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Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 4: Immunity to HEMP - Specifications of protective devices against HEMP radiated disturbance - Basic EMC publication

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Part 5: Installation and mitigation guidelines – Section 4: Immunity to HEMP – Specifications for protective devices against HEMP radiated disturbance – Basic EMC publication

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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 cooperation 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.
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- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
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- 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 Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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 1000-5-4, which is a technical report of type 2, has been prepared by subcommittee 77C: Immunity to high altitude nuclear electromagnetic pulse (HEMP), of IEC technical committee 77: Electromagnetic compatibility.

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

FDIS	Report on voting
77C/26/CDV	77C/36/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 2 Technical Report series of publications (according to G.4.2.2 of part 1 of the IEC/ISO Directives as a "prospective standard for provisional application" in the field of electromagnetic compatibility because there is an urgent requirement for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this type 2 Technical Report will be carried out not later than three years after its publication, with the options of either extension for a further three years or conversion to an International Standard or withdrawal.

Annexes A and B are for information only.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 5: Installation and mitigation guidelines
Section 4: Immunity to HEMP – Specifications for protective devices against HEMP radiated disturbance –
Basic EMC publication

1 Scope

This technical report defines how protective devices for High Altitude Nuclear Electromagnetic Pulse (HEMP) protection of civilian systems are specified. Performance requirements will be given in future IEC standards. This technical report is intended to be used for the harmonization of existing or future specifications issued by protective devices manufacturers, electronic equipment manufacturers, administrative bodies and other buyers.

This technical report covers protective devices currently used for protection against HEMP radiated EM fields. In general, parameters relevant to HEMP, that is parameters related to very fast changes of EM fields, as a function of time, are dealt with.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this technical report. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this technical report are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

3 Definitions

For the purpose of this technical report, the following definitions apply.

HEMP/HA-NEMP: The two acronyms are equivalent and accepted for High Altitude Nuclear Electromagnetic Pulse. HEMP is preferable to HA-NEMP.

barrier: Separation used to insulate electrical circuits from electromagnetic disturbances. (A shield is a special type of barrier.)

contact resistance: Resistance measured in ohms between two objects in contact with each other.

compression set: The per cent of permanent height reduction in a material caused by compression under specific conditions of heat, pressure and time.

corrosion resistance: Resistance to a chemical action which causes gradual destruction of the surface of a metal by oxidation, electrolysis or chemical contamination.

cut-off frequency: The frequency at which the magnitude of a measured characteristic quantity has decreased to a specified fraction of its low-frequency value.

NOTE – For a waveguide it is the frequency below which electromagnetic energy is not efficiently propagated in the guide. This frequency depends on the cross-section geometry and dimensions of the guide.

elongation: The increase in length of a material stressed under tension.

point of entry: The physical place at the surface of a closed enclosure through which the energy penetrates.

protective device: An electrical component such as a filter, gas discharge tube, metal oxide varistor, etc., for protection against conducted disturbances, or a shield, gasket, waveguide trap, etc., for protection against radiated disturbances. Such an element, or a combination of several of them, thus forms part of the conceptual electromagnetic barrier of the system.

shield: Electrically conductive material placed around a system circuit, component, or cable to suppress the effect of an electromagnetic field within or beyond definite regions.

shielding effectiveness: The measure, generally in dB, of the reduction or attenuation of the amplitude of an electromagnetic field at a point in space before and after the placement of a shield, between a source and this point.

skin depth: The depth of a conductive material beyond which the current density has decreased by one Neper (1/e or 36,8 %) in comparison with its value at the surface of the material.

surface resistivity: The resistance of a material between two opposite sides of a unit square of its surface, commonly expressed in ohms per square.

surface transfer impedance (of a coaxial line): The quotient of the voltage induced in the centre conductor of a coaxial line per unit length by the current on the external surface of the coaxial line. [IEV 161-04-15]

tensile strength: The maximum tensile stress applied, during stretching, to a specimen to rupture.

transfer admittance: A mathematical relationship between the induced current on a conductor located on the protected side of a shielded region and the voltage on the unprotected side of the enclosure. This is the dual quantity of the transfer impedance.

transfer impedance (of a screened circuit): The quotient of the voltage appearing between two specified points in the screened circuit by the current in a defined cross-section of the screen. [IEV 161-04-14]

volume resistivity: The electrical resistance between opposite faces of 1 cm^3 of material, commonly expressed in ohms.centimetres.

waveguide below cut-off: A protective element consisting of a length of waveguide which limits the passage of electromagnetic energy below a fixed frequency.

waveguide trap: A waveguide below cut-off serving as an electromagnetic protection device in a barrier.

4 Specifications for protective devices against radiated disturbances

The shielding effectiveness of a shielded enclosure (Faraday cage, cabinet or shielded building) is violated by penetrations, openings and seams. All of these shall be treated in such a way that the resulting degradation of the shielding effectiveness is as small as possible. This goal is achieved by means of specific protection devices.

In the following, these protection devices are dealt with one by one, by explaining their principles of operation, showing their limitations in some cases, and finally listing the specifications that shall be given by the manufacturers.

The figures help demonstrate the principle of operation and may also serve as examples of how the frequency-dependent parameters might be presented.

4.1 *General classification for shielding devices*

Barrier materials:

- shielding materials;
- viewing windows;
- air vent panels;
- waveguide traps;
- conductive coatings;
- conductive adhesives and sealants.

Shielded cables and conduits:

- solid shields;
- leaky shields;
- connectors.

Gasketing materials:

- knitted wire mesh gaskets;
- metal fibers and screen gaskets;
- oriented wire gaskets;
- conductive elastomer gaskets.

Shielding components:

- toggle boots;
- shaft seals;
- connector gaskets;
- ring seals;
- foil tapes;
- etc.

4.2 *General requirements*

The shielding materials needed to reach the required shielding effectiveness shall meet several electrical, mechanical and environmental criteria.

Electrical requirements

For barrier materials, attenuation values shall be supplied for E and H fields, and for plane waves in the frequency range 10 kHz to 1000 MHz. For gasketing materials the same information as above is required, and in addition, the d.c. resistance shall be provided. For shielded cables the specification of transfer impedance and, if necessary, transfer admittance in the frequency range 10 kHz to 100 MHz is required.

Mechanical requirements

All the mechanical characteristics necessary for the correct use of the materials should be available to the user. These are listed in the following subclauses.

Environmental requirements

The total shielding effectiveness of a shielded enclosure is limited by the failure of seams to achieve adequate electrical contact. The shielding integrity of a seam can be increased by improving this contact. This might be achieved by using conductive gasketing.

However, the use of certain gaskets does not maintain the shielding integrity for a long time and environmental conditions, such as dust, moisture and vapors shall be taken into consideration. For example, to seal against dust and moisture, flat or strip EMI gaskets joined to a sponge or solid elastomer are adequate. Therefore, information concerning the appropriate environmental use of specific gasketing materials is required.

4.3 *Specifications*

4.3.1 *General*

Both mechanical and electrical design aspects should be considered in order to specify protection devices.

Specifications include:

- general description (presentation, purpose);
- application information (specific use);
- material description (material, consistency, color, finish, etc.);
- performance characteristics (E, H and plane wave attenuation, d.c. resistance, temperature range, mechanical properties, transfer impedance and if necessary transfer admittance);
- dimensions;
- recommendations for use (surface preparation, pressure, safety and operational cautions);
- methods of construction;
- mounting techniques (way of assembly);
- storage recommendations.

4.3.2 *Barrier materials*

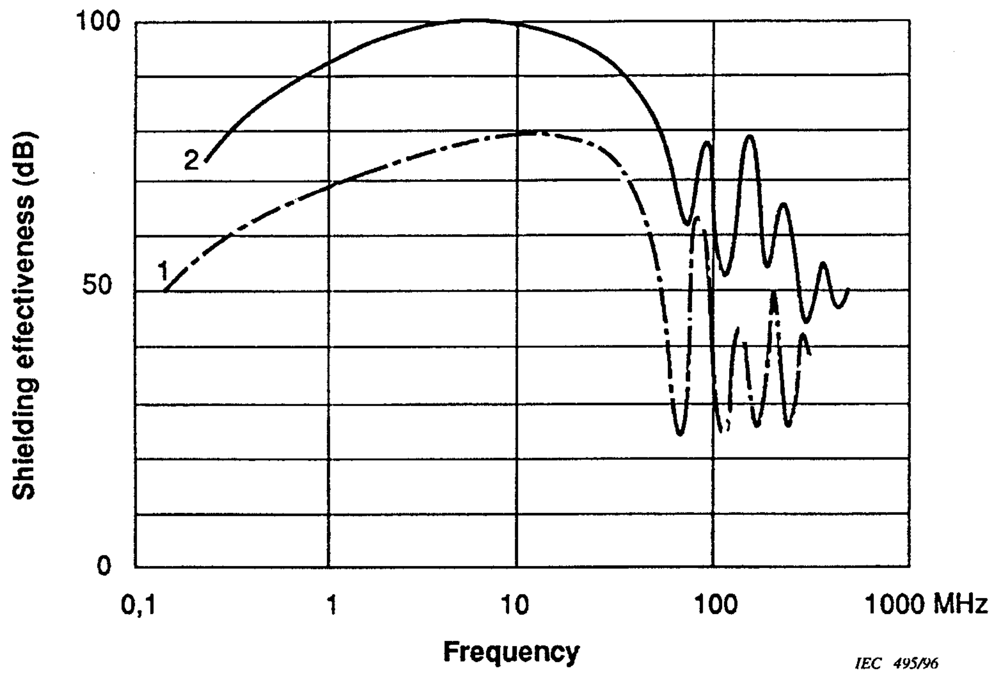
4.3.2.1 *Shielding materials*

Two types are generally available:

a) *Wire mesh*

The shielding effectiveness depends on the size of the volume to be shielded, and especially on the mesh size and the wire mesh manufacturing. The shielding effectiveness increases when the mesh size decreases or when using a double shield, the two shields being insulated from each other and presenting only one connection point to the earth.

For the cage sizes presented in figure 1, the cut-off frequency is about 80 MHz. At higher frequencies, there is a resonant effect resulting in oscillations.



Curve 1: dimensions 3 m x 3,25 m x 3 m
Hexagonal mesh: 15 mm x 17 mm
Curve 2: dimensions 4 m x 4 m x 3 m
Square mesh: 4 mm

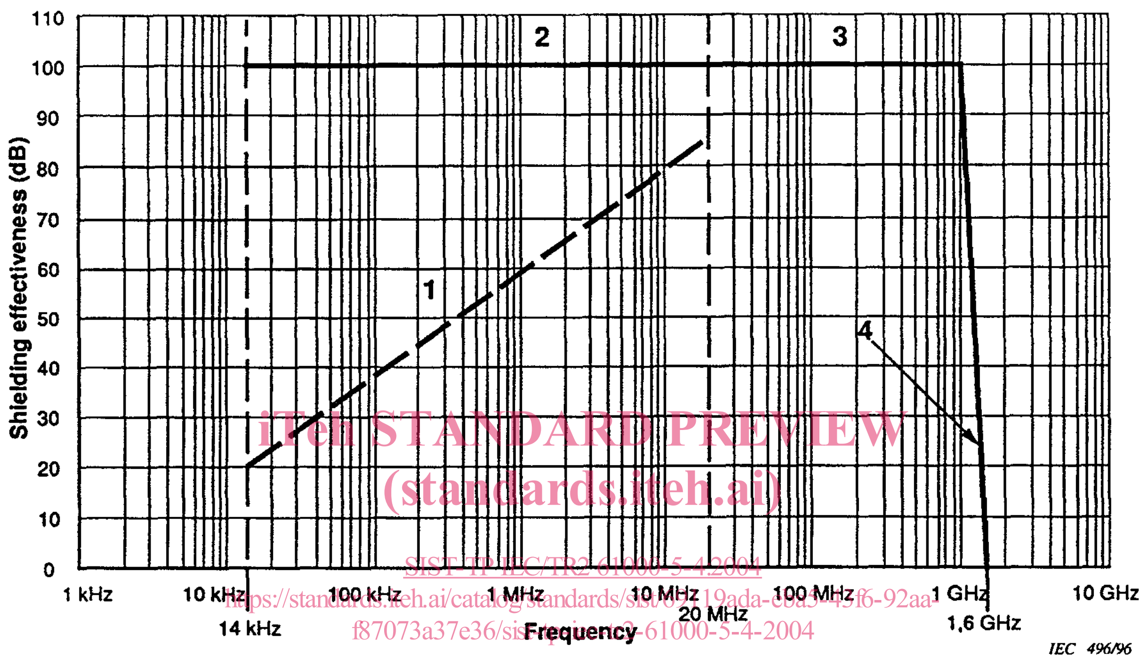
Figure 1 – Typical plane wave attenuation for double-wall cages

b) *Metal sheet*

The attenuation of cages with homogeneous metal sheets is higher. The shielding effectiveness increases with frequency due to the skin depth, so that even very thin sheets are efficient at high frequencies.

Simple formulas allow the computation of absorption losses, reflection losses and shielding effectiveness of metal sheets for plane waves when their dimensions are large compared to the wavelengths considered. These are presented in annex A.

An example of a specification for the shielding effectiveness of a Faraday cage is given in figure 2.



1: magnetic field
2: electric field
3: plane wave
4: 10 cm diameter waveguide below cut-off

Figure 2 – Example of HEMP shielding effectiveness of a Faraday cage

Specifications required:

Shielded rooms:

- general description;
- dimensions of the different elements;
- weight;
- way of assembly;
- point and surface loads admitted;
- type of material;
- types of doors possible;
- different points of entry (POEs) with their mechanical characteristics;
- shielding effectiveness.