

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

AMENDMENT 1  
AMENDEMENT 1

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

**Compatibilité électromagnétique (CEM) –  
Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs  
électromagnétiques rayonnés aux fréquences radioélectriques**

IT'S STANDARD PREVIEW  
(standards.iteh.ai)

IEC 61000-4-3:2006/AMD1:2007  
<https://standards.iteh.ai/catalog/standards/sist/216280b7-abff-456a-88e3-d7e3e26c0e0e/iec-61000-4-3-2006/amd1-2007>





## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Email: [inmail@iec.ch](mailto:inmail@iec.ch)  
Web: [www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: [www.iec.ch/webstore/custserv](http://www.iec.ch/webstore/custserv)

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00

### A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: [www.iec.ch/searchpub/cur\\_fut-f.htm](http://www.iec.ch/searchpub/cur_fut-f.htm)

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: [www.iec.ch/webstore/custserv/custserv\\_entry-f.htm](http://www.iec.ch/webstore/custserv/custserv_entry-f.htm)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tél.: +41 22 919 02 11  
Fax: +41 22 919 03 00



# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

AMENDMENT 1  
AMENDEMENT 1

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

**Compatibilité électromagnétique (CEM) –  
Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs  
électromagnétiques rayonnés aux fréquences radioélectriques**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

PRICE CODE  
CODE PRIX

R

## FOREWORD

This amendment has been prepared by subcommittee 77B: High frequency phenomena of IEC technical committee 77: Electromagnetic compatibility.

The text of this amendment is based on the following documents:

FDIS	Report on voting
77B/546/FDIS	77B/556/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.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**iTeh STANDARD PREVIEW**  
(standards.iteh.ai)

Page 3

CONTENTS

[IEC 61000-4-3:2006/AMD1:2007](https://standards.iteh.ai/catalog/standards/sist/216280b7-abff-456a-88e3-000da5fe0e76/iec-61000-4-3-2006-amd1-2007)  
<https://standards.iteh.ai/catalog/standards/sist/216280b7-abff-456a-88e3-000da5fe0e76/iec-61000-4-3-2006-amd1-2007>

*Add, to the existing list of annexes, the following new title:*

Annex I (informative) Calibration method for E-field probes

Page 25

*Add, at the end of the sixth dashed item (beginning with “– An isotropic field sensor”), the following new sentence:*

Annex I provides a calibration method for E-field probes.

Page 111

*Add the following new annex:*

## **Annex I** (informative)

### **Calibration method for E-field probes**

#### **I.1 Overview**

E-field probes with broad frequency range and large dynamic response are extensively used in the field uniformity calibration procedures in accordance with IEC 61000-4-3. Among other aspects, the quality of the field probe calibration directly impacts the uncertainty budget of a radiated immunity test.

Generally, probes are subject to relatively low field strengths, e.g. 1 V/m – 30 V/m, during the field uniformity calibration in accordance with IEC 61000-4-3. Therefore a calibration of the E-field probes used within IEC 61000-4-3 shall take the intended frequency and dynamic ranges into consideration.

Currently probe calibration results may show differences when the probe is calibrated in different calibration laboratories. Therefore the environment and method for a field probe calibration are to be specified. This annex provides relevant information on calibration of probes to be used in IEC 61000-4-3.

For frequencies above the several hundred megahertz to gigahertz range, using standard gain horn antennas to establish a standard field inside an anechoic chamber is one of the most widely used methods for calibrating probes for IEC 61000-4-3 applications. However, there is a lack of an established method for validating the test environment for field probe calibrations.

In using this method, differences have been observed between calibration laboratories, beyond their reported measurement uncertainties.

Field probe calibrations in the 80 MHz to a few hundred megahertz range that are usually carried out in TEM waveguides are generally found to be more reproducible.

This informative annex therefore concentrates on improving the probe calibration procedures with horn antennas in anechoic chambers to which a comprehensive calibration procedure is depicted.

#### **I.2 Probe calibration requirements**

##### **I.2.1 General**

The calibration of E-Field probes intended to be used for UFA calibration procedure as defined in IEC 61000-4-3 shall satisfy the following requirements.

##### **I.2.2 Calibration frequency range**

The frequency range shall normally cover 80 MHz to 6 GHz but it may be limited to the frequency range required by the tests.

##### **I.2.3 Frequency steps**

To be able to compare test results between different calibration laboratories, it is necessary to use fixed frequencies for the calibration.

80 MHz to 1 GHz:

Use the following frequencies for the calibration of E-field probes (typically 50 MHz step width)

80, 100, 150, 200, ..., 950, 1 000 MHz

1 GHz to 6 GHz:

Use the following frequencies for the calibration of E-field probes (200 MHz step width)

1 000, 1 200, 1 400, ..., 5 800, 6 000 MHz

NOTE It is not intended to measure a probe at 1 GHz twice, but in case it is used up to or from 1 GHz, the probe needs to be measured at that frequency.

### I.2.4 Field strength

The field strength at which a probe is calibrated should be based on the field strength required for the immunity test. As the preferred method for uniformity field calibration is carried out at field strength of at least 1,8 times the field strength to be applied to the EUT, it is recommended that the probe calibration be carried out at twice the intended test field strength (see Table I.1). If a probe is to be used at different field levels, it has to be calibrated at multiple levels according to its linearity, at least the minimum and maximum levels. See also I.3.2.

NOTE 1 This also covers the 1 dB compression requirement of the power amplifier.

NOTE 2 The calibration is performed using CW signals without modulation.

**Table I.1 – Calibration field strength level**

Calibration level	Calibration field strength
1	2 V/m
2	6 V/m
3	20 V/m
4	60 V/m
X	Y V/m

NOTE X,Y is an open calibration level which can be higher or lower than one of the other levels 1-4. This level may be given in the product specification or test laboratory.

## I.3 Requirements for calibration instrumentation

### I.3.1 Harmonics and spurious signals

Any harmonics or spurious signals from the power amplifiers shall be at least 20 dB below the level at the carrier frequency. This is required for all field strength levels used during calibration and linearity check. Since the harmonic content of power amplifiers is usually worse at higher power levels, the harmonic measurement may be performed only at the highest calibration field strength. The harmonic measurement can be performed using a calibrated spectrum analyzer which is connected to the amplifier output through an attenuator, or through a directional coupler.

NOTE 1 The antenna may have additional influence on harmonic content and may need to be checked separately.

Calibration laboratories shall perform a measurement to validate that the harmonic and/or spurious signals from the amplifier satisfy the requirements for all measurement setups. This

may be done by connecting a spectrum analyzer to Port 3 of the directional coupler (replacing the power meter sensor with the spectrum analyzer input – see Figure I.2).

NOTE 2 It should be assured that the power level does not exceed the maximum allowable input power of the spectrum analyzer. An attenuator may be used.

The frequency span shall cover at least the third harmonic of the intended frequency. The validation measurement shall be performed at the power level that will generate the highest intended field strength.

Harmonic suppression filters may be used to improve the spectrum purity of the power amplifier(s) (see Annex D).

### I.3.2 Linearity check for probe

The linearity of the probe which is used for the chamber validation according to I.4.2.5 shall be within  $\pm 0,5$  dB from an ideal linear response in the required dynamic range (see Figure I.1). Linearity shall be confirmed for all intended range settings if the probe has multiple ranges or gain settings.

In general probe linearity does not change significantly with frequency. Linearity checking can be performed at a spot frequency that is close to the central region of the intended use of frequency range, and where the probe response versus frequency is relatively flat. The selected spot frequency is to be documented in the calibration certificate.

The field strength for which the linearity of the probe is measured should be within  $-6$  dB to  $+6$  dB of the field strength which is used during the validation of the chamber, with a sufficiently small step size, e.g. 1 dB. Table I.2 shows an example of the field strength levels to be checked for a 20 V/m application.

IEC 61000-4-3:2006/AMD1:2007  
<https://standards.iteh.ai/catalog/standards/sist/216280b7-abff-456a-88e3-000da51e0e76/iec-61000-4-3-2006-amd1-2007>  
**Table I.2 – Example for the probe linearity check**

Signal level	Calibration field strength
dB	V/m
-6,0	13,2
-5,0	14,4
-4,0	14,8
-3,0	15,2
-2,0	16,3
-1,0	18,0
0	20,0
1,0	22,2
2,0	24,7
3,0	27,4
4,0	30,5
5,0	34,0
6,0	38,0

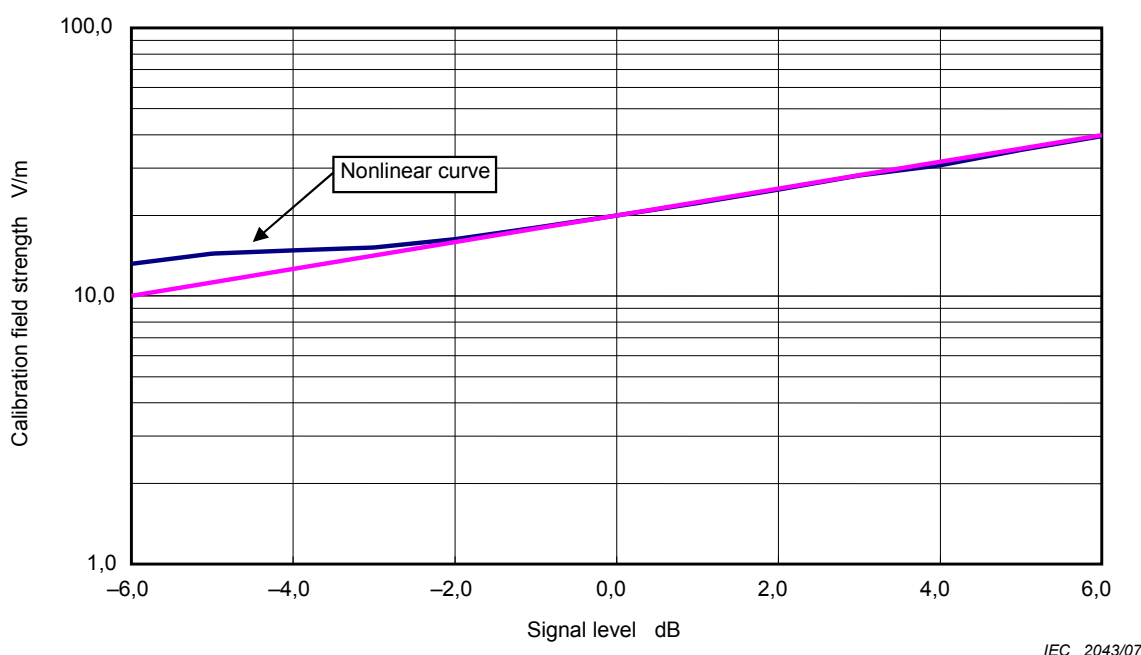


Figure I.1 – Example of linearity for probe

### I.3.3 Determination of the gain of the standard horn antennas

Far field gain of the standard pyramidal horn antennas can be determined fairly accurately (less than 0,1 dB of uncertainties have been reported in [1]<sup>1</sup>). The far-field gain is typically valid for distances greater than  $8D^2/\lambda$  (where  $D$  is the largest dimension of the horn aperture, and  $\lambda$  is the wavelength). Calibrations of field probes at such distances may not be practical due to the large anechoic chamber and high power amplifiers required. Field probes are typically calibrated in the near field region of the transmitting antennas. The near-field gain of standard gain horn antennas have been determined by using equations such as those described in [2]. The gain is computed based on the physical dimensions of a standard pyramidal horn, and by assuming a quadratic phase distribution at the horn aperture. The gain determined in this manner is inadequate for use in performing the chamber VSWR test and subsequent probe calibrations.

The equations (as given in [2]) were derived using aperture integration, by assuming that no reflection occurs at the aperture of the horn and that the field incident on the aperture is a TE<sub>10</sub> mode, but with a quadratic phase distribution across the aperture. Some approximations were applied during the integration to obtain the close form result. Other effects such as multiple reflections from the horn edge, and higher order modes at the aperture are not accounted for. Depending on the frequency and horn design, the error is generally in the order of  $\pm 0,5$  dB, but can be larger.

For better accuracy, a numerical method using full wave integration can be used. For example, the uncertainties in the gain calculation by a numerical method can be reduced to less than 5 % [3].

The gain of a horn antenna can also be determined experimentally. For example, the gain can be determined at reduced distances with a three-antenna method by an extrapolation technique, such as that described in [4], or some variations of the method.

<sup>1</sup>) Figures in square brackets refer to the reference documents in Clause I.6.



It is recommended that the distance between the horn antenna and the probe under test be at least  $0,5D^2 / \lambda$  during the calibration. Large uncertainties in determining gains can result from a closer distance. The standing waves between the antenna and the probe can also be large for closer distances, which again would result in large measurement uncertainties in the calibration.

## **I.4 Field probe calibration in anechoic chambers**

### **I.4.1 Calibration environments**

The probe calibration should be performed in a fully anechoic room (FAR) or in a semi-anechoic chamber with absorbers on the ground plane which satisfies the requirement of I.4.2.

When a FAR is used, the recommended minimum size of the FAR internal working volume for performing the probe calibration is 5 m (D) × 3 m (W) × 3 m (H).

NOTE 1 For frequencies above several hundred MHz, using standard gain horn antennas to establish a standard field inside an anechoic chamber is one of the most widely used methods for calibrating field probes for IEC 61000-4-3 applications. At lower frequencies, such as 80 MHz to several hundred MHz, the use of an anechoic chamber may not be practical. So the field probe may be calibrated in other facilities also used for immunity tests against electromagnetic fields. Therefore, TEM waveguides etc. are included in this annex as alternative calibration environments for these lower frequencies.

The system and the environment used for probe calibration shall meet the following requirements.

NOTE 2 Alternatively, the electric field can be established using a transfer probe (see I.5.4).

### **I.4.2 Validation of anechoic chambers for field probe calibration**

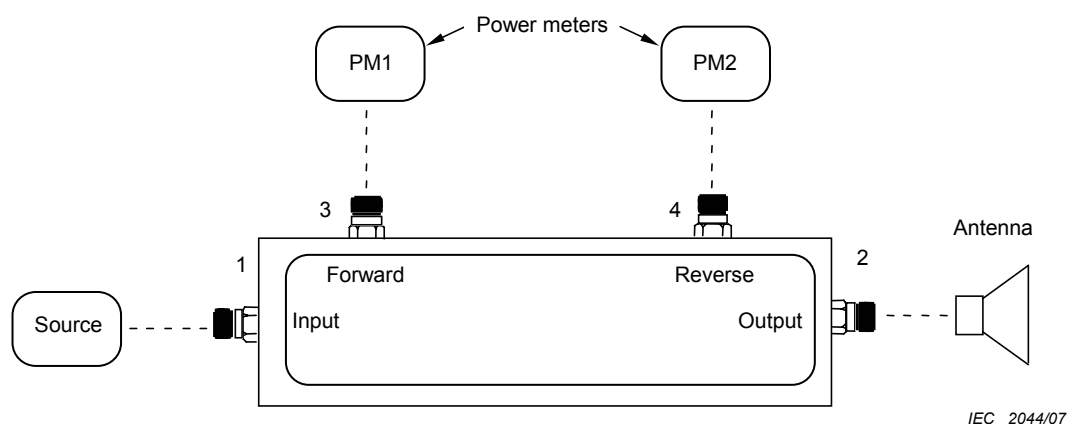
The probe calibration measurements assume a free space environment. A chamber VSWR test using a field probe shall be performed to determine whether it is acceptable for subsequent probe or sensor calibration. The validation method characterizes the performance of the chamber and absorbing material.

Each probe has a specific volume and physical size, for example the battery case and/or the circuit board. In other calibration procedures, a spherical quiet zone is guaranteed in the calibration volume. The specific requirements of this annex concentrate on a VSWR test for test points located at the antenna beam axes.

Test fixtures and their influences (such as the fixtures to hold the probe, which may be exposed to electromagnetic fields and interfere with the calibration) cannot be entirely evaluated. A separate test is required to validate the influences of the fixtures.

#### **I.4.2.1 Measuring net power to a transmitting device using directional couplers**

Net power delivered to a transmitting device can be measured with a 4-port bi-directional coupler, or two 3-port single directional couplers connected back-to-back (forming the so-called "dual directional coupler"). A common setup using a bi-directional coupler to measure the net power to a transmitting device is shown in Figure I.2.



**Figure I.2 – Setup for measuring net power to a transmitting device**

The forward coupling, reverse coupling and transmission coupling are defined as the following equations in case where each port is connected with a matched load and a matched source:

$$C_{\text{fwd}} = \frac{P_3}{P_1},$$

$$C_{\text{rev}} = \frac{P_4}{P_2},$$

$$C_{\text{trans}} = \frac{P_2}{P_1},$$

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

where  $P_1, P_2, P_3, P_4$  are the respective powers at each port of the directional coupler.

The net power delivered to the transmitting device is then:

$$P_{\text{net}} = \frac{C_{\text{trans}}}{C_{\text{fwd}}} PM_1 - \frac{PM_2}{C_{\text{rev}}},$$

where  $PM_1$  and  $PM_2$  are the power meter readings in linear units.

Where the VSWR of the antenna is known, then a single three-port coupler can be used. For example, when the antenna has a VSWR of 1,5 this is equivalent to a voltage reflection coefficient (VRC) of 0,2.

The accuracy is affected by the directivity of the coupler. The directivity is a measure of the coupler's ability to isolate the forward and the reverse signals. For a well-matched transmitting device, the reverse power is much smaller than the forward power. The effect of the directivity is therefore less important than in a reflectivity application. For example, when the transmitting antenna has a VSWR of 1,5 and the coupler has a directivity of 20 dB, the absolute maximum uncertainty in the net power due to the finite directivity is 0,22 dB – 0,18 dB = 0,04 dB with a U-shaped distribution (where the 0,22 dB is the loss of the apparent incident power due to VSWR of 1,5).

The net power delivered to the transmitting device is then:

$$P_{\text{net}} = C_{\text{fwd}} PM_1 (1 - VRC^2)$$

#### I.4.2.2 Establishing a standard field using horn antennas

The gain of the horn antenna is determined by the methods described in I.3.3. The on-axis electric field (in V/m) is determined by

$$E = \sqrt{\frac{\eta_0 P_{\text{net}} g}{4\pi}} \frac{1}{d},$$

where  $\eta_0 = 377 \Omega$  for free space,  $P_{\text{net}}$  (in W) is the net power determined by the method described in I.4.2.1,  $g$  is the numeric gain of the antenna determined by I.3.3 and  $d$  (in m) is the distance from the antenna aperture.

#### I.4.2.3 Chamber validation test frequency range and frequency steps

The chamber VSWR test shall cover the frequency range for which the calibration of the probe is intended, and use the same frequency steps as given in I.2.3.

VSWR tests shall be carried out in the chamber at the lowest and highest frequencies of operation of each antenna. Where narrow band absorbers are used, e.g. ferrites, more frequency points may need to be measured. The chamber should be used for probe calibration only in the frequency range where it meets the VSWR criteria.

#### I.4.2.4 Chamber validation procedure

The chamber used for the probe calibration shall be verified by the following procedure, except in cases where the physical conditions of the chamber do not allow it to be used. In such cases the alternative method of I.4.2.7 can be applied.

The probe shall be located at the measurement position using a support material with a low permittivity (e.g. styrene foam) in accordance with Figure I.3 and Figure I.4.

A field probe is placed at the location where it will be used for calibration. Its polarization and position along the boresight of the transmitting horn antenna will be varied to determine the chamber VSWR. The transmit antenna shall be the same for both the chamber VSWR test and the probe calibration.

The arrangements of the standard gain horn antenna and the probe inside the chamber are shown in Figure I.3. The probe and the horn antenna shall be set on the same horizontal axis with a separation distance  $L$  measured from the front face of the antenna to the centre of the probe.

In every case the field probe shall be laterally positioned in the centre of the horn antenna face.

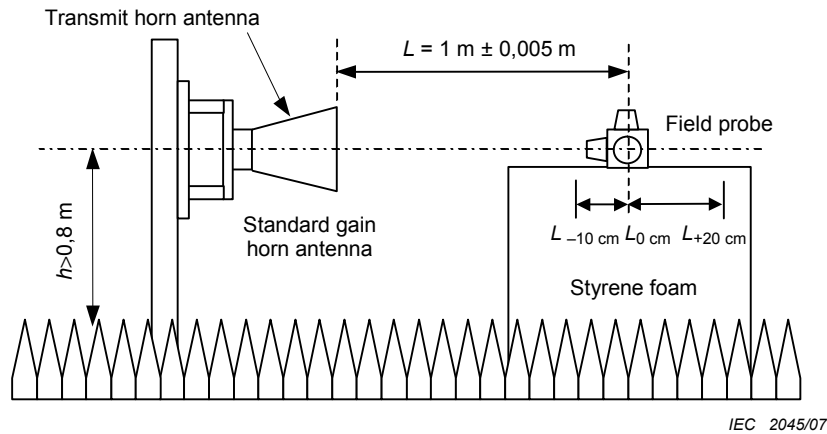


Figure I.3 – Test setup for chamber validation test

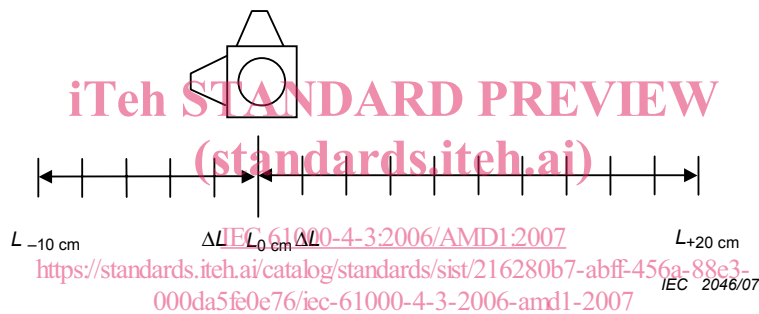


Figure I.4 – Detail for measurement position  $\Delta L$

The setup is illustrated in Figure I.3 and Figure I.4, where  $L_{-10\text{ cm}}$  to  $L_{+20\text{ cm}}$  is the probe calibration distance, measured from the face of the horn antenna to the centre of the field probe.  $L_0\text{ cm}$  is defined as position 0.

The positions will be  $L_{-10\text{ cm}}$ ,  $L_{-8\text{ cm}}$ ,  $L_{-6\text{ cm}}$ , ...,  $L_0$ ,  $L_{+2\text{ cm}}$ ,  $L_{+4\text{ cm}}$ , ...,  $L_{+20\text{ cm}}$ ,  $\Delta L = 2\text{ cm}$ .

If the probe is placed in the near field of the transmitting horn antenna (distance  $< 2 D^2/\lambda$ , where  $D$  is the largest dimension of the antenna and  $\lambda$  is the free space wavelength), the gain of the transmitting antenna is not constant, and may need to be determined for each position.

A constant power creating certain field strength (e.g. 20 V/m) at 1 m distance is applied for all probe positions. With the transmit antenna and field probe both vertically polarized, the probe readings for all positions at all frequencies are recorded. The test is repeated with antenna and probe horizontally polarized.

All the readings shall satisfy the requirement shown in I.4.2.5.

**I.4.2.5 VSWR acceptance criteria**

VSWR measurement results shall be compared by using the following procedure. For the calculation of the field strength, refer to I.4.2.2.

- a) Calculation of the field strength

The electrical field strength in the spatial area between the distances 90 cm and 120 cm is calculated in 2 cm steps for each frequency.

This calculation is based on the E-field strength of a 1 m distance used for verification.

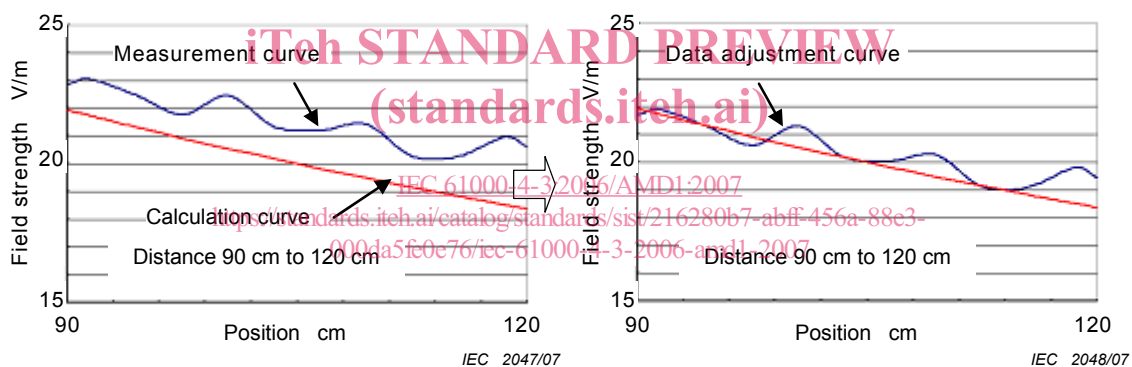
#### b) Data adjustment

Data is adjusted with the following process because the probe used for the VSWR measurement may not deliver a reading equal to the calculated field strength.

- E-field strength indication value of the probe at a 1 m distance shall be adjusted to the 1 m position of the calculation. The obtained difference between probe indications and calculated strength is used as the correction value  $k$  for all the data at 90 cm and 120 cm.

For example: comparison between probe measurement value  $V_{mv}$  (e.g. 21 V/m) and calculated value  $V_{cv}$  (e.g. 20 V/m) at 1 m distance. In this case the correction value  $k$  is  $V_{cv} - V_{mv} = -1$  V/m.

- The correction value  $k$  shall be added to the data that is observed at 90 cm to 120 cm measurement positions.
- The same calculation shall be applied to all measurement values of all measured frequencies. In the case of the above example,  $k = -1$  V/m. Therefore  $k = -1$  is added to all probe measurement value data.



**Figure I.5 – Example of data adjustment**

#### c) Comparison of measurement data and calculation data

When the data difference in calculation curve and measurement curve exceeds  $\pm 0,5$  dB in any measurement position, the chamber shall not be used for probe calibration.

NOTE The 0,5 dB criterion is established according to the measurement uncertainty budget and has been verified in several existing chambers that are suitable for calibration of field probes (including at least one national measurement institute calibration facility). It is anyhow only one contributor to the overall uncertainty.

Some field probes have a metal box or a pole such as the battery or a circuit. These units may cause reflection errors at certain distances and frequencies. When these probes are used, the influence of the reflection shall be minimized e.g. by rotating the probe or changing its orientation.

#### I.4.2.6 Probe fixture validation

The probe fixture may cause reflections of electromagnetic fields during the probe calibration. Therefore, the influence of the fixture on the calibration results shall be checked in advance.

The procedure defined in this clause shall be performed for any new probe fixtures to be used.