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Elektromagnetna združljivost - Meritve oddajanja v popolnoma neodbojnih sobah

Electromagnetic compatibility - Emission measurements in fully anechoic chambers

Elektromagnetische Verträglichkeit - Störaussendung in Absorberräumen

Compatibilité électromagnétique - Emission en chambres anéchoïques entiers

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Electromagnetic compatibility - Emission measurements in fully anechoic chambers

Compatibilité électromagnétique - Emission en chambres anéchoïques entiers

Elektromagnetische Verträglichkeit - Störaussendung in Absorberräumen

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: Avenue Marnix 17, B - 1000 Brussels

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Foreword

This Technical Report was prepared by the Technical Committee CENELEC TC 210, Electromagnetic Compatibility (EMC).

This document supersedes R210-010:2002.

In order not to loose the information provided in R210-010:2002, CENELEC TC 210 decided to transfer the content of that document unchanged into a Technical Report. It should be noted that CISPR incorporated a major part of the document R210-010:2002 into the CISPR 16 series and the references to standards were not updated.

The document still provides a comprehensive overview and describes some fundamental items of interest for the appropriate use of fully anechoic chambers. The main reason for keeping the document in the public domain in this new form is that it contains background information that has not been included in EN 55016-1-4.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

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1 Scope

This Technical Report applies to emission measurements of radiated electromagnetic fields in Fully Anechoic Rooms (FAR) in the frequency range from 30 MHz to 18 GHz. This Technical Report covers the frequency range from 30 MHz – 1 000 MHz. The frequency range above 1 GHz is under consideration, due to the absence of practical experience.

This Technical Report describes the validation procedure for the Fully Anechoic Room for radiated emission tests and the procedures to carry out the tests (e.g. test set up, EUT position, cable layout and termination, test procedures). Recommendations for the relation between FAR emission limits and common Open Area Test Site (OATS) emission limits given in standards such as EN 55011 and EN 55022 are given in Annex B.

This FAR emission method may be chosen by product committees as an alternative method to emission measurement on an Open Area Test Site (OATS) as described in CISPR 16 series. In such cases, the product committee should also define the appropriate limits. Typical measurement uncertainty values for FARs and OATS are given in Annex C.

2 References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50147-1, *Anechoic chambers – Part 1: Shield attenuation measurement*

EN 55011, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement* (CISPR 11, mod.)

EN 55022:1998 [1)], *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement* (CISPR 22:1997, mod.)

CISPR 16-1:1999 [2)], *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 16-2 [3)], *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbance and immunity*

CISPR 16-3:2000 [4)], *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: Reports and recommendations of CISPR*

CISPR 16-4 series, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainties, statistics and limit modelling*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

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1) Superseded by EN 55022:2006, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement* (CISPR 22:2005, mod.).

2) Superseded by CISPR 16-1 series, harmonized as EN 55016-1 series, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*.

3) Superseded by CISPR 16-2 series, harmonized as EN 55016-2 series, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbance and immunity*.

4) Superseded by CISPR 16-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161 and the following apply.

3.1.1
Fully Anechoic Room (FAR)
shielded enclosure whose internal surfaces are lined with radio frequency absorbing material (i.e. RAM), that absorbs electromagnetic energy in the frequency range of interest

NOTE The fully Absorber-Lined Room is intended to simulate free space environment.

3.1.2
Equipment Under Test (EUT)
test sample including connected cables

NOTE The EUT may consist of one or several pieces of equipment.

3.1.3
test volume
region of the room that meets the *NSA* requirements of this Technical Report and which contains the EUT as fully set up

3.1.4
free space antenna factor (AF_{FS})
antenna factor of an antenna which is not affected by mutual coupling to conducting bodies in the environment of the antenna

NOTE It is also the antenna factor measured when the antenna under test is illuminated by a plane wave, which implies that the source antenna is in the far-field of the antenna under test. Antenna factor is defined as the ratio of the magnitude of the E-field in which the antenna is immersed to the voltage at the antenna output of a given transmission line impedance, usually 50 Ω.

3.1.5
antenna reference point
physical position on the antenna from which the separation distance to the defined reference plane on the EUT is measured

NOTE For dipole and biconical antennas this will be the centre of the antenna in line with the central antenna elements. For an LPDA antenna and a hybrid antenna, the reference point is the mark on the antenna provided by the manufacturer for this purpose. The reference point is approximately at the mid-way point between the array elements that are active at the top and bottom frequencies at which the measurements are being made. Hybrid antenna is here defined as a combination of a biconical and LPDA antenna which has a frequency range including 30 MHz to 1 GHz.

3.1.6
Normalised Site Attenuation (*NSA*)
site attenuation obtained from the ratio of the source voltage connected to a transmitting antenna and the received voltage as measured on the receiving antenna terminals

NOTE Normalised site attenuation is site attenuation in decibels minus the antenna factors of the transmit and receive antenna factors. *NSA* was first introduced for evaluation of open area test sites with ground planes and was measured by height scanning the receive antenna. In this Technical Report, *NSA* is measured in a quasi-free space environment, and because there is no deliberate ground plane, height scanning is not required.

3.1.7
test distance (d_t)
distance measured from the reference point of the antenna to the front of the boundary of the EUT

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

EUT	Equipment Under Test
FAR	Fully Anechoic Room
NSA	Normalised Site Attenuation
AF_{FS}	Antenna Factor (free space)
LPDA	Log-Periodic Dipole Array
OATS	Open Area Test Site
RS	Reference Site
SA	Site Attenuation
SA_{R}	measurement of *SA* made on RS
NEC	Numerical Electromagnetic Code

4 Test and measurement equipment

Equipment in accordance with CISPR 16 series shall be used.

4.1 Fully Anechoic Rooms (FARs)

A Fully Anechoic Room is required for the emission testing in which the radiated electromagnetic waves propagate as in free space and only the direct ray from the transmitting antenna reaches the receiving antenna. All indirect and reflected waves shall be minimised with the use of proper absorbing material on all walls, the ceiling and the floor of the FAR.

The screening of the FAR shall have an adequate attenuation level to avoid outside electromagnetic radiation entering the room and influencing the measurement results. The shield attenuation is measured in accordance with EN 50147-1. Shielding recommendations are given in CLC/TR 50484.

4.2 Antenna

Linear polarised antennas shall be used to measure the emitted electromagnetic field of the EUT. Biconical or log-periodic antennas and hybrid antennas are typical antennas used. The free space antenna factor shall be used. CISPR 16-3:2000, 4.7 gives parameters of broadband antennas. However no length limitation on LPDA or hybrid antennas is given. CISPR 16-1:1999, 5.5.4 and 5.5.5 give information on antennas. CISPR 16-1:1999, 5.5.5.2 b) states “it is essential that the variation of the effective distance of the antenna from the source and its gain with frequency be taken into account”. Antennas over 1,5 m in length could increase the uncertainties of emission testing using a separation of 3 m between the reference point of the antenna and the front of the EUT.

5 Anechoic room performance

5.1 Theoretical normalised site attenuation

The Site Attenuation (*SA*) is the loss measured between the connectors of two antennas on a particular site. For a free space environment the *SA* (in dB) can be defined by Equation (1) (see Annex D):

$$SA = 20\log_{10}\left[\left(\frac{5Z_O}{2\pi}\right)\left(\frac{d}{\sqrt{1-\frac{1}{(\beta d)^2}+\frac{1}{(\beta d)^4}}}\right)\right] - 20\log_{10} f_m + AF_R + AF_T \quad [\text{dB}] \tag{1}$$

where

AF_R is the antenna factor of the receive antenna in dB/m;

AF_T is the antenna factor of the transmit antenna in dB/m;

d is the distance between the reference points of both antennas in meters;

Z_0 is the reference impedance (i.e. 50 Ω);

ß is defined as $2\pi/\lambda$;

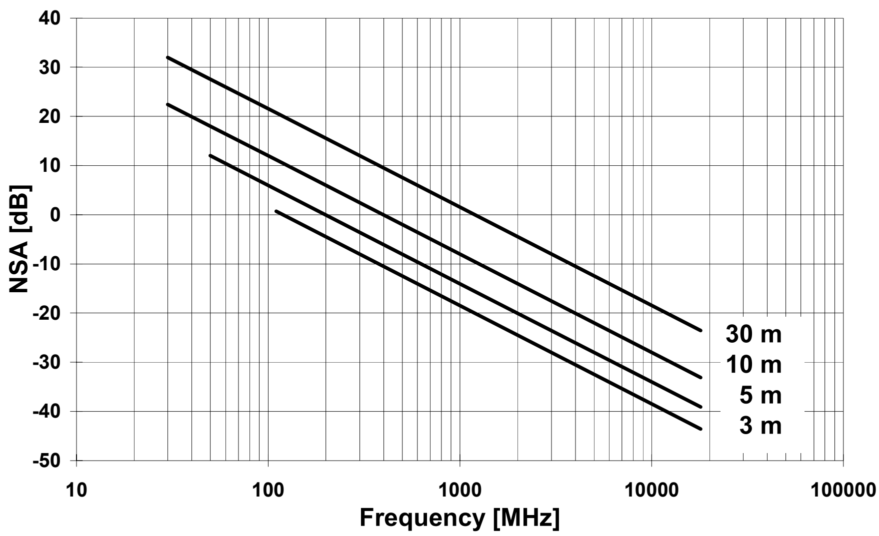
f_m is the frequency in MHz.

The theoretical Normalised Site Attenuation (*NSA*) in dB is defined as site attenuation with respective antenna factors subtracted, thus:

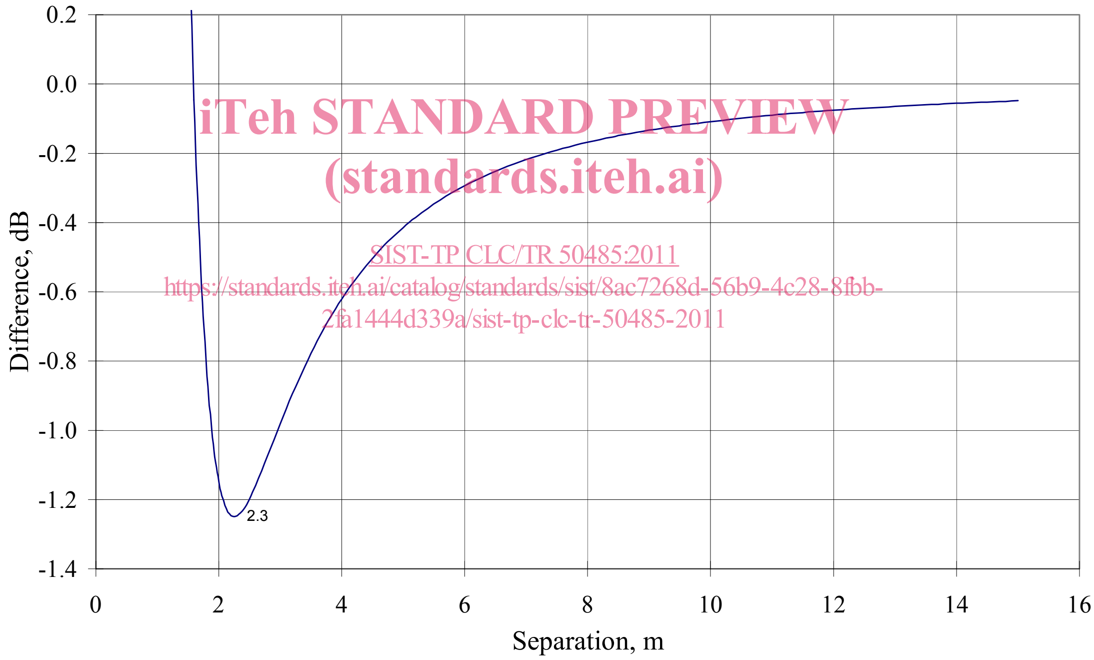
$$NSA_{calc} = 20\log_{10}\left[\left(\frac{5Z_O}{2\pi}\right)\left(\frac{d}{\sqrt{1-\frac{1}{(\beta d)^2}+\frac{1}{(\beta d)^4}}}\right)\right] - 20\log_{10} f_m \tag{2}$$

In far-field conditions Equation (2) simplifies to Equation (3) by omitting the near field terms:

$$NSA_{calc} = 20\log_{10}\left[\frac{5Z_O d}{2\pi}\right] - 20\log_{10} f_m \tag{3}$$



1a) Plot of theoretical *NSA* values in free space for far field conditions (Equation (3))



Distances relate to a frequency of 30 MHz.

1b) Difference in theoretical *NSA* between Equation (2) and Equation (3)

Figure 1 – Theoretical *NSA*

Using the simplified Equation (3) the error is less than 0,1 dB at frequencies above 60 MHz for 5 m distance and above 110 MHz for 3 m distance. Figure 1b shows the worst case near-field error which is at 30 MHz. However at higher frequencies there are Fresnel zone errors for large antennas which are treated in Annex F.

Equation (1) and Equation (2) account for near field effects of small antennas. In this context, using a transmit antenna less than 40 cm long, near-field effects become significant (> 0,2 dB) where the receive antenna length is greater than a quarter of the separation distance. This assumes the use of a 1,4 m long biconical antenna at 300 MHz. Figure F.1 shows that the error is less than 0,2 dB for a separation of 3 m and a maximum frequency of 200 MHz (it is common to change to a log antenna above 200 MHz). To cater for the general use of antennas (biconicals up to 300 MHz, or bilogs), the site reference method (6.2.1 and Annex A) shall be used for chamber validation at distances up to 5 m. In this method the site attenuation measured in the FAR are compared to those measured on a free space reference site.

5.2 Room validation procedure

The test volume must meet the room requirements given in 5.3. The shape of the test volume will be a cylinder, due to the rotation of the EUT on a turntable. The minimum height and diameter of the test volume shall be 1 m. The height and diameter do not have to be equal between the maximum and minimum values.

A single *SA* measurement is insufficient to pick up possible reflections from the construction and/or absorbing material comprising the walls, the floor and the ceiling of the Fully Anechoic Room.

In validating the Fully Anechoic Room *SA* measurements shall be performed at 15 measurement points for horizontal and vertical polarisation of the antennas:

1) at three heights of the test volume: bottom, middle and top of test volume;

2) at five positions in all three horizontal planes: the centre, left, right, front and back position of the horizontal plane.

For *SA* measurements, two broadband antennas shall be used: one transmit antenna at the measurement points of the test volume and one receive antenna outside this test volume at a prescribed orientation and position. The transmit antenna shall approximate an omnidirectional antenna pattern and shall have a maximum dimension of 40 cm. Typical antennas are biconical antennas. The receive antenna used during the room validation shall be of the same type as the receive antenna used during radiated emission testing of the EUT.

The frequency range 30 MHz to 1 GHz can be covered with one antenna, a hybrid antenna. The measurement results may be different if separate biconical and LPDA antennas are used.

For FAR validation the receive antenna shall be in the position of the middle level of the test volume as shown in Figure 2 and operated in horizontal and vertical polarisation. The distance between reference points of the receive and transmit antennas shall be $d_{nominal}$. The height of the measurement volume is less than the height of the test volume by the height of the transmit antenna. This is in order that the tip of the vertically polarised transmit antenna does not protrude above the top plane or below the top plane of the test volume. This treatment has not been applied, by reducing the diameter, to the horizontally aligned antenna, because it is room height rather than width which is at issue.

When varying the transmit antenna to the other positions of the test volume the receive antenna shall be moved to $d_{nominal}$. In all positions and polarisation the antennas shall face each other (receive antenna tilted). When the transmit antenna is placed in the upper and bottom level, the receive antenna remains in the middle level. The transmit antenna is moved to all 15 positions, and the 30 site validation measurements are performed. Tilting of the antennas implies that only one site reference measurement is needed to cover all 15 positions.

The back-position does not need to be taken into account if the distance between the boundary of the test volume and tips of the absorber is more than 1 m. Experiments and modelling have shown that this distance could be reduced to 0,5 m and further work may be needed to confirm this.

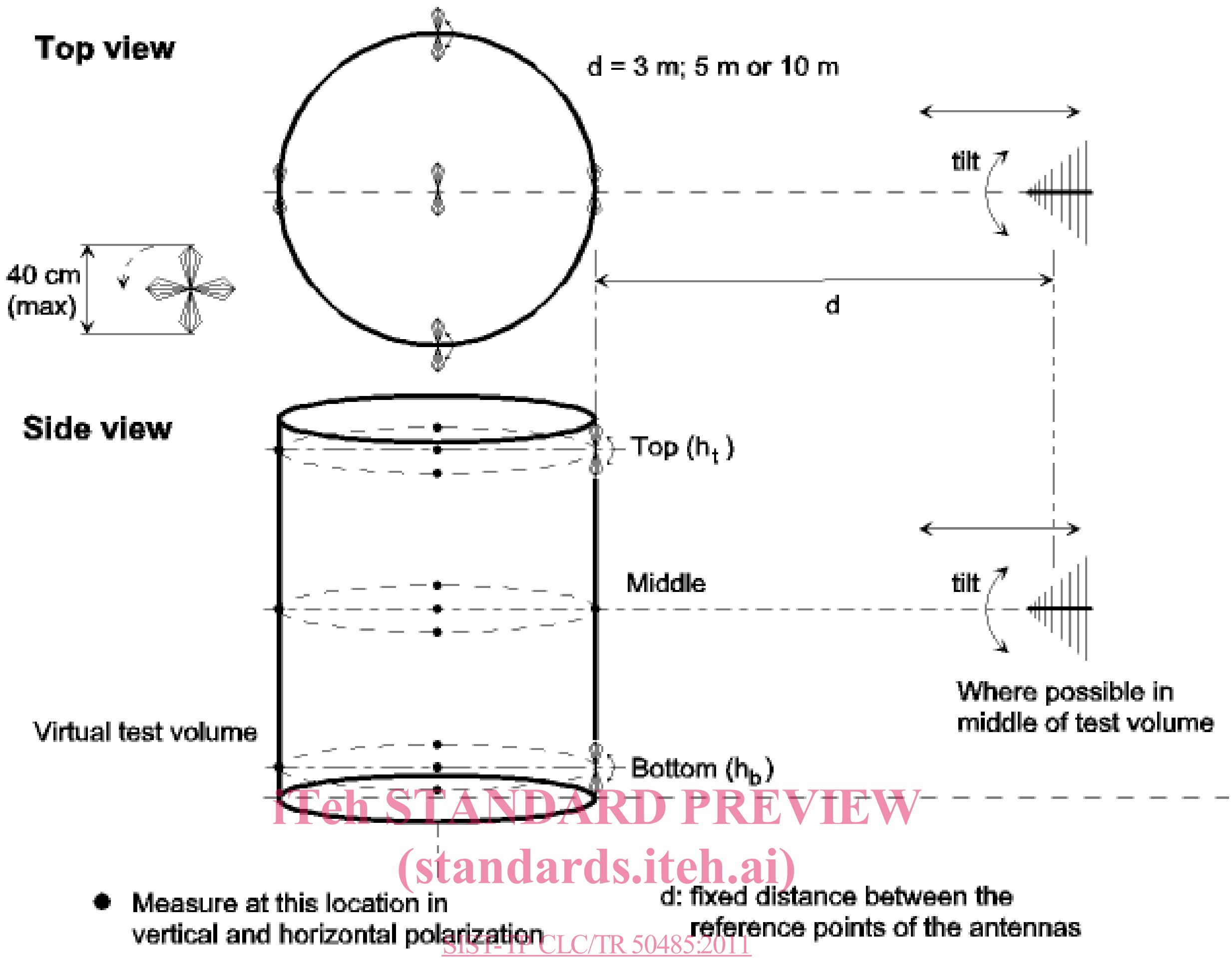


Figure 2 – Measurement points in room validation procedure

For each measurement the frequency range is incrementally swept. The frequency step size shall not exceed 1 % and need not be less than 1 MHz as given in Table 1.

Table 1 – Frequency ranges and step sizes

Frequency range MHz	**Maximum frequency step** MHz
30 – 100	1
100 – 500	5
500 – 1 000	10

For validating the room performance, two methods exist:

1) the site-reference method, preferred for a test distance up to 5 m;

2) the *NSA*-method, preferred for test distances larger than 5 m.

NOTE With reference to the site reference method, achieving quasi-free space conditions requires expertise. The problem is in sufficiently eliminating reflections from the ground. In practice this probably confines the site reference method as described in Annex A to distances of less than 5 m. On the other hand there are also limitations with the *NSA* method in that the free space antenna factor is used. At 3 m distance the antenna coupling is not negligible and expertise is required to correct the free space antenna factor for coupling. A practical solution is to confine the *NSA* method to distances greater than 5 m. Corrections, such as to phase centre, are required, but this can be done precisely.