA method.

5.2 Site comparison method (SCM)

With this method, the measured site attenuation of the SUV is compared with the measured site attenuation of an ACS. The site attenuation deviation ΔA_{SUV} is the difference between the results measured on the SUV and those measured on the ACS using the same pair of antennas on both sites. The ΔA_{SUV} are then compared with the site acceptance criterion (see 8.1.5).

The SCM is specified in 8.2.

NOTE 1—In this case, the antenna factors (AFs) do not need to be known because they are canceled out.

NOTE 2—It is recognized that a test laboratory might not have their own ACS, and it is acceptable to use a third party.

NOTE 3—The SCM method is intended to be identical to the Reference Site Method described in CISPR 16-1-4:2020 [B14].

5.3 Delta NSA (DNSA) method

This method is based on measuring the site attenuation of the SUV that is then corrected with both near-free-space antenna factors (NFSAFs) and calculated correction values (ΔAF_{DNSA}) to derive NSA values. These NSA values are then subtracted from the theoretical NSA values to obtain ΔA_{SUV} , which are then compared with the site acceptance criterion (see 8.1.5).

The DNSA method is specified in 8.3.

This method can only be used with standard biconical antennas, in the frequency range 30 MHz to 200 MHz.

NOTE—Within this standard, factors have been introduced to allow the DNSA method to be used for validated test volumes having a height greater than 2 m, and also for a 5 m measurement distance.

5.4 Traditional NSA (TNSA) method

This method is based on measuring the site attenuation of the SUV that is then corrected with both NFSAF and various correction factors (see Table 2) in order to derive NSA values. These NSA values are then subtracted from the theoretical NSA values to obtain ΔA_{SUV} , which are then compared with the site acceptance criterion (see 8.1.5).

The TNSA method is specified in 8.4.

Geometry-specific correction factors (GSCFs) can be obtained from numerical computation or from measured data on an ACS. Numerically computed GSCF corrections are available only for standard biconical antennas in the frequency range 30 MHz to 200 MHz.

NOTE—The TNSA method was the only procedure specified in ANSI C63.4-2014 [B1] and ANSI C63.14a-2017 [B2] and has been included in this standard to allow a simple transition to the use of the SCM and DNSA. The TNSA method uses complicated corrections factors (GSCFs), which can lead to confusion and errors.¹⁴

5.5 Common symbols

Some common symbols associated with the three SV methods are as follows:

ΔA_{SUV}	is the site attenuation deviation of the SUV (in decibels)
h_1	is the height of the reference point of the transmit antenna above the ground plane (in meters; see Table C.1 for allowed tolerance)
h_{2d2}	is the height of the reference point of the receive antenna above the ground plane (in meters; see Table C.1 for allowed tolerance)
f_M	is the frequency (in megahertz)
R	is the measurement distance (in meters; see definition in 3.1)

6. Measurement instrumentation and measurement antennas

6.1 Measurement instrumentation

The following contain general information for measurement instrumentation, use of ferrite, and signal sources. Where more specific information is detailed in a procedure that takes precedence.

- All measurement instrumentation (including network analyzers, signal generators, spectrum analyzers, receivers, etc.) shall have a nominal impedance of 50 Ω .
- Impedance mismatches can result in reflections that could cause errors. These reflection errors can be reduced by the use of attenuators, for example, at the antenna end of the transmit antenna cable and at the receiver end of the receive antenna cable, for both V_{DIRECT} and V_{SITE} measurements. Attenuator values of 6 dB or 3 dB could be sufficient to reduce the errors. Alternatively, when using a vector network analyzer, a full two-port calibration at the measurement plane where the cables connect to the antenna pair reduces the impact of the reflections; in this case, matching attenuators might not be necessary. See Figure 3.

¹⁴ The site validation process using measured *GSCF* values obtained as specified in Annex I of ANSI C63.5-2017 is mathematically equivalent to comparing the measured site attenuation results directly to the results from the antenna calibration site (Chen [B12]). The SV process using *GSCF* values for biconical antennas (see Annex F), or ΔAF_{TOT} for tuned dipole antennas (see Annex D) is functionally equivalent to comparing the measured site attenuation results to numerically-derived site attenuation values for an ideal site.

NOTE 1—A full two-port network analyzer calibration typically includes open, short, load, and through measurements.

- c) Ferrite materials may be applied (for example, positioned at 25 cm intervals for the first 2 m of cable where the cable attaches to the antenna) to both the transmit antenna cable and the receive antenna cable, to serve as a common-mode choke that reduces the induced currents on the cable shield due to coupling with the radiating elements.
- d) The signal source shall provide sufficient power to produce a signal at the receiver input of at least 6 dB above the system noise floor. The following methods may be used for improving the signal-to-noise ratio: reducing the intermediate frequency bandwidth, using averaging, and/or adding an amplifier before the transmit antenna and/or a low-noise pre-amplifier after the receive antenna.

NOTE 2—To improve the measurement accuracy, it is recommended that the measured levels are significantly greater than the minimum system noise floor, for example, 20 dB above the system noise floor (rather than the minimum requirement of 6 dB).

- e) It is recommended to extend cables attached to antennas in the same horizontal plane as the antenna's reference point for a minimum distance of 1 m.

6.2 Measurement antennas

Table 1 specifies the types of antennas permitted to be used for SV measurements and their associated frequency range limitations.

NOTE 1—Hybrid antennas of any type are not currently considered suitable because of the additional measurement uncertainty associated with using these antennas.

NOTE 2—Dipole antennas can operate effectively over a wider range than the single frequency selected.

Table 1—Measurement antennas and frequency ranges

#	Antenna	Type	Frequency range	Other term used
1	Resonant tuned dipole (passive)	Single frequency	30 MHz to 1 GHz	Tuned dipole Roberts dipole
2	Standard biconical	Broadband	30 MHz to 200 MHz	N/A
3	Biconical (non standard)	Broadband	30 MHz to 300 MHz	N/A
4	Log-periodic dipole array (LPDA)	Broadband	200 MHz to 1 GHz	N/A

6.3 Calibration of measuring equipment

6.3.1 General requirements

When the SV measurements are performed, the following equipment shall have been calibrated within the last three years in a manner that is traceable to the international system of units (SI):

- a) Receiver (for example: spectrum analyzer, network analyzer, EMI receiver)
- b) Signal source (for example: signal generator, network analyzer, tracking generator)
- c) The transmit antenna and the receive antenna, as specified in 6.3.2

Equipment used for SV measurements shall be recalibrated after repair, when damage or deterioration is suspected or known to have occurred.

NOTE—While the loss of passive elements and the gain of amplifiers/preamplifiers cancel out when calculating the SA, it is good practice to characterize these, for identifying any items that are damaged or out of specification.

6.3.2 Antenna calibration

6.3.2.1 General

Antennas shall be calibrated over the frequency range of intended use. See Table 1 for limitations of the frequency range for given antennas. The quantities that shall be calibrated as a function of frequency are given in 6.3.2.2 through 6.3.2.4, while 6.3.2.5 specifies how to determine the free-space antenna factors.

6.3.2.2 Antenna and correction factors

The antenna pair shall be calibrated in accordance with ANSI C63.5-2017¹⁵ for the requirements shown in Table 3. The necessary antenna factors and correction factors depend on the SV process used. Table 2 lists the required antenna factors, while the necessary correction factors are specified in brackets. The method used to calibrate the antenna pair shall be documented.

NOTE 1—Antenna calibration in accordance with ANSI C63.5-2017 is a challenging process with additional site performance requirements as specified in Annex J of ANSI C63.5-2017 and other aspects that can cause problems. The process can only be performed using proper equipment, relevant procedures, and experienced staff. The regulatory authority, accreditation body, or purchasing agency might require accreditation of the laboratories that perform this calibration.

Antenna factors usually account for losses in the balun. If either a separate balun or any integrally associated attenuators, or both, are used, their effects shall be included in the antenna calibration results.

Where antennas are calibrated with external matching attenuators and the associated losses are included in the antenna factors, these external matching pads shall remain attached to the antennas during V_{SITE} measurements (see Figure 3).

NOTE 2—These external matching attenuators are not to be confused with other attenuators that can be inserted in the SV setup for reducing VSWR on its various cables. See Figure 3.

The two antennas shall be labeled based upon the arrangement used during calibration and the same arrangement shall be used during the site validation measurement. The labeling shall include the following arrangement characteristics:

- a) Antenna used to transmit
- b) Antenna used to receive
- c) Side having the antenna elements oriented towards the ground plane when in vertical polarization
- d) Top position (or orientation) of the balun when the antenna is in horizontal polarization

¹⁵ Information on references can be found in Clause 2.

Table 2—Antenna calibration and correction factor requirements for each SV method

#	Antenna types	Distances ^a	Method		
			TNSA	SCM	DNSA
1	Tuned dipole	3 m	NFSAF ^b (ΔAF_{TOT} , see Table D.5 ^c)	No AFs or correction factors necessary.	n/a
		10 m, 30 m	NFSAF ^b		
2	Standard biconical	3 m	NFSAF ^b (ΔAF_{BICONS} , see Table F.1) (GSCF, see Table F.4)		NFSAF ^b (ΔAF_{DNSA} , see Table A.1)
		5 m ^d	NFSAF ^b (ΔAF_{BICONS} , see Table F.1) (GSCF, see Table F.3)		
		10 m	NFSAF ^b (ΔAF_{BICONS} , see Table F.1) (GSCF, see Table F.2)		
3	Biconical (nonstandard)	3 m, 5 m ^d , 10 m ^e	NFSAF ^b + measured GSCF ^f		n/a
4	LPDA	3 m, 5 m ^d , 10 m ^e	NFSAF ^b + measured GSCF ^f		n/a

^a See Table C.1 for the allowed tolerance.

^b For DNSA, see 8.3.2. For TNSA, see 8.4.3.

^c The factors listed in Table D.5 are for Roberts dipoles only; other factors are required if other types of dipoles are used.

^d Some regulatory authorities or purchasing agencies might not accept the use of a 5 m distance for measurements of radiated emissions.

^e Other distances may be used when using TNSA and SCM methods.

^f The GSCFs shall be measured using the methods specified in Annex I of ANSI C63.5-2017.

6.3.2.3 Return loss or VSWR at the antenna coaxial port

For each antenna, the return loss at its coaxial port shall be controlled using one of the following methods:

- An attenuator of minimum 4 dB shall be installed directly on the antenna coaxial connector.
- The return loss shall be greater than or equal to 7.36 dB, or the VSWR shall be less than or equal to 2.5:1, as measured in accordance with A.8.7 of CISPR 16-1-6:2017. The return loss (or VSWR) need not be periodically calibrated. However, it shall be re-calibrated after repair, when damage or deterioration is suspected or known to have occurred.

6.3.2.4 Antenna symmetry, for broadband antennas

The antenna symmetry for broadband antennas shall be calibrated in accordance with ANSI C63.5-2017, except for the SCM in 8.2.

The antenna symmetry need not be periodically calibrated. However, it shall be re-calibrated after repair, when damage or deterioration is suspected or known to have occurred.

6.3.2.5 Near-free-space and free-space antenna factors

The NFSAF of an antenna pair is obtained using a single geometry calibration, with both antennas in horizontal polarization and separated by a 10 m distance, the transmit antenna at 2 m height, and the receive antenna scanned in height from 1 m to 4 m (see ANSI C63.5-2017). The calibration from this step yields the sum of the NFSAFs for the antenna pair, which is calculated using Equation (1):

$$AF_{T,NFS} + AF_{R,NFS} = SA + E_D^{max} + 20 \log f_M - 48.92 \quad (1)$$

where

$AF_{T,NFS}$	is the NFSAF for the transmitting antenna [dB(1/m)]
$AF_{R,NFS}$	is the NFSAF for the receiving antenna [dB(1/m)]
SA	is the measured site attenuation, equal to the minimum site insertion loss obtained from the height-scanned measurement, in decibels
E_D^{max}	is a quantity calculated from the equations in Annex H [dB(μV/m)]
f_M	is the frequency in megahertz.

The free-space antenna factor (FSAF) of the pair of antennas is derived from the NFSAF of the pair by subtracting a calculated offset based on the modeling for specific conditions. The factors are only valid when these specific conditions are used. For example, in case of the DNSA method, the FSAF is determined by subtracting the correction factor ΔAF_{DNSA} (see Table A.1) from the NFSAF, while the specific conditions in this case are: the antenna is a standard biconical antenna with the correct impedance (for example, 50 Ω).

6.3.3 Measurement validity

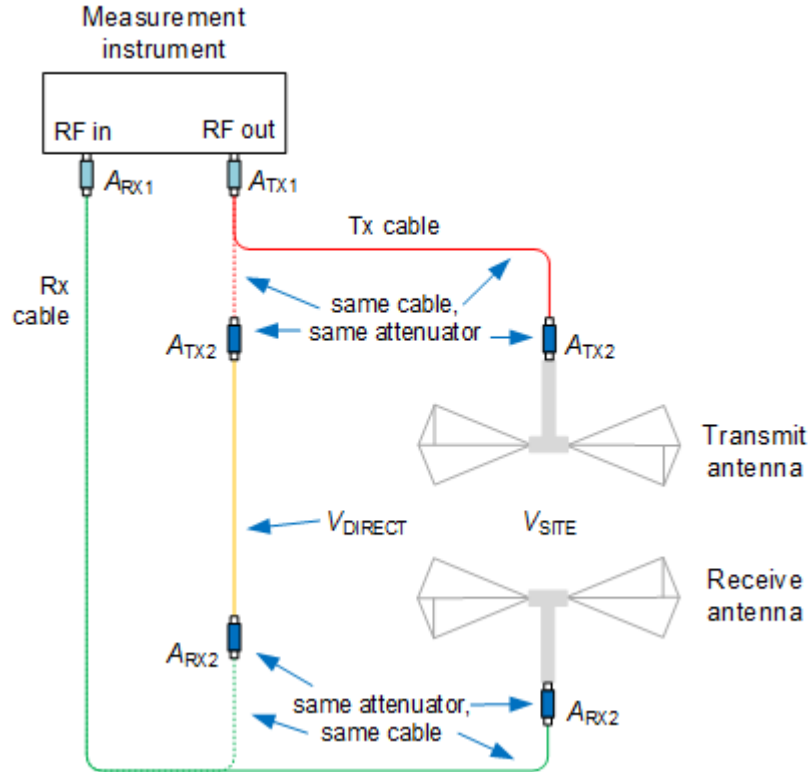
For measurements on a SUV to be considered valid the following conditions shall be satisfied:

- Each V_{SITE} measurement shall be performed within a period of 24 h from the corresponding V_{DIRECT} measurement.
- The change in ambient temperature between any V_{SITE} measurement and the corresponding V_{DIRECT} measurement shall be less than 15 °C.

NOTE 1—Repeat the V_{DIRECT} measurement if the 24 h time period has elapsed. In addition, repeating the V_{DIRECT} measurement resets the ambient temperature range.

NOTE 2—Cable losses can vary due to damage or large variations in the ambient temperature.

6.4 Figures for Clause 6



1. Attenuators can be used, for example, at the antenna end of the transmit antenna cable (A_{TX2}) and at the receiver end of the receive antenna cable (A_{RX1}), for both V_{DIRECT} and V_{SITE} measurements, to reduce impedance mismatches; see 6.1b). Additional attenuators can be inserted at the other ends of the two cables (antenna end of the receive antenna cable and measurement instrument's end of the transmit antenna cable). However, too much attenuation degrades the achievable noise floor of the entire measurement setup, especially for V_{SITE} measurements.
2. Where antennas are calibrated with external matching attenuators and the associated losses are included in the antenna factors, these attenuators (A_{TX2} and/or A_{RX2}) shall remain attached to the antennas during V_{SITE} measurements; see 6.3.2.2. However, contrary to what is illustrated in the figure, these attenuations shall not be included in the V_{DIRECT} measurements (since they need to stay attached to the antenna and their loss is included in the antenna factor of the antenna).
3. The antenna shall have a $VSWR \leq 2.5:1$ or an attenuator of at least 4 dB shall be installed on its coaxial port for site validation measurements (A_{TX2} and A_{RX2}); see 6.3.2.3. These attenuators can be used for both V_{DIRECT} and V_{SITE} measurements, as illustrated in the figure.
4. An extra cable can be necessary for the V_{DIRECT} measurements; for example, where the Tx cable is installed in a conduit below the ground plane and the Rx cable is permanently attached to the antenna mast. Furthermore, additional attenuation can be necessary for the V_{DIRECT} measurements to prevent overloading the measurement instrument's input. Where these are used, their loss shall be accounted for when determining V_{DIRECT} .

NOTE—While not illustrated in this figure, an amplifier can be inserted in the RF output path and/or a pre-amplifier in the RF input path for increasing the dynamic range of the measurement setup. These devices benefit from the use of matching attenuators.

Figure 3—Use of attenuators during V_{DIRECT} and V_{SITE} measurements

7. Process selection and limitations

This standard gives various methods for performing SV measurements. The appropriate SV method to be used is based on many factors, which are documented in Table 3.

Table 3—Site validation method selection criteria

Method	Antenna type	Frequency range	Height of the test volume ^a	Antenna polarization ^b	h_1 ^c	
					Lower height	Upper height
TNSA (5.4) SCM (5.2)	Broadband	30 MHz to 1 GHz	Up to 2 m	Horizontal	1 m	2.0 m
				Vertical	1 m	1.5 m
			2 m to 2.5 m	Horizontal	1 m	2.5 m
				Vertical	1 m	2.0 m
			2.5 m to 3.0 m	Horizontal	1 m	3.0 m
				Vertical	1 m	2.5 m
	Tuned dipole	30 MHz to 1 GHz	Up to 2 m	Horizontal	—	2.0 m
				Vertical	—	2.75 m ^d
DNSA (5.3)	Standard biconical only	30 MHz to 200 MHz	Up to 2 m	Horizontal	1 m	2.0 m
				Vertical	1 m	1.5 m
			2 m to 2.5 m	Horizontal	1 m	2.5 m
				Vertical	1 m	2.0 m
			2.5 m to 3.0 m	Horizontal	1 m	3.0 m
				Vertical	1 m	2.5 m
NOTE 1—Due to their dimensions at low frequencies, tuned dipoles cannot be used in all the various positions required for validating an alternative site (see 4.3). The antenna tips might be too close to the ground plane, the wall or ceiling absorbers, or the weather-protection covering.						
NOTE 2—For the purposes of this document, the height of the test volume is not expected to be taller than 3 m; therefore, the second antenna height for SV need not be greater than 3 m.						

^a For test volumes with heights not listed in this table, NSA values need to be calculated in accordance with Annex H.

^b For an example of a horizontal polarization setup, see Figure 4; for an example of a vertical polarization setup, see Figure 5.

^c See Table C.1 for allowed tolerance.

^d The limiting factor of maintaining at least a 25 cm (see Table C.1 for allowed tolerance) clearance between the ground plane and the lower tip of the receive antenna and the transmit antenna is addressed by fixing the transmit antenna height at 2.75 m (see Table C.1 for allowed tolerance) for vertical polarization and restricting the downward travel of the receive antenna. See Table D.4.

8. General site validation requirements

8.1 Common process

8.1.1 General

Subclause 8.1 contains SV requirements that are common to the three methods specified in this standard, SCM (5.2), DNSA (5.3), and TNSA (5.4).

The basic SV measurement uses two antennas that are set up on the SUV in an appropriate measurement geometry, as illustrated in Figure 4 and Figure 5. The SV procedure requires two different measurements of the voltage received (V_R). The first reading of V_R , called V_{DIRECT} , is with the two coaxial cables disconnected from the two antennas and connected to each other via an adapter. The second reading of V_R , called V_{SITE} , is taken with the coaxial cables reconnected to their respective antennas and the maximum signal measured