INTERNATIONAL STANDARD

IEC 60489-1

1983

AMENDMENT 2
1999-05

Amendment 2

Methods of measurement for radio equipment used in the mobile services –

Part 1: General definitions and standard conditions of measurement

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Amendement 2

Méthodes de mesure applicables au matériel de radiocommunication utilisé dans les services mobiles –

Partie 1: Définitions générales et conditions normales de mesure

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Международная Электротехническая Комиссия

PRICE CODE XA

For price, see current catalogue

FOREWORD

This amendment has been prepared by IEC technical committee 102: Equipment used in radio communications for mobile services and for satellite communication systems.

The text of this amendment is based on

FDIS	Report on voting
102/41/FDIS	102/49/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

A bilingual version of this amendment may be issued at a later date.

Add the following reference to the list of "Other IEC publications quoted in this standard":

IEC 60489-8:1984, *Methods of measurement for radio equipment used in the mobile services – Part 8: Antennas*

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Add the following Annex A after figure 3.

Annex A
(normative)

Guide for the use of test sites and radio-frequency coupling devices (RFCDs)

A.1 General

Test sites are basic means to perform radiation measurements. Radio-frequency coupling devices (RFCDs) are means generally designed to perform many equipment radiation measurements economically, using the same measuring method as equipment with antenna terminals.

This annex describes low reflection test sites (LRTS) and anechoic chambers (AC) for upper frequency limit extension and interference-free measurements, as well as random field measurement sites for measurements similar in the real field and for measurement equipment with a diversity antenna. TEM cells and GTEM cells are also described for wideband upper-frequency limit extension and interference-free measurements.

The evaluation measurement of a test site is the method to judge whether a test site construction satisfies the required conditions and is introduced for LRTS, AC and RFM sites in this annex. The evaluation measurement for OATS was studied, but not introduced because the available evaluation measurement required important measurement condition changes.

The calibration method for a test site is the process for determining the numerical relationship between equipment radiation power and the observed output of a radio-frequency signal generator which replaces the EUT during the substitution measurement, or the numerical relationship between the field strength where the EUT is placed and the indication of the selective measuring device with the calibration antenna.

RFCDs were originally used only for ratio measurement of equipment receiving radio-frequency electromagnetic energy. The radiation sensitivity measured in the RFCD was called "the reference sensitivity (RFCD)" and defined as the level of RFCD input signal in microvolts (µV).

This annex also describes calibration methods. Calibration is the procedure for determining the numerical relationship between RFCD input or output voltage and the equivalent field strength where the EUT is placed, or the radiated power of the EUT. RFCDs should be principally calibrated. Therefore, RFCDs need no evaluation measurement.

Test site overview and overview of RFCDs are shown in tables A.1 and A.2 respectively.

Table A.1 – Test site overview

Test sites	Advantages	Disadvantages
OATS: Open area test site	Low construction cost Available for large size EUT Includes ground reflection effects	Needs a lot of space Interference from others Weather dependency Measurement fluctuation is relatively high at frequencies higher than 1 GHz
LRTS: Low reflection test site	Clear and flexible evaluation criterion Possible to reduce error Wide frequency range Available for large size EUT No influence of ground reflections	Does not reflect reality Is affected by absorber size Interference from others
AC: Anechoic chamber	No interference No weather dependency No influence of ground reflections	Limited lower frequency Limited EUT size Expensive, especially for low frequency
RFM: Random field measurement site	Few construction site requirements (anywhere) Evaluation of real world antenna efficiency Clear and flexible evaluation criterion Available for the evaluation of diversity antenna	Needs many measurement values and their calculation

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Table A.2 – Overview of radio-frequency coupling devices (RFCDs)

RFCDs	Maximum size of EUT [mm]	Features
Narrowband RFCD Test fixture	---------- (Only for specific EUT)	Available in small size Not expensive Only for specific EUT Only for specific or approximate frequency
Wideband RFCDs		More than twice frequency range
Stripline arrangement	200 l × 200 b × 250 h for maximum frequency of 200 MHz 400 l × 400 b × 500 h for maximum frequency of 100 MHz	Can be constructed with detailed information Influence of surroundings Limited frequency range
TEM cell	100 l × 150 b × 50 h for maximum frequency of 500 MHz 200 l × 300 b × 100 h for maximum frequency of 250 MHz	No influence from surroundings Limited frequency range
GTEM cell	300 l × 300 b × 200 h to greater than 5 GHz or 1 000 l × 1 000 b × 500 h to greater than 5 GHz	No influence from surroundings Wide frequency range

NOTE – A certain manufacturer specifies d.c. to 17 GHz for the frequency range of a GTEM cell.

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A.1.1 Abbreviations:

AC Anechoic chamber
ETSI European Telecommunication Standards Institute
EUT Equipment under test
GTEM GHz TEM
LRTS Low reflection test site
OATS Open area test site
RFCD Radio-frequency coupling device
RFM Random field measurement
TEM Transverse electromagnetic mode

A.2 Test sites

A.2.1 Introduction, outline and selection of test sites

The radiation characteristics of equipment are measured at test sites. Both equipment emitting radio-frequency electromagnetic energy and equipment receiving it can be measured. Emission measurements can be made for all radio-frequency parameters pertaining to radiated radio-frequency electromagnetic energy, for example, transmitter radiated power, transmitter radiated spurious power, receiver radiated spurious power. Receiver measurements can be made for all radio-frequency parameters pertaining to received radio-frequency electro-magnetic energy, for example, receiver radiation sensitivity.

OATSs are the classic test sites and have been left as before. ACs are already widely used, and the new evaluation measurement has been introduced. LRTS and RFM site are newly introduced test sites. Both LRTS and RFM sites have clear and flexible evaluation criteria which allow for easy appraisal of conformity to construction requirements.

All test sites use the substitution method for emission measurements and this reduces measurement error. The EUT is to be substituted with a half-wave dipole antenna and a radio-frequency signal generator. The field strength in receiver measurements is to be measured by the calibration antenna and the selective measuring device.

A guide for the selection of test sites is shown in table A.1.

A.2.2 Open area test site (OATS)

A.2.2.1 General

Open area test sites are applicable to all kinds of measurements on mobile radio equipment in areas where no interfering radio services are operating, and no other radio services may interfere with the propagation of the measuring frequencies power used on the test site. In other cases indoor test sites are recommended.

On an OATS, the measuring antenna or the calibration antenna receives the combination of a direct wave and a ground reflected wave. By contrast, the measuring antenna or the calibration antenna on the LRTS receives only a direct wave, while the ground reflection is suppressed.

Measuring distances of 3 m and 30 m are applied for OATS.

Emission measurements can be made on any measuring distance for all radio parameters concerning radiated electromagnetic energy, for example, transmitter radiated power, transmitter radiated spurious power, receiver radiated spurious power. The shorter measuring distance test site can measure low power. The longer one can measure a large size of EUT and lower frequency.

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Receiver measurements can be made only on 30 m test site for all radio parameters concerning received electromagnetic energy, for example receiver radiation sensitivity. The 3 m test site has great field gradient in higher frequencies.

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A.2.2.2 Test site characteristics

Characteristics	Limits for a 3 m test site
Useful frequency range	100 MHz to 1 000 MHz
Nominal site attenuation	12 dB to 38 dB for 100 MHz
Nominal site attenuation	32 dB to 58 dB for 1 000 MHz
Equipment size limits	0,6 m maximum, including the antenna
NOTE - The nominal attenuation of the test site for a half-wave dipole is 18 dB for 100 MHz and 38 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.	

Characteristics	Limits for a 30 m test site
Useful frequency range	25 MHz to 1 000 MHz
Nominal site attenuation	20 dB to 46 dB for 25 MHz
Nominal site attenuation	52 dB to 78 dB for 1 000 MHz
Equipment size limits	6 m, including the antenna
NOTE - The nominal attenuation of the test site for a half-wave dipole is 26 dB for 25 MHz and 58 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.	

A.2.2.3 Basic measuring procedure

A.2.2.3.1 Transmitter emission measurements

a) Place the transmitter under test on the platform. Orientate the measuring antenna so that it has the same polarization as the transmitter. Orientate the transmitter so that an intended direction is perpendicular to the direction of the measuring antenna and operate the transmitter.

b) Tune the selective measuring device to the radiated power component.

c) Raise and lower the measuring antenna to obtain the maximum indication on the selective measuring device. Note the maximum indication.

d) Substitute the auxiliary antenna and the radio-frequency signal generator for the transmitter under test. Adjust the measuring antenna height to the maximum point where reading in the selective measuring device can be obtained.

e) Adjust or calculate the radio-frequency signal generator output level to the level obtained in step c). This level is the radiated power of the transmitter under test for an intended direction.

NOTE 1 – The selection of the measuring distance and the connection of the equipment in the test site are not included in the above steps.

NOTE 2 – The measuring antenna height in step c) and step d) may vary. The measuring antenna height in step c) for another intended direction may differ from the original.

A.2.2.3.2 Receiver measurement receiving radio-frequency electromagnetic energy

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a) Calibrate the radio-frequency signal generator level to the electromagnetic field strength received by the calibration antenna and the selective measuring device. It should be confirmed that the transmitting antenna is less dependent upon small changes in antenna height before the calibration.

b) Replace the calibration antenna and the selective measuring device by a receiver under test. Orientate the receiver so that an intended direction is perpendicular to the direction of the transmitting antenna and operate the receiver.

c) Adjust the signal generator level to the level which just satisfies the receiver radiation sensitivity according to the sensitivity measurement procedure.

d) Read or calculate the average of signal generator level and convert it to the calibrated level. This level is the radiation sensitivity of the receiver in an intended direction.

NOTE – Connection of the equipment in the test site is not included in the above steps. The measuring distance is 30 m.

A.2.2.4 Construction of a radiation test site

The measuring arrangement for equipment emitting radio-frequency electromagnetic energy is shown in figure A.1. The measuring arrangement for equipment receiving electromagnetic energy is shown in figure A.2.

The radiation test site shall be on ground level having uniform electrical characteristics and being free from reflecting objects over an area as wide as possible, to ensure that the extraneous electromagnetic fields do not affect the accuracy and repeatability of the test results.

A.2.2.4.1 3 m test site

A continuous ground screen (either sheet metal or wire mesh having openings no greater than 10 mm, which should maintain good electrical contact between the wire) shall be used to establish a uniformly conducting earth over part of the test site. The turntable shall be metallic and shall be flush with the ground screen. The minimum ground screen area is shown in figure A.3.

A.2.2.4.2 30 m test site

The minimum boundary of the test site shall be an ellipse having a major axis equal to 60 m and a minor axis equal to 52 m. The EUT and the measuring antenna or the transmitting antenna shall be located at the foci.

No extraneous conducting objects having any dimensions in excess of 50 mm shall be in the immediate vicinity of either the EUT or the antennas.

The test site shall have a turntable and a support for the measuring antenna. The measuring distance is the distance in the horizontal plane between the central vertical axis of the turntable and the central vertical axis of the measuring antenna. A shelter may be provided for the whole or a part of the test site. All such constructions having any dimensions greater than 50 mm should be of wood, plastic, or other non-conducting material. Wood shall be impregnated to ensure minimum water absorption.

All test equipment, if located above ground, shall be powered preferably by batteries. If the equipment is powered by mains, each of the supply cables shall be provided with a suitable radio-frequency filter. The cable connecting the filter and the measuring equipment shall be as short as possible and shielded. The cable connecting the filter and mains shall either be shielded and grounded, or buried to a depth of approximately 300 mm.

A.2.2.5 Position of the EUT

The equipment with its cabinet or housing in which it is normally operated shall be placed on a horizontal platform, the upper side of which is 1,50 m above the ground. The platform and its support shall be made of non-conductive material.

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For equipment with an integral antenna, the equipment shall be placed on the platform in a position which is closest to that in normal use.

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Equipment having a rigid external antenna shall be mounted so that the antenna is in a vertical position. Equipment having a non-rigid external antenna shall be mounted vertically, using a non-conducting support.

It shall be possible to rotate the equipment around the central vertical axis of its antenna. It is recommended that a turntable, preferably remotely controlled, be used for this purpose. If the equipment has a power cord, it should extend down to the turntable, and any excess should be coiled on it.

For information on the use of alternative test mounting arrangements for equipment which is hand-carried or carried on a person in normal operation, see clause A.4.

A.2.2.6 Measuring antenna

The measuring antenna shall be suitable for the reception of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, to increase the sensitivity and to attenuate remaining reflections, a more complex antenna, having high directivity and broad bandwidth, is preferred. For low frequencies short dipoles are recommended.

The measuring antenna shall be mounted at the end of a horizontal boom supported by a vertical pole, both made of non-conducting materials. The boom shall project at least 1 m from the pole in the direction to the EUT and shall be arranged so that it may be raised and lowered from 1 m to 4 m. The mounting shall permit the antenna to be positioned for measuring both horizontal and vertical components of the electric field. The mount shall permit the antenna to be tilted so as to permit simultaneous inclusion of both the direct and reflected rays. The lower end of the antenna, when oriented for vertical polarization and placed at its lowest position, shall be at least 0,3 m above the ground.

The antenna cable shall be routed along the horizontal boom for at least 2 m, preferably at ground level. Suitable antenna clearance is recommended. Alternatively, the cable may be routed underground.

A.2.2.7 Transmitting antenna

The transmitting antenna shall be suitable for the radiation of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, to increase the sensitivity and to attenuate remaining reflections, a more complex antenna having high directivity and broad bandwidth is preferred. For low frequencies short dipoles are recommended.

The transmitting antenna shall be mounted at the end of a horizontal boom supported by a vertical pole, both made of non-conducting material. The boom shall project at least 1 m from the pole in the direction of the equipment under test and shall be arranged so that the centre of the antenna is 3 m ± 0,2 m above the ground. The mounting shall permit the antenna to be positioned for the same polarization as that of the receiver antenna.

The antenna cable shall be routed along the horizontal boom for at least 2 m, preferably at ground level. Suitable antenna clearance is recommended. Alternatively, the cable may be routed underground.

At some frequencies, an appreciable variation of signal level occurs for a small change in antenna height due to ground reflections. Where this occurs, the transmitting antenna should be moved up or down by an amount that will place the antenna in a region of small height sensitivity and make the test site calibration less dependent upon small changes in antenna position.

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A.2.2.8 Auxiliary antenna

The auxiliary antenna substitutes for the equipment under test during calibration. The auxiliary antenna shall be a half-wave dipole and shall be arranged in a manner similar to that of the measuring antenna, except that the centre of the auxiliary antenna should coincide approximately with the normal position of the centre of radiation of the equipment under test. A broadband antenna also may be used as the substitution antenna.

At frequencies below about 60 MHz, the above condition may be impossible to achieve for vertical polarization. In this case, the lower end of the antenna should be placed 0,3 m above the ground, and the EUT shall be positioned to satisfy the above listed conditions.

A.2.2.9 Calibration antenna

The calibration antenna replaces the EUT during calibration of the receiver receiving electromagnetic energy measurement. The calibration antenna shall be an antenna for which the available power output has been calibrated in field strength. The centre of the calibration antenna is located so that this point coincides with the centre of the radiation centre of the EUT.

The antenna, including the cable, shall be matched to the input impedance of the selective measuring device.

At frequencies below about 60 MHz, the above condition may be impossible to achieve when the antenna is arranged for vertical polarization. In this case, the lower end of the antenna should be placed 0,3 m above the ground and the EUT shall be positioned to satisfy the above conditions.

A.2.2.10 Radio-frequency signal generator

A well-shielded radio-frequency signal generator, with a matching or combining network (if required) and its associated output cable, shall be placed so that it will not affect the accuracy of the results, and shall be connected to and matched to the auxiliary antenna.

A.2.2.11 Selective measuring device

The selective measuring device should be a calibrated field strength meter or a spectrum analyzer (with preselector), and shall be placed, together with its associated input cable, in a position where it will not affect the accuracy of the test results.

A.2.2.12 Calibration method for OATS

A.2.2.12.1 General

The test site calibration is the procedure for determining the numerical relationship between the EUT radiated power and the selective measuring device indication in an emission measurement site, or the field strength where the EUT is placed, and the radio-frequency signal generator equivalent output voltage in a receiver measurement site.

Measurement distance is not so important for the substitution method. Only the adjustment of the radiation centre of the EUT at the measurement distance to that of the auxiliary antenna for substitution is meaningful.

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The radiation centre of the receivers is not recognized and the radiation centre of the calibration antenna may differ from that of the receivers. This means that the field strength measured by the calibration antenna might be different from the field strength at the radiation centre of the receivers.

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A.2.2.12.2 Calibration for measurement of equipment emitting radio-frequency electromagnetic energy

This method is applicable to the radiated radio-frequency power of transmitters and the radiated spurious components of receivers.

a) Connect the equipment as illustrated in the chosen test site with the auxiliary antenna and the measurement antenna oriented to provide the polarization intended for the measurement.

b) Adjust the auxiliary antenna (if applicable) to the correct length for the frequency to be measured and adjust the frequency of the radio-frequency signal generator to the same frequency.

c) Adjust the measurement antenna (if applicable) to the correct length for the frequency to be measured and tune the selective measuring device to the operating frequency of the radio-frequency signal generator.

d) Adjust the output level of the radio-frequency signal generator to –10 dBm (103 dBµV).

e) Raise and lower the measuring antenna to obtain the maximum indication on the selective measuring device. Record the indication level of the selective measuring device.

f) The radiated radio-frequency power for other values of the selective measuring device indication is given by:

   radiated power = (new indication level in decibels (dB)) – (indication level in step e) in decibels (dB)) – 10 dBm

NOTE – The calibration is only valid for the frequency, antennas, polarization, and antenna position used in the calibration procedure. If any of these change, the site should be recalibrated.

A.2.2.12.3 Calibration for measurement of equipment receiving radio-frequency electromagnetic energy in a 30 m test site

a) Connect the equipment as illustrated in the chosen test site with the transmitting antenna and the calibration antenna oriented to provide the polarization intended for the receiver under test.

b) Adjust the frequency of the radio-frequency signal generator to the operating frequency of the receiver.

c) Adjust the calibration antenna (if applicable) to the correct length for the frequency to be measured and tune the selective measuring device to the operating frequency of the radio-frequency signal generator.

d) Adjust the output level of the radio-frequency signal generator to produce a reading of 100 µV/m (40 dBµV/m) on the selective measuring device. Record the output of the radio-frequency signal generator in microvolts.

e) The field strength for other values of the radio-frequency signal generator output is given by:

$$\text{field strength} = \frac{\text{new output level}}{\text{output level recorded in step d)}} \times 100\ \mu\text{V/m}$$

or

field strength in dBµV/m = 40 + 20 lg (new output level in microvolts)
–20 lg (output level in microvolts recorded in step d).

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NOTE 1 – The calibration is only valid for the frequency, antennas, polarization, and antenna position used in the calibration procedure. If any of these change, the site should be recalibrated.

NOTE 2 – Measurement distance is not so important for the substitution method, but the radiation centre coincidence between calibration antenna and the receiver under test is very important because the radiation centre difference between them means a calibration error. To reduce this error, a longer measurement distance is recommended because it has a lesser degree of field strength variation than a shorter measurement distance. Especially at high frequency, this becomes severe, for example an 8 dB variation with 100 mm height difference is observed at 900 MHz at a measurement distance of 3 m. Therefore, a 3 m test site for equipment receiving radio-frequency electromagnetic energy is not recommended.

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A.2.3 Low reflection test sites (LRTS, reduced ground reflections)

A.2.3.1 Introduction

The open area test sites (OATS) are widely used and popular test sites. Recently, upper frequency limitation improvement became necessary and some studies were made. One of the effective improvement methods is to suppress the ground-reflected waves. It also improves the measurement repeatability.

On an OATS, the measuring antenna or the calibration antenna receives the combination of a direct wave and a ground reflected wave. By contrast, the measuring antenna or the calibration antenna on the LRTS receives only a direct wave, while the ground reflection is suppressed.

The suppression of ground-reflected waves makes the characteristics of the test site similar to those of anechoic chambers and not to those of OATS.

LRTS have simple and clear evaluation criteria which can be adapted to any level of measuring error or repeatability requirements. LRTS require no specific construction requirements and can be applied to any measuring distance, for example, 3 m, 5 m, 10 m or 30 m.

For suppression of ground-reflected waves, use of a high directivity antenna and any other means are recommended. However, the quality of the construction is to be judged only by the evaluation criterion. (see A.2.3.4 and A.2.3.5)

NOTE – ETSI indoor test site is involved in LRTS. It requires a specific construction and a specific evaluation criterion.

A.2.3.2 Test site characteristics

Measuring distances of 3 m to 30 m can be used in combination with ground-reflected wave suppression described in A.2.3.4. Longer distance sites are unusual. Only the lowest frequency to be used and the largest dimension of the equipment under test require a longer measuring distance. LRTS characteristics are very similar to those of an anechoic chamber. The anechoic chamber can be used as an LRTS. The useful frequency range is extended to 18 GHz (depending on site performance).

As an example, a measuring distance of 3 m is shown below.

Characteristics	Limits for a distance of 3 m
Useful frequency range	100 MHz to 18 GHz
Nominal site attenuation	32 dB to 44 dB for 1 000 MHz
Equipment size limits	0,6 m maximum

A.2.3.3 Basic measuring procedure

A.2.3.3.1 Transmitter emission measurements

a) Place the transmitter under test on the platform. Orientate the measuring antenna so that it has the same polarization as the transmitter. Orientate the transmitter so that an intended direction is perpendicular to the direction of the measuring antenna and operate the transmitter.

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b) Tune the selective measuring device to the radiated power component.

c) Raise and lower the measuring antenna around the same height as the transmitter under test, to obtain the maximum indication on the selective measuring device. Note the maximum indication.

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d) Substitute the auxiliary antenna and the radio-frequency signal generator for the transmitter under test. Adjust the auxiliary antenna height to the maximum reading point in the selective measuring device.

e) Adjust or calculate the radio-frequency signal generator output level to the level obtained in step c). This level is the radiated power of the transmitter under test for an intended direction.

NOTE 1 – Selection of the measuring distance, connection of the equipment in the test site and the evaluation measurements are not included in the above steps.

NOTE 2 – The measuring antenna height, the transmitter radiation centre and the auxiliary antenna will be the same.

A.2.3.3.2 Receiver measurement receiving radio-frequency electromagnetic energy

a) Calibrate the radio-frequency signal generator level to the electromagnetic field strength received by the calibration antenna and the selective measuring device.

b) Replace the calibration antenna and the selective measuring device by a receiver under test. Orientate the receiver so that an intended direction is perpendicular to the direction of the transmitting antenna and operate the receiver.

c) Adjust the signal generator level to the level which just satisfies the receiver radiation sensitivity according to the sensitivity measurement procedure.

d) Read or calculate the average of the signal generator level and convert it to the calibrated level. This level is the radiation sensitivity of the receiver in an intended direction.

NOTE – Selection of the measuring distance, connection of the equipment in the test site and the evaluation measurements are not included in the above steps.

A.2.3.4 Construction of a radiation test site

The measuring arrangement for equipment emitting radio-frequency electromagnetic energy is shown in figure A.4. The measuring arrangement for equipment receiving electromagnetic energy is shown in figure A.5.

For the ground reflected wave suppression, use of a high directivity antenna and any of the measures in figure A.6 are suggested.

If a radio-wave screening curtain is used for the suppression of ground-reflected waves, the height of the curtain should be adjusted to be the optimum clearance as shown in figure A.6a. The optimum clearance will be 80 % to 100 % of the first Fresnel zone, which is calculated by the following formula. The output of the measuring antenna or the calibration antenna becomes a maximum at the optimum clearance.

$$H_0 = \sqrt{\frac{d_1 d_2}{d_1 + d_2}}$$

If a radio-wave absorber is used for the suppression of the ground-reflected wave, the width of the absorber area projected circle on the perpendicular plane to the ground-reflected wave path should be more than the circle with the same radius as the first Fresnel zone (see figure A.6d).

The other side area of the high directive measuring antenna or transmitting antenna should be as wide as possible to avoid extraneous reflected waves.

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No extraneous conducting objects shall be in the immediate vicinity of either the equipment under test or antennas. It is also not recommended to use high permittivity dielectric in the immediate vicinity of either the equipment under test or the antennas. It may affect field distribution in the 800 MHz band or a higher frequency band.

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The extraneous reflected waves increase the standing wave ratio in the evaluation measurement and this means an increase of the measurement error.

The test site shall have a turntable. The measuring distance is not critical in substituting a measurement if the centre of the equipment under test and the centre of the measuring antenna are placed in the same position.

A.2.3.5 Evaluation measurements

The evaluation measurement is the procedure to judge whether the test site construction satisfies the required conditions.

The reflected waves cause standing waves. The ratio value in decibels (dB) between a peak and an adjacent valley measured field strength means the maximum measuring value variation in decibels (dB). The maximum value measured in the volume of EUT is to be the maximum measuring error or the repeatability of the test site. The standing waves should be measured at least in two directions, in the three perpendicular directions of the measuring antenna or the calibration antenna. Measurement should be made by moving the measuring antenna or the calibration antenna continuously.

The length of the standing-wave measurement should be greater than the size of the EUT or a half-wave length, whichever is longer. The centre of the standing-wave measurement should be almost the same point to the radiation centre of the EUT.

Any value of the evaluation criterion could be used if both the purchaser and the manufacturer agree. However, ±1 dB to ±3 dB would be realistic.

A.2.3.6 Position of the EUT

The position of the EUT is recommended to be as high as possible because the higher position makes larger incident angle difference between the ground-reflected wave and the direct wave. Consequently, the received power of the ground-reflected wave is reduced by the increased directivity of the measuring antenna. The higher position also increases the propagation loss of the ground-reflected wave which reduces the power of the reflected wave.

Some examples of higher positions are shown in figure A.7.

The equipment in the cabinet or housing in which it normally operates shall be placed on a platform. The platform and its support shall be made of non-conducting materials. Equipment having an integral antenna shall be placed on the platform in a position which is closest to its normal use. If dielectric material is used for supporting the stand position of the equipment, low permittivity material is recommended.

It shall be possible to rotate the equipment about the vertical axis through the centre of the antenna of the EUT. It is recommended that a platform in the form of a turntable, preferably remotely controlled, should be used for this purpose. If the equipment has a power cable, it should extend down the turntable.

For information on the use of alternative test mounting arrangements on this test site for equipment which is hand-carried or carried on a person while in normal operation, see clause A.4.

A.2.3.7 Measuring antenna

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IEC 60489-1:1983/AMD2:1999
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The measuring antenna shall be suitable for the reception of linearly polarized waves and shall be a high directive antenna for suppressing the receiving power of the ground-reflected wave and other extraneous reflected waves.

The mounting shall permit the antenna to be positioned for measuring both horizontal and vertical components of the electric field.

NOTE – EUT is generally designed for vertical polarization. However, it may have other stronger polarizations in higher frequency spurious components.

A.2.3.8 Transmitting antenna

The transmitting antenna shall be the same as the measuring antenna except that the transmitting antenna height and direction shall be adjusted so that the received power of the calibration antenna becomes maximum.

A.2.3.9 Auxiliary antenna

The auxiliary antenna replaces the EUT during part of the emission measurement. The auxiliary antenna shall be a half-wave dipole (see A.7.1).

The auxiliary antenna height shall be adjusted so that the received power of the measuring antenna becomes maximum after the measuring antenna height has been adjusted to the maximum point of the received power from the EUT. This procedure makes the radiation centre of the auxiliary antenna coincide with the radiation centre of the equipment under test.

A.2.3.10 Calibration antenna

The calibration antenna replaces the equipment under test during calibration of the receiver receiving electromagnetic energy measurement. The calibration antenna shall be an antenna for which the available power output has been calibrated in field strength. The centre of the calibration antenna shall be located so that this point coincides with the centre of the radiation centre of the EUT. The antenna, including the cable, shall be matched to the input impedance of the selective measuring device.

A.2.3.11 Calibration method for LRTS

A.2.3.11.1 General

The test site calibration is the procedure for determining the numerical relationship between EUT radiated power and the selective measuring device indication in an emission measurement site, or the field strength where the EUT is placed and the radio-frequency signal generator equivalent output voltage in a receiver measurement site.

The measurement distance is not so important for the substitution method. Only the adjustment of the radiation centre of the EUT at the measurement distance to that of the calibration antenna for substitution is meaningful.

Radiation measurement directions in a vertical plane are almost always horizontal and may differ from that of an OATS or an AC with ground plane.

A.2.3.11.2 Calibration for measurement of equipment emitting radio-frequency electromagnetic energy

This method is applicable to the radiated radio-frequency power of transmitters and the radiated spurious components of receivers.

a) Connect the equipment as illustrated in the chosen test site with the auxiliary antenna and the measurement antenna oriented to provide the polarization intended for the measurement.

b) Adjust the auxiliary antenna (if applicable) to the correct length for the frequency to be measured and adjust the frequency of the radio-frequency signal generator to the same frequency.

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c) Adjust the measurement antenna (if applicable) to the correct length for the frequency to be measured and tune the selective measuring device to the operating frequency of the radio-frequency signal generator.

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https://standards.iteh.ai/catalog/standards/sist/82708407-37df-4018-8764-cc948f8c309d/iec-60489-1-1983-amd2-1999

d) Adjust the output level of the radio-frequency signal generator to –10 dBm (103 dBμV).

e) Raise and lower, for example ±0,3 m, the measuring antenna to obtain the maximum indication on the selective measuring device. Record the indication level of the selective measuring device. The same height to the auxiliary antenna may be acceptable if the above indication shows flatness or very little variation.

f) The radiated radio-frequency power for other values of the selective measuring device indication is given by:

   radiated power = (new indication level in decibels (dB)) – (indication level in step e) in decibels (dB)) – 10 dBm

NOTE – Calibration is only valid for frequency, antennas, polarization, and the antenna position used in the calibration procedure. If any of these change, the site should be recalibrated.

A.2.3.11.3 Calibration for measurement of equipment receiving radio-frequency electromagnetic energy

a) Connect the equipment as illustrated in the chosen test site with the transmitting antenna and the calibration antenna oriented to provide the polarization intended for the receiver under test.

b) Adjust the frequency of the radio-frequency signal generator to the operating frequency of the receiver.

c) Adjust the calibration antenna (if applicable) to the correct length for the frequency to be measured and tune the selective measuring device to the operating frequency of the radio-frequency signal generator.

d) Raise and lower, for example ±0,3 m, the calibration antenna to obtain the maximum indication on the selective measuring device. The same height to the auxiliary antenna may be acceptable if the indication shows flatness or very little variation.

e) Adjust the output level of the radio-frequency signal generator to produce a reading of 100 µV/m (40 dBµV/m) on the selective measuring device. Record the output of the radio-frequency signal generator in microvolts (µV).

f) The field strength for other values of the radio-frequency signal generator output is given by

$$\text{field strength} = \frac{\text{new output level}}{\text{output level recorded in step e)}} \times 100\ \mu\text{V/m}$$

or

field strength in dBµV/m = 40 + 20 lg (new output level in microvolts (µV))
–20 lg (output level in microvolts (µV) recorded in step e))

NOTE – Calibration is only valid for frequency, antennas, polarization, and the antenna position used in the calibration procedure. If any of these change, the site should be recalibrated.

A.2.4 Anechoic chamber

A.2.4.1 General

The anechoic chamber is a well-shielded chamber which allows disturbing influences on the measurements from outside to be avoided.

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All inside surfaces are covered by electromagnetic absorption material which suppresses reflections and simulates free-space conditions. However, the suppressing of reflections is limited in reality by the frequency or the room to be used.

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A.2.4.2 Characteristics of an anechoic chamber

Example of an anechoic chamber with the dimensions of 5 m × 5 m × 10 m.

Characteristics	Limits for a 10 m chamber
Useful frequency range	100 MHz to above 1 000 MHz
Useful measuring distance	3 m to 5 m
Nominal site attenuation	5 m distance and 100 MHz 26 dB
Nominal site attenuation	5 m distance and 1 000 MHz 46 dB
Minimum shielding attenuation	100 dB
Minimum return loss of absorbers	10 dB
Maximum equipment size	1 m

A.2.4.3 Basic measuring procedure

The basic measuring procedure of the anechoic chamber is the same as that of the LRTSs (see A.2.3.3).

A.2.4.4 Example of the construction of an anechoic chamber

An example of a chamber with dimensions of 5 m × 5 m × 10 m, which is shown in figure A.8, has internal room dimensions of 3 m × 3 m × 8 m, so that a maximum measuring distance of 5 m in the middle axis of the room is available. The chamber consists of shielded walls, ceiling and floor. The ceiling and walls of the chamber are coated with about 1 m high pyramid absorbers. The floor can be covered with floor absorbers which can be walked on. The ground reflections need not be considered and the antenna height has basically no influence on the results.