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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but no immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 1000-5-1, which is a technical report of type 3, has been prepared by subcommittee 77B: High-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

The text of this technical report is based on the following documents:

Committee draft	Report on voting
77B/155/CDV	77B/177/RVC

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

This document is issued in the type 3 technical report series of publications (according to G.3.2.3 of part 1 of the IEC/ISO Directives) as a purely informative document.

This document is not to be regarded as an International Standard.

INTRODUCTION

IEC 1000-5 is a part of the IEC 1000 series, according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as international standards or as technical reports.

These sections of IEC 1000-5 will be published in chronological order and numbered accordingly.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5: Installation and mitigation guidelines – Section 1: General considerations

1 Scope

This technical report covers general considerations and guidelines on mitigation methods aimed at ensuring electromagnetic compatibility (EMC) among electrical and electronic apparatus or systems used in industrial, commercial, and residential installations. This technical report is intended for use by installers and users, and to some extent manufacturers, of sensitive electrical or electronic installations and systems, and equipment with high emission levels that could degrade the overall electromagnetic (EM) environment. It applies primarily to new installations, but where economically feasible, it may be applied to extensions or modifications to existing facilities.

Specific topics, such as recommendations on the design and implementation of the earthing system, including the earth electrode and the earth network, the design and implementation of bonding apparatus or systems to earth or to the earth network, the selection and installation of appropriate cables, and the design and implementation mitigation means involving shielded enclosures, high-frequency filters, isolating transformers, surge-protective devices, etc. will be addressed in other sections of part 5.

The recommendations presented in this report address the EMC concerns of the installation, not the safety aspects of the installation nor the efficient transportation of power within the installation. Nevertheless, these two prime objectives are taken into consideration in the recommendations concerning EMC. These two primary objectives can be implemented concurrently for enhanced EMC of the installed sensitive apparatus or systems without conflict by applying the recommended practices presented in this report and the relevant safety requirements such as those of IEC 364. As each installation is unique, it is the responsibility of the designer and the installer to select the relevant recommendations most appropriate to a particular installation.

2 Reference documents

IEC 50(161): 1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 50(826): 1982, *International Electrotechnical Vocabulary (IEV) – Chapter 826: Electrical installations of buildings*

IEC 1000-1-1: 1992, *Electromagnetic compatibility (EMC) – Part 1: General – Section 1: Application and interpretation of fundamental definitions and terms*

IEC 1000-2-5: 1995, *Electromagnetic compatibility (EMC) – Part 2: Environment – Section 5: Classification of electromagnetic environments – Basic EMC publication*

IEC 1000-4: *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques*

IEC 1024-1: 1990, *Protection of structures against lightning – Part 1: General principles*

3 Definitions

For the purpose of this technical report, the definitions given in IEC 50(161) and IEC 50(826) apply, as well as the definitions listed below.

A list of acronyms is provided at the end of this clause.

3.1 **bonding:** The act of connecting together exposed conductive parts and extraneous conductive parts of apparatus, systems, or installations that are at essentially the same potential. [new, WG2]

3.2 **disturbance level:** The level of a given electromagnetic disturbance existing at a given location, which results from all contributing disturbance sources. [IEV 161-03-09A]

3.3 **earth; ground (USA):** The conductive mass of the earth, whose electric potential at any point is conventionally taken as equal to zero. [IEV 826-04-01]

3.4 **earth electrode:** A conductive part or a group of conductive parts in intimate contact with and providing an electrical connection with earth. [IEV 826-04-02]

3.5 **earthing network:** Conductors of the earthing system, not in contact with the soil, connecting apparatus, systems, or installations to the earth electrode or to other means of earthing. [new, WG2]

3.6 **earthing:** The act of connecting exposed conductive parts or other selected conductors of apparatus, systems or installations to the earth electrode or earth arrangement. [new, WG2]

3.7 **earthing system:** The three-dimensional electrical circuit which performs the earthing.

NOTE – The earthing system includes two parts: the earth electrode and the earth network. [new, WG2]

3.8 **(electromagnetic) compatibility level:** The specified disturbance level at which an acceptable, high probability of electromagnetic compatibility should exist. [IEV 161-03-10]

3.9 **facility:** Something (like a hospital, factory, machinery, etc.) that is built, constructed, installed or established to perform some particular function or to serve or facilitate some particular end. [new WG2)]

3.10 **immunity margin:** The ratio of the immunity limit to the electromagnetic compatibility level. [IEV 161-03-16]

3.11 **immunity level:** The maximum level of a given electromagnetic disturbance, incident in a specified way on a particular device, equipment or system, at which no degradation of operation occurs. [IEV 161/A 1.2.2]

3.12 **in-plant point of coupling; (abbreviation IPC):** The point of coupling inside the system or installation to be studied. [future IEV 161-03-26]

3.13 **point of common coupling; (abbreviation PCC):** The point of the public supply network, electrically nearest to a particular consumer's installation, and at which other consumers' installations are, or may be, connected. [IEV 161-07-15]

3.14 **port:** Specific interface of the specified apparatus with the external electromagnetic environment.

3.15 **Acronyms**

a.c.	alternating current	ESD	electrostatic discharge
d.c.	direct current	HF	high frequency
EM	electromagnetic	IPC	in-plant point of coupling
EMC	electromagnetic compatibility	PCC	point of common coupling

4 General considerations on electromagnetic compatibility (EMC) of installations

Different types of standards are available to define conditions for compliance with EMC requirements for electrical and electronic products:

– dedicated product standards;
– product family standards;
– generic standards;
– basic standards.

Definitions and characteristics of these standards have been established by the Advisory Committee on Electromagnetic Compatibility (ACEC). One essential aspect of a standard is the availability of suitable tests to verify compliance with the standard. In the case of an installation, however, testing the complete installation is generally not practical or appropriate, when EMC for sensitive installations and systems is concerned. Therefore, installation guidelines are necessary to adapt to a maximum of situations. There are many types of installations and successful EMC has been achieved through different approaches. ***Thus, this technical report recommends a general approach, while not precluding other approaches if appropriate. Special mitigation methods might not be necessary when the equipment satisfies applicable emissions and immunity standards.***

The process adopted for ensuring electromagnetic compatibility of installations may take two approaches, depending on how early in the design the EMC specialist is offered an opportunity to contribute.

a) At the early stages of a major installation, each compatibility level (specific for a given electromagnetic disturbance) can be assigned for the particular environment of the installation. Through specification of overall mitigation schemes, apparatus and its installation practice are then specified with immunity and emission levels corresponding to the predetermined compatibility level.

b) At later stages of the design, for the installation of additional apparatus or the initial installation of commercially available apparatus for which no opportunity exists to modify its EMC characteristics, a mismatch may occur between the overall, *de facto* compatibility level of the site and the capability of the apparatus. In such a case, mitigation methods shall be selected to close the gap between the environment and the apparatus immunity levels to a minimum.

The first approach has been successfully applied for installations where a single engineering entity has the authority to prescribe and enforce a certain compatibility level. As a general principle, this approach is illustrated by the global protection topology of figures 3 and 4. A concrete example of this very successful approach is the insulation coordination of high-voltage apparatus applied by electric utilities where the maximum overvoltage level to be expected is determined by the ***prior choice*** of surge arresters, ***followed*** by specification of apparatus with an insulation level consistent with the protective level provided by the arresters.

The second approach is generally applied in existing installations where the owner or designer lacks the leverage to impose a predetermined compatibility level for the environment or immunity/emission level for the apparatus. Figure 5 shows the typical topology associated with this approach. This situation is encountered in low-voltage, end-user commercial or industrial facilities, and in residential environments.

In this second approach, the task of the EMC specialist then becomes one of matching the equipment and environment after the fact. In favourable cases, this matching can still be done before problems occur – the very purpose of the present series of publications is indeed to make this matching happen. However, this approach is often applied to correct problems after they have occurred. That approach is not the most cost-effective or time-effective method. Regardless of the applicable approach, several steps shall be taken. The sequence of the steps depends on the approach selected, as shown below. (Complementary information on the related case of low-frequency conducted disturbances on the power supply system is given in annex B.)

Approach a:

1) Environment characterization
2) Specification of mitigation method
3) Evaluation of mitigation performance
4) Specification of apparatus immunity/emissions
5) Verification of apparatus immunity/emissions
6) Verification of EMC (if possible)

Approach b:

1) Environment characterization
2) Passive acceptance of apparatus immunity
3) Identification of mismatch
4) Specification of mitigation method
5) Evaluation of the quality of installations
6) Verification of EMC (if possible)

4.1 *Aim of proper installation and design*

Depending on the electromagnetic environment of an installation site and for a given phenomenon, there is a high probability of having a certain level of EM disturbances. According to the concepts of EM environment classification, there should be a determined (or specified) compatibility level. Furthermore, each apparatus has an intrinsic immunity level which can be sufficient or not sufficient in view of the disturbances occurring on the site. As environmental conditions and performance criteria for immunity of apparatus can vary for each installation, the information given in the IEC 1000-5 series will serve as recommendations. Consequently, the IEC 1000-5 series should serve:

– to plan and check installations of new apparatus and systems;
– to check and improve installations already existing.

Actions taken by applying these installation guidelines should:

– reduce disturbances below the immunity level of apparatus;
– not introduce other disturbances.

Finally, the proposed method should help obtain EMC in an effective manner, especially when technical compromises have to be sought to reach an economical solution.

4.2 *Emitter, coupling, susceptor*

EM disturbances are caused by conducted or radiated phenomena. Figure 1 depicts in a general manner how EM disturbances may affect sensitive apparatus. An apparatus can be both the emitter and susceptor (potential victim) at the same time.

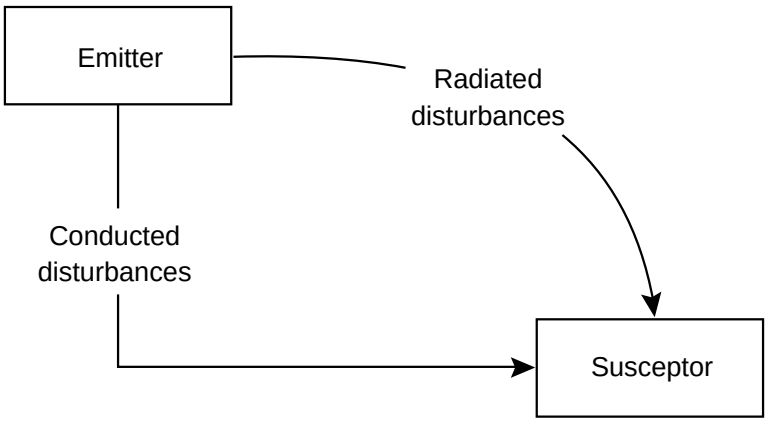

Figure 1 – Electromagnetic influence representation