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(including amendment A1:2001)
(IEC 61000-4-8:1993 + A1:2000)

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Compatibilité électromagnétique (CEM) — Partie 4-8: Techniques d'essai et de mesure — Essai d'immunité au champ magnétique à la fréquence du réseau
(inclut l'amendement A1:2001)
(CEI 61000-4-8:1993 + A1:2000)

Elektromagnetische Verträglichkeit (EMV) — Teil 4-8: Prüf- und Meßverfahren — Prüfung der Störfestigkeit gegen Magnetfelder mit energietechnischen Frequenzen
(enthält Änderung A1:2001)
(IEC 61000-4-8:1993 + A1:2000)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 77B(CO)7, as prepared by Sub-Committee 77B: High frequency phenomena, of IEC Technical Committee 77: Electromagnetic compatibility, was submitted to the IEC-CENELEC parallel vote in September 1991.

The reference document was approved by CENELEC as EN 61000-4-8 on 16 June 1992.

The following dates were fixed:

—latest date of publication of an identical national standard	(dop) 1994-06-01
—latest date of withdrawal of conflicting national standards	(dow) 1994-06-01

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given only for information. In this standard, Annex A, Annex B and Annex ZA are normative and Annex C and Annex D are informative.

Foreword to amendment A1

The text of documents 77B/291 + 293/FDIS, future amendment 1 to IEC 61000-4-8:1993, prepared by SC 77B, High-frequency phenomena, of IEC TC 77, Electromagnetic compatibility, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 61000-4-8:1993 on 2000-12-01.

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—latest date by which the national standards conflicting with the amendment have to be withdrawn	(dow) 2003-12-01

Contents

		Page
Foreword		2
1	Scope	5
2	Normative references	5
3	General	5
4	Definitions	6
4.1	EUT	6
4.2	induction coil	6
4.3	induction coil factor	6
4.4	immersion method	6
4.5	proximity method	6
4.6	ground (reference) plane (GRP)	6
4.7	decoupling network, back filter	6
5	Test levels	6
6	Test equipment	7
6.1	Test generator	7
6.2	Induction coil	8
6.3	Test and auxiliary instrumentation	9
7	Test set-up	10
7.1	Ground (reference) plane	10
7.2	Equipment under test	10
7.3	Test generator	10
7.4	Induction coil	10
8	Test procedure	11
8.1	Laboratory reference conditions	11
8.2	Carrying out the test	11
9	Evaluation of test results	12
10	Test report	12
Annex A (normative) Induction coil calibration method		16
Annex B (normative) Characteristics of the induction coils		16
Annex C (informative) Selection of the test levels		22
Annex D (informative) Information on power frequency magnetic field strength		24
Annex ZA (normative) Other international publications quoted in this standard with the references of the relevant European publications		26
Figure 1 — Example of application of the test field by the immersion method		13
Figure 2 — Schematic circuit of the test generator for power frequency magnetic field		13
Figure 3 — Example of test set-up for tabletop equipment		14
Figure 4 — Example of test set-up for floor-standing equipment		14

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Page

Figure 5 — Example of investigation of susceptibility to magnetic field by the proximity method 15

Figure 6 — Illustration of Helmholtz coils 15

Figure B.1 — Characteristics of the field generated by a square induction coil (1 m side) in its plane 18

Figure B.2 — 3 dB area of the field generated by a square induction coil (1 m side) in its plane 18

Figure B.3 — 3 dB area of the field generated by a square induction coil (1 m side) in the mean orthogonal plane (component orthogonal to the plane of the coil) 19

Figure B.4 — 3 dB area of the field generated by two square induction coils (1 m side) 0,6 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils) 19

Figure B.5 — 3 dB area of the field generated by two square induction coils (1 m side) 0,8 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils) 20

Figure B.6 — 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) in its plane 20

Figure B.7 — 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) in its plane (ground plane as a side of the induction coil) 21

Figure B.8 — 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) with ground plane, in the mean orthogonal plane (component orthogonal to the plane of the coil) 21

Table 1 — Test levels for continuous field 7

Table 2 — Test levels for short duration: 1 s to 3 s 7

Table D.1 — Values of the maximum magnetic field produced by household appliances (results of the measurements of 100 different devices of 25 basic types) 24

Table D.2 — Values of the magnetic field generated by a 400 kV line 24

Table D.3 — Values of the magnetic field in high voltage substation areas 24

Table D.4 — Values of the magnetic field in power plants 25

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1 Scope

This international standard relates to the immunity requirements of equipment, only under operational conditions, to magnetic disturbances at power frequency related to:

— residential and commercial locations;

— industrial installations and power plants;

— medium voltage and high voltage substations.

The applicability of this standard to equipment installed in different locations is determined by the presence of the phenomenon, as specified in clause 3.

This standard does not consider disturbances due to capacitive or inductive coupling in cables or other parts of the field installation.

Other IEC standards dealing with conducted disturbances cover these aspects.

The object of this Standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment for household, commercial and industrial applications when subjected to magnetic fields at power frequency (*continuous and short duration field*).

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The standard defines:

— recommended test levels;

— test equipment;

— test set-up;

— test procedure.

Other kinds of magnetic fields would be object of standardization:

— fields at other power frequencies (16 2/3 – 20 or 30 – 400 Hz);

— fields of harmonic currents (100 Hz to 2 000 Hz);

— fields of higher frequencies (up to 150 kHz, e.g. for mains signalling systems);

— D.C. fields.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 1000-4. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 1000-4 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 68-1:1988, *Environmental testing — Part1: General and guidance.*

3 General

The magnetic fields to which equipment is subjected may influence the reliable operation of equipment and systems.

The following tests are intended to demonstrate the immunity of equipment when subjected to power frequency magnetic fields related to the specific location and installation condition of the equipment (e.g. proximity of equipment to the disturbance source). The power frequency magnetic field is generated by power frequency current in conductors or, more seldom, from other devices (e.g. leakage of transformers) in the proximity of equipment.

As for the influence of nearby conductors, one should differentiate between:

— the current under normal operating conditions, which produces a steady magnetic field, with a comparatively small magnitude;

— the current under fault conditions which can produce comparatively high magnetic fields but of short duration, until the protection devices operate (a few milliseconds with fuses, a few seconds for protection relays).

The test with a steady magnetic field may apply to all types of equipment intended for public or industrial low voltage distribution networks or for electrical plants.

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The test with a short duration magnetic field related to fault conditions, requires test levels that differ from those for steady state conditions; the highest values apply mainly to equipment to be installed in exposed places of electrical plants.

The test field waveform is that of power frequency.

In many cases (household areas, substations and power plant under normal conditions), the magnetic field produced by harmonics is negligible. However, in very special cases like heavy industrial areas (large power convertors, etc.) they occur, and will be considered in a future revision of this standard.

4 Definitions

The following definitions and terms are used in this standard and apply to the restricted field of magnetic disturbances; not all of them are included in IEV(50)161.

4.1
EUT
equipment under test

4.2
induction coil
conductor loop of defined shape and dimensions, in which flows a current, generating a magnetic field of defined constancy in its plane and in the enclosed volume

4.3
induction coil factor
ratio between the magnetic field strength generated by an induction coil of given dimensions and the corresponding current value; the field is that measured at the centre of the coil plane, without the EUT

4.4
immersion method
method of application of the magnetic field to the EUT, which is placed in the centre of an induction coil (Figure 1)

4.5
proximity method
method of application of the magnetic field to the EUT, where a small induction coil is moved along the side of the EUT in order to detect particularly sensitive areas

4.6
ground (reference) plane (GRP)
a flat conductive surface whose potential is used as a common reference for the magnetic field generator and the auxiliary equipment (the ground plane can be used to close the loop of the induction coil, as in Figure 4
(IEV 161-04-36, modified)

4.7
decoupling network, back filter
electrical circuit intended to avoid reciprocal influence with other equipment not submitted to the magnetic field test

5 Test levels

The preferential range of test levels, respectively for continuous and short duration application of the magnetic field, applicable to distribution networks at 50 Hz and 60 Hz, is given in Table 1 and Table 2.

The magnetic field strength is expressed in A/m; 1 A/m corresponds to a free space induction of 1,26 μT.

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Table 1 — Test levels for continuous field

Level	Magnetic field strength A/m
1	1
2	3
3	10
4	30
5	100
x[a]	special

[a] "x" is an open level. This level can be given in the product specification.

Table 2 — Test levels for short duration: 1 s to 3 s

Level	Magnetic field strength A/m
1	n.a.[b]
2	n.a.[b]
3	n.a.[b]
4	300
5	1 000
x[a]	special

[a] "x" is an open level. This level, as well the duration of the test, can be given in the product specification.
[b] "n.a." = not applicable

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Information on the selection of the test levels is given in Annex C.

Information on actual levels is given in Annex D.

6 Test equipment

The test magnetic field is obtained by a current flowing in an induction coil; the application of the test field to the EUT is by the *immersion method.*

An example of application of the immersion method is given in Figure 1.

The test equipment includes the current source (test generator), the induction coil and auxiliary test instrumentation.

6.1 Test generator

The generator, with the output waveform corresponding to the test magnetic field, shall be able to deliver the required current in the induction coils specified in **6.2.**

The generator power capability shall therefore be dimensioned by taking into account the coil impedance; the inductance may range from 2,5 µH for the 1 m standard coil, to several µH (e.g. 6 µH) for a rectangular induction coil (1 m × 2,6 m, see **6.2**).

The specifications of the generator are:

— current capability, determined by the maximum selected test level and induction coil factor (see 6.2.2 and Annex A), ranging from 0,87 m^{-1} (1 m standard coil for testing tabletop or small equipment) to 0,66 m^{-1} (rectangular induction coil, 1 m × 2,6 m, for testing floor standing or large equipment);

— operability in short circuit condition;

— low output terminal connected to the earth terminal (for connection to the safety earth of the laboratory);

— precautions to prevent the emission of large disturbances that may be injected in the power supply network or may influence the test results.

The characteristics and performances of the current source or test generator for the different fields considered in this standard are given in **6.1.1.**

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6.1.1 *Characteristics and performances of the test generator*

The current source typically consists of a voltage regulator (connected to the mains distribution network), a current transformer and a circuit for the control of short duration application. The generator shall be able to operate in continuous mode or short duration mode.

Specifications

Output current range for continuous mode operation:	1 A to 100 A, divided by the coil factor
Output current range for short duration mode operation:	300 A to 1 000 A, divided by the coil factor
Total distortion factor of the output current:	less than 3 %
Set time for short duration mode operation:	1 s to 3 s

NOTE The output current range, for the standard coil is from 1,2 A to 120 A for continuous mode, and from 350 A to 1 200 A for short duration mode.

The waveform of the output current is a sinusoid.

The schematic circuit of the generator is given in Figure 2.

6.1.2 *Verification of the characteristics of the test generator*

In order to compare the results for different test generators, the essential characteristics of the output current parameters shall be verified. The output current shall be verified with the generator connected to the standard induction coil specified in 6.2.1 a); the connection shall be realized by twisted conductors of up to 3 m length and suitable cross-section.

The emission of disturbances by the generator shall be verified (see **6.1**).

The characteristics to be verified are:

— output current value;

— total distortion factor.

The verifications shall be carried out with a current probe and measurement instrumentation having ±2 % accuracy.

6.2 Induction coil

6.2.1 *Characteristics of the induction coil*

The induction coil, connected to the test generator previously defined (see **6.1.1**), shall generate a field strength corresponding to the selected test level and the defined homogeneity.

The induction coil shall be made of copper, aluminium or any conductive non-magnetic material, of such cross-section and mechanical arrangement as to facilitate its stable positioning during the tests. A same coil is suitable for the generation of the magnetic fields considered in this standard; it may be a "*single turn*" coil and shall have a suitable current capability, as may be necessary for the selected test level.

Multi-turn coils may be used in order to have a lower testing current.

The induction coil shall be adequately dimensioned to surround the EUT (three orthogonal positions). Depending on the size of the EUT, induction coils of different dimensions may be used. The dimensions recommended below are suitable for the generation of magnetic fields over the whole volume of the EUT's (*tabletop equipment or floor-standing equipment*), with an acceptable variation of ±3 dB.

The characteristics of induction coils in respect of the magnetic field distribution are given in Annex B.

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a) *Induction coil for tabletop equipment*

The induction coil of standard dimensions for testing small equipment (e.g. computer monitors, watthour meters, transmitters for process control, etc.) has a square (or circular) form with 1 m side (or diameter), made of a conductor of relatively small cross-section.

The test volume of the standard square coil is 0,6 m × 0,6 m × 0,5 m (height).

A double coil of standard size (Helmholtz coil) could be used in order to obtain a field homogeneity better than 3 dB or for testing larger EUTs. The double coil (Helmholtz coil) shall comprise of two or more series of turns, properly spaced (see Figure 6, Figure B.4, Figure B.5).

The test volume of a double standard size coil, 0,8 m spaced, for a 3 dB homogeneity is 0,6 m × 0,6 m × 1 m (height).

For example, the Helmholtz coils, for a 0,2 dB homogeneity, have dimensions and separation distances as given in Figure 6.

b) *Induction coil for floor-standing equipment*

Induction coils shall be made according to the dimensions of the EUT and the different field polarizations. The coil shall be able to envelop the EUT; the coil dimensions shall be such as to give a minimum distance of coil conductors to EUT walls equal to 1/3 of the dimension of the EUT considered. The coils shall be made of conductors of relatively small cross-section.

NOTE Due to the possible large dimensions of EUT's, the coils may be made of "C" or "T" sections in order to have sufficient mechanical rigidity.

The test volume is determined by the testing area of the coil (60 % × 60 % of each side) multiplied by a depth corresponding to 50 % of the shorter side of the coil.

6.2.2 *Calibration of the induction coil, coil factor*

In order to make it possible to compare the test results from different test equipment, the induction coils shall be calibrated in their operating condition, before conducting the test (without the EUT, in free space condition).

An induction coil of the correct dimensions for the EUT dimensions, shall be positioned at 1 m minimum distance from the wall of the laboratory and any magnetic material, by using insulating supports, and shall be connected to the test generator as prescribed in **6.1.2.**

Appropriate magnetic field sensors shall be used to verify the magnetic field strength generated by the induction coil.

The field sensor shall be positioned at the centre of the induction coil (without the EUT) and with suitable orientation to detect the maximum value of the field.

The current in the induction coil shall be adjusted to obtain the field strength specified by the test level. The calibration shall be carried out at power frequency. The calibration procedure shall be carried out with the test generator and induction coil. The coil factor is determined (and verified) by the above procedure. The coil factor gives the current value to be injected in the coil to obtain the required test magnetic field (H/I).

Information on the measurement of the test magnetic field is given in Annex A.

6.3 Test and auxiliary instrumentation

6.3.1 *Test instrumentation*

The test instrumentation includes the current measuring system (sensors and instrument) for setting and measuring the current injected in the induction coil.

NOTE The termination networks, back filters, etc. on power supply, control and signal lines that are part of the test set-up for other tests may be maintained.

The current measuring system is a calibrated current, measuring instrument, probe or shunt.

The accuracy of the measurement instrumentation shall be ±2 %.

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6.3.2 *Auxiliary instrumentation*

The auxiliary instrumentation comprises a simulator and any other instrument necessary for the operation and verification of the EUT functional specifications.

7 Test set-up

The test set-up comprises the following components:

— ground (reference) plane (GRP);
— equipment under test (EUT);
— induction coil;
— test generator.

Precautions shall be taken if the test magnetic field may interfere with the test instrumentation and other sensitive equipment in the vicinity of the test set-up.

Examples of test set-ups are given in the following figures:

Figure 3: Example of test set-up for tabletop equipment;
Figure 4: Example of test set-up for floor-standing equipment.

7.1 Ground (reference) plane

The ground plane (GRP) shall be placed in the laboratory; the EUT and auxiliary test equipment shall be placed on it and connected to it.

The ground plane shall be a non magnetic metal sheet (copper or aluminium) of 0,25 mm thickness; other metals may be used but in this case they shall have 0,65 mm minimum thickness. The minimum size of the ground plane is 1 m × 1 m. The final size depends on the dimensions of the EUT.

The ground plane shall be connected to the safety earth system of the laboratory.

7.2 Equipment under test

The equipment is configured and connected to satisfy its functional requirements. It shall be placed on the GRP with the interposition of a 0,1 m thickness insulating support (e.g. dry wood).

The equipment cabinets shall be connected to the safety earth directly on the GRP via the earth terminal of the EUT.

The power supply, input and output circuits shall be connected to the sources of power supply, control and signal.

The cables supplied or recommended by the equipment manufacturer shall be used. In absence of any recommendation, unshielded cables shall be adopted, of a type appropriate for the signals involved. All cables shall be exposed to the magnetic field for 1 m of their length.

The back filters, if any, shall be inserted in the circuits at 1 m cable lengths from the EUT and connected to the ground plane. The communication lines (data lines) shall be connected to the EUT by the cables given in the technical specification or standard for this application.

7.3 Test generator

The test generator shall be placed at less than 3 m distance from the induction coil. One terminal of the generator shall be connected to the ground plane as far as used.

7.4 Induction coil

The induction coil, of the type specified in **6.2.1**, shall enclose the EUT placed at its centre.

Different induction coils may be selected for testing in the different orthogonal directions, according to the general criteria specified in **6.2.1**a) and **6.2.1**b).

Induction coils used in the vertical position (horizontal polarization of the field) can be bonded (at the foot of one vertical conductor) directly to the ground plane, which represents the low side of the coil, as a part of it. In this case, 0,1 m minimum distance from EUT to the ground plane is sufficient.

The induction coil shall be connected to the test generator in the same way as for the calibration procedure specified in **6.2.2**. The induction coil selected for the tests shall be specified in the test plan.

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8 Test procedure

The test procedure shall include:

— verification of the laboratory reference conditions;

— preliminary verification of the correct operation of the equipment;

— carrying out the test;

— evaluation of the test results.

8.1 Laboratory reference conditions

In order to minimize the effect of environmental parameters on the test results, the test shall be carried out in climatic and electromagnetic reference conditions as specified in 8.1.1 and 8.1.2.

8.1.1 *Climatic conditions*

A1 Unless otherwise specified by the committee responsible for the generic or product standard, the climatic conditions in the laboratory shall be within any limits specified for the operation of the EUT and the test equipment by their respective manufacturers.

Tests shall not be performed if the relative humidity is so high as to cause condensation on the EUT or the test equipment.

NOTE Where it is considered that there is sufficient evidence to demonstrate that the effects of the phenomenon covered by this standard are influenced by climatic conditions, this should be brought to the attention of the committee responsible for this standard. A1

8.1.2 *Electromagnetic conditions*

The electromagnetic conditions of the laboratory shall be such as to guarantee the correct operation of the EUT in order not to influence the test results; otherwise, the tests shall be carried out in a Faraday cage. In particular, the electromagnetic field value of the laboratory shall be at least 20 dB lower than the selected test level.

8.2 Carrying out the test

The test shall be carried out on the basis of a test plan including verification of the performances of the EUT as defined in the technical specification.

The power supply, signal and other functional electrical quantities shall be applied within their rated range. If the actual operating signals are not available, they may be simulated.

Preliminary verification of equipment performances shall be carried out prior to applying the test magnetic field.

The test magnetic field shall be applied by the immersion method to the EUT, previously set up as specified in 7.2.

The test level shall not exceed the product specification.

NOTE In order to detect the most susceptible side/positions of the EUT, mainly of a stationary type, the proximity method may be used for investigation purposes. This method is not to be used for certification. An example of application of the test field by proximity method is given in Figure 5.

The test field strength and the duration of the test shall be as determined by the selected test level, according to the different type of field (continuous or short duration field) established in the test plan.

a) *Tabletop equipment*

The equipment shall be subjected to the test magnetic field by using the induction coil of standard dimensions (1 m × 1 m) specified in 6.2.1 a) and shown in Figure 3.

The induction coil shall then be rotated by 90° in order to expose the EUT to the test field with different orientations.

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b) *Floor-standing equipment*

The equipment shall be subjected to the test magnetic field by using induction coils of suitable dimensions as specified in 6.2.1 b); the test shall be repeated by moving and shifting the induction coils, in order to test the whole volume of the EUT for each orthogonal direction. The test shall be repeated with the coil shifted to different positions along the side of the EUT, in steps corresponding to 50 % of the shortest side of the coil.

NOTE The moving of the induction coil in steps corresponding to 50 % of the shortest side of the coil gives overlapping test fields.

The induction coil shall then be rotated by 90° in order to expose the EUT to the test field with different orientations and the same procedure followed.

A2 9 Evaluation of test results

The test results shall be classified in terms of the loss of function or degradation of performance of the equipment under test, relative to a performance level defined by its manufacturer or the requestor of the test, or agreed between the manufacturer and the purchaser of the product. The recommended classification is as follows:

a) normal performance within limits specified by the manufacturer, requestor or purchaser;

b) temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention;

c) temporary loss of function or degradation of performance, the correction of which requires operator intervention;

d) loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software, or loss of data.

The manufacturer's specification may define effects on the EUT which may be considered insignificant, and therefore acceptable.

This classification may be used as a guide in formulating performance criteria, by committees responsible for generic, product and product-family standards, or as a framework for the agreement on performance criteria between the manufacturer and the purchaser, for example, where no suitable generic, product or product-family standard exists.

10 Test report

The test report shall contain all the information necessary to reproduce the test. In particular, the following shall be recorded:

— the items specified in the test plan required by clause 8 of this standard;

— identification of the EUT and any associated equipment, for example, brand name, product type, serial number;

— identification of the test equipment, for example, brand name, product type, serial number;

— any special environmental conditions in which the test was performed, for example, shielded enclosure;

— any specific conditions necessary to enable the test to be performed;

— performance level defined by the manufacturer, requestor or purchaser;

— performance criterion specified in the generic, product or product-family standard;

— any effects on the EUT observed during or after the application of the test disturbance, and the duration for which these effects persist;

— the rationale for the pass/fail decision (based on the performance criterion specified in the generic, product or product-family standard, or agreed between the manufacturer and the purchaser);

— any specific conditions of use, for example, cable length or type, shielding or grounding, or EUT operating conditions, which are required to achieve compliance. A1

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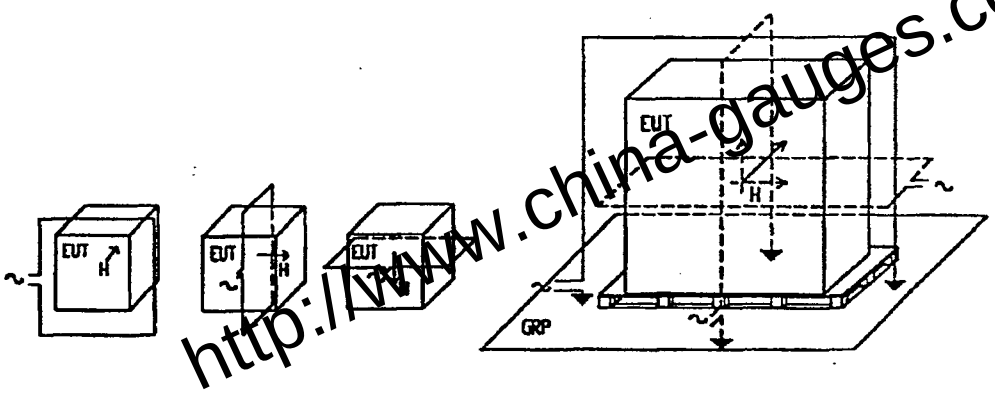
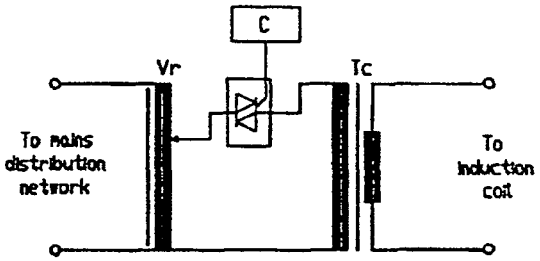


Table-top equipment Floor-standing equipment

Figure 1 — Example of application of the test field by the immersion method



Vr: Voltage regulator

C: Control circuit

Tc: Current transformer

Figure 2 — Schematic circuit of the test generator for power frequency magnetic field

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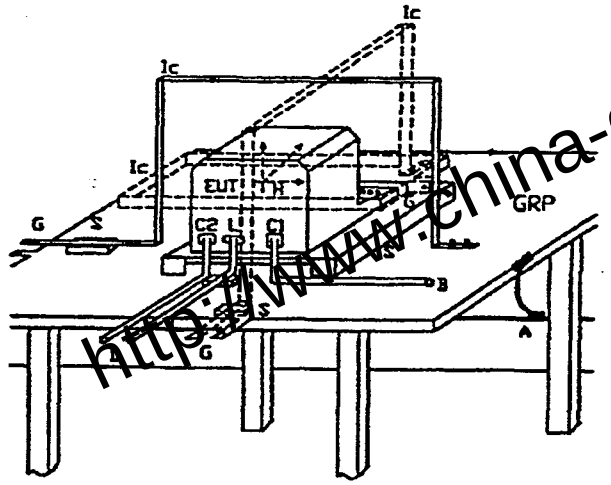

Figure 3 — Example of test set-up for tabletop equipment

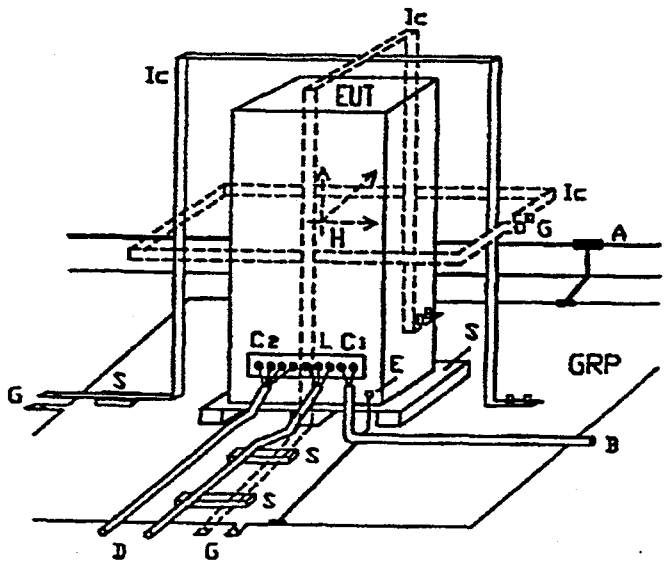

Figure 4 — Example of test set-up for floor-standing equipment

References common to Figure 3 and Figure 4

GRP:	Ground plane	C1:	Power supply circuit
A:	Safety earth	C2:	Signal circuit
S:	Insulating support	L:	Communication line
EUT:	Equipment under test	B:	To power supply source
Ic:	Induction coil	D:	To signal source, simulator
E:	Earth terminal	G:	To the test generator

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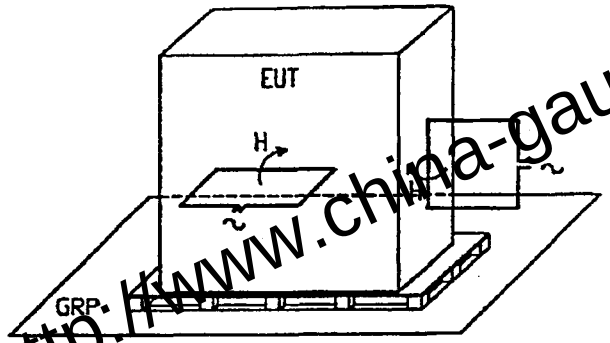

Figure 5 — Example of investigation of susceptibility to magnetic field by the proximity method

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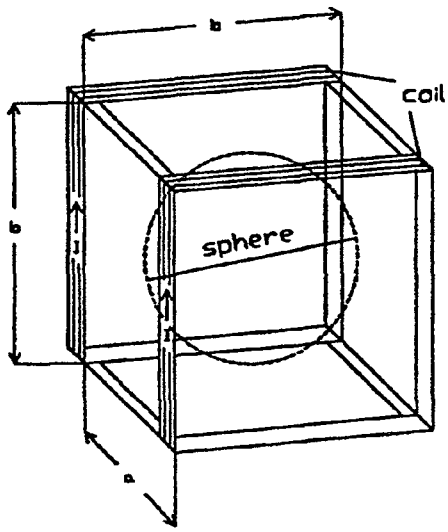

n:	Number of turns in each coil	a:	Separation of the coils
b:	Side of the coils (m)	I:	Current value (A)
H:	Magnetic field strength (A/m)	H:	1,22 x n/b x I

(with a = b/2,5 the non-homogeneity of the magnetic field strength is ± 0,2 dB)

Figure 6 — Illustration of Helmholtz coils

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Annex A (normative)
Induction coil calibration method

A.1 Magnetic field measurement

The magnetic field test is related to free space condition, without the EUT and at 1 m minimum distance from the laboratory walls and any magnetic material.

The measurement of the magnetic field may be done with a measurement system comprising of calibrated sensors e.g. a "Hall effect" or multi-turn loop sensor with a diameter of at least one order of magnitude smaller than the test induction coil and a power frequency narrow band instrument.

A.2 Calibration of the induction coil

The calibration shall be carried out by injecting the calibration current at power frequency in the induction coil and measuring the magnetic field by sensors placed at its geometrical centre.

Proper orientation of the sensor shall be selected in order to obtain the maximum value.

The *"induction coil factor"* shall be determined for each induction coil as the ratio "field strength/current" of injection (H/A). The "coil factor", determined at a.c. current, is not related to the current waveform, because it is a characteristic parameter of the induction coil; it is therefore applicable for the evaluation of magnetic field at power frequency.

For standard dimension coil, the coil factor is determined by the manufacturer of the coil, and can be verified by laboratory measurements before carrying out the tests.

Annex B (normative)
Characteristics of the induction coils

B.1 General

This annex considers the problems of generation of the test magnetic fields.

In the first stage, both the immersion and proximity methods were considered. In order to know the limits of application of such methods, some questions have been emphasized. In the following the reasons for the values are explained.

B.2 Induction coil requirements

The requirement of the induction coil is *"3 dB tolerance of the test field in the volume of the EUT"*; this tolerance has been considered a reasonable technical compromise in respect of a test characterized by severity levels in 10 dB steps, due to practical limits in the generation of constant field over a wide range of volumes.

The constancy of the field is a requirement limited to a single direction, orthogonal to the coil plane. The field in different directions is obtainable in successive test steps by rotating the induction coil.

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B.3 Induction coil characteristics

The characteristics of induction coils of different dimensions suitable for testing *tabletop equipment* or *floor standing equipment* are given in diagrams showing:

— profile of the field generated by a square induction coil (1 m side) in its plane (see Figure B.1);

— 3 dB area of the field generated by a square induction coil (1 m side) in its plane (see Figure B.2);

— 3 dB area of the field generated by a square induction coil (1 m side) in the mean orthogonal plane (component orthogonal to the plane of the coil) (see Figure B.3);

— 3 dB area of the field generated by two square induction coils (1 m side) 0,6 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils) (see Figure B.4);

— 3 dB area of the field generated by two square induction coils (1 m side) 0,8 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils) (see Figure B.5);

— 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) in its plane (see Figure B.6);

— 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) in its plane (ground plane as a side of the induction coil) (see Figure B.7);

— 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m), with ground plane, in the mean orthogonal plane (component orthogonal to the plane of the coil) (see Figure B.8).

In the selection of the form, arrangement and dimensions of the test coil, the following points have been considered:

— the 3 dB area, inside and outside the induction coil, is related to the shape and dimensions of the induction coil;

— for a given field strength, driving current value, power and energy of the test generator are proportional to the dimensions of the induction coil.

B.4 Summary of characteristics of induction coils

On the basis of the data on the field distribution of coils with different sizes, and in view of adopting the test method given in this standard to different classes of equipment, the conclusions that can be drawn are as follows:

— *single square coil, 1 m side*: testing volume 0,6 m × 0,6 m × 0,5 m high (0,2 m minimum distance from EUT to the coil);

— *double square coils, 1 m side, 0,6 spaced*: testing volume 0,6 × 0,6 × 1 m high (0,2 m minimum distance from EUT to the coil); increasing of the separation of the coils up to 0,8 m, extends the maximum height of testable EUT (see the 3 dB area, in the mean orthogonal plane) up to 1,2 m.

— *single rectangular coil, 1 m × 2,6 m*: testing volume 0,6 m × 0,6 m × 2 m high (0,2 and 0,3 m minimum distance from EUT to the coil, respectively for the horizontal and vertical dimensions of EUT); if the induction coil is bonded to the GRP, a 0,1 m distance from it is sufficient.

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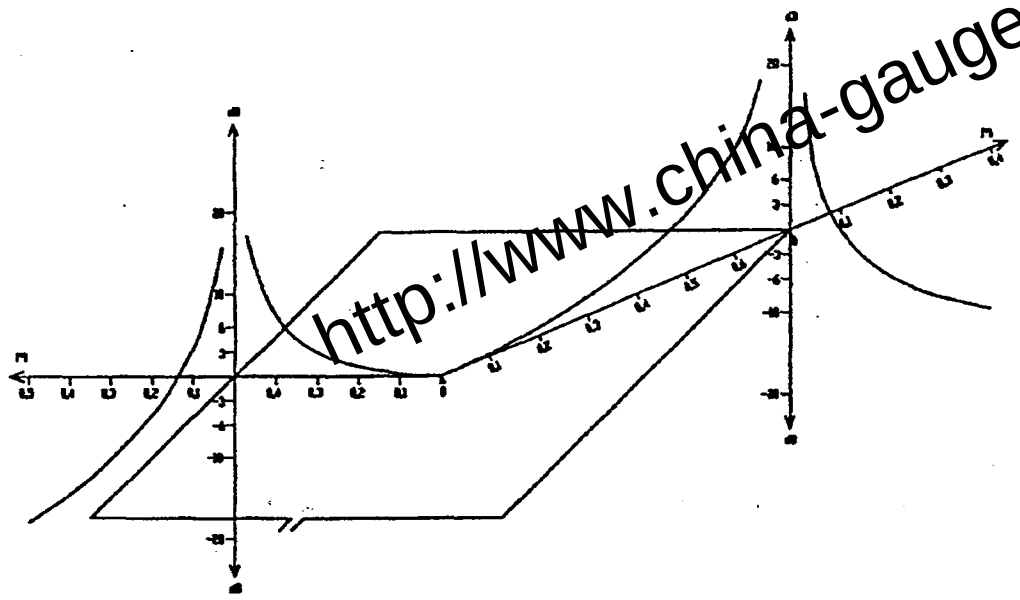

Figure B.1 — Characteristics of the field generated by a square induction coil (1 m side) in its plane

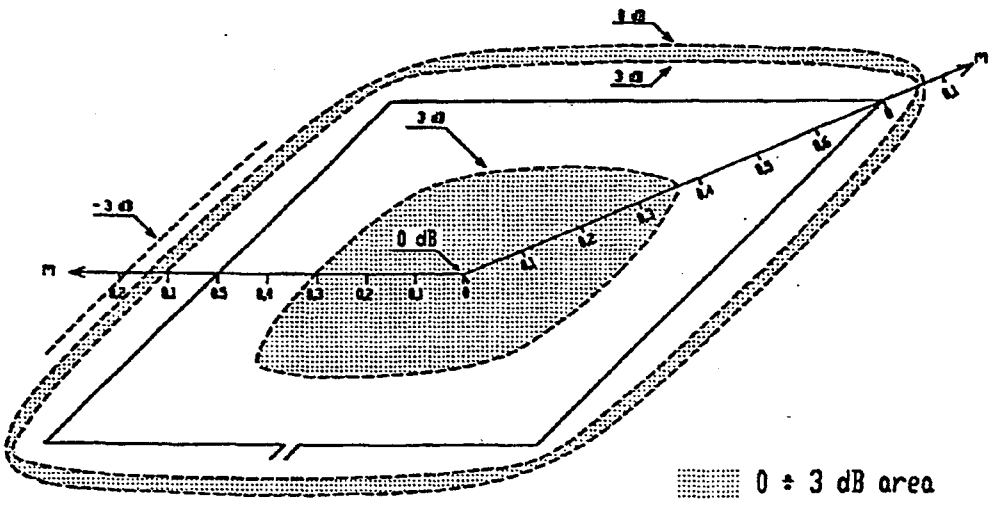

Figure B.2 — 3 dB area of the field generated by a square induction coil (1 m side) in its plane

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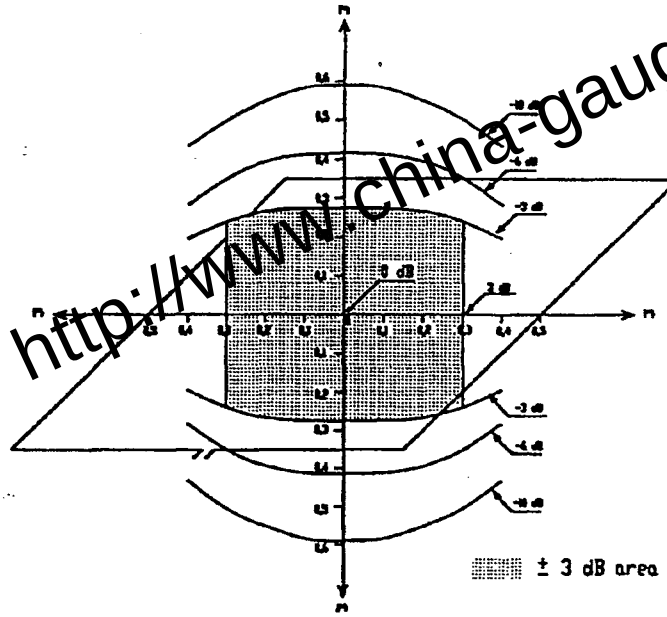

Figure B.3 — 3 dB area of the field generated by a square induction coil (1 m side) in the mean orthogonal plane (component orthogonal to the plane of the coil)

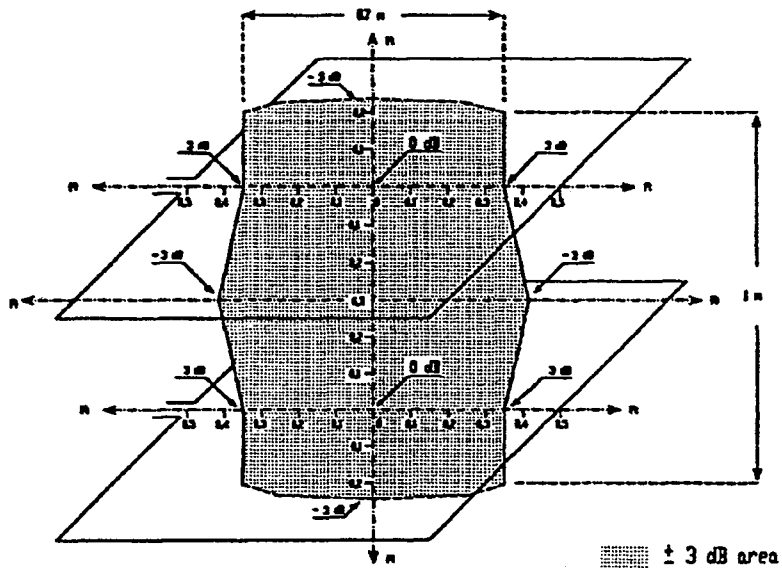

Figure B.4 — 3 dB area of the field generated by two square induction coils (1 m side) 0,6 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils)

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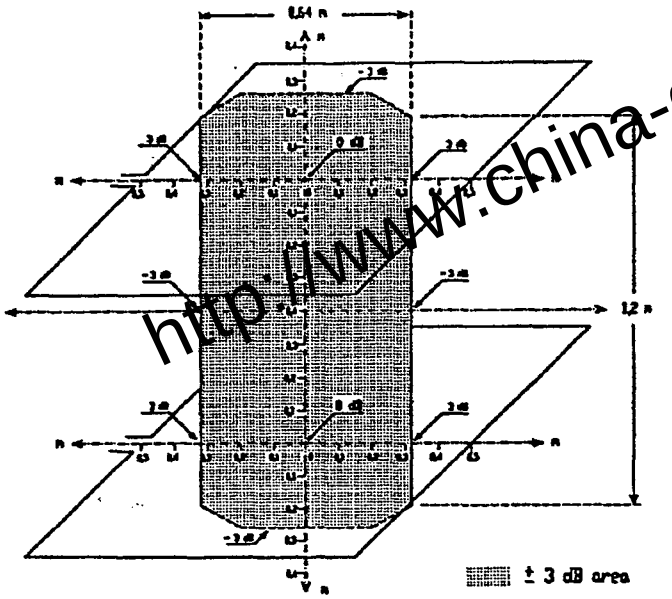

Figure B.5 — 3 dB area of the field generated by two square induction coils (1 m side) 0,8 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils)

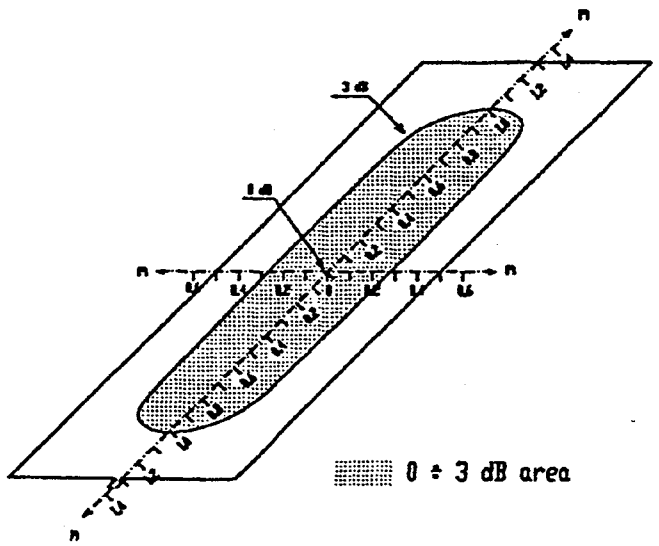

Figure B.6 — 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) in its plane

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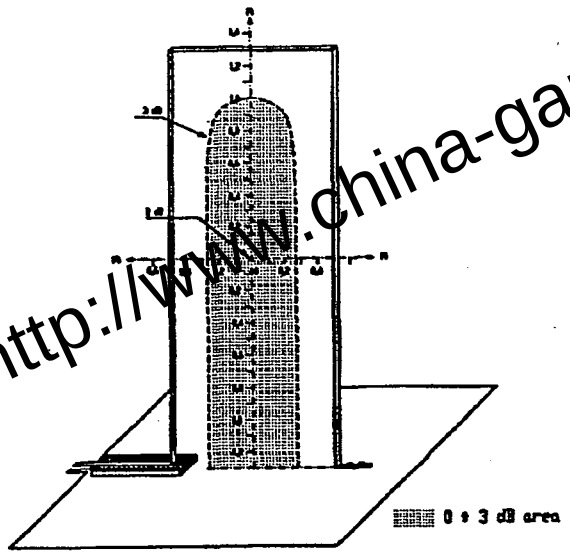

Figure B.7 — 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) in its plane (ground plane as a side of the induction coil)

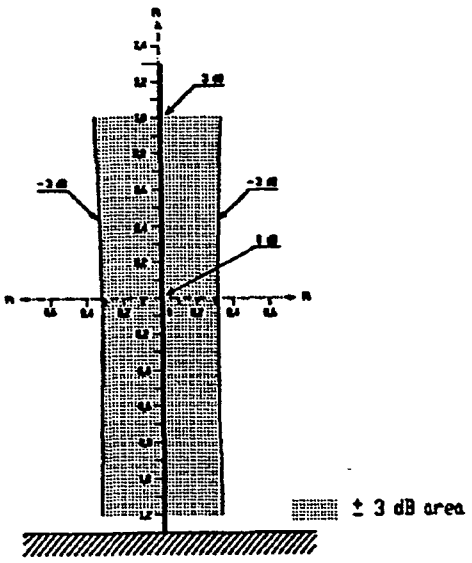

Figure B.8 — 3 dB area of the field generated by a rectangular induction coil (1 m × 2,6 m) with ground plane, in the mean orthogonal plane (component orthogonal to the plane of the coil)

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Annex C (informative)
Selection of the test levels

The test levels shall be selected in accordance with the most realistic installation and environmental conditions. These levels are outlined in clause 5.

The immunity tests are correlated with these levels in order to establish a performance level for the environment in which the equipment is expected to operate. A survey of power frequency magnetic field strength is given in Annex B.

The test level shall be chosen according to:

— the electromagnetic environment;

— the proximity of the disturbances sources to the equipment concerned;

— the compatibility margins.

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Based on common installation practices, a guide for the selection of test levels for magnetic fields testing may be the following:

Class 1: Environmental level where sensitive device using electron beam can be used.

Monitors, electron microscope, etc., are representative of these devices.

NOTE 90 % of the computer screens are submitted to only 1 A/m. However, screens located near source of disturbance such as transformers or power lines shall withstand higher levels to be set by product committees (other measures can be necessary like moving screens away from these sources).

Class 2: Well protected environment

The environment is characterized by the following attributes:

— absence of electrical equipment like power transformers that may give rise to leakage fluxes;

— areas not subjected to the influence of H.V. bus-bars.

Household, office, hospital protected areas far away from earth protection conductors, areas of industrial installations and H.V. substations may be representative of this environment.

Class 3: Protected environment

The environment is characterized by the following attributes:

— electrical equipment and cables that may give rise to leakage fluxes or magnetic field;

— proximity of earth conductors of protection systems;

— M.V. circuits and H.V. bus-bars far away (a few hundred metres) from equipment concerned.

Commercial areas, control building, field of not heavy industrial plants, computer room of H. V. substations may by representative of this environment.

Class 4: Typical industrial environment

The environment is characterized by the following attributes:

— short branch power lines such as bus-bars, etc.;

— high power electrical equipment that may give rise to leakage fluxes;

— ground conductors of protection system;

— M.V. circuits and H.V. bus-bars at relative distance (a few tens of metres) from equipment concerned.

Fields of heavy industrial and power plants and the control room of H. V. substations may be representative of this environment.

Class 5: Severe industrial environment

The environment is characterized by the following attributes:

— conductors, bus-bars or M.V., H.V. lines carrying tens of kA;

— ground conductors of the protection system;

— proximity of M.V. and H.V. bus-bars;

— proximity of high power electrical equipment.

Switchyard areas of heavy industrial plants, M.V., H.V. and power stations may be representative of this environment.

Class x: Special environment

The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that the equipment lines of a higher level can penetrate a lower severity environment.

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Annex D (informative)
Information on power frequency magnetic field strength

Data on the strength of the magnetic field considered are given below. Athough not exhaustive, they may give information on the field strength expected at different locations and/or situations. Product committees may take them into account in the selection of the test levels, strictly related to each specific application.

Data are limited to available bibliography and/or measurements.

a) *Household appliances*
A survey on the magnetic fields produced by about 100 different appliances of 25 basic types is given in Table D.1. The field strength is related to the surfaces of appliances (it is quite localized) and at greater distances. At a distance of 1 m or more it would vary from the maximum expected field at that distance by only 10 % to 20 % when measured in any direction from the appliance. Background magnetic field in the homes where appliances were measured ranged from 0,05 A/m to 0,1 A/m.

The faults in domestic low-voltage power lines gives field strength higher than specified, depending on the short circuit current of each installation; the duration is in the order of hundreds ms, depending on the protection devices installed.

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Table D.1 — Values of the maximum magnetic field produced by household appliances (results of the measurements of 100 different devices of 25 basic types)

Distance from the surface of the device	d = 0,3 m	d = 1,5 m
95 % of the measurements	0,03 A/m – 10 A/m	< 0,1 A/m
Highest measurements	21 A/m	0,4 A/m

b) *High voltage lines*
Because the magnetic field is dependent on the line configuration, load and fault conditions, the field profile may be more significant to determine the electromagnetic environment to which equipment may be exposed.

General information on the environment produced by high voltage lines is given in IEC 1000-2-3.

The quantitative survey of the actual field measurement is given in Table D.2.

Table D.2 — Values of the magnetic field generated by a 400 kV line

Under the line tower	Under a mid span section	At 30 m lateral distance
10 A/m/kA	16 A/m/kA	about 1/3 of previous values

c) *H.V. substation area*
The quantitative survey of the actual field measurements related to 220 kV and 400 kV high voltage substations is given in Table D.3.

Table D.3 — Values of the magnetic field in high voltage substation areas

Substation	220 kV	400 kV
Under the bus-bars near connection to a line carrying about 0,5 kA	14 A/m	9 A/m
In the relay room (kiosk)	Near event recorders at about 0,5 m distance: 3,3 A/m Near measurement voltage transformer: d = 0,1 m:7,0 A/m d = 0,3 m:1,1 A/m	
In the equipment room	Maximum 0,7 A/m	

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d) *Power plants and industrial plants*
Measurements were carried out at different areas of a power plant; most of them are comparable, for the kind of power supply lines and electrical equipment, to industrial plants.

The survey of the actual field measurement is given in Table D.4.

Table D.4 — Values of the magnetic field in power plants

Source of magnetic field	Field (A/m) at a distance of:			
	0,3 m	0,5 m	1 m	1,5 m
Medium voltage bus-bars carrying 2,2 kA[a]	14 – 85	12,5 – 71	8,5 – 35	5,7 –
190 MVA, MV/HV transformer, 50 % load	—	—	6,4	—
6 kV cells[a]	8 – 13	6,5 – 9	3,5 – 4,3	2 – 2,4
6 kV twisted power cables	—	2,5	—	—
6 MVA pumps (at full load, 0,65 kA)	26	15	7	—
600 kVA, MV/LV transformer	14	9,6	4,4	—
Control building, multipoint paper recorder	10,7	—	—	—
Control room, far away from sources	0,9			

[a] These ranges include the values related to the different direction of the distance and geometry of the installation.

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Annex ZA (normative)
Other international publications quoted in this standard with the references of the relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

NOTE When the international publication has been modified by CENELEC common modifications, indicated by (mod), the relevant EN/HD applies.

IEC publication	Date	Title	EN/HD	Date
68-1	1988	*Environmental testing — Part 1: General and guidance*	HD 323.1 S2	1988

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