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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Nuclear power plants – Instrumentation, control and electrical power systems – Requirements for electromagnetic compatibility testing

Centrales nucléaires de puissance – Systèmes d'instrumentation, de contrôle-commande et d'alimentation électrique – Exigences relatives aux essais de compatibilité électromagnétique

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NUCLEAR POWER PLANTS – INSTRUMENTION, CONTROL AND ELECTRICAL POWER SYSTEMS – REQUIREMENTS FOR ELECTROMAGNETIC COMPATIBILITY TESTING

FOREWORD

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International Standard IEC 62003 has been prepared by subcommittee 45A: Instrumentation, control and electrical power systems of nuclear facilities, of IEC technical committee 45: Nuclear instrumentation.

This second edition cancels and replaces the first edition published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) title modified.

b) expand the scope to encompass Electromagnetic Magnetic Compatibility (EMC) considerations for electrical equipment.

c) provide guidance for addressing the use of wireless technology.

d) enhance the description of the electromagnetic environment to provide clarification when selecting custom test levels or for test exemptions.

e) include example information to be contained within an EMC test plan.

f) provide guidance for characterization of the electromagnetic environment at the point of installation within a nuclear facility.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
45A/1299/FDIS	45A/1303/RVD

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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INTRODUCTION

a) Technical background, main issues and organization of the standard

This International Standard was prepared and based, to a very strong extent, on the current application of the IEC 61000 series for commercial equipment qualification for electromagnetic compatibility (EMC).

It is intended that this standard be used by operators of nuclear power plants (utilities), systems evaluators and by licensors.

b) Situation of the current standard in the structure of the SC 45A standard series

IEC 62003 is the third level SC 45A document dealing with the issue of qualification for electromagnetic compatibility (EMC) applicable to Instrumentation and Control (I&C) and electrical systems important to safety in nuclear facilities.

For more details on the structure of the SC 45A standard series see item d) of this introduction.

c) Recommendation and limitation regarding the application of this standard

It is important to note that this standard establishes no additional functional requirements for safety systems but clarifies the criteria to be applied for qualification to Electromagnetic and Radio Frequency Interference (EMI/RFI) from the commercial standards.

Aspects for which special requirements and recommendations have been produced, are:

1) IEC 61000 series with specific qualifications for nuclear applications around the world;
2) regulatory interpretations for requirements on level of qualification necessary and types of recommended testing to address all potential environmental stressors, related to this type of qualification;
3) IEC 61000-6-2, Electromagnetic compatibility (EMC) – Part 6-2: Generic Standards – Immunity for industrial environments, addresses requirements for all industrial environments while this standard addresses environments in nuclear facilities specifically.

This standard is intended to align with the guidance contained within IEC 61000-6-5 and IEC 61000-6-7 where possible. Additional considerations from these standards can be used in conjunction with this standard when addressing the EMC of electrical and I&C equipment in nuclear facilities.

d) Description of the structure of the IEC SC45A standard series and relationships with other IEC documents and other bodies documents (IAEA, ISO)

The top-level documents of the IEC SC45A standard series are IEC 61513 and IEC 63046. IEC 61513 provides general requirements for I&C systems and equipment that are used to perform functions important to safety in NPPs. IEC 63046 provides general requirements for electrical power systems of NPPs; it covers power supply systems including the supply systems of the I&C systems. IEC 61513 and IEC 63046 are to be considered in conjunction and at the same level. IEC 61513 and IEC 63046 structure the IEC SC45A standard series and shape a complete framework establishing general requirements for instrumentation, control and electrical systems for nuclear power plants.

IEC 61513 and IEC 63046 refer directly to other IEC SC45A standards for general topics related to categorization of functions and classification of systems, qualification, separation, defence against common cause failure, control room design, electromagnetic compatibility, cybersecurity, software and hardware aspects for programmable digital systems, coordination of safety and security requirements and management of ageing. The standards referenced directly at this second level should be considered together with IEC 61513 and IEC 63046 as a consistent document set.

At a third level, IEC SC45A standards not directly referenced by IEC 61513 or by IEC 63046 are standards related to specific equipment, technical methods, or specific activities. Usually these documents, which make reference to second-level documents for general topics, can be used on their own.

A fourth level extending the IEC SC45 standard series, corresponds to the Technical Reports which are not normative.

The IEC SC45A standards series consistently implements and details the safety and security principles and basic aspects provided in the relevant IAEA safety standards and in the relevant documents of the IAEA nuclear security series (NSS). In particular this includes the IAEA requirements SSR-2/1, establishing safety requirements related to the design of nuclear power plants (NPPs), the IAEA safety guide SSG-30 dealing with the safety classification of structures, systems and components in NPPs, the IAEA safety guide SSG-39 dealing with the design of instrumentation and control systems for NPPs, the IAEA safety guide SSG-34 dealing with the design of electrical power systems for NPPs and the implementing guide NSS17 for computer security at nuclear facilities. The safety and security terminology and definitions used by SC45A standards are consistent with those used by the IAEA.

IEC 61513 and IEC 63046 have adopted a presentation format similar to the basic safety publication IEC 61508 with an overall life-cycle framework and a system life-cycle framework. Regarding nuclear safety, IEC 61513 and IEC 63046 provide the interpretation of the general requirements of IEC 61508-1, IEC 61508-2 and IEC 61508-4, for the nuclear application sector. In this framework IEC 60880, IEC 62138 and IEC 62566 correspond to IEC 61508-3 for the nuclear application sector. IEC 61513 and IEC 63046 refer to ISO as well as to IAEA GS-R part 2 and IAEA GS-G-3.1 and IAEA GS-G-3.5 for topics related to quality assurance (QA). At level 2, regarding nuclear security, IEC 62645 is the entry document for the IEC/SC45A security standards. It builds upon the valid high level principles and main concepts of the generic security standards, in particular ISO/IEC 27001 and ISO/IEC 27002; it adapts them and completes them to fit the nuclear context and coordinates with the IEC 62443 series. At level 2, IEC 60964 is the entry document for the IEC/SC45A control rooms standards and IEC 62342 is the entry document for the ageing management standards.

NOTE 1 It is assumed that for the design of I&C systems in NPPs that implement conventional safety functions (e.g. to address worker safety, asset protection, chemical hazards, process energy hazards) international or national standards would be applied.

NOTE 2 IEC/SC45A domain was extended in 2013 to cover electrical systems. In 2014 and 2015 discussions were held in IEC/SC45A to decide how and where general requirements for the design of electrical systems were to be considered. IEC/SC45A experts recommended that an independent standard be developed at the same level as IEC 61513 to establish general requirements for electrical systems. Project IEC 63046 is now launched to cover this objective. When IEC 63046 is published this NOTE 2 of the introduction of IEC/SC45A standards will be suppressed.

NUCLEAR POWER PLANTS – INSTRUMENTION, CONTROL AND ELECTRICAL POWER SYSTEMS – REQUIREMENTS FOR ELECTROMAGNETIC COMPATIBILITY TESTING

1 Scope

This document establishes requirements for electromagnetic compatibility testing of instrumentation, control, and electrical equipment supplied for use in systems important to safety at nuclear power plants and other nuclear facilities. The document lists the applicable IEC standards (principally the IEC 61000 series) which define the general test methods, and provides the necessary application-specific parameters and criteria to ensure that nuclear safety requirements are met.

The normative part of this document is limited to the testing of equipment prior to installation in a nuclear power plant to demonstrate immunity to electromagnetic disturbances and to demonstrate that the equipment does not generate excessive emissions. Testing for the generation of excessive emissions is also applicable to non-safety equipment. This document includes informative annexes which provide additional guidance and describes approaches to maintaining electromagnetic compatibility for installed equipment. The intent of this document is to provide guidance for conducting the electromagnetic compatibility (EMC) qualification testing of the equipment and does not provide guidance for the installation of the equipment to prevent electromagnetic and radio frequency interference (EMI/RFI). However, the configuration of the equipment under test during EMC qualification testing is representative of the intended installation in a nuclear facility.

Protection against a high altitude electromagnetic pulse (HEMP) and intentional electromagnetic interference (IEMI) are outside of the scope of this document, but information can be found in IEC 61000-4-23, IEC 61000-4-24, and IEC 61000-4-25 (HEMP) and IEC 61000-4-36 (IEMI) to address these phenomena.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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/IEEE 60780-323, *Nuclear facilities – Electrical equipment important to safety – Qualification*

IEC TR 61000-1-6, *Electromagnetic compatibility (EMC) – Part 1-6: General – Guide to the assessment of measurement uncertainty*

IEC TR 61000-2-5, *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Description and classification of electromagnetic environments*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-9, *Electromagnetic compatibility (EMC) – Part 4-9: Testing and measurement techniques – Impulse magnetic field immunity test*

IEC 61000-4-10, *Electromagnetic compatibility (EMC) – Part 4-10: Testing and measurement techniques – Damped oscillatory magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-12, *Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test*

IEC 61000-4-13, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurements techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*

IEC 61000-4-14, *Electromagnetic compatibility (EMC) – Part 4-14: Testing and measurement techniques – Voltage fluctuation immunity test*

IEC 61000-4-16, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz*

IEC 61000-4-17, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test*

IEC 61000-4-18, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC 61000-4-20, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides*

IEC 61000-4-28, *Electromagnetic compatibility (EMC) – Part 4-28: Testing and measurement techniques – Variation of power frequency, immunity test*

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

IEC 61000-4-34, *Electromagnetic compatibility (EMC) – Part 4-34: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61000-6-5, *Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment*

IEC 61000-6-7, *Electromagnetic compatibility (EMC) – Part 6-7: Generic standards – Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations*

IEC 61226, *Nuclear power plants – Instrumentation and control important to safety – Classification of instrumentation and control functions*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
acceptance criteria
specified bounds on the value of a functional indicator or condition indicator used to assess the ability of a structure, system or component to perform its design function

[SOURCE: IAEA Safety Glossary, edition 2016]

3.2
electromagnetic compatibility
EMC
ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:1990, 161-01-07]

3.3
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

[SOURCE: IEC 60050-161:1990, 161-01-01]

3.4
immunity <to a disturbance>
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-20]

3.5
electrostatic discharge
transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

[SOURCE: IEC 60050-161:1990, 161-01-22]

3.6
equipment under test
EUT
equipment under test can be a single unit or multiple units interconnected by cables, data links, etc.

[SOURCE: IEC 61000-4-25:2001, 3.10]

3.7
port
particular interface of an equipment, which couples this equipment with the external electromagnetic environment and through which the equipment is influenced by the environment (see Figure 1)

[SOURCE: IEC 60050-161:1990, 161-01-27]

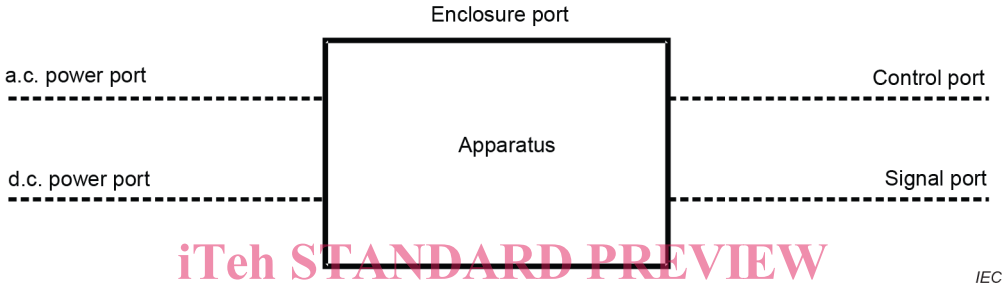

Figure 1 – Examples of ports

3.8
radiofrequency
RF
frequency of the electromagnetic spectrum that is between the audio frequency portion and the infrared portion

[SOURCE: IEC 61000-4-23:2000, 3.37]

3.9
transient
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval that is short when compared with the time-scale of interest

[SOURCE: IEC 60050-161:1990, 161-02-01]

4 Abbreviated terms

AC	Alternative current
DC	Direct current
EFT	Electrical fast transient
EMI/RFI	Electromagnetic and radiofrequency interference
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
EUT	Equipment under test
HEMP	High altitude electromagnetic pulse

HV	High voltage
IEMI	Intentional electromagnetic interference
I/O	Input/output
I&C	Instrumentation and control
LISN	Line impedance stabilization network
LV	Low voltage
MV	Medium voltage
UPS	Uninterruptible power system

5 EMC test requirements

Nuclear instrumentation, control, and electrical equipment important to the safety of a nuclear plant (as defined in the IEC/IEEE 60780-323 standard) shall satisfy the requirements for emissions generated by the equipment and immunity to electromagnetic interference as documented in this document. Controlling the emissions from all types of equipment (important to safety and non-safety equipment) is necessary to ensure that the electromagnetic environment is bounded by the test levels recommended in this standard.

Table 1 contains a list and description of the EMC immunity and emissions tests applicable to nuclear I&C and electrical equipment important to safety to be installed into a nuclear facility. These tests address the main types of electromagnetic disturbances found in a typical nuclear power plant environment and not all types of tests may be applicable for a particular piece of equipment or installation. Adequate technical justification for the elimination of particular tests should be provided in the EMC purchase specification, test plan, and/or test report. Further guidance regarding the applicability of the various tests, test levels, and frequency ranges can be found in IEC 61000-6-5 (immunity for power station equipment) and IEC 61000-6-7 (immunity for safety-related system in industrial locations).

In the case of existing and installed equipment inside nuclear power plants, the requirements defined in this document may be aligned according to the state-of-the-art for EMC qualification testing valid during the time of installation. For such equipment, operational experience may be taken into account.

The guidance in this document was developed for I&C equipment but may also be applied to electrical equipment. However, because of the unique nature of electrical (power) equipment, some additional considerations might be required. An example of these considerations is provided in Annex H.

When the electromagnetic environment in a plant is unknown, it may become necessary to obtain emissions data at the point of the installation, using guidance in Annex D. Guidance in Annex E can be used to determine the EMC performance of equipment already installed in a nuclear power plant facility.

Table 1 – Description of applicable EMC immunity and emissions tests for nuclear I&C and electrical equipment important to safety

Test standard	EMC test description
EMC immunity tests	
IEC 61000-4-2	Electrostatic Discharge (ESD)
IEC 61000-4-3/IEC 61000-4-20	High frequency radiated
IEC 61000-4-4	Electrical Fast Transient (EFT)
IEC 61000-4-5	Surge (combination wave)
IEC 61000-4-6	High frequency conducted
IEC 61000-4-8	Magnetic field – Power frequency
IEC 61000-4-9	Pulse magnetic field
IEC 61000-4-10	Damped oscillatory magnetic field
IEC 61000-4-11	Voltage dips, interrupts (AC ≤ 16 A)
IEC 61000-4-12	Surge (ring wave)
IEC 61000-4-13	Power frequency harmonics
IEC 61000-4-14	Voltage fluctuations
IEC 61000-4-16	Low frequency conducted
IEC 61000-4-17	Ripple on d.c. power supply
IEC 61000-4-18	Surge (damped oscillatory wave)
IEC 61000-4-28	Power frequency variation
IEC 61000-4-29	Voltage dips, interrupts (DC)
IEC 61000-4-34	Voltage dips, interrupts (AC > 16 A)
EMC emissions tests	
IEC 61000-6-4	High frequency conducted
IEC 61000-6-4	High frequency radiated

6 Electromagnetic environment

The typical locations covered by this document are found within nuclear power plants and similar nuclear facilities. The locations generally follow a typical power plant installation shown in Figure 2 based on IEC 61000-6-5. In Figure 2, the solid lines do not represent physical boundaries between the areas where the equipment is installed, but indicate generic boundaries between electromagnetic environments. A majority of the I&C and electrical equipment covered under this document will be located in environments defined as interface type 2 meaning that it will not directly interface with the electrical process (medium and high voltage power distribution). For I&C and electrical equipment that does directly interface with the electrical process, the typical environment would be defined as interface type 3 in Figure 2. Therefore, the test levels specified in this document will be based upon the assumption that the equipment to be tested will be installed in these interface type 2 or interface type 3 areas of the plant.

It should be noted that the electromagnetic environment within these interface type 2 and 3 (and other) areas can vary significantly depending on the specific plant location and installation/design practices. If the equipment will be installed in a more or less severe environment (or if the country specific standards are different), then the test levels can deviate from those presented in this document as long as an appropriately documented justification is provided. Guidance is provided in Annex B to aid in determining specific test levels and providing the proper justification based upon the intended installation location. Further information on the interface types in typical power stations can be found in