

**Guidelines on how to use
anechoic enclosures that do
not fulfil the requirements
regarding normalized site
attenuation for pre-compliance
tests of products**

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Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Foreword	2
Text of R110-003	3

National foreword

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English version

Guidelines on how to use anechoic enclosures that do not fulfil the requirements regarding normalized site attenuation for pre-compliance tests of products

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

A number of existing enclosures cannot meet the requirements concerning normalized site attenuation (NSA) proposed in EN 50147-2 for radiated emissions. Whilst these enclosures may not be accepted for final compliance testing, they can be very useful for other measurements, e.g. in the development phase of products.

Users are encouraged to submit reports on their own results of normalized site attenuation measurements and chamber factor measurements to the Chairman of Working Group 4, address as below:

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Contents

	Page
Foreword	2
1 Scope	3
2 Object	3
3 Definitions	3
3.1 Semi anechoic enclosure	3
3.2 Fully anechoic enclosure	3
3.3 Chamber factor	3
3.4 Grey factor	4
4 Theory concerning the use of chamber factors	4
5 Equipment for chamber factor measurements	5
6 Reference site	6
6.1 Reference site for semi anechoic enclosures	6
7 Procedure for Chamber factor measurements	6
7.1 Semi anechoic enclosure	6
8 Determination of chamber factor and grey factor	7
8.1 Semi anechoic enclosure	7
9 Application of chamber factor and grey factor	8
10 Error budget	8
11 References	9
Figures	10
Annex A Specification of reference radiator	15
Annex B Examples of results of normalized site attenuation measurements and chamber factor measurements	16
B.1 Measurement methods	16
B.2 Test equipment	16
B.3 Reference sites	16
B.4 Calibration of broadband antennas	16
B.5 Results	17
B.6 Conclusions	18

1 Scope

This guideline deals with the application of absorber-lined enclosures for radiated-emission tests according to CISPR 16 [1], CISPR 11[2], CISPR 22 [3] and EN 50147-2 [4] in the frequency range of 30 - 1000 MHz.

Standard site acceptability criteria based on normalized site attenuation (NSA) measurements are given in [1, 4]. The chamber factor concept shall provide a method for more detailed evaluations of the performance characteristics of enclosures. Measured chamber factor data can, furthermore, be used to correlate test results from equipment under test (EUT) to open site results. Whereas NSA evaluates chamber performance with respect to theoretically calculated reference values, chamber factors are derived from comparative measurements between an enclosure and a good reference site.

If the measured site attenuation exceeds the " ± 4 dB"-limit only in the frequency range of 30 - 200 MHz and by not more than ± 12 dB, then the methods described in this report may be applied. For equipment that is no larger than half a wavelength (including cables) the enclosure can then be used at the expense of higher test uncertainty in the lower frequency range.

2 Object

The object of this guideline is to give assistance in the evaluation of shielded anechoic enclosures used for radiated emission measurements. Furthermore it describes acceptability criteria for pre-compliance/diagnostic tests of products during their development stage where the NSA criterion of ± 4 dB is exceeded.

3 Definitions

3.1 Semi-anechoic enclosure

Shielded enclosure where all internal surfaces are covered with anechoic material, except the floor, which is reflective (metal groundplane). Protecting material on the groundplane must not influence the reflectivity.

3.2 Fully anechoic enclosure

Shielded enclosure where all internal surfaces are covered with anechoic material.

3.3 Chamber factor

Individual correlation factor of a particular test volume in a particular enclosure to an open area test site (OATS) as the reference.

3.4 Grey factor

Uncertainty in chamber factor.

4 Theory concerning the use of chamber factors

The chamber factor is a new concept for comprehensive evaluation of anechoic enclosures. If necessary, the enclosure characteristics measured in the chamber factor test can also be used to correct measurements in such a manner as to enable a comparison with OATS test results.

The evaluation of chamber characteristics based on the normalized site attenuation with broadband dipole antennas is regarded as incomplete. The effective reflection attenuation of absorbers is a function of the impedance of the waves impinging on the absorbers: particularly in the frequency range of 30 MHz to 200 MHz absorbers exhibit different reactions to fields radiated by various field sources.

Undesired wall reflections due to insufficient performance of the absorbers can cause errors in radiated emission test results. To some extent, these errors can be corrected by applying chamber factors, which are functions of the following parameters:

1. Phases of undesired reflected waves

Dipole- and loop-type sources can cause reflected waves of different phase [5]. Actual equipment under test (EUT) typically contains both kinds of radiating sources.

2. Wave impedance in the near-field of the source

Absorber reflectivity is a function of the wave impedance. Dipole-type sources generate high-impedance fields in the near-field, loop-type sources generate low-impedance fields in the near-field. In the frequency range of 30 MHz to 200 MHz, the absorbers may not be located in the far field of the EUT, depending on the dimensions of the chamber and of the EUT, i. e. the wave impedance deviates from the 377Ω characteristic impedance in free space. EUT typically contains both kinds of radiating sources.

Thus it is necessary to determine the response of the absorbers to various EUTs. However the EUT cannot be properly simulated unless it is used for just these purposes: The reaction of the absorbers towards different EUTs is not predictable. Two extreme EUT configurations can be simulated. On the one hand, EUTs with a high-impedance field source and, on the other hand, EUTs with a low-impedance field source. If a shortened dipole is used as the high-impedance field source and a loop is used as the low-impedance field source, the possible extremes of the impedance spectrum of a field generated by real EUTs can be simulated, i. e. the impedance of a wave generated by a random EUT lies between the simulated extremes. The aim of this simulation with two different field sources is thus not to simulate a random number of complex radiation emission behaviours of real EUTs, but rather, to register the response of the absorbers to extreme wave impedances and thus determine the characteristics of the absorber enclosure as a measuring device. In contrast to this, the NSA only characterises the enclosure for high-impedance field sources.

3. Volume occupied by EUT

Sources of radiation can be located anywhere within an EUT or even on outside connection cables such as the mains supply line. Phase relationships between direct, ground-reflected and undesired reflected waves change when the position of the source changes. Thus, errors in field-strength readings can be of different magnitude for EUT of different sizes. This phenomenon makes it impossible to introduce chamber factors of general validity for equipment that is larger than approximately half a wavelength. For equipment of given maximum linear dimension d (in meters, including cables!) the upper frequency limit F_G for the application of chamber factors is $F_G \text{ [MHz]} = 150/d$.

The idea of the chamber factor is to determine the possible spread in the correlation factors that can occur, when the above mentioned parameters are varied. This has to be done for each frequency and polarisation. Then the mean correlation factor for each frequency and polarisation is used as the chamber factor. Alternatively, the upper envelope curve of all correlation factors can be used as worst-case chamber factor.

Chamber factors are determined by comparative measurements between a reference open-area test site (reference OATS) and the enclosure.

Experience has shown that comparative measurements using actual EUT are not suitable to determine correlation factors: Emissions are usually not sufficiently stable in frequency and amplitude. The number of spectral lines is not sufficient and their frequency spacing is too large to allow sufficient resolution of narrowband resonances. Furthermore, reproducibility is poor if any cable connections are used (e. g. mains supply line). These cables are radiators. For cables that are at least a quarter wavelength long, the radiation characteristics can change significantly when the cable layout is changed.

Therefore a suitable reference radiator (see Annex A informative) should be used for the comparative measurements. This radiator is operated in turn on the reference OATS and in the enclosure. Field-strength is recorded in both cases using the standard test procedure.

The effect of extreme values of the parameters 1 (phase) and 2 (wave impedance) on the wave propagation conditions in the chamber is found if the reference radiator is equipped first with a dipole antenna (generating high wave impedance in the near-field) and then with a loop antenna (generating low wave impedance in the near-field).

Extreme values of parameter 3 (volume) are found, if the "volume method" given by CENELEC [4] is applied: 10 different positions of the transmit antenna within the volume that can be occupied by EUT.

5 Equipment for chamber factor measurements

The reference radiator shall operate without any metallic cable connections, as these would act as secondary radiators. The generator shall at least provide the following frequency resolution:

30 - 100 MHz:	Frequency step $\leq$ 1 MHz
100 - 200 MHz:	Frequency step $\leq$ 5 MHz
200 - 500 MHz:	Frequency step $\leq$ 5 MHz
500 - 1000 MHz:	Frequency step $\leq$ 10 MHz

Furthermore, the frequency spacing has to be sufficiently large to ensure, that the receiver / spectrum analyzer always measures sinewave signals. Broadband measurements of a continuous noise spectrum could cause additional errors.

Computer-controlled operation is necessary in order to allow fast, efficient measurements. Software for automatic data acquisition, processing and documentation is recommended.

One set of comparative measurements is made using the dipole, then another set of measurements is made using the loop of the reference radiator.

The receive antenna shall be of the same kind as the antenna that is used for radiated-emission tests of EUTs in the enclosure that is investigated.

Attention should be paid to the influence of the receive antenna cable in vertical polarisation. It is recommended to

- use ferrite loaded cable to reduce common mode current on the cable shield
- route the cable horizontally away behind the antenna for at least two meters
- use the same cable layout for both the measurements on the reference site (OATS) and in the enclosure.

6 Reference sites

6.1 Reference site for semi anechoic enclosures

In order to achieve high accuracy in the chamber factors it is necessary to use an OATS, that has a site attenuation with only very small deviations from the ideal values, see paragraph 10.

7 Procedure for chamber factor measurements

Measurements shall be carried out in the frequency range of 30-200 MHz in order to determine chamber factors. Furthermore it is recommended to investigate the performance of the site also in the frequency range of 200-1000 MHz.

The set of measurements specified in subclause 7.1 is considered the minimum number necessary to determine the possible spread in the correlation factors. Additional measurements may be needed in special cases.

7.1 Semi anechoic enclosure

1. The reference radiators are operated on the reference site. Transmit antennas are chosen as specified in section 5. All configurations of transmit and receive antenna given in Figure 1 (dipole and loop, horizontal and vertical polarisation) and Figure 2 (volume method) are used in turn.

For each combination, field-strength is recorded as a function of frequency and polarisation. These field-strength measurements shall be carried out in exactly the same way as it is done in radiated-emission measurements in the enclosure to be calibrated.