IEC 62110

Edition 1.0 2009-08

INTERNATIONAL STANDARD

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colour inside

Electric and magnetic field levels generated by AC power systems – Measurement procedures with regard to public exposure

Champs électriques et magnétiques générés par les systèmes d’alimentation à courant alternatif – Procédures de mesure des niveaux d’exposition du public

IEC 62110:2009

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX XA

ICS 17.220.20; 29.240

ISBN 2-8318-1059-3

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRIC AND MAGNETIC FIELD LEVELS GENERATED BY AC POWER SYSTEMS – MEASUREMENT PROCEDURES WITH REGARD TO PUBLIC EXPOSURE

FOREWORD

International Standard IEC 62110 has been prepared by IEC technical committee 106: Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure.

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

FDIS	Report on voting
106/177/FDIS	106/185/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Terms defined in Clause 3 appear in *italics* throughout the document.

The committee has decided that the contents of this 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- withdrawn,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.

The contents of the corrigendum of January 2015 have been included in this copy.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

All populations of the world are now exposed to electric and magnetic fields and the levels will continue to increase with developing industry and technology. A number of countries have implemented regulations on public exposure to these fields. Therefore, in order to evaluate human exposure levels to these fields adequately, common measurement procedures are required by not only professionals of national authorities and electric power industries, but also the general public.

This standard is applied to the measurement of fields generated by AC power systems in areas accessible to the public. It establishes a common measurement procedure to evaluate the exposure levels of the human body to electric and magnetic fields among the general public.

The values obtained are for use to determine whether the fields comply with exposure limits by comparing them with the field limits for general public exposure such as the reference levels from the ICNIRP (International Commission on Non-Ionizing Radiation Protection) Guidelines [1][1)], MPE (maximum permissible exposure) from the IEEE (Institute of Electrical and Electronics Engineers) [2] or in national regulations. If the values obtained are higher than the reference level or MPE, it does not necessarily mean that the basic restriction has been exceeded, in which case other methods must be used to ensure that basic restriction is not exceeded.

The values obtained by using the procedures in this standard are for the load conditions occurring at the time of measurement. Therefore, in the case of magnetic field, in order to check compliance with some exposure guidelines or regulations these values may need to be extrapolated to take account of the maximum load of the circuits.

This standard is not applicable to occupational exposure associated with, for example, the operation and/or maintenance of the power systems. Such exposure may occur when working inside a distribution or transmission substation, a power plant, in a manhole or a tunnel for underground cables, or on an overhead line tower or pole.

[1)] Numbers in square brackets refers to the Bibliography.

ELECTRIC AND MAGNETIC FIELD LEVELS GENERATED BY AC POWER SYSTEMS – MEASUREMENT PROCEDURES WITH REGARD TO PUBLIC EXPOSURE

1 Scope

This International Standard establishes measurement procedures for electric and magnetic field levels generated by AC power systems to evaluate the exposure levels of the human body to these fields. This standard is not applicable to DC power transmission systems.

This International Standard is applicable to public exposure in the domestic environment and in areas accessible to the public.

This standard specifies fundamental procedures for the measurement of fields, and, with regard to human exposure, for obtaining a field value that corresponds to a spatial average over the entire human body.

This standard is not applicable to occupational exposure associated with, for example, the operation and/or maintenance of the power systems. Such exposure may occur when working inside a distribution or transmission substation, a power plant, in a manhole or a tunnel for underground cables, or on an overhead line tower or pole.

2 Normative 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.

IEC 61786, *Measurement of low-frequency magnetic and electric fields with regard to exposure of human beings – Special requirements for instruments and guidance for measurements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions given below apply. Internationally accepted SI-units are used throughout the standard.

NOTE The distinction between “magnetic flux density” and “magnetic field strength” is only relevant when considering magnetic fields in magnetic materials. In air it is common to use “magnetic fields” as a generic term to cover both of these two quantities.

3.1
single-point measurement
procedure to measure the field level at a specified height, used for uniform fields

NOTE The conditions under which the field can be considered as uniform or non-uniform are given in section 5.1.

3.2
three-point measurement
procedure to measure the field levels at three specified heights at a single location, used for non-uniform fields

3.3
five-point measurement
procedure to measure the field levels at five points at a specified height, used for non-uniform fields generated by field sources below the floor or the ground

3.4
average exposure level
spatial average over the entire human body of fields to which the individual is exposed

3.5
three-point average exposure level
arithmetic mean of the three values obtained from the *three-point measurement* or of the largest three values obtained from the *five-point measurement*

NOTE This arithmetic mean is used as an estimate of the *average exposure level* at a single location.

3.6
maximum exposure level
the maximum of the single-point measurements or *average exposure levels* over the area of interest

3.7
power system
system consisting of overhead lines and underground cables, substations and other power distribution and transmission equipment. Railway systems are covered by a specific standard and therefore are excluded from the present standard.

4 Measurement principle for electric and magnetic fields

4.1 General

Detailed generic information and requirements regarding measurement of electric and magnetic fields are given in IEC 61786 and in other technical documents such as CIGRE technical brochures [6][8] and IEEE guides [7][9].

4.2 Instruments

Instruments for measuring electric and magnetic fields shall meet the requirements regarding calibration and specification given in IEC 61786 or another appropriate national or international standard. These instruments should be used under appropriate conditions, particularly with regard to electromagnetic immunity, temperature, and humidity, recommended by the manufacturer.

A three-axis instrument measures r.m.s. values of resultant field F_r. A single-axis instrument can be used to obtain F_r by measuring F_x, F_y, and F_z, using Equation (1).

$$F_\mathrm{r} = \sqrt{F_x^{\,2} + F_y^{\,2} + F_z^{\,2}} \qquad (1)$$

where

F_x, F_y, and F_z are r.m.s. values of the orthogonal three-axis components of electric or magnetic fields.

When the field has no harmonics, F_r can also be obtained by measuring F_max and F_min, and then using Equation (2).

$$F_r = \sqrt{F_{max}{}^2 + F_{min}{}^2} \quad (2)$$

where

F_{max} is the maximum r.m.s. value of the semi-major axis of the field ellipse;

F_{min} is the minimum r.m.s. value of the semi-minor axis of the field ellipse.

4.3 Harmonic content

Harmonics are generally caused by non-linear equipment. Harmonics may be present on transmission lines and on distribution lines. Generally, the total harmonic voltage distortion of AC power distribution systems (see [3][4]) is low enough to not significantly affect the exposure, and so it is normally not necessary to quantify the harmonic content. AC transmission systems have lower harmonic contents.

Where there is significant concern that the harmonic content of fields cannot be ignored, existing methods of assessing the field harmonic content should be used following IEC 61786 for measurement. The assessment of the fields taking account of the harmonic frequencies should be evaluated according to the procedure specified in the safety standard (e.g. [5]) to be applied.

4.4 Record of measurement result

In the measurement report, the following information should be recorded:

– date, time, and weather conditions (e.g. sunny, rain, snow and wind conditions) when the measurement is carried out;
– temperature and humidity (for electric field measurement);
– type (overhead line, cable, substation, etc.) and nominal voltage of the power system, configuration and phase arrangement of overhead conductors and/or underground cables that generate the measured fields, if available;
– information on instruments [instrument manufacturer, model, probe size and geometry, type of probe or meter (free-body meter, ground reference meter, fluxgate meter, coil probe, Hall effect probe), magnitude range, pass bandwidth, latest calibrated date], if available;
– estimation of the uncertainty of measurement;

  NOTE 1 Measurement uncertainty can be estimated using a procedure proposed by, e.g., IEC 61786.

– person/company who performs the measurement;
– height(s) above the ground or the floor where the measurement is performed;
– measurement location related to the power systems of interest;
– measurement location in the room when the measurement is carried out in a building;
– measured field (electric or magnetic) levels;
– clear indication of what field quantity is being reported, for example, resultant field, r.m.s. values of each orthogonal three-axis component of the field or maximum or minimum r.m.s. values of the semi-major or semi-minor axis of the field;
– type, spatial position, and operating condition of other field sources near the measurement point;
– sketch and/or photograph of the measurement site with measurement location and other field sources;
– type, sort of material, dimensions and spatial position of permanent and removable objects for electric field measurement;
– type, sort of material, dimensions and spatial position of permanent and removable objects that contain magnetic materials or non-magnetic conductors for magnetic field measurement;

– current values flowing when magnetic field measurement is carried out, if possible and relevant;

NOTE 2 There might be some cases in which these load values would be difficult to obtain. Moreover, for low voltage distribution systems, the net current can be the more relevant parameter.

NOTE 3 One possible way to survey the variation of the load is to use a second magnetic field meter at a fixed position (see [6]).

– harmonic contents, if significant.

The above information is important when the measurement results are compared with the calculated levels and/or other measurement results.

An example of a measurement report is given in Annex D.

4.5 Measurement considerations

4.5.1 Field orientation

4.5.1.1 Electric field

Electric field measurement instruments are either single-axis or three-axis. The latter is the preferred option.

The electric field adjacent to a conducting surface is normal to the surface, Therefore, the horizontal component of the electric field, particularly where it is generated by overhead lines, can be ignored close to the ground surface. Single-axis measurement (vertical component) is therefore sufficient near the ground. Some examples of calculated electric field levels at a height of 1,0 m above the ground under overhead lines are shown in A.3.3. These demonstrate that at 1,0 m above the ground, the vertical component is similar to the resultant (see Figures A.9 and A.10).

Particular care must be taken in the presence of conducting objects (see 4.5.2.1) or when the clearance of the conductor from the ground is small.

4.5.1.2 Magnetic field

Magnetic field measurements should be made with three-axis instruments and should be of the resultant field, except where there is a particular reason for using single-axis instruments. Reasons for using single-axis instruments include the desire to know the direction of the field and the maximum r.m.s. value of the semi-major axis of the field ellipse, the wish to investigate the orientation and shape of the magnetic field ellipse, and cases when the direction of a linearly polarised field is already known; however, these are not covered by this standard.

When a suitable three-axis instrument is not available, a single-axis instrument may be used to determine the resultant field using Equation (1) or Equation (2), provided that the field level remains stable during the time taken to perform the measurements. In this case, use of a fixture made from non-conducting materials for orienting the probe in three orthogonal directions will expedite the measurement process.

NOTE Three-axis instruments often measure the three components sequentially which should be taken into account when field is changing.

Generally, the r.m.s. value of the semi-minor axis of the field ellipse under transmission lines is significantly smaller than that of the semi-major axis. Single-axis instruments may be used in such a case (see B.3.3).

4.5.2 Measurement locations

4.5.2.1 Electric field

In order to take electric field level measurements representing the unperturbed field at a given location, the area should be free as far as possible from other power lines, towers, trees, fences, tall grass, or other irregularities. It is preferred that the location should be relatively flat. It should be noted that the influence of vegetation on the electric field level can be significant. In general, field enhancement occurs above individual items of vegetation and field attenuation occurs near the sides. Field perturbation can depend markedly on the water content in the vegetation.

All movable objects should be removed when possible. If not, then the distance between the probe and the object should be more than three times the height of the object (non-permanent object) or 1,0 m (permanent object) [6].

If these recommendations cannot be fulfilled, it should be clearly noted on the measurement report.

4.5.2.2 Magnetic field

Non-permanent objects containing magnetic materials or nonmagnetic conductors should be at least three times the largest dimensions of the object away from the point of measurement in order to measure the unperturbed field value. The distance between the probe and permanent magnetic objects should not be less than 1,0 m in order to accurately measure the ambient unperturbed field [7].

If these recommendations cannot be fulfilled, it should be clearly noted on the measurement report.

4.5.3 Perturbing effects of an operator in electric field measurement

To reduce perturbation of a measured electric field, the distance between the electric field measurement instrument and the operator should be at least 1,5 m and 3 m should be recommended [6]. This can be achieved using a fibre optic cable between the monitor and the probe with the latter on a non-conductive support.

4.5.4 Effects from other sources in magnetic field measurement

Magnetic field sources other than power systems near the measurement point should be turned off or removed, if possible, to minimise their influence on the measurement result. If it is difficult to turn off or remove the sources, relevant information about them, for example, type of source, location relative to the measurement point, etc. should be recorded.

4.5.5 Humidity condition in electric field measurement

Electric field measurement may be perturbed if the relative humidity is more than 70 % due to condensation effect on the probe and support [6]. Since the effect of humidity depends on the field meter, the ability of the field meter to work correctly under those conditions should be checked before measurement.

5 Fundamental measurement procedures for electric and magnetic fields

5.1 General procedure

Different procedures are specified here that use single-, three- or five-point measurement. If the values obtained are all below the reference level or MPE, no further processing is necessary for demonstration of compliance.

When measuring field levels under overhead lines, the field near the ground is considered to be uniform (see justification in B.3.2.1); therefore, single-point measurements are sufficient. Other situations such as public areas adjacent to underground cables, indoor substations, etc. are considered to be non-uniform and three- or five- point measurement shall be used as appropriate.

5.2 Single-point measurement

Where the field is considered to be uniform, the electric or magnetic field level at the point of interest should be measured at 1,0 m above the ground or the floor in the building. This measured level is recognised as the *average exposure level* (see Annexes A and B).

If necessary, other heights may be used, in which case the actual measurement height should be explicitly recorded in the measurement report.

5.3 Three-point measurement

Where the field is considered to be non-uniform, the electric and magnetic field level at the position of interest should be measured at the three heights, 0,5 m, 1,0 m, and 1,5 m above the ground or floor level in a building. Beside power equipment or in a building, measurement should be performed at a horizontal distance of 0,2 m from its surface or boundary or a wall.

In situations where the equipment has a height less than 1,5 m, the three-point measurements must be performed at equidistant heights with the highest being at the same height as the top of the equipment (see Figure 1).

If necessary, other heights may be used, in which case the actual measurement heights should be explicitly recorded in the measurement report.

NOTE In the case where the safety standard does not allow spatial averaging (such as [2]), then the maximum of the three measured values should be used.

The *three-point average exposure level* is recognised as the *average exposure level* (see Annex C).

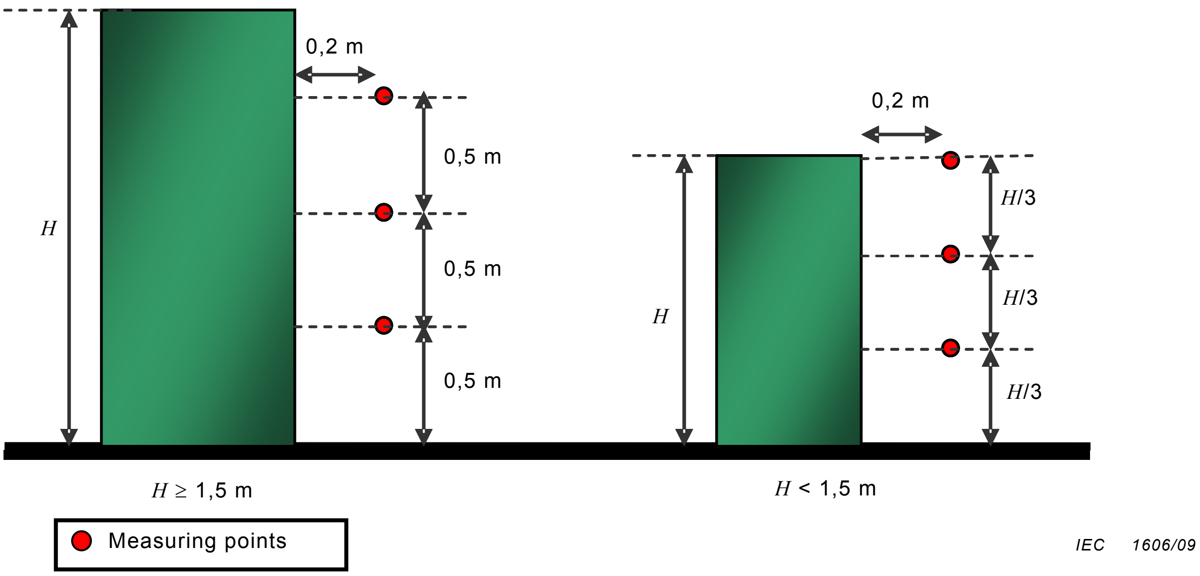

Figure 1 – Heights of *the three-point measurement*