BS EN 61326-3-1:2008

BSI British Standards

Electrical equipment for measurement, control and laboratory use – EMC requirements —

Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications

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National foreword

This British Standard is the UK implementation of EN 61326-3-1:2008. It is identical with IEC 61326-3-1:2008. Together with BS EN 61326-1:2006, BS EN 61326-2-1:2006, BS EN 61326-2-2:2006, BS EN 61326-2-3:2006, BS EN 61326-2-4:2006, BS EN 61326-2-5:2006, BS EN 61326-2-6:2006 and BS EN 61326-3-2:2008, it supersedes BS EN 61326:1998 which is withdrawn

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/1, System considerations.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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English version

Electrical equipment for measurement, control and laboratory use - EMC requirements -
Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) -
General industrial applications
(IEC 61326-3-1:2008)

Matériel électrique de mesure, de commande et de laboratoire - Exigences relatives à la CEM - Partie 3-1: Exigences d'immunité pour les systèmes relatifs à la sécurité et pour les matériels destinés à réaliser des fonctions relatives à la sécurité (sécurité fonctionnelle) - Applications industrielles générales
(CEI 61326-3-1:2008)

Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 3-1: Störfestigkeitsanforderungen für sicherheitsbezogene Systeme und für Geräte, die für sicherheitsbezogene Funktionen vorgesehen sind (Funktionale Sicherheit) - Allgemeine industrielle Anwendungen
(IEC 61326-3-1:2008)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 65A/500/FDIS, future edition 1 of IEC 61326-3-1, prepared by SC 65A, System aspects, of IEC TC 65, Industrial-process measurement, control and automation, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61326-3-1 on 2008-06-01.

The EN 61326 series supersedes EN 61326:1997 + corrigendum September 1998 + A1:1998 + A2:2001 + A3:2003.

This standard is to be used in conjunction with EN 61326-1.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2009-03-01

– latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2011-06-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61326-3-1:2008 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60204-1	NOTE	Harmonized as EN 60204-1:2006 (modified).
IEC 61508-4	NOTE	Harmonized as EN 61508-4:2001 (not modified).
IEC 61511	NOTE	Harmonized in EN 61511 series (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

Publication	Year	Title	EN/HD	Year
IEC 60050-161	- [1)]	International Electrotechnical Vocabulary (IEV) - Chapter 161: Electromagnetic compatibility	-	-
IEC 61000-4-2 A1 A2	1995 1998 2000	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2 A1 A2	1995 1998 2001
IEC 61000-4-3	2006	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	2006
IEC 61000-4-4	2004	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	2004
IEC 61000-4-5	2005	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006
IEC 61000-4-6 + A1 + A2	2003 2004 2006	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6 + corr. August	2007 2007
IEC 61000-4-8 A1	1993 2000	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8 A1	1993 2001
IEC 61000-4-11	2004	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	2004
IEC 61000-4-16 A1	1998 2001	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	EN 61000-4-16 A1	1998 2004

[1)] Undated reference.

Publication	Year	Title	EN/HD	Year
IEC 61000-4-29	2000	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	EN 61000-4-29	2000
IEC 61000-6-2	2005	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments	EN 61000-6-2 + corr. September	2005 2005
IEC 61326-1	2005	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	EN 61326-1	2006
IEC 61326-2-1	2005	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-1: Particular requirements - Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications	EN 61326-2-1	2006
IEC 61326-2-2	2005	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-2: Particular requirements - Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems	EN 61326-2-2	2006
IEC 61326-2-3	2006	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-3: Particular requirements - Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning	EN 61326-2-3	2006
IEC 61326-2-4	2006	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-4: Particular requirements - Test configurations, operational conditions and performance criteria for insulation monitoring devices according to IEC 61557-8 and for equipment for insulation fault location according to IEC 61557-9	EN 61326-2-4	2006
IEC 61326-2-5	2006	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-5: Particular requirements - Test configurations, operational conditions and performance criteria for field devices with interfaces according to IEC 61784-1, CP 3/2	EN 61326-2-5	2006

Publication	Year	Title	EN/HD	Year
IEC 61326-3-2	2008	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - Industrial applications with specified electromagnetic environment	EN 61326-3-2	2008
IEC 61508-2	2000	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems	EN 61508-2	2001
ISO/IEC Guide 51	1999	Safety aspects - Guidelines for their inclusion in standards	-	-

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL AND LABORATORY USE – EMC REQUIREMENTS –

Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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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International Standard IEC 61326-3-1 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement and control.

The IEC 61326 series cancels and replaces IEC 61326:2002 and constitutes a technical revision.

IEC 61326-3-1 is to be read in conjunction with IEC 61326-1.

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

FDIS	Report on voting
65A/500/FDIS	65A/505/RVD

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

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

A list of all the parts of the IEC 61326 series, under the general title *Electrical equipment for measurement, control and laboratory use – EMC requirements*, can be found on the IEC website.

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

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

The contents of the corrigendum of September 2008 have been included in this copy.

INTRODUCTION

Functional safety is that part of the overall safety relating to the equipment under control (EUC) and the EUC control system which depends on the correct functioning of the electrical safety-related systems. To achieve this all items of equipment of the safety-related system which are involved in the performance of the safety functions must behave in a specified manner under all relevant conditions.

The IEC basic safety publication for functional safety of electrical/electronic/programmable electronic safety-related systems is IEC 61508. It sets the overall requirements to achieve functional safety. Sufficient immunity to electromagnetic disturbances is one of those requirements.

The concept of IEC 61508 distinguishes between the consideration of the application and the design of safety-related electrical and electronic systems. The interface between both is the safety requirements specification (SRS). It specifies all relevant requirements of the intended application, as follows.

a) Definition of the safety function, based on a risk assessment of the intended application (which function is intended to reduce risk).

b) Appropriate safety integrity level (SIL) for each safety-function based on a risk assessment of the intended application.

c) Definition of the environment in which the system is intended to work including the electromagnetic environment as required by IEC 61508-2.

Hence, with regard to immunity against electromagnetic phenomena, the essential starting point is that the electromagnetic environment and its phenomena are considered in the SRS, as required by IEC 61508. The safety-related system intended to implement the specified safety function has to fulfil the SRS, and, from it, corresponding immunity requirements have to be derived for the items of equipment, which results in an equipment requirement specification. With respect to the electromagnetic environment, the SRS and the equipment requirement specification should be based on a competent assessment of the foreseeable electromagnetic threats in the real environment over the whole operational life of the equipment. Hence, immunity requirements for the equipment depend on the characteristics of the electromagnetic environment in which the equipment is intended to be used.

The equipment manufacturer, therefore, has to prove that the equipment fulfils the equipment requirement specification and the system integrator must prove that the system fulfils the SRS. Evidence has to be produced by application of appropriate methods. They do not need to consider any other aspects of the application, for example, risk of the application associated to any failure of the safety-related system. The objective is for all equipment in the system to comply with particular performance criteria taking into account functional safety aspects (for example, the performance criterion FS) up to levels specified in the SRS independent of the required safety integrity level (SIL).

There are basically two approaches on how to deal with the electromagnetic environments and to conclude on immunity requirements.

(A) To consider a general electromagnetic environment with no specific restrictions, for example, an industrial environment, and to take into account all the electromagnetic phenomena that can occur as well as their maximum amplitudes when deriving appropriate immunity levels for the system and the equipment. This approach has been used to determine the levels specified within this part of IEC 61326 leading to increased immunity levels for some electromagnetic phenomena compared to immunity levels which are derived without functional safety considerations.

(B) To control the electromagnetic environment, for example, by the application of particular installation and mitigation practices, in such a way that electromagnetic phenomena and their amplitudes could occur only to a certain extent. These phenomena and restricted amplitudes are then taken into account by appropriate

immunity levels. These levels are not necessarily higher than those derived without functional safety considerations because it is ensured by corresponding means that higher amplitudes are not normally expected. This approach is considered in IEC 61326-3-2.

Applying approach (A) with regard to a general industrial environment requires appropriate knowledge of the electromagnetic phenomena and the amplitudes to be expected there. For this purpose and as it is also requested by IEC 61508, electromagnetic environment data of IEC 61000-2-5 are to be used. This IEC publication gives information about electromagnetic phenomena to be expected and describes their amplitudes in terms of compatibility levels. Since they can be considered as disturbance levels at which an acceptable electromagnetic compatibility should exist, these levels are used as the basis for normal immunity requirements as given in non-safety-related standards such as IEC 61326-1, IEC 61326-2-X or the generic standard IEC 61000-6-2. This normal approach applied to achieve electromagnetic compatibility is based on a technical/economical compromise allowing a certain amount of harmful interference cases. This approach, however, is not sufficient in the case of safety-related systems and the equipment used in them. Immunity levels have to be determined which take into account all electromagnetic phenomena and the maximum levels to be expected in the electromagnetic environment under consideration and hence for many electromagnetic phenomena these levels are increased compared to the normal ones.

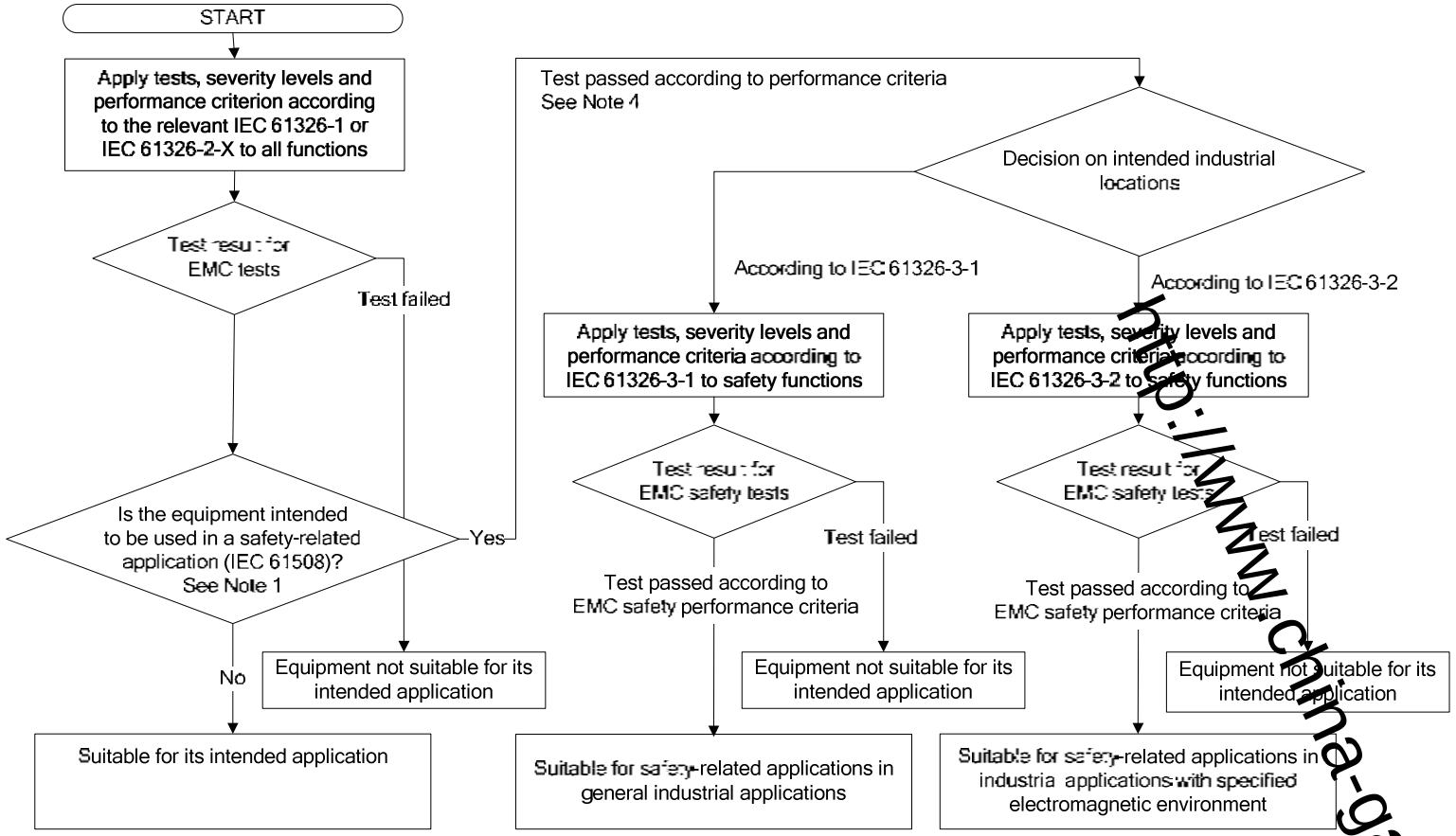
Following approach (A), IEC 61326-3-1 gives specific electromagnetic immunity requirements that apply to safety-related systems and equipment intended to be used in safety-related systems. These requirements supplement certain requirements of IEC 61326-1, and the selected electromagnetic phenomena and defined immunity test levels are expected to match with the environmental conditions of most industrial applications.

The correlation between the standards IEC 61326-1, IEC 61326-2-X, IEC 61326-3-1 and IEC 61326-3-2 is described in the diagram of Figure 1.

The increased specified test levels in this standard are derived from the highest levels to be expected in the environment of most industrial applications. These increased test levels are related to the electromagnetic environment (that can occur). They cannot be related in an analytical way to the SIL required for the safety-related system because there is no practically provable relationship between test level and probability of failure during use. The influences of electromagnetic phenomena are considered as systematic effects and by their nature often result in common cause events.

Design features of equipment must take into account the required SIL and must be designed to avoid dangerous systematic failures. Sufficient immunity against electromagnetic disturbances can only be ensured by design, mitigation and construction techniques which take into account electromagnetic aspects, which, however, are not within the scope of this standard.

It is therefore recommended that the approach to achieve the capability for the required SIL should be through the adoption of design features on the one hand and through appropriate test performance parameters in order to increase the level of confidence in the test results on the other hand.



NOTE 1 Functional safety requirements for equipment considered as proven in use according to IEC 61511-1 are excluded from the scope of IEC 61326-3-1 and 61326-3-2.
NOTE 2 The term EMC tests refers to test levels of the relevant standards, for example, IEC 61326-1, IEC 61326-2-X or IEC 61000-6-2.
NOTE 3 This flowchart does not intend to give requirements about the sequence of test.
NOTE 4 For equipment intended to be used in safety related applications, see additional requirements in Table 4 of IEC 61326-3-1.

IEC 2338/07

Figure 1 – Correlation between the standards IEC 61326-1, IEC 61326-2-X, IEC 61326-3-1 and IEC 61326-3-2

ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL AND LABORATORY USE – EMC REQUIREMENTS –

Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications

1 Scope

The scope of IEC 61326-1 applies to this part of IEC 61326 but is limited to systems and equipment for industrial applications intended to perform safety functions as defined in IEC 61508 with SIL 1-3.

The electromagnetic environments encompassed by this product family standard are industrial, both indoor and outdoor, as described for industrial locations in IEC 61000-6-2 or defined in 3.7 of IEC 61326-1. Equipment and systems intended for use in other electromagnetic environments, for example, in the process industry or in environments with potentially explosive atmospheres, are excluded from the scope of this product family standard, IEC 61326-3-1.

Equipment and systems considered as “proven-in-use” according to IEC 61508 or IEC 61511 are excluded from the scope of IEC 61326-3-1.

Fire alarm systems and security alarm systems intended for protection of buildings are excluded from the scope of IEC 61326-3-1.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-161, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

IEC 61000-4-2:2001, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2004, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*[1]

Amendment 1 (2000)

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques –Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-16:1998, *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*

Amendment 1 (2001)

IEC 61000-4-29:2000, *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 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61326-1:2005, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61326-2-1:2005, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-1: Particular requirements – Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications*

IEC 61326-2-2:2005, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-2: Particular requirements – Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems*

IEC 61326-2-3:2006, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-3: Particular requirements – Test configurations, operational conditions and performance criteria for transducers with integrated or remote signal conditioning*

IEC 61326-2-4:2006, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-4: Particular requirements – Test configurations, operational conditions and performance criteria for insulation monitoring devices according to IEC 61557-8 and for equipment for insulation fault location according to IEC 61557-9*

IEC 61326-2-5:2006, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-5: Particular requirements – Test configurations, operational conditions and performance criteria for field devices with interfaces according to IEC 61784-1, CP 3/2*

IEC 61326-3-2:2008, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – Industrial applications with specified EM environment*

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[1] There exists a consolidated edition 1.1 (2001) that includes edition 1.0 and its amendment.

IEC 61508-2:2000, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

ISO/IEC Guide 51:1999, *Safety aspects – Guidelines for their inclusion in standards*

3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 61326-1 and IEC 60050-161, as well as the following, apply.

NOTE Other definitions, not included in IEC 60050-161 and in this standard, but nevertheless necessary for the application of the different tests, are given in the EMC basic publications of the IEC 61000 series.

3.1
dangerous failure
failure which has the potential to put the safety-related system in a hazardous or fail-to-function state

NOTE Whether or not the potential is realised may depend on the channel architecture of the system; in systems with multiple channels to improve safety, a dangerous hardware failure is less likely to lead to the overall dangerous or fail-to-function state.

[IEC 61508-4, 3.6.7]

3.2
equipment
the term equipment as used in this document is extremely general and is applied to a wide variety of possible subsystems, apparatus, appliances and other assemblies of products

3.3
equipment under control (EUC)
equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities

NOTE The EUC control system is separate and distinct from the EUC.

3.4
functional safety
part of the overall safety relating to the EUC and the EUC control system which depends on the correct functioning of the E/E/PE safety-related systems, other technology safety-related systems and external risk reduction facilities

[IEC 61508-4, 3.1.9]

3.5
harm
physical injury or damage to the health of people, or damage to property or the environment

[ISO/IEC Guide 51, 3.3]

3.6
hazard
potential source of **harm**

NOTE The term includes danger to persons arising within a short time scale (for example, fire and explosion) and also those that have a long-term effect on a person's health (for example, release of a toxic substance).

[ISO/IEC Guide 51, 3.5, modified]

3.7
safe failure
failure which does not have the potential to put the safety-related system in a hazardous or fail-to-function state

NOTE Whether or not the potential is realised may depend on the channel architecture of the system; in systems with multiple channels to improve safety, a safe hardware failure is less likely to result in an erroneous shut-down.

[IEC 61508-4, 3.6.8]

3.8
safety function
function to be implemented by an E/E/PE safety-related system, other technology safety-related system or external risk reduction facilities, which is intended to achieve or maintain a safe state for the EUC, in respect of a specific hazardous event (see 3.4.1)

[IEC 61508-4, 3.5.1]

3.9
programmable electronic (PE)
based on computer technology which may be comprised of hardware, software and of input and/or output units

NOTE This term covers microelectronic devices based on one or more central processing units (CPUs) together with associated memories, etc.

EXAMPLE The following are all programmable electronic devices:

– microprocessors;
– micro-controllers;
– programmable controllers;
– application specific integrated circuits (ASICs);
– programmable logic controllers (PLCs);
– other computer-based devices (for example, smart sensors, transmitters, actuators).

[IEC 61508-4, 3.2.5]

3.10
electrical/electronic/programmable electronic (E/E/PE)
based on electrical (E) and/or electronic (E) and/or programmable electronic (PE) technology

NOTE The term is intended to cover any and all devices or systems operating on electrical principles.

EXAMPLE: Electrical/electronic/programmable electronic devices include

– electro-mechanical devices (electrical);
– solid-state non-programmable electronic devices (electronic);
– electronic devices based on computer technology (programmable electronic); see 3.2.5 (of IEC 61326-1).

[IEC 61508-4, 3.2.6]

3.11
d.c. distribution network
local d.c. electricity supply network in the infrastructure of a certain site or building intended for connection of any type of equipment

NOTE Connection to a local or remote battery is not regarded as a d.c. distribution network if such a link comprises only the power supply for a single piece of equipment.

3.12
system (in the context of this document)
combination of apparatus and/or active components constituting a single functional unit and intended to be installed and operated to perform (a) specific task(s)

NOTE "Safety-related systems" are specifically "designed" equipment that both

– implement the required safety functions necessary to achieve or maintain a safe state for a controlled equipment;

– are intended to achieve on their own or with other safety-related equipment or external risk reduction facilities, the necessary safety integrity for the safety requirements.

[IEC 61508-4, 3.4.1, modified]

3.13
EUT
the equipment (devices, appliances and systems) subjected to immunity tests

3.14
auxiliary equipment (AE)
equipment necessary to provide the equipment under test (EUT) with the signals required for normal operation and equipment to verify the performance of the EUT

4 General

In addition to the requirements in IEC 61326-1, this standard specifies additional requirements for systems and equipment for industrial applications intended to perform safety functions according to IEC 61508. These additional requirements do not apply to the non-safety-related functions of the equipment or systems.

NOTE 1 The overall design process and the necessary design features to achieve functional safety of electrical and electronic systems are defined in IEC 61508. This includes requirements for design features that make the system tolerant (IEC 61508-2:2000, 7.4.5.1) of electromagnetic disturbances.

The immunity requirements in IEC 61326-1 have been selected to ensure an adequate level of immunity for equipment used in non-safety-related applications, but the required immunity levels do not cover extreme cases that may occur at any location but with an extremely low probability of occurrence.

The possibility of occurrence of higher disturbance levels is not considered in IEC 61326-1 and it is also not considered on a statistical basis. Therefore, increased immunity test levels are defined as a systematic measure intended to avoid dangerous failures caused by electromagnetic phenomena. Consequently, it is not necessary to take into account the effect of electromagnetic phenomena in the quantification of hardware safety integrity, for example, probability of failure on demand. Increased immunity test levels are defined phenomenon by phenomenon where necessary.

Increased immunity test levels are related to functional safety aspects only, they are not applicable for the assessment of reliability and availability aspects. The increased immunity test levels apply only to the safety-related functions having a specific performance criterion for functional safety (performance criterion FS). The increased immunity test levels set the limits for the maximum test values. Further tests with higher values are not required for compliance with this standard.

NOTE 2 The safety-related system intended to implement the specified function should fulfil the SRS as required in IEC 61508. The SRS specifies all relevant requirements of the intended application. Equipment intended for use in that system has to fulfil the relevant requirements derived from the SRS.

5 EMC test plan

5.1 General

An EMC test plan shall be established prior to testing. It shall contain as a minimum the elements given in 5.2 to 5.5.

It may be determined from consideration of the electrical characteristics and usage of a particular apparatus that some tests are inappropriate and therefore unnecessary. In such cases the decision not to test shall be recorded in the EMC test plan.

5.2 Configuration of EUT during testing

5.2.1 General

Measurement, control and laboratory equipment often consists of systems with no fixed configuration. The kind, number and installation of different subassemblies within the equipment may vary from system to system.

To simulate EMC conditions realistically the equipment assembly shall represent a typical installation as specified by the manufacturer. EMC tests shall be carried out as type tests under normal conditions as specified by the manufacturer.

5.2.2 Composition of EUT

All devices, racks, modules, boards, etc. which are potentially relevant to EMC and belonging to the EUT shall be documented.

5.2.3 Assembly of EUT

If an EUT has a variety of internal or external configurations, the type tests shall be made with the most susceptible configuration, as expected by the manufacturer. All types of modules shall be tested at least once. The rationale for this selection shall be documented in the EMC test plan. The possibility of any electromagnetic interactions between items of equipment shall be taken into account when building up the most susceptible configuration.

5.2.4 I/O ports

Where there are multiple I/O ports all of the same type and function, connecting a cable to just one of those ports is sufficient, provided that it can be shown that the additional cables would not affect the results significantly. The rationale for this selection shall be documented in the EMC test plan.

5.2.5 Auxiliary equipment

When a variety of items of auxiliary equipment are provided for use with the EUT, at least one of each type of item of auxiliary equipment shall be selected to simulate actual operating conditions. Auxiliary equipment can be simulated.

5.2.6 Cabling and earthing (grounding)

The cables and earth (ground) shall be connected to the EUT in accordance with the manufacturer's specifications. There shall be no additional earth connections.

5.3 Operation conditions of EUT during testing

5.3.1 Operation modes

A selection of representative operation modes shall be made, taking into account that not all functions, but only the most typical functions of the equipment can be tested. The estimated worst-case operating modes for the intended application shall be selected.

5.3.2 Environmental conditions

The tests shall be carried out within the manufacturer’s specified environmental operating range (for example, ambient temperature, humidity, atmospheric pressure), and within the

rated ranges of supply voltage and frequency, except where the test requirements state otherwise.

5.3.3 EUT software during test

The software used for simulating the different modes of operation shall be documented. This software shall represent the estimated worst-case operating mode for the intended application.

5.4 Specification of performance criteria

Performance criteria for each port and test shall be specified, where possible, as quantitative values.

5.5 Test description

Each test to be applied shall be specified in the EMC test plan. The description of the tests, the test methods, the characteristics of the tests, and the test set-ups are given in the basic standards, which are referred to in Table 1. The contents of these basic standards need not be reproduced in the test plan; however, additional information needed for the practical implementation of the tests is given in this standard. In some cases, the EMC test plan shall specify the application in detail.

NOTE Not all known disturbance phenomena have been specified for testing purposes in this standard, but only those which are considered as critical. For further information, see Annex A.

6 Performance criteria

Performance criteria are used to describe and to assess the reaction of the equipment under test when being exposed to electromagnetic phenomena. With regard to functional safety purposes, a particular performance criterion FS shall be considered.

6.1 Performance criteria A, B and C

Performance criterion A: During testing, normal performance within the specification limits.

Performance criterion B: During testing, temporary degradation, or loss of function or performance which is self-recovering.

Performance criterion C: During testing, temporary degradation, or loss of function or performance which requires operator intervention or system reset occurs.

NOTE Examples for the performance criteria mentioned above are given in IEC 61326-1.

The performance criteria A, B and C, the same as in IEC 61326-1, are not related to functional safety aspects and should therefore not be used as performance criteria for the increased test levels. Therefore, a specific performance criterion FS is defined taking into account functional safety aspects.

6.2 Performance criterion FS

Performance criterion FS is as follows.

The functions of the EUT intended for safety applications

- are not affected outside their specifications; or
- may be disturbed temporarily or permanently if the EUT reacts on a disturbance in a way that detectable, defined state or states of the EUT are:

  - maintained, or
  - achieved within a stated time.
- Also, destruction of components is allowed if a defined state of the EUT is maintained or achieved within a stated time.

The functions not intended for safety applications may be disturbed temporarily or permanently.

NOTE In consequence, it will be possible for the defined state to be outside normal operating limits or otherwise detectable.

6.3 Application of the performance criterion FS

The performance criterion FS is only applicable for functions of the EUT intended for safety applications. It is relevant for any phenomenon. There is no differentiation required between continuous and transient electromagnetic phenomena.

Equipment performing or intended to perform functions intended for safety applications or parts of such functions shall behave in a specified manner. The specified behaviour of a safety-related system is intended to achieve or maintain safe conditions of the equipment and the related equipment under control. To achieve this, the behaviour of the equipment shall be known under all considered conditions.

In the SRS of a system both the undisturbed function and the required behaviour in case of failure or occurrence of a fault are specified. The SRS in some cases also specifies time constraints. The required functional behaviour and the related time constraints may differ from the general specification for performance criteria A, B or C as defined in the generic standards or in IEC 61326-1.

Where an item of equipment or a system performs both, functions intended for safety applications and functions not intended for safety applications the requirements for functional safety apply in context with the functions intended for safety applications only.

7 Immunity requirements

Table 1 gives immunity test requirements additional to those given in IEC 61326-1. Table 4 gives an overview of the allowed effects of electromagnetic disturbances on functions intended for safety applications and functions not intended for safety applications.

Some of the electromagnetic phenomena listed in Table1 may relate to an operating state of equipment in a statistical way only, for example, the instant of an impulse with respect to the momentary state of a digital circuit or a digital signal transmission. In order to increase the level of confidence for safety-related systems and equipment intended for higher SIL regarding immunity against electromagnetic disturbances, it is required to perform immunity tests against such electromagnetic phenomena with a larger number of impulses compared to the test performance requirements of the corresponding basic EMC standards. This can be done by using a longer test time or by applying more test impulses (see text in Table 1).

Table 1a – Immunity test requirements for equipment intended for use in industrial locations – Enclosure port

	Phenomenon	Basic standard	Tests for functions intended for safety applications Test value – Performance criterion	
1.1	Electrostatic discharge (ESD)	IEC 61000-4-2	6 kV/8 kV contact/air[a, b]	FS
1.2	Electromagnetic field	IEC 61000-4-3	20 V/m (80 MHz to 1 GHz)[c] 10 V/m (1,4 GHz to 2 GHz)[c] 3 V/m (2,0 GHz to 2,7 GHz)[c]	FS
1.3	Rated power frequency magnetic field	IEC 61000-4-8	30 A/m[d] No increased test level applies; see row 6 of Table A.1	FS

[a] Levels shall be applied in accordance with the environmental conditions described in IEC 61000-4-2 on parts which may be accessible by persons other than staff working in accordance with defined procedures for the control of ESD but not to equipment where access is limited to appropriately trained personnel only.

[b] For equipment intended to be used in SIL 3 applications, the number of discharges at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[c] These increased values shall be applied in frequency ranges as given in Table 2 used for mobile transmitters in general, except when reliable measures are realised to avoid the use of such equipment nearby. ISM frequencies shall be taken into account on an individual basis.

[d] Applicable only to equipment containing devices susceptible to magnetic fields.

Table 1b – Immunity test requirements for equipment intended for use in industrial locations – Input and output a.c. power ports

	Phenomenon	Basic standard	Tests for functions intended for safety applications Test value – Performance criterion	
2.1	Burst	IEC 61000-4-4	3 kV (5/50 ns, 5 kHz)[a]	FS
2.2	Surge	IEC 61000-4-5	2 kV[b] /4 kV [c, d] See Note 1	FS
2.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)[e]	FS
2.4	Voltage dips	IEC 61000-4-11	0 % during 1 cycle 40 % during 10/12 cycles[f] 70 % during 25/30 cycles[f]	FS FS FS
2.5	Short interruptions	IEC 61000-4-11	0 % during 250/300 cycles [f]	FS
2.6	Conducted common-mode voltage	IEC 61000-4-16 See Note 2	1,5 kHz to 15 kHz, 1 V to 10 V, 20 dB/Dec. 15 kHz to 150 kHz, 10 V	FS

NOTE 1 The required immunity level can be achieved through the use of external protection devices.

NOTE 2 This test does not need to be applied to equipment for which by design and installation instructions occurrence of this phenomenon is avoided (for example, instructions according to IEC 60204-1).

[a] For equipment intended to be used in SIL 3 applications, the duration of the test at the highest level shall be increased by a factor of 5 compared to the duration as given in the basic standard.

[b] Line to line.

[c] Line to ground.

[d] For equipment intended to be used in SIL 3 applications, the number of pulses at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[e] The increased values shall be applied in frequency ranges as given in Table 3 used for mobile transmitters in general, except when reliable measures are realised to avoid the use of such equipment nearby. ISM frequencies have to be taken into account on an individual basis.

[f] “10/12 cycles” means “10 cycles for 50 Hz test” and “12 cycles for 60 Hz test” (and similarly for 25/30 cycles and 250/300 cycles).

Table 1c – Immunity test requirements for equipment intended for use in industrial locations – Input and output d.c. power ports

	Phenomenon	Basic standard	Tests for functions intended for safety applications Test value – Performance criterion	
3.1	Burst	IEC 61000-4-4	3 kV (5/50 ns, 5 kHz)[a]	FS
3.2	Surge	IEC 61000-4-5	1 kV[b] /2 kV[c, d]	FS
3.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)[e]	FS
3.4	Conducted common mode voltage	IEC 61000-4-16 See Note	1,5 kHz to 15 kHz 1 V to 10 V, 20 dB/Dec. 15 kHz to 150 kHz, 10 V DC, 16 2/3 Hz, 50/60 Hz, 10 V continuous 100 V short duration (1 s) 150/180 Hz, 10 V continuous	FS
3.5	Voltage dips	IEC 61000-4-29	40 % U_T for 10 ms	FS
3.6	Short interruptions	IEC 61000-4-29	0% U_T for 20 ms	FS

NOTE This test does not need to be applied for equipment for which by design and installation instructions occurrence of this phenomenon is avoided (for example, instructions according to IEC 60204-1).

DC connections between parts of equipment/system which are not connected to a d.c. distribution network are treated as I/O signal/control ports (see Tables 1d and 1e).

[a] For equipment intended to be used in SIL 3 applications, the duration of the test at the highest level shall be increased by a factor of 5 compared to the duration as given in the basic standard.

[b] Line to line.

[c] Line to ground.

[d] For equipment intended to be used in SIL 3 applications, the number of pulses at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[e] The increased values shall be applied in frequency ranges as given in Table 3 used for mobile transmitters in general, except when reliable measures are realised to avoid the use of such equipment nearby. ISM frequencies shall be taken into account on an individual basis.

Table 1d – Immunity test requirements for equipment intended for use in industrial locations – I/O signal/control ports

	Phenomenon	Basic standard	Tests for functions intended for safety applications Test value – Performance criterion	
4.1	Burst	IEC 61000-4-4	2 kV (5/50 ns, 5 kHz)[a, b]	FS
4.2	Surge	IEC 61000-4-5	2 kV[c, d, e] See Note 1	FS
4.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)[f]	FS
4.4	Conducted common mode voltage [d, g]	IEC 61000-4-16 See Note 2	1,5 kHz to 15 kHz 1 V to 10 V, 20 dB/Dec. 15 kHz to 150 kHz, 10 V DC, 16 2/3 Hz, 50/60 Hz 10 V continuous 100 V short duration (1 s) 150/180 Hz, 10 V continuous	FS

NOTE 1 The required immunity level can be achieved through the use of external protection devices.

NOTE 2 This test does not need to be applied to equipment for which by design and installation instructions occurrence of this phenomenon is avoided (for example, instructions according to IEC 60204-1).

[a] Only in case of lines >3 m.

[b] For equipment intended to be used in SIL 3 applications, the duration of the test at the highest level shall be increased by a factor of 5 compared to the duration as given in the basic standard.

[c] Line to ground.

[d] Only in case of long-distance lines (see 3.6 of IEC 61326-1).

[e] For equipment intended to be used in SIL 3 applications, the number of pulses at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[f] The increased values shall be applied in frequency ranges as given in Table 3 used for mobile transmitters in general, except when reliable measures are realised to avoid the use of such equipment nearby. ISM frequencies shall be taken into account on an individual basis.

[g] Only in case of earthed systems or equipment, respectively.

Table 1e – Immunity test requirements for equipment intended for use in industrial locations – I/O signal/control ports connected direct to power supply networks

	Phenomenon	Basic standard	Tests for functions intended for safety applications Test value – Performance criterion	
5.1	Burst	IEC 61000-4-4	3 kV (5/50 ns, 5 kHz)[a]	FS
5.2	Surge	IEC 61000-4-5	2 kV[b] /4 kV [c, d] See Note 1	FS
5.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz)[e]	FS
5.4	Conducted common-mode voltage	IEC 61000-4-16 See Note 2	1,5 kHz to 15 kHz, 1 V to 10 V, 20 dB/Dec. 15 kHz to 150 kHz, 10 V DC, 16 2/3 Hz, 50/60 Hz 10 V continuous 100 V short duration (1 s) 150/180 Hz, 10 V continuous	FS

NOTE 1 The required immunity level can be achieved through the use of external protection devices.

NOTE 2 This test does not need to be applied to equipment for which by design and installation instructions occurrence of this phenomenon is avoided (for example, instructions according to IEC 60204-1).

[a] For equipment intended to be used in SIL 3 applications, the duration of the test at the highest level shall be increased by a factor of 5 compared to the duration as given in the basic standard.

[b] Line to line.

[c] Line to ground.

[d] For equipment intended to be used in SIL 3 applications, the number of pulses at the highest level shall be increased by a factor of 3 compared to the number as given in the basic standard.

[e] The increased values shall be applied in frequency ranges as given in Table 3 used for mobile transmitters in general, except when reliable measures are realised to avoid the use of such equipment nearby. ISM frequencies shall be taken into account on an individual basis.

Table 1f – Immunity test requirements for equipment intended for use in industrial locations – Functional earth port

	Phenomenon	Basic standard	Tests for functions intended for safety applications Test value – Performance criterion	
6.1	Burst	IEC 61000-4-4	2 kV (5/50 ns, 5 kHz)[a]	FS

[a] For equipment intended to be used in SIL 3 applications, the duration of the test at the highest level shall be increased by a factor of 5 compared to the duration as given in the basic standard.

Table 2 – Selected frequencies for electromagnetic field tests

Centre frequency MHz	Frequency range MHz	Purpose
84,000	83,996 – 84,004	ISM UK only
	137 – 174	Div. Mobile and SRD
168,000	167,992 – 168,008	ISM UK only
	390 – 430	TETRA
	430 – 470	AMATEUR
433,920	433,05 – 434,79	ISM Region 1only
896,000	880,000 – 906,000	ISM UK only
897,500	880 – 915	GSM
915,000	902 – 928	ISM Region 2 only
	925 – 960	GSM
1 745,750	1 710 – 1 785	GSM
	1 805 – 1 880	GSM
	1 900 – 2 025	UMTS
	2 110 – 2 200	UMTS
2 450	2 400 – 2 500	ISM
	2 500 – 2 690	UMTS

Table 3 – Selected frequencies for conducted r.f. tests

Centre frequency MHz	Frequency range MHz	Purpose
3,39	3,370 – 3,410	ISM Netherlands only
6,780	6,765 – 6,795	ISM
13,560	13,553 – 13,567	ISM
27,120	26,957 – 27,283	ISM/CB/SRD
40,680	40,66 – 40,70	ISM/SRD

8 Test set-up and test philosophy for EUTs with functions intended for safety applications

8.1 Testing of safety-related systems and equipment intended to be used in safety-related systems

A safety-related system may comprise a complex and extended installation and may also be built up in various physical arrangements. Immunity testing of such systems can hardly be performed in a practical way by means of the various basic standards as given in the tables of clause 7. Hence, corresponding immunity tests shall be carried out preferably on equipment level as described in 8.2.

In case of physically small safety-related systems corresponding immunity tests can be applied to entire safety-related systems which is described in 8.3.

8.2 Test philosophy for equipment intended for use in safety-related systems

Even though functional safety requires the correct functioning of the complete system, for example, comprising sensors, logic solver and actuators, it is possible to test its devices individually. The individual devices intended to be used for implementation into a safety-related system shall be sufficiently specified. This specification comprises the intended function and the allowed behaviour in case of failure. The objective of the immunity tests is to prove that the specification is fulfilled for the considered electromagnetic phenomena.

Equipment intended for use in safety-related systems has a specification of its intended functions only. Whether or not a disturbed function will become dangerous is unknown because it depends on the future application in a safety-related system. Therefore the test has to show the behaviour of the EUT. Deviations from the undisturbed functions shall be detectable and shall be documented in the test report.

The performance criterion FS places additional requirements on the equipment that is intended for use in safety-related applications. In this case, the normal performance criteria within their associated limits and the performance criterion FS both apply. The normal performance criteria within their associated limits and the performance criterion FS are considered separately. The general approach of applying performance criteria for the different types of functions is shown in Table 4.

Table 4 – Applicable performance criteria and observed behaviour during test for equipment intended for use in safety-related systems

Specified function			
Function intended for safety application		**Function not intended for safety application**	
Normal EMC test levels	**EMC safety test levels**	**Normal EMC test levels**	**EMC safety test levels**
Performance criteria according to the relevant product standard - A, or - B + observed deviation + recovery time to be documented, or - C + observed behaviour, detectable and documented	**Performance criteria FS**	**Performance criteria according to the relevant product standard** - A, or - B, or - C	**May fail**
NOTE 1 The description of the performance criteria A, B and C is given in the relevant product standards such as IEC 61326-1. NOTE 2 For more detailed information about allowed effects during immunity testing, see Tables B.1 and B.2.			

Figure 2 shows a typical configuration of a test set-up for equipment intended for use in a safety-related system. In this configuration the immunity tests apply to the considered equipment only. Other devices used to run the EUT during test are separated from any electromagnetic influences.

Figure 3 shows a typical configuration of a test set-up for equipment intended for use in a safety-related system when tested stand-alone. In this configuration the immunity tests apply

to the equipment considered. Other devices used to run the EUT during test are separated from any electromagnetic influences.

8.3 Test philosophy for safety-related systems

For a safety-related system its intended functions and possible safe states are specified. The aim of the immunity tests is to show whether the system as a whole behaves as specified and as required by the performance criterion FS (see Clause 6).

The performance criteria for functional safety place additional requirements on safety-related systems. The normal performance criteria within their associated limits and the functional requirements for functional safety are considered separately. Table B.2 illustrates the application of the relevant performance criteria by showing which effects due to specific electromagnetic phenomena are allowed.

Figure 4 shows a typical configuration of a test set-up for a safety-related system. In this configuration, the immunity tests apply to the whole safety-related system. This figure is meant to show that the EUT shall be monitored during testing by a system not subjected to electromagnetic disturbances.

8.4 Test configuration

A EUT shall be tested to show that its functionality is in compliance with this standard. If the EUT is not an entire safety-related system then the interfaces of the EUT should be connected to other elements simulating the safety system (sensors/logic elements/actuators) or other loads simulating the characteristics of actual elements.

The EUT shall cooperate with the devices of a safety system, which are necessary for the function of the EUT and for performing the specified function of the EUT intended for safety applications.

The auxiliary devices which are necessary for the function of the EUT and for performing the function intended for safety applications shall be mounted in a well-protected electromagnetic environment (see Figure 2). During the test, these devices shall not be exposed to electromagnetic disturbances.

Relevant I/O ports of the EUT shall be connected with the appropriate ports of the devices of the safety system, which are necessary for the function of the EUT and for performing the function intended for safety applications.

Lines and I/O Ports of the EUT that are not used shall be terminated as specified by the manufacturer.

Only cables specified by the manufacturer of the EUT or the safety system shall be used in the test set-up.

8.5 Monitoring

During testing the specified functions of the EUT intended for safety applications shall be monitored.

The monitoring system shall monitor whether the EUT functions as intended or an observable, defined state of the EUT is achieved within a stated time.

For this, the monitoring system shall observe, if applicable:

- the data communication between the EUT and the devices, which are necessary for the function of the EUT and for performing the function intended for safety applications; and

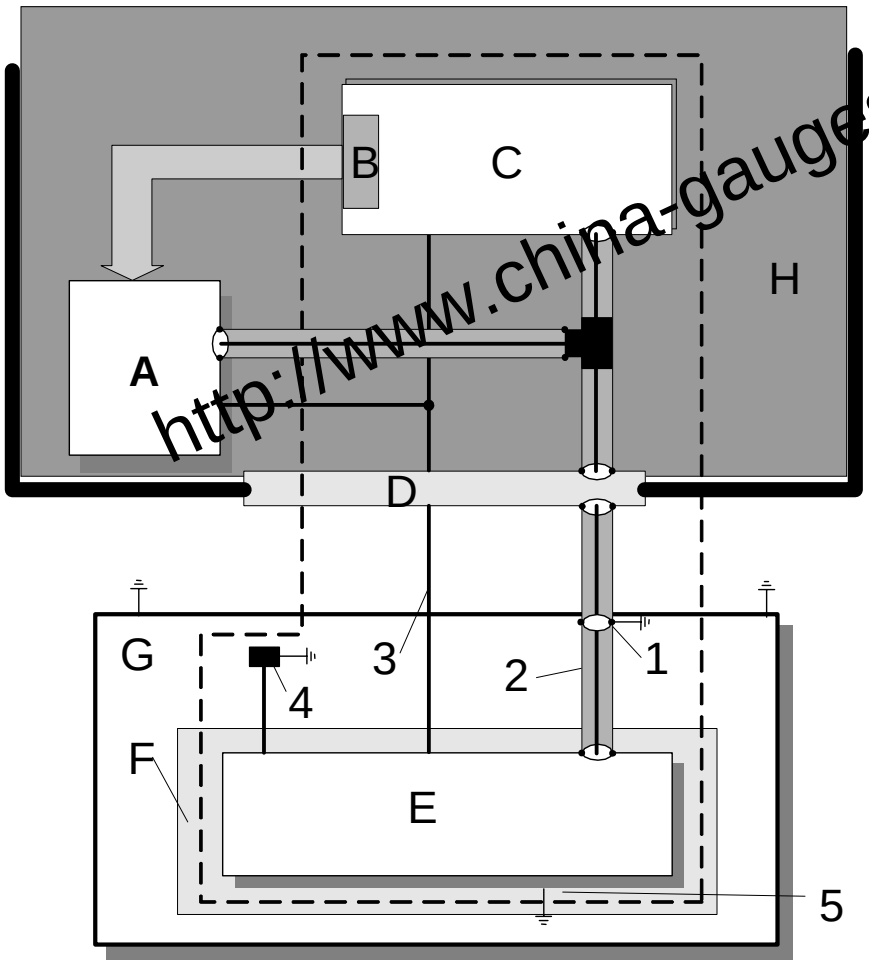
- the status of the outputs whose functions are intended for safety applications.

9 Test results and test report

The test results shall be documented in a comprehensive test report with sufficient detail to provide for test repeatability.

The test report shall contain the following minimum information:

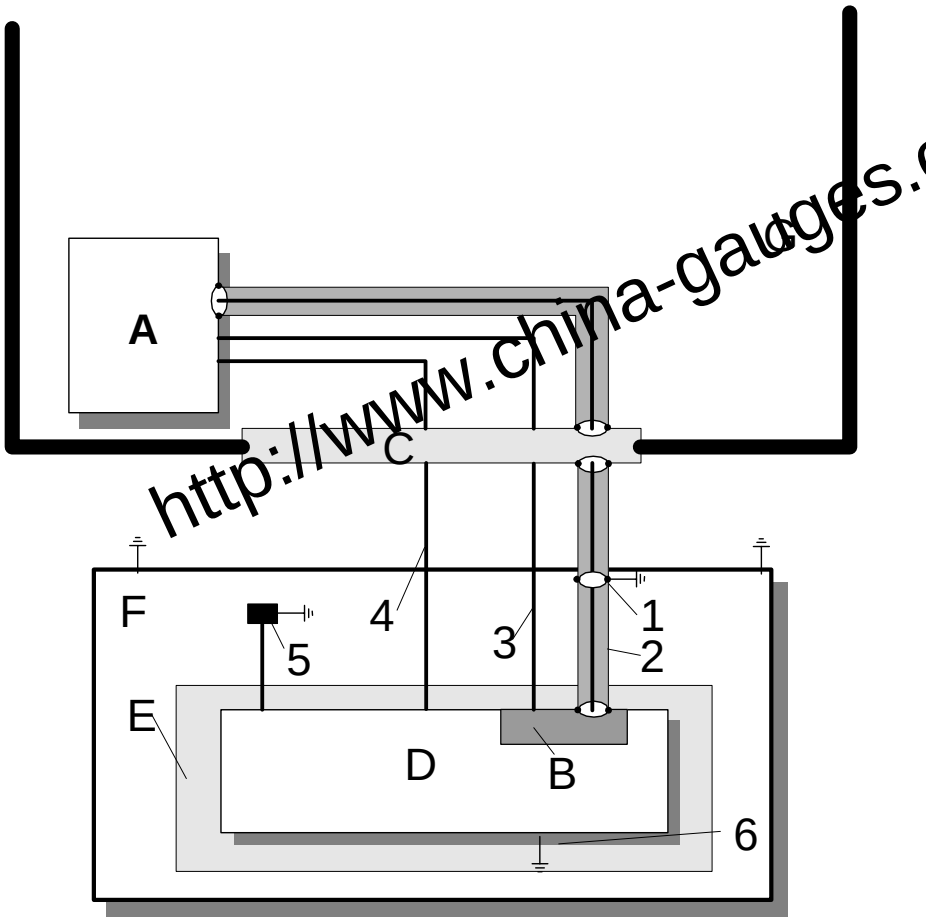
– EUT description;
– EMC test plan;
– test data and results;
– test equipment and set-up;
– the behaviour observed during the test.



Key

A	Monitoring system	1	Earthing point for cable shield
B	Monitoring output	2	Shielded cable for monitoring
C	Part of the safety-related system not under test	3	Unshielded cable for monitoring
D	Decoupling network at the shield between the protected and unprotected environment	4	Terminating device for interfaces (earthed if required by the manufacturer)
E	EUT	5	Earth connection to the ground plane if required
F	Insulation support		
G	Ground plane		
H	Electromagnetic decoupled environment		

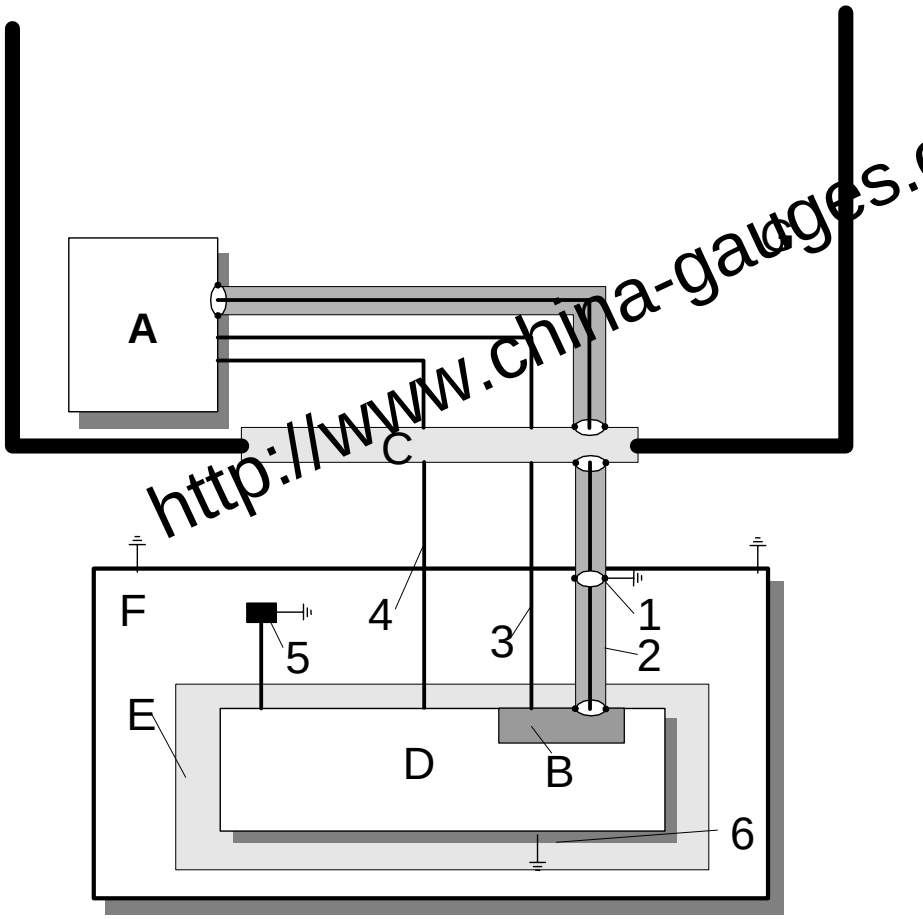
Figure 2 – Typical test set-up for equipment intended for use in a safety-related system integrated into a representative safety-related system during test



Key

A	Monitoring system	1	Earthing point for cable shield
B	Safety-related output interface	2	Output shielded signal line intended for a safety purpose
C	Decoupling network at the shield between the protected and unprotected environment	3	Output unshielded signal line intended for a safety purpose
D	EUT	4	Non-safety-related monitoring signal line
E	Insulation support	5	Terminating device for interfaces (earthed if required by the manufacturer)
F	Ground plane	6	Earth connection to the ground plane if required
G	Electromagnetic decoupled environment		

Figure 3 – Typical test set-up for equipment intended for use in safety-related system tested stand-alone



Key

A	Monitoring system	1	Earthing point for cable shield
B	Monitoring output	2	Shielded cable for monitoring
C	Decoupling network at the shield between the protected and unprotected environment	3	Unshielded cable for monitoring
D	EUT	4	Non-safety-related monitoring signal line
E	Insulation support	5	Terminating device for interfaces (earthed if required by the manufacturer)
F	Ground plane	6	Earth connection to the ground plane if required
G	Electromagnetic decoupled environment		

Figure 4 – Typical test set-up for a safety-related system

Annex A
(informative)

Evaluation of electromagnetic phenomena

The relationship between EMC and safety requires due consideration particularly because the consequences of safety failures can be serious. EMC requirements for safety-related equipment and systems can only be based on extensive discussions between the parties involved. Some IEC standards or technical specifications and reports like IEC 61508 and IEC 61000-1-2 deal with EMC and functional safety aspects but both of them refer to IEC 61000-2-5.

The objective of the requirements to achieve functional safety with E/E/PE systems is, according to IEC 61508, to limit the maximum probability of a dangerous failure of a safety function by a value given by the SIL. This means that the E/E/PE system must perform the intended function sufficiently with a probability greater than the value derived from the SIL or, in the case of a fault, perform a defined fault-reaction function. To achieve this goal, IEC 61508 requires the application of specific techniques and measures to avoid failures or to control faults that may occur during operation of the system. These requirements relate to all possible sources that could cause failures. IEC 61508 refers to the IEC 61000 series concerning EMC and asks for an EMC specification issued by the parties involved. The EMC specification shall be based on IEC 61000-2-5. Well-known electromagnetic phenomena are described in IEC 61000-2-5 for different environments. The selection of the relevant phenomena and appropriate test levels is up to the parties involved.

Safety aspects are not covered by the EMC requirements for normal use. While the EMC requirements for normal use, for example, as defined in IEC 61000-6-2, aim to support sufficient operation under normal conditions, it is the aim of the safety requirements to assure safety of the equipment or the equipment under control.

The classical approach for deriving immunity levels in the EMC area can be demonstrated by means of Figure A.1 (for further details, see IEC 61000-1-1 and IEC 61000-2-5). It shows the probability density of the occurrence of electromagnetic disturbances resulting from the emissions from individual sources leading to an electromagnetic disturbance level (left curve in the diagram).

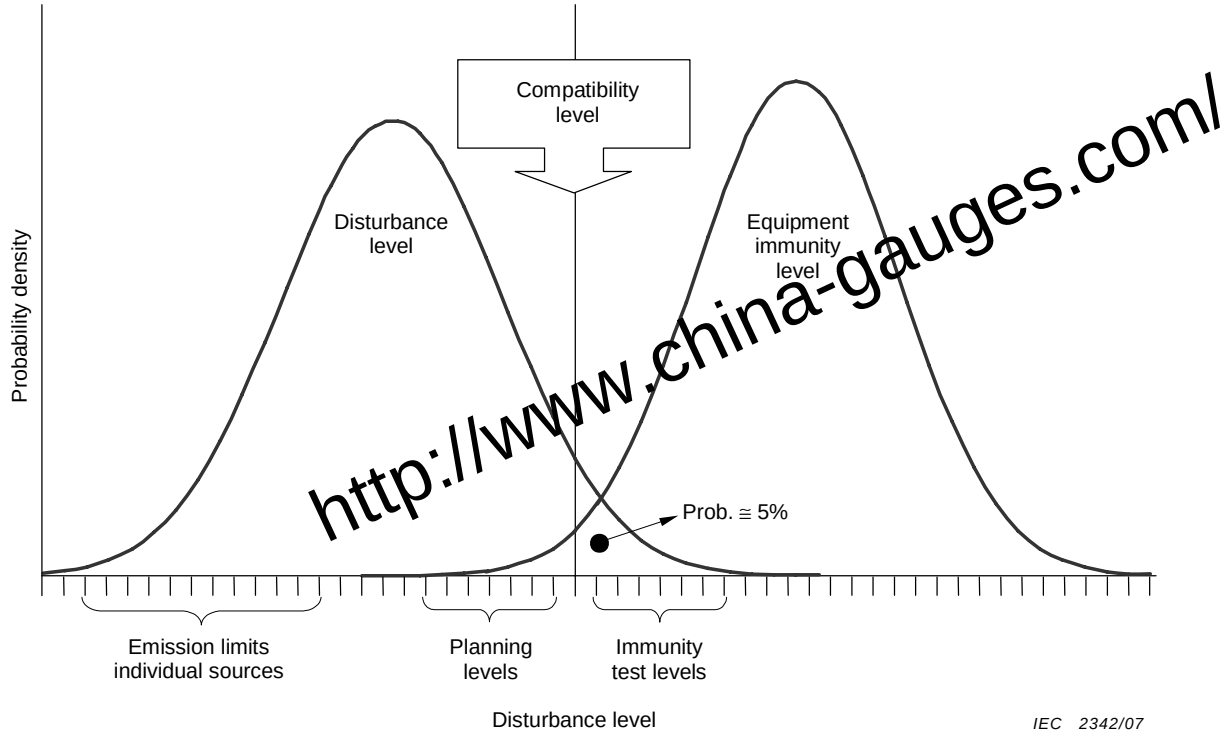


Figure A.1 – Emission/immunity levels and compatibility level, with an example of emission/immunity levels for a single emitter and susceptor, as a function of some independent variables (see IEC 61000-1-1)

Adjacent to it a curve is shown which represents the immunity behaviour of equipment against electromagnetic disturbances. Immunity levels are normally given as discrete quantitative values. Nonetheless, a probabilistic curve results for the immunity behaviour of equipment. This curve reflects the fact that often equipment may have a higher immunity than the required one (the immunity is tested normally with respect to the required level only and not beyond this level), but also that there is a variation in the actual immunity due to uncertainties, such as tolerances in the equipment itself, in the equipment manufacturing process or uncertainties due to test equipment and test performance.

For a quantitative description of such a potential interference situation, a compatibility level is introduced and is chosen as a kind of reference level for the description of disturbances. Compatibility levels for the various electromagnetic phenomena are given in IEC 61000-2-5, for example, and they can be used as a starting-point for deriving immunity levels. Of course, their actual values strongly depend on the electromagnetic environment under consideration. Hence, EMC can be achieved only if the emission and immunity levels are controlled in such a way that, at each location, the disturbance level resulting from the cumulative emissions is sufficiently lower than the immunity level for each device, equipment and system situated at the same location. It should, however, be noted that compatibility levels can be phenomenon-, time- or location-dependent.

From the shape of the curves in Figure A.1, it can be concluded that an increasing margin between the compatibility level and the applied immunity level leads to a reduced probability for the occurrence of interference situations and therefore to a better immunity and in total to a “better” state of EMC. Hence for most of the electromagnetic phenomena to be considered, immunity test levels have to be used which are increased compared to those used for normal EMC.

In practice, the immunity levels for pure EMC purposes are derived so that the potential overlap between the area indicating the disturbance levels and that indicating the immunity levels is in the range of a small per cent (typically 5 % is shown in Figure A.1) of those areas. This approach represents a technical/economic compromise and it allows the possibility that in some cases the specified immunity levels are not high enough to avoid interference. The

overlap of 5 % does not necessarily mean that interference takes place in 5 % of the installations where these components are used. The resulting probability of interference is normally much lower as explained in Clause A.6 of IEC 61000-1-1.

The curves in Figure A.1 show the principal behaviour of the probability of disturbance levels and immunity and the positions of compatibility and immunity levels. These curves are phenomenon-, time- and/or location-dependent. Hence, a potential knowledge of such probabilistic density curves for a particular phenomenon at a particular installation cannot be transferred to any other electromagnetic phenomenon and installation.

The actual knowledge of such probabilistic curves is relatively poor for most electromagnetic phenomena. Indeed, detailed information is available only for few phenomena (as, for example, for the topic of lightning protection and the area of surge pulses). But also in these cases the knowledge exists more or less in the field of the phenomenon itself (in the case of lightning strokes by means of isokeraunic curves) and not so much in the subsequently acting stress onto an equipment due to these phenomena.

Even for the case of relatively well-known probabilistic curves, it can be expected that the probabilistic densities are well known in the areas where they have values of a small per cent or several tens of per cent. This, however, cannot be considered as sufficient when looking at probabilistic requirements as they are defined by the SIL.

In the field of safety, the engineers of a safety-related system have to take into account probabilities of 10^{-5} to 10^{-9} dangerous failures per hour, or probabilities of dangerous failure down to per 10^{-5} demand, which figures are far from any reliable probabilistic data concerning both the occurrence of electromagnetic disturbances and the occurrence of the levels related to the disturbances.

From those boundary conditions it can be concluded that in most cases there will be no reliable, evident and provable way to find a clear correlation between the compatibility level of disturbances within an installation and the immunity level for an item of equipment to be installed in a safety-related system.

The only practical way to derive appropriate immunity levels seems to be the assessment of the particular electromagnetic environment in which the safety-related system is intended to be used and to determine immunity levels by means of technical arguments. The compatibility levels as given in IEC 61000-2-5 can be used as basis for deriving the required immunity.

A proposal applying this approach and taking into account the knowledge of EMC and functional safety experts to avoid a worst-case specification in this field is given in Table A.1 of this standard. The column “Test value for functions of the EUT intended for safety applications” gives information on how these test levels are related to the test levels for normal functions. They are derived by multiplication of the test level for normal functions (taken, for example, from IEC 61326-1 for industrial locations) by a certain factor or alternatively by applying the next test level in the order of test levels as given in the basic standard under consideration. In both cases this conclusion on test levels for safety functions was made on the basis of the levels as described in IEC 61000-2-5 in conjunction with engineering arguments.

Table A.1 – Exemplary considerations on electromagnetic phenomena and test levels with regard to functional safety in industrial applications

No	Phenomena	Basic standard	Different test level for functions of the EUT intended for safety applications	Comments
1	Electrostatic discharge (ESD)	IEC 61000-4-2	Yes partly next level of IEC 61000-4-2	Levels shall be applied in accordance with the environmental conditions described in IEC 61000-4-2 on parts which may be accessible by persons other than staff working in accordance with defined procedures for the control of ESD
			No	Access to equipment limited to appropriately trained personnel only
2	Electromagnetic field	IEC 61000-4-3	Yes Factor 2 - 3	An increased level shall be applied in frequency ranges used for mobile transmitters in general, except when reliable measures are realized to avoid the use of such equipment nearby. ISM frequencies shall be taken into account on an individual basis
3	Burst	IEC 61000-4-4	Yes Factor 1,5 - 2	
4	Surge	IEC 61000-4-5	Yes Factor 1 - 2	External protection devices are allowed to achieve the required immunity
5	Conducted r.f.	IEC 61000-4-6	Yes Factor 3	An increased level shall be applied in frequency ranges used for mobile transmitters in general, except when reliable measures are realized to avoid the use of such equipment nearby. ISM frequencies shall be taken into account on an individual basis
6	Power frequency magnetic field	IEC 61000-4-8	No	Application in accordance with the common exceptions given in the generic standard No safety margin in general. A safety margin may be necessary in an environment as defined in IEC 61000-6-5 or similar like an industrial switch yard
7	Voltage dips	IEC 61000-4-11	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related
8	Short interruptions	IEC 61000-4-11	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related
9	Conducted common-mode voltage	IEC 61000-4-16	Yes	Yes, but for short-time power frequency phenomena only. Limited to the rated voltage of the power supply
10	Voltage dips	IEC 61000-4-29	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related
11	Short interruptions	IEC 61000-4-29	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related

Annex B
(informative)

Allowed effects during immunity tests

Tables B.1 and B.2 give an overview of the allowed effects during immunity tests on the different functions, i.e., functions intended for safety applications and functions not intended for safety applications. The occurrence of eight possible effects is considered. Table B.1 refers to the situation when equipment is concerned and Table B.2 refers to the situation when looking at the entire safety-related system.

These tables present the philosophy used in this standard for determining allowed effects during tests. These effects depend on the following considerations:

- type of function (function intended for safety application or function not intended for safety application); and
- type of test (normal EMC test or EMC safety test).

Table B.1 – Allowed effects during immunity tests on functions of equipment

		Functions intended for safety applications				Functions not intended for safety applications		
		Normal EMC test level		EMC safety test level		Normal EMC test level		
No.	Effect during interference	Continuous electromagnetic phenomena	Transient electromagnetic phenomena	Continuous electromagnetic phenomena	Transient electromagnetic phenomena	Continuous electromagnetic phenomena	Short-time transient electromagnetic phenomena	Long-time transient electromagnetic phenomena
1	Function undisturbed	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**
2	Temporary reproducible degradation of performance, degradation information is provided (degradation is not necessarily detectable by automatic diagnostic)	**Allowed within specified limits only**	**Allowed**	**Allowed**	**Allowed**	**Allowed within specified limits only**	**Allowed but no need to provide information**	**Allowed but no need to provide information**
3	Temporary loss of function, operates as intended after test (self-recovering) + failure is detectable by automatic diagnostic (failure information is provided)	**Not allowed** (function should not fail, normal undisturbed operation is required due to normal EMC behaviour)	**Allowed**	**Allowed**	**Allowed**	**Not allowed**	**Allowed**	**Allowed**
4	Temporary loss of function, operates as intended after test (self-recovering) + failure is not detectable by automatic diagnostic (internal or external of the EUT)	**Not allowed**	**Not allowed** (FS specific aspect dominates)	**Not allowed**	**Not allowed**	**Not allowed**	**Allowed**	**Allowed**
5	Temporary loss of function which requires operator intervention or reset for recovery + failure is detectable, for example, by diagnostic (failure information is provided)	**Not allowed** (normal EMC requirement dominates, i.e., the function should not fail)	Allowed	**Allowed**	**Allowed**	**Not allowed**	**Not allowed**	Allowed

Table B.1 *(continued)*

		Functions intended for safety applications				Functions not intended for safety applications		
		Normal EMC test level		EMC safety test level		Normal EMC test level		
No.	**Effect during interference**	**Continuous electromagnetic phenomena**	**Transient electromagnetic phenomena**	**Continuous electromagnetic phenomena**	**Transient electromagnetic phenomena**	**Continuous electromagnetic phenomena**	**Short-time transient electromagnetic phenomena**	**Long-time transient electromagnetic phenomena**
6	Temporary loss of function which requires operator intervention or reset for recovery + failure is not detectable by automatic diagnostic (internal or external of the EUT)	**Not allowed**	**Not allowed** (except safe failure)	**Not allowed** (except safe failure)	**Not allowed** (except safe failure)	**Not allowed**	**Not allowed**	**Allowed**
7	As 5, however, no recovery (damage included)	**Not allowed** (normal EMC requirement dominates)	**Not allowed** (normal EMC requirement dominates)	**Allowed**	**Allowed**	**Not allowed**	**Not allowed**	**Not allowed**
8	As 6, however no recovery (damage included)	**Not allowed**	**Not allowed**	**Not allowed** (except safe failure)	**Not allowed** (except safe failure)	**Not allowed**	**Not allowed**	**Not allowed**
NOTE 1 As short-time transient electromagnetic phenomena are considered: ESD, burst, surge; and as long-time transient electromagnetic phenomena are considered: voltage dips and voltage interruptions.								

Table B.2 – Allowed effects during immunity tests on functions of a system

		Safety-related function				Non-safety-related function		
		Normal EMC test level		EMC safety test level		Normal EMC test level		
No.	Effect during test	Continuous electromagnetic phenomena	Transient electromagnetic phenomena	Continuous electromagnetic phenomena	Transient electromagnetic phenomena	Continuous electromagnetic phenomena	Short-time transient electromagnetic phenomena	Long-time transient electromagnetic phenomena
1	Function undisturbed	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**	**Always allowed**
2	Temporary loss of function, operates as intended after test (self-recovering) + fault reaction as specified is performed	**Not allowed** (function should not fail, normal undisturbed operation is required due to normal EMC behaviour)	**Allowed**	**Allowed**	**Allowed**	**Not allowed**	**Allowed**	**Allowed**
3	Temporary loss of function, operates as intended after test (self-recovering) + specified fault reaction is not performed	**Not allowed**	**Not allowed** (FS specific aspect dominates)	**Not allowed**	**Not allowed**	**Not allowed**	**Allowed**	**Allowed**
4	Temporary loss of function which requires operator intervention or reset for recovery + specified fault reaction is performed	**Not allowed** (normal EMC requirement dominates i.e. the function must not fail)	**Allowed**	**Allowed**	**Allowed**	**Not allowed**	**Not allowed**	**Allowed**
5	Temporary loss of function which requires operator intervention or reset for recovery + specified fault reaction is not performed	**Not allowed**	**Not allowed** (except safe failure)	**Not allowed** (except safe failure)	**Not allowed** (except safe failure)	**Not allowed**	**Not allowed**	**Allowed**

Table B.2 *(continued)*

		Safety-related function				Non-safety-related function		
		Normal EMC test level		EMC safety test level		Normal EMC test level		
No.	**Effect during test**	**Continuous electromagnetic phenomena**	**Transient electromagnetic phenomena**	**Continuous electromagnetic phenomena**	**Transient electromagnetic phenomena**	**Continuous electromagnetic phenomena**	**Short-time transient electromagnetic phenomena**	**Long-time transient electromagnetic phenomena**
6	As 4, however, no recovery (damage included)	**Not allowed** (normal EMC requirement dominates)	**Not allowed** (normal EMC requirement dominates)	**Allowed**	**Allowed**	**Not allowed**	**Not allowed**	**Not allowed**
7	As 5, however, no recovery (damage included)	**Not allowed**	**Not allowed**	**Not allowed** (except safe failure)	**Not allowed** (except safe failure)	**Not allowed**	**Not allowed**	**Not allowed**

NOTE 1 As short-time transient electromagnetic phenomena are considered: ESD, burst, surge; and as long-time transient electromagnetic phenomena are considered: voltage dips and voltage interruptions

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