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INTERNATIONAL STANDARD

colour inside

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

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61326-3-1 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

- extension of the frequency range up to 6 GHz for the radio-frequency electromagnetic field test according to IEC 61000-4-3,
- replacement of the performance criterion FS with DS according to the generic standard IEC 61000-6-7,
- adding Table 1 – Aspects to be considered during application of performance criterion DS,
- including immunity tests for devices with current consumption > 16 A according to IEC 61000-4-34,
- updating Table 8 – Frequency ranges of mobile transmitters and ISM equipment,
- updating Figure A.1 and Figure 1 for better readability.

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/819/FDIS	65A/825/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 stability date indicated on the IEC website 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 overall safety requirements specification ~~(SRS). It~~ specifies all relevant requirements of the intended application, as follows:

a) definition of the safety functions, based on a risk assessment of the intended application (which functions are 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.

The requirements for each safety function are then specified in one or more system safety requirements specifications (SSRS). Hence, with regard to immunity against electromagnetic phenomena, the essential starting point is that the electromagnetic environment and its phenomena are considered in the SSRS, as required by IEC 61508. The safety-related system intended to implement the specified safety function has to fulfil the SSRS, 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 SSRS 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 SSRS. 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~~ DS) up to levels specified in the SSRS independent of the required safety integrity level (SIL).

For approaches on how to apply IEC 61326-3 series, see Annex A.

There exists meanwhile the generic EMC standard IEC 61000-6-7 dealing with functional safety aspects in industrial environments. Generic EMC standards are designed to apply for a defined electromagnetic environment, to products for which no dedicated product family EMC/product EMC standards exist. However, for the equipment in the scope of this document, the information given in the generic EMC standard was considered not to be sufficient. More detailed information and specifications were needed, for example specific test set-ups, consideration of the functional earth port or the deliberate differentiation between types of electromagnetic environments relevant for the equipment in the scope of this document.

Though historically this product standard was developed several years before the generic EMC standard, this 2nd edition considers the information given in the generic EMC standard and applies it where appropriate.

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

This part of IEC 61326 covers all equipment within 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 3.8 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 document.

Equipment and systems considered as "proven-in-use" according to IEC 61508 or "prior use" according to IEC 61511 are excluded from the scope of this document.

Fire alarm systems and security alarm systems intended for protection of buildings are excluded from the scope of this document.

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 60050-161, *International Electrotechnical Vocabulary – Part 161: Electromagnetic compatibility* (available at <http://www.electropedia.org/)

IEC 61000-4-2:~~2001~~ 2008, *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 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:~~2004~~ 2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:~~2005~~ 2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:~~2004~~ 2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:~~1993~~ 2009, *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~~ 2015, *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 61000-4-34:2005, *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 61000-4-34:2005/AMD1:2009

IEC 61000-6-2:~~2005~~ 2016, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61326-1:~~2005~~ 2012, *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~~___[2], *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-2: Immunity requirements for safety-related systems and for*

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

equipment intended to perform safety-related functions (functional safety) – Industrial applications with specified ~~EM~~ electromagnetic environment

IEC 61508-2:~~2000~~ 2010, *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, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61326-1 and IEC 60050-161 and the following 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

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

3.1.1
dangerous failure
failure ~~which has the potential to put the safety-related system in a hazardous or fail-to-function state~~ of an element and/or subsystem and/or system that plays a part in implementing the safety function that:

a) prevents a safety function from operating when required (demand mode) or causes a safety function to fail (continuous mode) such that the EUC is put into a hazardous or potentially hazardous state; or

b) decreases the probability that the safety function operates correctly when required

~~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.~~

[SOURCE: IEC 61508-4:2010, 3.6.7]

3.1.2
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

3.1.3
equipment under control
EUC
equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities

Note 1 to entry: The EUC control system is separate and distinct from the EUC.

[SOURCE: IEC 61508-4:2010, 3.2.1]

2 Under preparation. Stage at the time of publication: IEC/DIS 61326-3-2:2016.

3.1.4
functional safety
part of the overall safety relating to the EUC and the EUC control system that depends on the correct functioning of the E/E/PE safety-related systems~~, other technology safety-related systems and external risk reduction facilities~~ and other risk reduction measures

[SOURCE: IEC 61508-4:2010, 3.1.12]

3.1.5
harm
physical injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1, modified – "physical" has been added]

3.1.6
hazard
potential source of harm

Note 1 to entry: The term includes short-term or immediate danger ~~to persons arising within a short time scale~~ (such as from fire or explosion) and ~~also those that have a~~ long-term effects on ~~a person's~~ health (such as from release of a toxic substance).

[SOURCE: ISO/IEC Guide 51:2014, 3.2, modified – the note to entry has been added]

3.1.7
safe failure
failure ~~which does not have the potential to put the safety-related system in a hazardous or fail-to-function state~~ of an element and/or subsystem and/or system that plays a part in implementing the safety function that:

a) results in the spurious operation of the safety function to put the EUC (or part thereof) into a safe state or maintain a safe state; or

b) increases the probability of the spurious operation of the safety function to put the EUC (or part thereof) into a safe state or maintain a safe 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.~~

[SOURCE: IEC 61508-4:2010, 3.6.8]

3.1.8
safety function
function to be implemented by an E/E/PE safety-related system~~, other technology safety-related system or external risk reduction facilities~~ or other risk reduction measures, that is intended to achieve or maintain a safe state for the EUC, in respect of a specific hazardous event ~~(see 3.4.1)~~

EXAMPLE Examples of safety functions include:

– functions that are required to be carried out as positive actions to avoid hazardous situations (for example switching off a motor); and

– functions that prevent actions being taken (for example preventing a motor starting).

[SOURCE: IEC 61508-4:2010, 3.5.1]

3.1.9
programmable electronic
PE
based on computer technology which may be comprised of hardware, software and of input and/or output units

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).

Note 1 to entry: This term covers microelectronic devices based on one or more central processing units (CPUs) together with associated memories, etc.

[SOURCE: IEC 61508-4:2010, 3.2.12]

3.1.10
electrical/electronic/programmable electronic
E/E/PE
based on electrical (E) and/or electronic (E) and/or programmable electronic (PE) technology

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 61326-1:2012).

Note 1 to entry: The term is intended to cover any and all devices or systems operating on electrical principles.

[SOURCE: IEC 61508-4:2010, 3.2.13, modified – the reference in the last dash is modified]

3.1.11
DC distribution network
local DC electricity supply network in the infrastructure of a certain site or building intended for connection of any type of equipment

Note 1 to entry: Connection to a local or remote battery is not regarded as a DC distribution network if such a link comprises ~~only~~ the power supply for ~~only~~ a single piece of equipment.

~~**3.1.12**~~
~~**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]~~

3.1.12
safety-related system
designated system that both

- implements the required safety functions necessary to achieve or maintain a safe state for the EUC; and
- is intended to achieve, on its own or with other E/E/PE safety-related systems and other risk reduction measures, the necessary safety integrity for the required safety functions

Note 1 to entry: A safety-related system includes all the hardware, software and supporting services (for example, power supplies) necessary to carry out the specified safety function (sensors, other input devices, final elements (actuators) and other output devices are therefore included in the safety-related system).

[SOURCE: IEC 61508-4:2010, 3.4.1, modified – notes 1, 2, 3, 4, 5 and 7 have been removed]

3.1.13
equipment under test
EUT
the equipment (devices, appliances and systems) subjected to immunity tests

3.1.14
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

3.1.15
system safety requirements specification
SSRS
specification containing the requirements for the safety functions and their associated safety integrity levels

3.1.16
safety integrity level
SIL
discrete level (one out of a possible four), corresponding to a range of safety integrity values, where safety integrity level 4 has the highest level of safety integrity and safety integrity level 1 has the lowest

Note 1 to entry: The target failure measures for the four safety integrity levels are specified in Tables 2 and 3 of IEC 61508-1:2010.

Note 2 to entry: Safety integrity levels are used for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems.

Note 3 to entry: A safety integrity level (SIL) is not a property of a system, subsystem, element or component. The correct interpretation of the phrase "SIL n safety-related system" (where n is 1, 2, 3 or 4) is that the system is potentially capable of supporting safety functions with a safety integrity level up to n.

[SOURCE: IEC 61508-4:2010, 3.5.8, modified – the reference to 3.5.17 of IEC 61508-1 has been removed and its date of publication added]

3.2 Abbreviations

AE	auxiliary equipment
DS	defined state
E/E/PE	electrical/electronic/programmable electronic
EUC	equipment under control
EUT	equipment under test
ISM	industrial, scientific and medical
PE	protective earth
SIL	safety integrity level
SSRS	system safety requirements specification

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~~ 2010, 7.4.7.1) 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 compared to IEC 61326-1 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~~ DS). 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 5.6.

~~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.~~

If any tests are deemed unnecessary to prove compliance with this standard, the rationale for not performing those tests shall be documented in the EMC test plan.

5.2 Instruction for testing

The instructions for testing immunity in case of safety-functions shall be detailed and unambiguous. Hence all relevant details when performing such a series of immunity tests shall be described in the test plan. Such a test plan shall contain at least information about

- input and output ports relevant for immunity testing,
- configuration of the EUT including any necessary auxiliary and monitoring equipment,
- operation mode of safety functions,
- levels for the immunity test,
- specified performance criteria including the defined state(s),
- monitoring of the behaviour of the EUT,

- assessment of the reaction of the EUT against the manufacturers' specified performance criteria.

5.3 Configuration of EUT during testing

5.3.1 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.

In some cases auxiliary set-ups are necessary to monitor the proper operation of the safety function when electromagnetic disturbances act on the EUT.

5.3.2 Composition of EUT

All devices, racks, modules, boards, etc. which are potentially relevant to EMC and belonging to the EUT shall be documented. The rationale for the composition of the EUT selected for testing shall be documented in the EMC test plan.

5.3.3 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. The rationale for the assembly selected for testing shall be documented in the EMC test plan.

5.3.4 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.

5.3.5 Auxiliary equipment (AE)

When a variety of items of AE is provided for use with the EUT, at least one of each type of item of AE shall be selected to simulate actual operating conditions. AE ~~can~~ may be simulated. Any software used by AE shall be documented sufficiently to allow repeating the test.

It is strongly recommended that the AE used is not susceptible to electromagnetic disturbances, such as for example mechanical equipment, to ease detection and assessment of the reaction of the EUT.

5.3.6 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.

5.4 Operation conditions of EUT during testing

5.4.1 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 within the specification of the equipment for the intended application shall be selected.

NOTE Worst-case operating mode is for example the most susceptible mode of operation.

5.4.2 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.

5.4.3 EUT software during test

The software used for ~~simulating the different~~ exercising the selected modes of operation shall be documented sufficiently to allow repeating the test. ~~This software shall represent the estimated worst-case operating mode for the intended application.~~

5.5 Specification of performance criteria

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

5.6 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 B.

6 Performance criteria

6.1 Performance criterion ~~FS~~ DS

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~~ DS shall be ~~considered~~ applied. Performance criterion ~~FS~~ DS is as follows.

a) The functions of the EUT intended for use in safety applications

   1) are not affected outside their specification, or

   2) may be ~~disturbed~~ affected temporarily or permanently (even by destruction of components), if the EUT reacts to a disturbance in a way that a detectable and defined state(s) of the EUT is (are)

      i) maintained, or

      ii) achieved within a stated time.

~~3) Also, destruction of components is allowed if a defined state of the EUT is maintained or achieved within a stated time.~~

b) The functions not intended for use in safety applications may be disturbed temporarily or permanently.

NOTE 1 ~~In consequence,~~ It ~~will be~~ is possible for the defined state to be outside normal operating limits ~~or otherwise detectable~~.

NOTE 2 Edition 1 of this standard used the abbreviation FS for that performance criterion. According to the basic standard IEC 61000-1-2 and generic standard IEC 61000-6-7, the abbreviation DS is used now without having changed the technical content.

~~**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 Application of the performance criterion ~~FS~~ DS

The performance criterion ~~FS~~ DS is applicable only 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 as defined by performance criterion DS. 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~~ safety functions shall be checked before, during and after the immunity test.

~~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.

The necessity to assess safety functions according to the performance criterion DS calls for a precise monitoring of the technical state of the EUT. To that end, performance criterion DS shall be stated unambiguously. In many cases, specific auxiliary equipment will be necessary to unambiguously identify and monitor the correct operation of the safety function under consideration. It shall be ensured that such auxiliary equipment does not affect the behaviour of the EUT during immunity tests.

6.3 Aspects to be considered during application of performance criterion DS

If an EUT reacts to a disturbance by going to the defined state, it shall be verified that this achievement of the defined state is not only an occasional result, but that this behaviour is

reproducible. To verify the reproducibility, the rules defined in Table 1 shall be applied on the application of performance criterion DS.

Table 1 – Reaction of EUT during test

Test	Reaction of EUT during test	How to continue with testing
Transient [a]	The EUT goes to a defined state and an interaction of the user is needed to continue operation.	The EUT shall be brought back to normal operation and the test shall be repeated 3 times with this test level and polarity and the EUT shall react in a way that complies with performance criterion DS each time. In this case, the test shall be continued with the next test level or polarity according to the basic standard.
	The EUT goes to a defined state and is permanently damaged.	The EUT shall be replaced or repaired and the test shall be repeated 3 times with this test level and polarity and the EUT shall react in a way that complies with performance criterion DS each time. In this case, the test shall be continued with the next test level or polarity according to the basic standard.
Continuous [b]	The EUT goes to a defined state at a certain test frequency as described under a) 2) in 6.1.	The EUT shall be re-tested 3 times at that frequency and the EUT shall react in a way that complies with performance criterion DS each time. If the EUT reacts each time in the same way, the subsequent frequencies may be tested only one time per frequency.
[a] Tests according IEC 61000-4-2, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-11, IEC 61000-4-29, IEC 61000-4-34. [b] Tests according IEC 61000-4-3, IEC 61000-4-6, IEC 61000-4-8, IEC 61000-4-16.		

7 Immunity requirements

Table 2 to Table 7 give immunity test requirements additional to those given in IEC 61326-1. Table 10 gives an overview of the allowed effects of electromagnetic disturbances on functions intended for safety applications and functions not intended for safety applications.

NOTE Some of the test values in Table 2 to Table 7 are less stringent than the values given in the generic EMC standard IEC 61000-6-7. According to IEC Guide 107, where a product family/product EMC standard specifies less stringent test values/levels for a phenomenon or if a phenomenon is only partially covered (e.g. the product family/product EMC standard only covers a subset of the recommended frequency range), either a justification or a reference to the relevant requirement in another EMC standard shall be given in the product family/product EMC standard. Such a reference can be made to IEC 61326-3-1:2008 from which the requirements in this standard were derived and which requirements have been proven in practice.

Some of the electromagnetic phenomena listed in Table 1 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 2 – 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 contact discharge [a, b] ± 8 kV air discharge [a, b]	~~FS~~ DS
1.2	Electromagnetic field	IEC 61000-4-3	20 V/m (80 MHz to 1 GHz, 1 kHz (80 % AM)) [c] 10 V/m (1,4 GHz to 2 GHz, 1 kHz (80 % AM)) [c] 3 V/m (2,0 GHz to ~~2,7~~ 6,0 GHz, 1 kHz (80 % AM)) [c]	~~FS~~ DS
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~~ DS

[a] ~~Levels~~ These values 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~~ test values shall be applied in frequency ranges as given in Table 8 ~~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 3 – Immunity test requirements ~~for equipment intended for use in industrial locations~~ – Input and output AC 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~~ DS
2.2	Surge	IEC 61000-4-5	2 kv (line to line) [b, c] 4 kV (line to ground) [b, c] ~~See Note 1~~	~~FS~~ DS
2.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) [d]	~~FS~~ DS
2.4	Voltage dips	IEC 61000-4-11 or IEC 61000-4-34	0 % during 1 cycle 40 % during 10/12 cycles [e] 70 % during 25/30 cycles [e]	~~FS~~ DS ~~FS~~ DS ~~FS~~ DS
2.5	Short interruptions	IEC 61000-4-11 or IEC 61000-4-34	0 % during 250/300 cycles [e]	~~FS~~ DS
2.6	Conducted common mode voltage	IEC 61000-4-16 ~~See Note 2~~	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz)	~~FS~~ DS

~~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] 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.

[c] The required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[d] These ~~increased~~ test values shall be applied in frequency ranges as given in Table 9 ~~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.

[e] "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 4 – Immunity test requirements ~~for equipment intended for use in industrial locations~~ – Input and output DC 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~~ DS
3.2	Surge	IEC 61000-4-5	1 kV (line to line) [b, c] 2 kV (line to ground) [b, c]	~~FS~~ DS
3.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))[d]	~~FS~~ DS
3.4	Conducted common mode voltage	IEC 61000-4-16 ~~See Note~~	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (DC, 16 2/3 Hz, 50/60 Hz and 150/180 Hz) 100 V short duration (1 s, DC, 16 2/3 Hz and 50/60 Hz)	~~FS~~ DS
3.5	Voltage dips	IEC 61000-4-29	40 % U_T for 10 ms	~~FS~~ DS
3.6	Short interruptions	IEC 61000-4-29	0% U_T for 20 ms	~~FS~~ DS

~~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 DC distribution network are treated as I/O signal/control ports (see Tables 5 and 6).

[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] 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.

[c] The required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[d] These ~~increased~~ test values shall be applied in frequency ranges as given in Table 9 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 5 – 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~~ DS
4.2	Surge	IEC 61000-4-5	2 kV (line to ground) [c, d, e] ~~See Note 1~~	~~FS~~ DS
4.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))[f]	~~FS~~ DS
4.4	Conducted common mode voltage [c, g]	IEC 61000-4-16 ~~See Note 2~~	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (DC, 16 2/3 Hz, 50/60 Hz and 150/180 Hz) 100 V short duration (1 s, DC, 16 2/3 Hz and 50/60 Hz)	~~FS~~ DS

~~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] Only in case of long-distance lines (see 3.10 of IEC 61326-1:2012).

[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 required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[f] These ~~increased~~ test values shall be applied in frequency ranges as given in Table 9 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 6 – 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~~ DS
5.2	Surge	IEC 61000-4-5	2 kV (line to line) [b, c, d] 4 kV (line to ground) [b, c, d] ~~See Note 1~~	~~FS~~ DS
5.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))[e]	~~FS~~ DS
5.4	Conducted common-mode voltage	IEC 61000-4-16 ~~See Note 2~~	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (DC, 16 2/3 Hz, 50/60 Hz and 150/180 Hz) 100 V short duration (1 s, DC, 16 2/3 Hz and 50/60 Hz)	~~FS~~ DS

~~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] 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.

[c] The required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[d] The coupling network AC/DC power lines shall be used.

[e] These ~~increased~~ test values shall be applied in frequency ranges as given in Table 9 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 7– 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~~ DS

[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	886,000 – 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 8 – Frequency ranges of mobile transmitters and ISM equipment for tests with electromagnetic fields

Test frequency	For information only	
range	Frequency range	
MHz	MHz	Service
84,000	83,996 – 84,004	ISM
		ISM (UK only)
137 – 174	137 – 174	Mobile & SRD
	151,820 – 151,880	MURS
	154,570 – 154,600	MURS
	167,992 – 168,008	ISM UK only
219,500	219 – 220	AMATEUR
380 – 400	380 – 400	TETRA
420 – 470	420 – 470	AMATEUR
	433,05 – 434,79	ISM
		(Region 1 only)
	450 – 470	4G/LTE-A
698 – 960	698 – 894	3G/UMTS
		3.9G/LTE
	746 – 845	TETRA
	825 – 845	TETRA
	830 – 840	3G/FOMA
	860 – 915	3.9G/LTE
	870 – 876	TETRA
	860 – 960	RFID
	886 – 906	ISM
		(UK only)
	880 – 915	GSM
		3G/FOMA
		3G/HSPA
	915 – 921	NADC
	902 – 928	ISM
		(Region 2 only)
	925 – 960	GSM
		3G/HSPA
1 240 – 1 300	1 240 – 1 300	AMATEUR
1 428 – 2 700	1 428 – 1 496	3.9G/LTE
		3G/HSPA
		3.9G/LTE

Test frequency	For information only	
range	Frequency range	
MHz	MHz	Service
1 428 – 2 700	1 476 – 1 511	3.9G/LTE
continued	1 525 – 1 559	
	1 627 – 1 661	
	1 710 – 1 785	
	1 710 – 1 785	GSM
		3G/UMTS
		3G/FOMA
		3G/HSPA
	1 805 – 1 880	GSM
		3G/UMTS
		3G/FOMA
		3G/HSPA
		3.9G/LTE
	1 900 – 2 025	3G/UMTS
		3G/FOMA
		3.9G/LTE
	2 110 – 2 200	3G/UMTS
		3G/FOMA
		3.9G/LTE
	2 300 – 2 450	AMATEUR
	2 400 – 2 500	ISM
	2 300 – 2 400	4G/LTE-A
		3.9G/LTE
	2 500 – 2 690	3.9G/LTE
3 300 – 3 600	3 300 – 3 500	AMATEUR
	3 400 – 3 600	4G/LTE-A
5 150 – 5 925	5 150 – 5 350	HIPERLAN
	5 470 – 5 725	HIPERLAN
	5 650 – 5 925	AMATEUR
	5 725 – 5 875	ISM
	5 795 – 5 815	RTTT

For those frequency bands where a single test frequency is indicated in the test frequency range column, the test shall be performed at that frequency only. If a frequency range is indicated in the test frequency range column, that frequency range shall be stepped through with a step size not larger than 1 % of the actual frequency.

NOTE 1 For the tests, the modulation scheme as given in the basic standard is applied. Other modulation parameters are possible.

NOTE 2 For more information about frequency allocation per region, see IEC 61000-2-5 or ITU publications.

Table 9 – ~~Selected~~ Frequency ranges of mobile transmitters and ISM equipment for the conducted RF tests

~~Centre~~ Test frequency MHz	For information only 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 Tables 2 to 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 system which is described in 8.3. If an alternative test philosophy is used, this shall be described in the EMC test plan and a rationale for its use given.

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~~ DS 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~~ DS both apply. The normal performance criteria within their associated limits and the performance criterion ~~FS~~ DS are considered separately. The general approach of applying performance criteria for the different types of functions is shown in Table 10.

Table 10 – 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~~ DS**	**Performance criteria according to the relevant product standard** - A, or - B, or - C	**~~May fail~~ Don't care**
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 C.1 and C.2.			

~~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

The EUT shall be monitored during test to show that its functionality is in compliance with this standard. This monitoring system shall not be affected by electromagnetic disturbances from the applied test.

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 by the manufacturer and as required by the performance criterion ~~FS~~ DS (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~~ examples of allowable 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 and test performance

Figure 1 shows a typical configuration of a test set-up for equipment intended for use in a safety-related system tested as stand-alone equipment or entire 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 1 is also valid if a safety-related system can be tested as an entire system.

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

~~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~~ ports 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.

In cases of combinations of equipment running with safety logic solver software according to IEC 61508, corresponding immunity tests shall be applied to at least one typical combination as long as a proof of immunity for other combinations can be provided through appropriate analytical evidence.

The AE 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 1). During the test, these ~~devices~~ AE shall not be ~~exposed to~~ affected by electromagnetic disturbances.

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

~~Lines~~ Cables 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.

If standardized test methods are available for communication links used for safety functions then it is strongly recommended that they are used (for example, for field bus communications refer to IEC 61784-3).

The safety functions of the safety related system shall be tested one after the other and in specified combinations. Immunity tests are carried out in the static mode of a safety function, e.g. a safety function is activated and then the test is performed.

Immunity tests are not required to be applied during the instances of activating or de-activating safety functions, but these may be added to the test plan by the manufacturer.

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.~~

If at all possible, the monitoring system shall not influence the behaviour of the EUT. If this is not possible, the extent of influence shall be documented. Under no circumstances shall the safety-related functions of the EUT be affected by the monitoring system.

~~For this,~~ The monitoring system shall observe, if applicable:

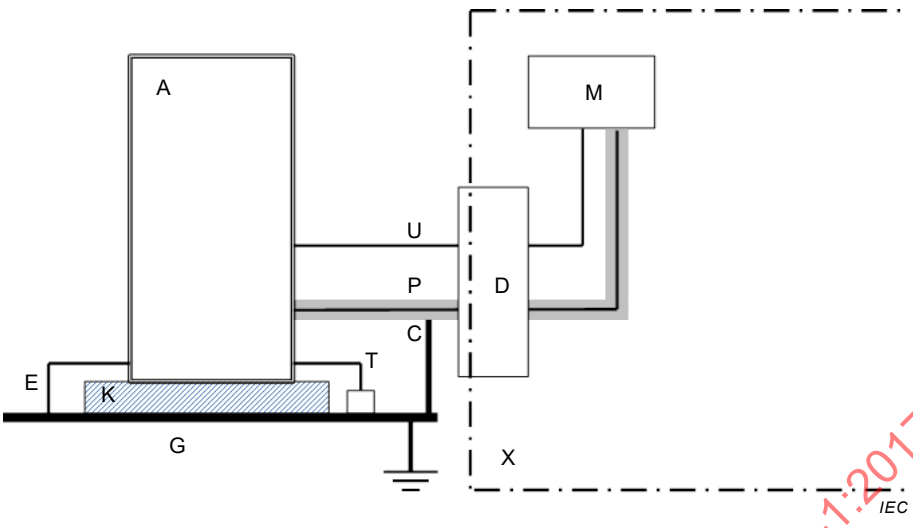
- the data communication between the EUT and the devices which are necessary for the function of the EUT and for performing the function intended for safety applications; and
- the status of the outputs whose functions are intended for safety applications.

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~~ the items specified in the test plan;
– test data and results;
– test equipment and set-up;
– the behaviour observed during the test.



Key

A EUT: safety related system under test

C grounding point for shielded cable(s) (if required by the manufacturer)

D decoupling network(s) at the interface between the EUT and the electromagnetically decoupled environment

E EUT grounding point (if required by the manufacturer)

G ground plane

M monitoring system

P shielded monitoring cable(s) (any necessary, and all safety-related, functions)

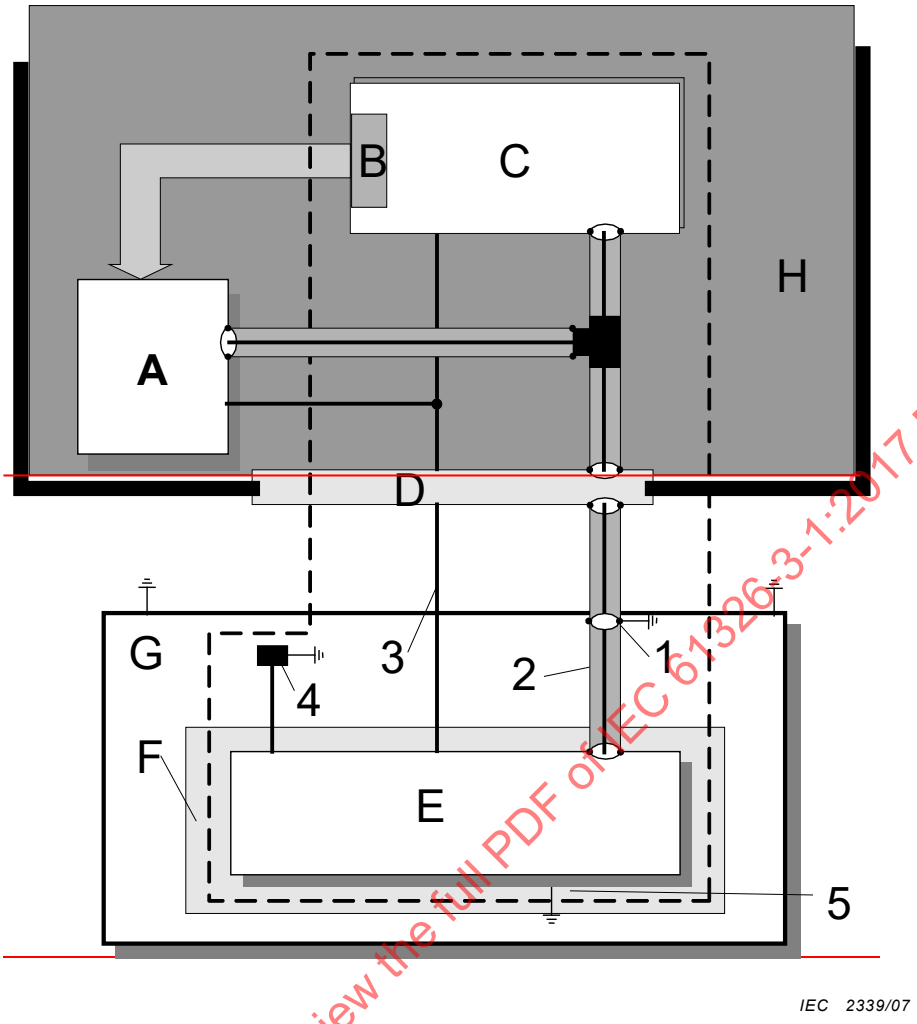
K insulated support

T EUT port terminations (grounded if required by the manufacturer)

U unshielded monitoring cable(s) (any necessary, and all safety-related, functions)

X electromagnetically decoupled environment

Figure 1 – Typical test set-up for equipment intended for use in safety-related system, tested as stand-alone equipment or entire system



~~Key~~

~~A Monitoring system~~

~~B Monitoring output~~

~~C Part of the safety-related system not under test~~

~~D Decoupling network at the shield between the protected and unprotected environment~~

~~E EUT~~

~~F Insulation support~~

~~G Ground plane~~

~~H Electromagnetic decoupled environment~~

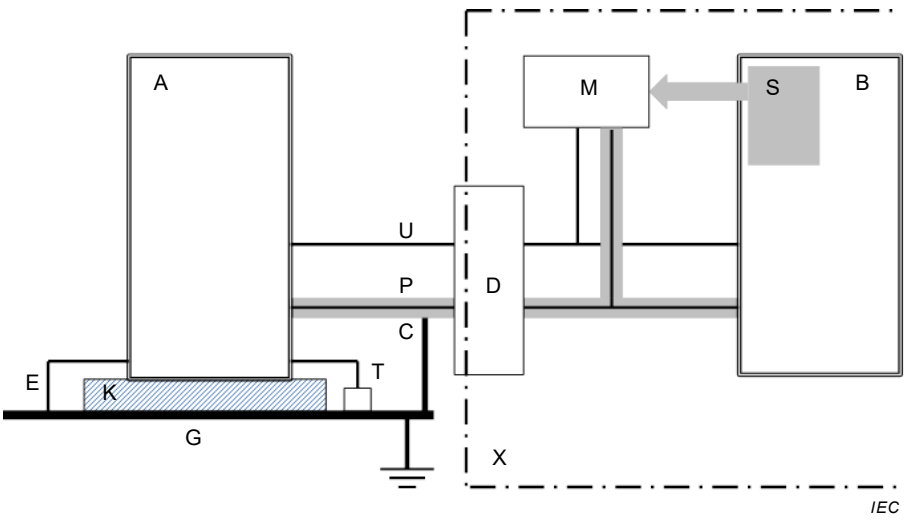
~~1 Earthing point for cable shield~~

~~2 Shielded cable for monitoring~~

~~3 Unshielded cable for monitoring~~

~~4 Terminating device for interfaces (earthed if required by the manufacturer)~~

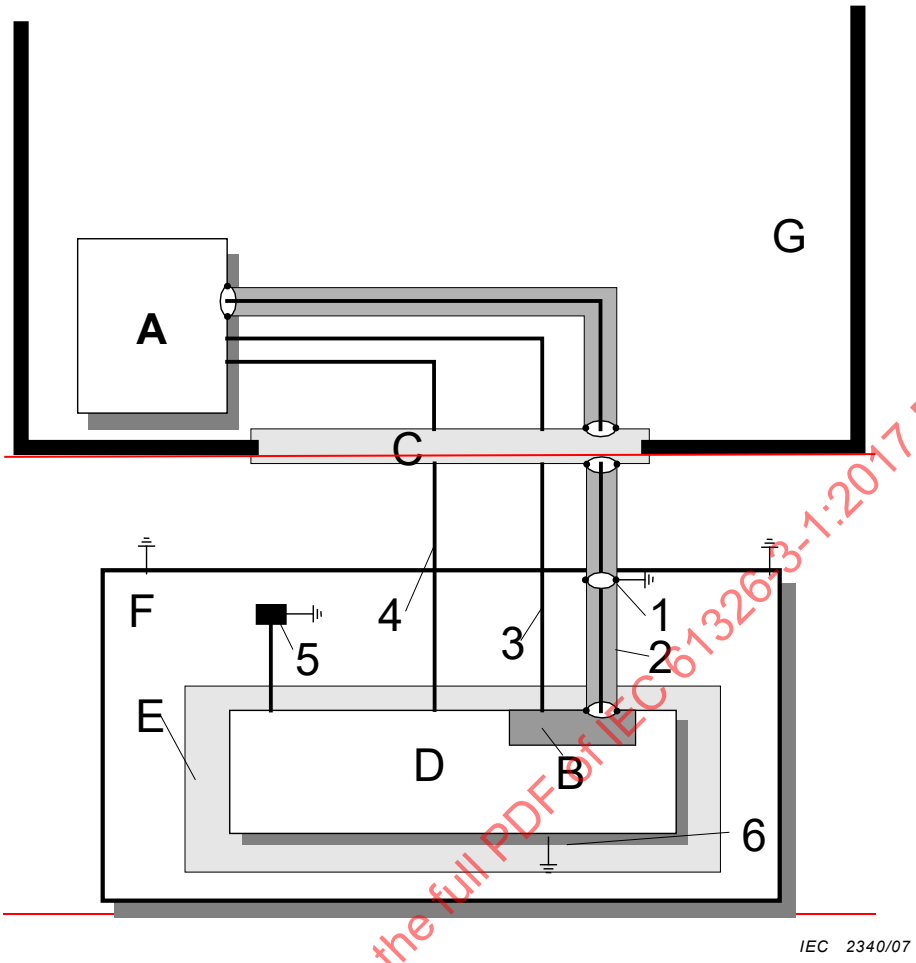
~~5 Earth connection to the ground plane if required~~



Key

A	EUT: part of the safety-related system under test
B	part of the safety-related system not under test, and auxiliary devices
C	grounding point for shielded cable (if required by the manufacturer)
D	decoupling network(s) at the interface between the EUT and the electromagnetically decoupled environment
E	EUT grounding point (if required by the manufacturer)
G	ground plane
M	monitoring system
P	shielded monitoring cable(s) (for any necessary functions as well as for all safety-related functions)
K	insulated support
S	safety-related system output – monitored
T	EUT port terminations (grounded if required by the manufacturer)
U	unshielded monitoring cables (any necessary, and all safety-related, functions)
X	electromagnetically decoupled environment

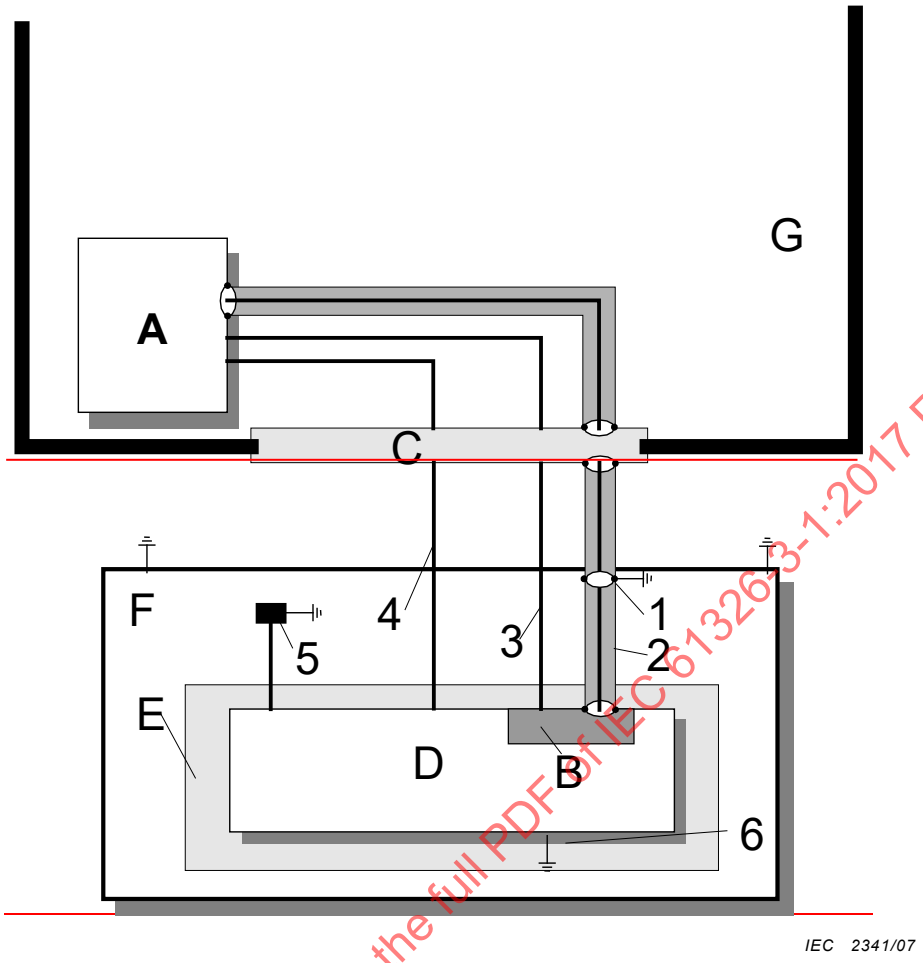
Figure 2 – Typical test set-up for equipment intended for use in a safety-related system integrated into a representative safety-related system during test



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)

Approaches on how to apply IEC 61326-3 series

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 document 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, the electromagnetic environment data of IEC 61000-2-5 are to be used, which 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), this document 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.

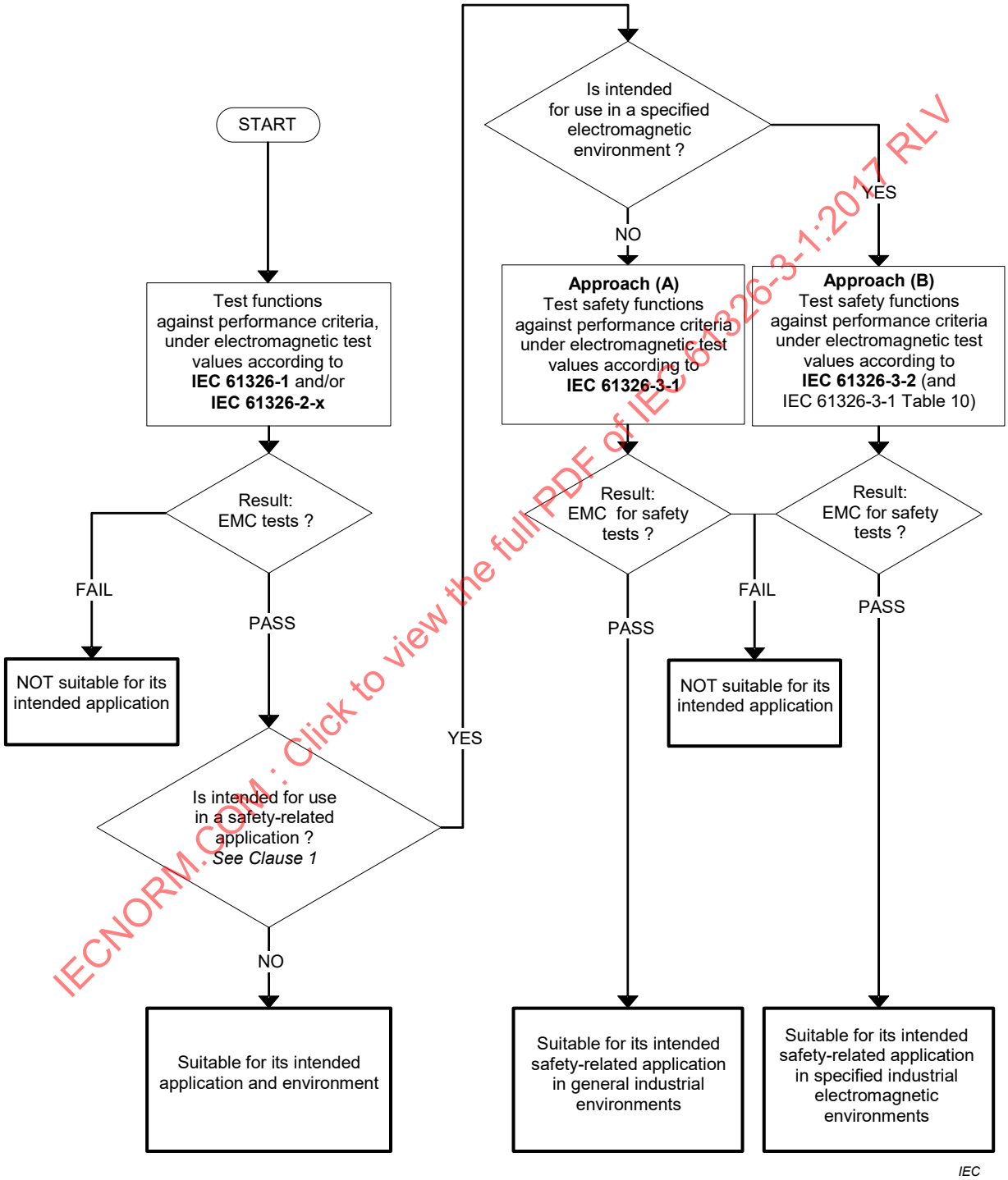
The correlation between the standards IEC 61326-1, IEC 61326-2-X, IEC 61326-3-1 and IEC 61326-3-2 is described in the diagram of Figure A.1.

The increased specified test levels in this document 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 shall take into account the required SIL and shall 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 document.

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.



NOTE This flowchart is not intended to give requirements about the sequence of test.

Figure A. – Correlation between the standards IEC 61326-1, IEC 61326-2-x, IEC 61326-3-1 and IEC 61326-3-2

Annex B
(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 TR 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 TR 61000-2-5. Well-known electromagnetic phenomena are described in IEC TR 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 B.1 (for further details, see IEC TR 61000-1-1 and IEC TR 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).

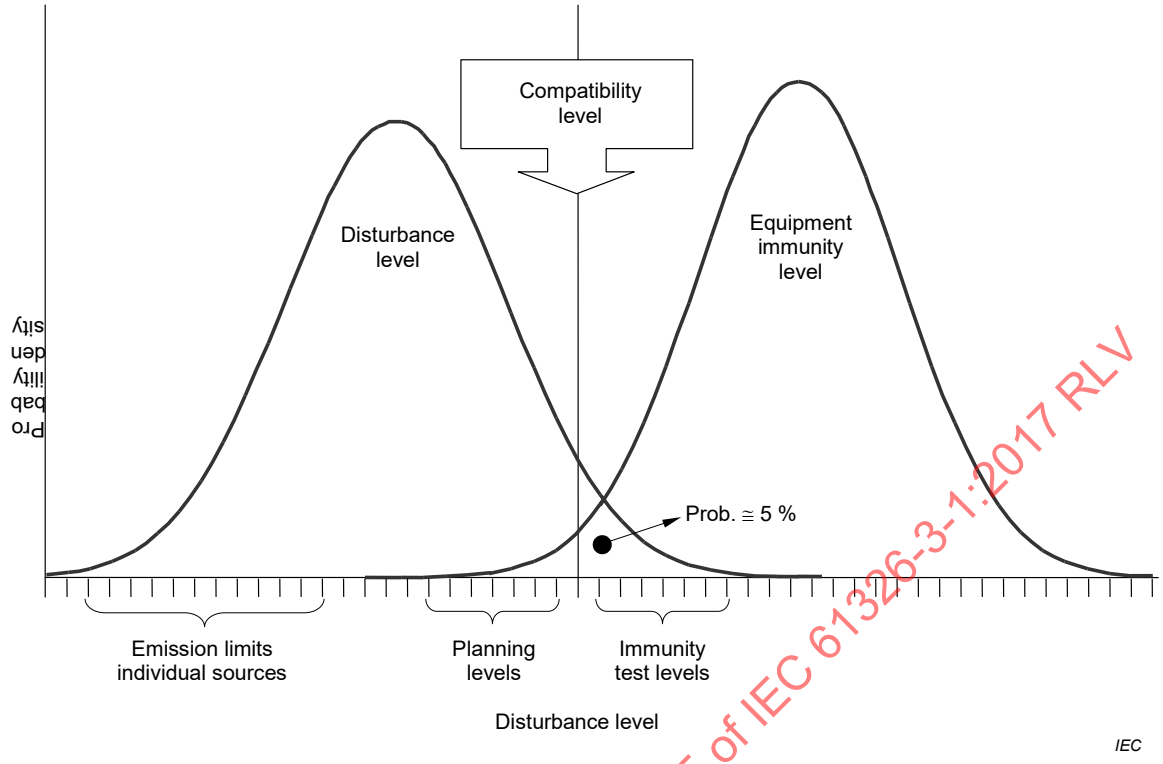


Figure B.1 – Emission/immunity levels and compatibility level, with an example of emission/immunity levels for a single emitter and susceptor, as a function of some independent variables (see IEC TR 61000-1-1)

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 TR 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 B.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 B.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 TR 61000-1-1.

The curves in Figure B.1 show the principal behaviour of the probability of disturbance levels and equipment immunity level, the ranges of planning levels and immunity test levels as well as the position of the compatibility level. 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 TR 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 B.1. The column “Different test ~~value~~ level 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 TR 61000-2-5 in conjunction with engineering arguments.

Table B.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 to 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 to 2	
4	Surge	IEC 61000-4-5	Yes Factor 1 to 2	External protection devices are allowed to achieve the required immunity
5	Conducted RF	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
12	Voltage dips	IEC 61000-4-34	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related
13	Short interruptions	IEC 61000-4-34	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related

Annex C
(informative)

Allowed effects during immunity tests

Tables C.1 and C.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 C.1 refers to the situation when equipment is concerned and Table C.2 refers to the situation when looking at the entire safety-related system.

These tables present the philosophy used in this document 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 C.1 – Allowed effects during immunity tests on functions of equipment *(1 of 2)*

		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~~ DS 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 C.1 *(2 of 2)*

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

Table C.2 – Allowed effects during immunity tests on functions of a system *(1 of 2)*

		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~~ DS 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 C.2 *(2 of 2)*

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

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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 61326-2-1:2012, *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 61326-2-2:2012, *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 61326-2-3:2012, *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 61326-2-4:2012, *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 61326-2-5:2012, *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 field bus interfaces according to IEC 61784-1*

IEC 61326-3-1:2008, *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 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61508-1:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*

IEC 61508-4:~~1998~~ 2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 4: Definitions and abbreviations*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

IEC 61784-3, *Industrial communication networks – Profiles – Part 3: Functional safety fieldbuses – General rules and profile definitions*

IEC Guide 107:2014, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*

ISO/IEC Guide 51:2014, *Safety aspects – Guidelines for their inclusion in standards*

IET Guide, Overview of techniques and measures related to EMC for Functional Safety, [viewed 2016-12-06] available at http://www.theiet.org/factfiles/emc/index.cfm

JAEKEL, Bernd: "Considerations on immunity test levels and methods with regard to functional safety", in LEWANDOWSKI, G. and JANISZEWSKI, JM (ed.). *Electromagnetic Compatibility 2006*, Wroclaw: Oficyna Wydawnicza Politechniki Wroclawskiej, 2006, p.187-192, ISBN 83-7085-947-X

IEC 61326-3-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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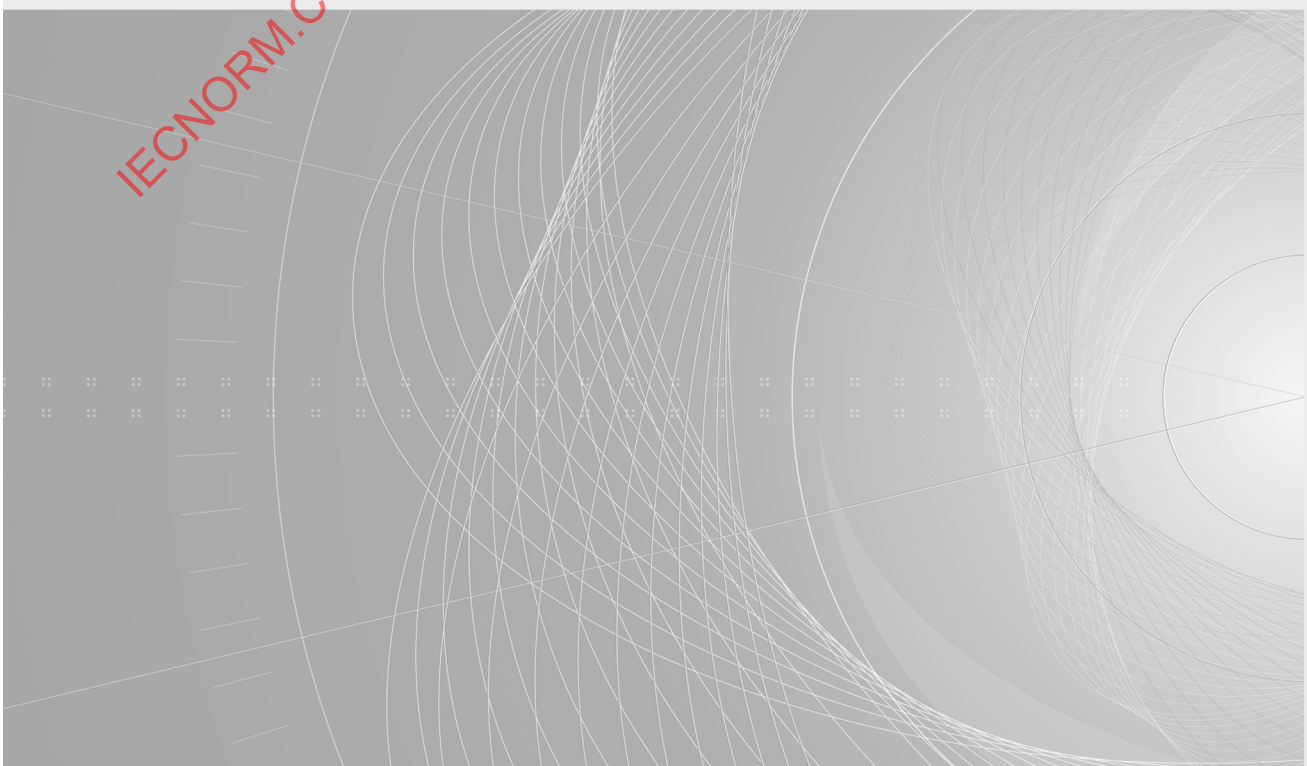
Electrical equipment for measurement, control and laboratory use – EMC requirements –
Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications

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



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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, control and automation.

This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

- extension of the frequency range up to 6 GHz for the radio-frequency electromagnetic field test according to IEC 61000-4-3,
- replacement of the performance criterion FS with DS according to the generic standard IEC 61000-6-7,
- adding Table 1 – Aspects to be considered during application of performance criterion DS,

- including immunity tests for devices with current consumption > 16 A according to IEC 61000-4-34,
- updating Table 8 – Frequency ranges of mobile transmitters and ISM equipment,
- updating Figure A.1 and Figure 1 for better readability.

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/819/FDIS	65A/825/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 stability date indicated on the IEC website 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 overall safety requirements specification specifies all relevant requirements of the intended application, as follows:

a) definition of the safety functions, based on a risk assessment of the intended application (which functions are 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.

The requirements for each safety function are then specified in one or more system safety requirements specifications (SSRS). Hence, with regard to immunity against electromagnetic phenomena, the essential starting point is that the electromagnetic environment and its phenomena are considered in the SSRS, as required by IEC 61508. The safety-related system intended to implement the specified safety function has to fulfil the SSRS, 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 SSRS 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 SSRS. 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 DS) up to levels specified in the SSRS independent of the required safety integrity level (SIL).

For approaches on how to apply IEC 61326-3 series, see Annex A.

There exists meanwhile the generic EMC standard IEC 61000-6-7 dealing with functional safety aspects in industrial environments. Generic EMC standards are designed to apply for a defined electromagnetic environment, to products for which no dedicated product family EMC/product EMC standards exist. However, for the equipment in the scope of this document, the information given in the generic EMC standard was considered not to be sufficient. More detailed information and specifications were needed, for example specific test set-ups, consideration of the functional earth port or the deliberate differentiation between types of electromagnetic environments relevant for the equipment in the scope of this document.

Though historically this product standard was developed several years before the generic EMC standard, this 2nd edition considers the information given in the generic EMC standard and applies it where appropriate.

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

This part of IEC 61326 covers all equipment within the scope of IEC 61326-1, 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 3.8 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 document.

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

Fire alarm systems and security alarm systems intended for protection of buildings are excluded from the scope of this document.

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 60050-161, *International Electrotechnical Vocabulary – Part 161: Electromagnetic compatibility* (available at <http://www.electropedia.org/)

IEC 61000-4-2:2008, *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 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

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 61000-4-16:2015, *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 61000-4-29:2000, *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 61000-4-34:2005, *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 61000-4-34:2005/AMD1:2009

IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61326-1:2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61326-3-2:___[1], *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*

IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61326-1 and IEC 60050-161 and the following 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

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

3.1.1
dangerous failure
failure of an element and/or subsystem and/or system that plays a part in implementing the safety function that:

[1] Under preparation. Stage at the time of publication: IEC/DIS 61326-3-2:2016.

a) prevents a safety function from operating when required (demand mode) or causes a safety function to fail (continuous mode) such that the EUC is put into a hazardous or potentially hazardous state; or

b) decreases the probability that the safety function operates correctly when required

[SOURCE: IEC 61508-4:2010, 3.6.7]

3.1.2
equipment
subsystems, apparatus, appliances and other assemblies of products

3.1.3
equipment under control
EUC
equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities

Note 1 to entry: The EUC control system is separate and distinct from the EUC.

[SOURCE: IEC 61508-4:2010, 3.2.1]

3.1.4
functional safety
part of the overall safety relating to the EUC and the EUC control system that depends on the correct functioning of the E/E/PE safety-related systems and other risk reduction measures

[SOURCE: IEC 61508-4:2010, 3.1.12]

3.1.5
harm
physical injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1, modified – "physical" has been added]

3.1.6
hazard
potential source of harm

Note 1 to entry: The term includes short-term or immediate danger (such as from fire or explosion) and long-term effects on health (such as from release of a toxic substance).

[SOURCE: ISO/IEC Guide 51:2014, 3.2, modified – the note to entry has been added]

3.1.7
safe failure
failure of an element and/or subsystem and/or system that plays a part in implementing the safety function that:

a) results in the spurious operation of the safety function to put the EUC (or part thereof) into a safe state or maintain a safe state; or

b) increases the probability of the spurious operation of the safety function to put the EUC (or part thereof) into a safe state or maintain a safe state

[SOURCE: IEC 61508-4:2010, 3.6.8]

3.1.8
safety function
function to be implemented by an E/E/PE safety-related system or other risk reduction measures, that is intended to achieve or maintain a safe state for the EUC, in respect of a specific hazardous event

EXAMPLE Examples of safety functions include:

– functions that are required to be carried out as positive actions to avoid hazardous situations (for example switching off a motor); and

– functions that prevent actions being taken (for example preventing a motor starting).

[SOURCE: IEC 61508-4:2010, 3.5.1]

3.1.9
programmable electronic
PE
based on computer technology which may be comprised of hardware, software and of input and/or output units

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).

Note 1 to entry: This term covers microelectronic devices based on one or more central processing units (CPUs) together with associated memories, etc.

[SOURCE: IEC 61508-4:2010, 3.2.12]

3.1.10
electrical/electronic/programmable electronic
E/E/PE
based on electrical (E) and/or electronic (E) and/or programmable electronic (PE) technology

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 61326-1:2012).

Note 1 to entry: The term is intended to cover any and all devices or systems operating on electrical principles.

[SOURCE: IEC 61508-4:2010, 3.2.13, modified – the reference in the last dash is modified]

3.1.11
DC distribution network
local DC electricity supply network in the infrastructure of a certain site or building intended for connection of any type of equipment

Note 1 to entry: Connection to a local or remote battery is not regarded as a DC distribution network if such a link comprises the power supply for only a single piece of equipment.

3.1.12
safety-related system
designated system that both

- implements the required safety functions necessary to achieve or maintain a safe state for the EUC; and
- is intended to achieve, on its own or with other E/E/PE safety-related systems and other risk reduction measures, the necessary safety integrity for the required safety functions

Note 1 to entry: A safety-related system includes all the hardware, software and supporting services (for example, power supplies) necessary to carry out the specified safety function (sensors, other input devices, final elements (actuators) and other output devices are therefore included in the safety-related system).

[SOURCE: IEC 61508-4:2010, 3.4.1, modified – notes 1, 2, 3, 4, 5 and 7 have been removed]

3.1.13
equipment under test
EUT
the equipment (devices, appliances and systems) subjected to immunity tests

3.1.14
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

3.1.15
system safety requirements specification
SSRS
specification containing the requirements for the safety functions and their associated safety integrity levels

3.1.16
safety integrity level
SIL
discrete level (one out of a possible four), corresponding to a range of safety integrity values, where safety integrity level 4 has the highest level of safety integrity and safety integrity level 1 has the lowest

Note 1 to entry: The target failure measures for the four safety integrity levels are specified in Tables 2 and 3 of IEC 61508-1:2010.

Note 2 to entry: Safety integrity levels are used for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems.

Note 3 to entry: A safety integrity level (SIL) is not a property of a system, subsystem, element or component. The correct interpretation of the phrase "SIL n safety-related system" (where n is 1, 2, 3 or 4) is that the system is potentially capable of supporting safety functions with a safety integrity level up to n.

[SOURCE: IEC 61508-4:2010, 3.5.8, modified – the reference to 3.5.17 of IEC 61508-1 has been removed and its date of publication added]

3.2 Abbreviations

AE	auxiliary equipment
DS	defined state
E/E/PE	electrical/electronic/programmable electronic
EUC	equipment under control
EUT	equipment under test
ISM	industrial, scientific and medical
PE	protective earth
SIL	safety integrity level
SSRS	system safety requirements specification

4 General

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

NOTE 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 61508-2:2010, 7.4.7.1) 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.

Increased immunity test levels compared to IEC 61326-1 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 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 DS). 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.

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 5.6.

If any tests are deemed unnecessary to prove compliance with this standard, the rationale for not performing those tests shall be documented in the EMC test plan.

5.2 Instruction for testing

The instructions for testing immunity in case of safety-functions shall be detailed and unambiguous. Hence all relevant details when performing such a series of immunity tests shall be described in the test plan. Such a test plan shall contain at least information about

- input and output ports relevant for immunity testing,
- configuration of the EUT including any necessary auxiliary and monitoring equipment,
- operation mode of safety functions,
- levels for the immunity test,
- specified performance criteria including the defined state(s),
- monitoring of the behaviour of the EUT,
- assessment of the reaction of the EUT against the manufacturers' specified performance criteria.

5.3 Configuration of EUT during testing

5.3.1 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.

In some cases auxiliary set-ups are necessary to monitor the proper operation of the safety function when electromagnetic disturbances act on the EUT.

5.3.2 Composition of EUT

All devices, racks, modules, boards, etc. which are potentially relevant to EMC and belonging to the EUT shall be documented. The rationale for the composition of the EUT selected for testing shall be documented in the EMC test plan.

5.3.3 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. The rationale for the assembly selected for testing shall be documented in the EMC test plan.

5.3.4 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.

5.3.5 Auxiliary equipment (AE)

When a variety of items of AE is provided for use with the EUT, at least one of each type of item of AE shall be selected to simulate actual operating conditions. AE may be simulated. Any software used by AE shall be documented sufficiently to allow repeating the test.

It is strongly recommended that the AE used is not susceptible to electromagnetic disturbances, such as for example mechanical equipment, to ease detection and assessment of the reaction of the EUT.

5.3.6 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.

5.4 Operation conditions of EUT during testing

5.4.1 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 within the specification of the equipment for the intended application shall be selected.

NOTE Worst-case operating mode is for example the most susceptible mode of operation.

5.4.2 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.

5.4.3 EUT software during test

The software used for exercising the selected modes of operation shall be documented sufficiently to allow repeating the test.

5.5 Specification of performance criteria

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

5.6 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 B.

6 Performance criteria

6.1 Performance criterion DS

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 DS shall be applied. Performance criterion DS is as follows.

a) The functions of the EUT intended for use in safety applications
   1) are not affected outside their specification, or
   2) may be affected temporarily or permanently (even by destruction of components), if the EUT reacts to a disturbance in a way that a detectable and defined state(s) of the EUT is (are)
      i) maintained, or
      ii) achieved within a stated time.

b) The functions not intended for use in safety applications may be disturbed temporarily or permanently.

NOTE 1 It is possible for the defined state to be outside normal operating limits.

NOTE 2 Edition 1 of this standard used the abbreviation FS for that performance criterion. According to the basic standard IEC 61000-1-2 and generic standard IEC 61000-6-7, the abbreviation DS is used now without having changed the technical content.

6.2 Application of the performance criterion DS

The performance criterion DS is applicable only 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 as defined by performance criterion DS. 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, safety functions shall be checked before, during and after the immunity test.

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.

The necessity to assess safety functions according to the performance criterion DS calls for a precise monitoring of the technical state of the EUT. To that end, performance criterion DS shall be stated unambiguously. In many cases, specific auxiliary equipment will be necessary to unambiguously identify and monitor the correct operation of the safety function under consideration. It shall be ensured that such auxiliary equipment does not affect the behaviour of the EUT during immunity tests.

6.3 Aspects to be considered during application of performance criterion DS

If an EUT reacts to a disturbance by going to the defined state, it shall be verified that this achievement of the defined state is not only an occasional result, but that this behaviour is reproducible. To verify the reproducibility, the rules defined in Table 1 shall be applied on the application of performance criterion DS.

Table 1 – Reaction of EUT during test

Test	Reaction of EUT during test	How to continue with testing
Transient [a]	The EUT goes to a defined state and an interaction of the user is needed to continue operation.	The EUT shall be brought back to normal operation and the test shall be repeated 3 times with this test level and polarity and the EUT shall react in a way that complies with performance criterion DS each time. In this case, the test shall be continued with the next test level or polarity according to the basic standard.
	The EUT goes to a defined state and is permanently damaged.	The EUT shall be replaced or repaired and the test shall be repeated 3 times with this test level and polarity and the EUT shall react in a way that complies with performance criterion DS each time. In this case, the test shall be continued with the next test level or polarity according to the basic standard.
Continuous [b]	The EUT goes to a defined state at a certain test frequency as described under a) 2) in 6.1.	The EUT shall be re-tested 3 times at that frequency and the EUT shall react in a way that complies with performance criterion DS each time. If the EUT reacts each time in the same way, the subsequent frequencies may be tested only one time per frequency.
[a] Tests according IEC 61000-4-2, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-11, IEC 61000-4-29, IEC 61000-4-34. [b] Tests according IEC 61000-4-3, IEC 61000-4-6, IEC 61000-4-8, IEC 61000-4-16.		

7 Immunity requirements

Table 2 to Table 7 give immunity test requirements additional to those given in IEC 61326-1. Table 10 gives an overview of the allowed effects of electromagnetic disturbances on functions intended for safety applications and functions not intended for safety applications.

NOTE Some of the test values in Table 2 to Table 7 are less stringent than the values given in the generic EMC standard IEC 61000-6-7. According to IEC Guide 107, where a product family/product EMC standard specifies less stringent test values/levels for a phenomenon or if a phenomenon is only partially covered (e.g. the product family/product EMC standard only covers a subset of the recommended frequency range), either a justification or a reference to the relevant requirement in another EMC standard shall be given in the product family/product EMC standard. Such a reference can be made to IEC 61326-3-1:2008 from which the requirements in this standard were derived and which requirements have been proven in practice.

Some of the electromagnetic phenomena listed in Table 1 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 2 – Immunity test requirements – 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 contact discharge [a, b] ± 8 kV air discharge [a, b]	DS
1.2	Electromagnetic field	IEC 61000-4-3	20 V/m (80 MHz to 1 GHz, 1 kHz (80 % AM)) [c] 10 V/m (1,4 GHz to 2 GHz, 1 kHz (80 % AM)) [c] 3 V/m (2,0 GHz to 6,0 GHz, 1 kHz (80 % AM)) [c]	DS
1.3	Rated power frequency magnetic field	IEC 61000-4-8	30 A/m [d]	DS

[a] These values 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 test values shall be applied in frequency ranges as given in Table 8. ISM frequencies shall be taken into account on an individual basis.

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

Table 3 – Immunity test requirements – Input and output AC 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]	DS
2.2	Surge	IEC 61000-4-5	2 kV (line to line) [b, c] 4 kV (line to ground) [b, c]	DS
2.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) [d]	DS
2.4	Voltage dips	IEC 61000-4-11 or IEC 61000-4-34	0 % during 1 cycle 40 % during 10/12 cycles [e] 70 % during 25/30 cycles [e]	DS DS DS
2.5	Short interruptions	IEC 61000-4-11 or IEC 61000-4-34	0 % during 250/300 cycles [e]	DS
2.6	Conducted common-mode voltage	IEC 61000-4-16	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz)	DS

[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] 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.

[c] The required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[d] These test values shall be applied in frequency ranges as given in Table 9. ISM frequencies have to be taken into account on an individual basis.

[e] "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 4 – Immunity test requirements – Input and output DC 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]	DS
3.2	Surge	IEC 61000-4-5	1 kV (line to line) [b, c] 2 kV (line to ground) [b, c]	DS
3.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) [d]	DS
3.4	Conducted common mode voltage	IEC 61000-4-16	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (DC, 16 2/3 Hz, 50/60 Hz and 150/180 Hz) 100 V short duration (1 s, DC, 16 2/3 Hz and 50/60 Hz)	DS
3.5	Voltage dips	IEC 61000-4-29	40 % U_T for 10 ms	DS
3.6	Short interruptions	IEC 61000-4-29	0 % U_T for 20 ms	DS

DC connections between parts of equipment/system which are not connected to a DC distribution network are treated as I/O signal/control ports (see Tables 5 and 6).

[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] 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.

[c] The required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[d] These test values shall be applied in frequency ranges as given in Table 9 used for mobile transmitters in general. ISM frequencies shall be taken into account on an individual basis.

Table 5 – Immunity test requirements – 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]	DS
4.2	Surge	IEC 61000-4-5	2 kV (line to ground) [c, d, e]	DS
4.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))[f]	DS
4.4	Conducted common mode voltage [c, g]	IEC 61000-4-16	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (DC, 16 2/3 Hz, 50/60 Hz and 150/180 Hz) 100 V short duration (1 s, DC, 16 2/3 Hz and 50/60 Hz)	DS

[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] Only in case of long-distance lines (see 3.10 of IEC 61326-1:2012).

[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 required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[f] These test values shall be applied in frequency ranges as given in Table 9 used for mobile transmitters in general. ISM frequencies shall be taken into account on an individual basis.

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

Table 6 – Immunity test requirements – 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]	DS
5.2	Surge	IEC 61000-4-5	2 kV (line to line) [b, c, d] 4 kV (line to ground) [b, c, d]	DS
5.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) [e]	DS
5.4	Conducted common mode voltage	IEC 61000-4-16	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (DC, 16 2/3 Hz, 50/60 Hz and 150/180 Hz) 100 V short duration (1 s, DC, 16 2/3 Hz and 50/60 Hz)	DS

[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] 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.

[c] The required immunity level can be achieved through the use of external protection devices. Any devices used and their installation requirements shall be specified in the user documentation.

[d] The coupling network AC/DC power lines shall be used.

[e] These test values shall be applied in frequency ranges as given in Table 9 used for mobile transmitters in general. ISM frequencies shall be taken into account on an individual basis.

Table 7 – Immunity test requirements – 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]	DS

[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 8 – Frequency ranges of mobile transmitters and ISM equipment for tests with electromagnetic fields

Test frequency range MHz	For information only	
	Frequency range MHz	Service
84,000	83,996 – 84,004	ISM *ISM (UK only)*
137 – 174	137 – 174	Mobile & SRD
	151,820 – 151,880	MURS
	154,570 – 154,600	MURS
	167,992 – 168,008	ISM UK only
219,500	219 – 220	AMATEUR
380 – 400	380 – 400	TETRA
420 – 470	420 – 470	AMATEUR
	433,05 – 434,79	ISM *(Region 1 only)*
	450 – 470	4G/LTE-A
698 – 960	698 – 894	3G/UMTS 3.9G/LTE
	746 – 845	TETRA
	825 – 845	TETRA
	830 – 840	3G/FOMA
	860 – 915	3.9G/LTE
	870 – 876	TETRA
	860 – 960	RFID
	886 – 906	ISM *(UK only)*
	880 – 915	GSM 3G/FOMA 3G/HSPA
	915 – 921	NADC
	902 – 928	ISM *(Region 2 only)*
	925 – 960	GSM 3G/HSPA
1 240 – 1 300	1 240 – 1 300	AMATEUR
1 428 – 2 700	1 428 – 1 496	3.9G/LTE 3G/HSPA 3.9G/LTE
1 428 – 2 700 *continued*	1 476 – 1 511 1 525 – 1 559 1 627 – 1 661 1 710 – 1 785	3.9G/LTE
	1 710 – 1 785	GSM 3G/UMTS 3G/FOMA 3G/HSPA
	1 805 – 1 880	GSM 3G/UMTS 3G/FOMA 3G/HSPA 3.9G/LTE
	1 900 – 2 025	3G/UMTS 3G/FOMA 3.9G/LTE
	2 110 – 2 200	3G/UMTS 3G/FOMA 3.9G/LTE
	2 300 – 2 450	AMATEUR
	2 400 – 2 500	ISM
	2 300 – 2 400	4G/LTE-A 3.9G/LTE
	2 500 – 2 690	3.9G/LTE
3 300 – 3 600	3 300 – 3 500	AMATEUR
	3 400 – 3 600	4G/LTE-A
5 150 – 5 925	5 150 – 5 350	HIPERLAN
	5 470 – 5 725	HIPERLAN
	5 650 – 5 925	AMATEUR
	5 725 – 5 875	ISM
	5 795 – 5 815	RTTT

For those frequency bands where a single test frequency is indicated in the test frequency range column, the test shall be performed at that frequency only. If a frequency range is indicated in the test frequency range column, that frequency range shall be stepped through with a step size not larger than 1 % of the actual frequency.

NOTE 1 For the tests, the modulation scheme as given in the basic standard is applied. Other modulation parameters are possible.

NOTE 2 For more information about frequency allocation per region, see IEC 61000-2-5 or ITU publications.

Table 9 – Frequency ranges of mobile transmitters and ISM equipment for the conducted RF tests

Test frequency MHz	For information only 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 Tables 2 to 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 system which is described in 8.3. If an alternative test philosophy is used, this shall be described in the EMC test plan and a rationale for its use given.

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.

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 DS 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 DS both apply. The normal performance criteria within their associated limits and the performance criterion DS are considered separately. The general approach of applying performance criteria for the different types of functions is shown in Table 10.

Table 10 – Applicable performance criteria and observed behaviour during test for equipment intended for use in safety-related systems

Function intended for safety application		Function not intended for safety application	
Normal EMC test	**EMC safety test**	**Normal EMC test**	**EMC safety test**
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** **DS**	**Performance criteria according to the relevant product standard** - A, or - B, or - C	**Don't care**
NOTE 1 The description of the performance criteria A, B and C is given in IEC 61326-1. NOTE 2 For more detailed information about allowed effects during immunity testing, see Tables C.1 and C.2.			

8.3 Test philosophy for safety-related systems

The EUT shall be monitored during test to show that its functionality is in compliance with this standard. This monitoring system shall not be affected by electromagnetic disturbances from the applied test.

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 by the manufacturer and as required by the performance criterion DS (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 examples of allowable effects due to specific electromagnetic phenomena.

8.4 Test configuration and test performance

Figure 1 shows a typical configuration of a test set-up for equipment intended for use in a safety-related system tested as stand-alone equipment or entire 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 1 is also valid if a safety-related system can be tested as an entire system.

Figure 2 shows a typical configuration of a test set-up for equipment intended for use in a safety-related system when tested as part of a representative safety related system. 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.

If the EUT is not an entire safety-related system, then the ports 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.

In cases of combinations of equipment running with safety logic solver software according to IEC 61508, corresponding immunity tests shall be applied to at least one typical combination as long as a proof of immunity for other combinations can be provided through appropriate analytical evidence.

The AE 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 1). During the test, these AE shall not be affected by electromagnetic disturbances.

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

Cables 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.

If standardized test methods are available for communication links used for safety functions then it is strongly recommended that they are used (for example, for field bus communications refer to IEC 61784-3).

The safety functions of the safety related system shall be tested one after the other and in specified combinations. Immunity tests are carried out in the static mode of a safety function, e.g. a safety function is activated and then the test is performed.

Immunity tests are not required to be applied during the instances of activating or de-activating safety functions, but these may be added to the test plan by the manufacturer.

8.5 Monitoring

If at all possible, the monitoring system shall not influence the behaviour of the EUT. If this is not possible, the extent of influence shall be documented. Under no circumstances shall the safety-related functions of the EUT be affected by the monitoring system.

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.

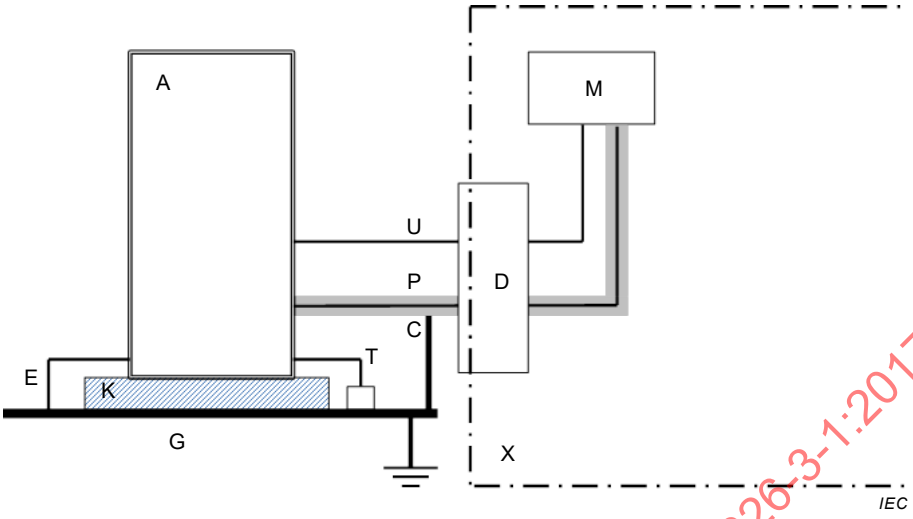
The test report shall contain the following minimum information:

– EUT description;

– the items specified in the test plan;

– test data and results;

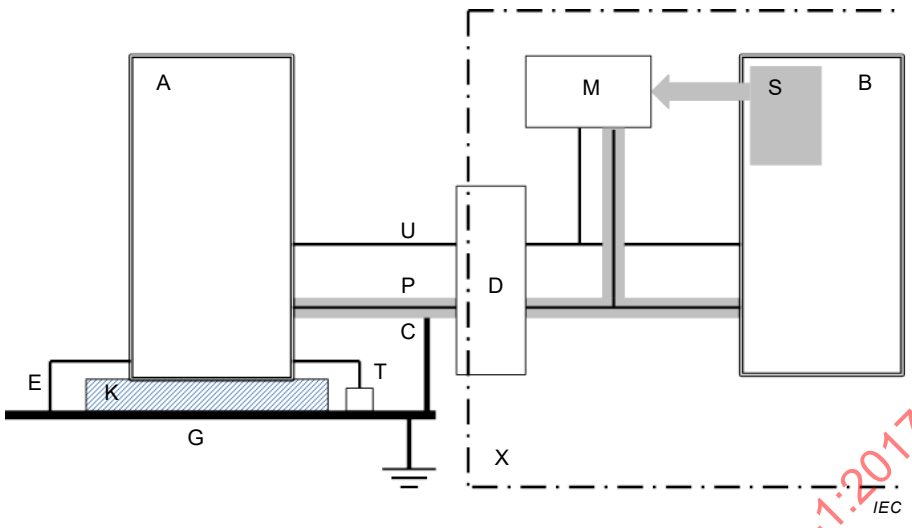
– test equipment and set-up;
– the behaviour observed during the test.



Key

A	EUT: safety related system under test
C	grounding point for shielded cable(s) (if required by the manufacturer)
D	decoupling network(s) at the interface between the EUT and the electromagnetically decoupled environment
E	EUT grounding point (if required by the manufacturer)
G	ground plane
M	monitoring system
P	shielded monitoring cable(s) (any necessary, and all safety-related, functions)
K	insulated support
T	EUT port terminations (grounded if required by the manufacturer)
U	unshielded monitoring cable(s) (any necessary, and all safety-related, functions)
X	electromagnetically decoupled environment

Figure 1 – Typical test set-up for equipment intended for use in safety-related system, tested as stand-alone equipment or entire system



Key

A	EUT: part of the safety-related system under test
B	part of the safety-related system not under test, and auxiliary devices
C	grounding point for shielded cable (if required by the manufacturer)
D	decoupling network(s) at the interface between the EUT and the electromagnetically decoupled environment
E	EUT grounding point (if required by the manufacturer)
G	ground plane
M	monitoring system
P	shielded monitoring cable(s) (for any necessary functions as well as for all safety-related functions)
K	insulated support
S	safety-related system output – monitored
T	EUT port terminations (grounded if required by the manufacturer)
U	unshielded monitoring cables (any necessary, and all safety-related, functions)
X	electromagnetically 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

Annex A
(informative)

Approaches on how to apply IEC 61326-3 series

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 document 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, the electromagnetic environment data of IEC 61000-2-5 are to be used, which 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.

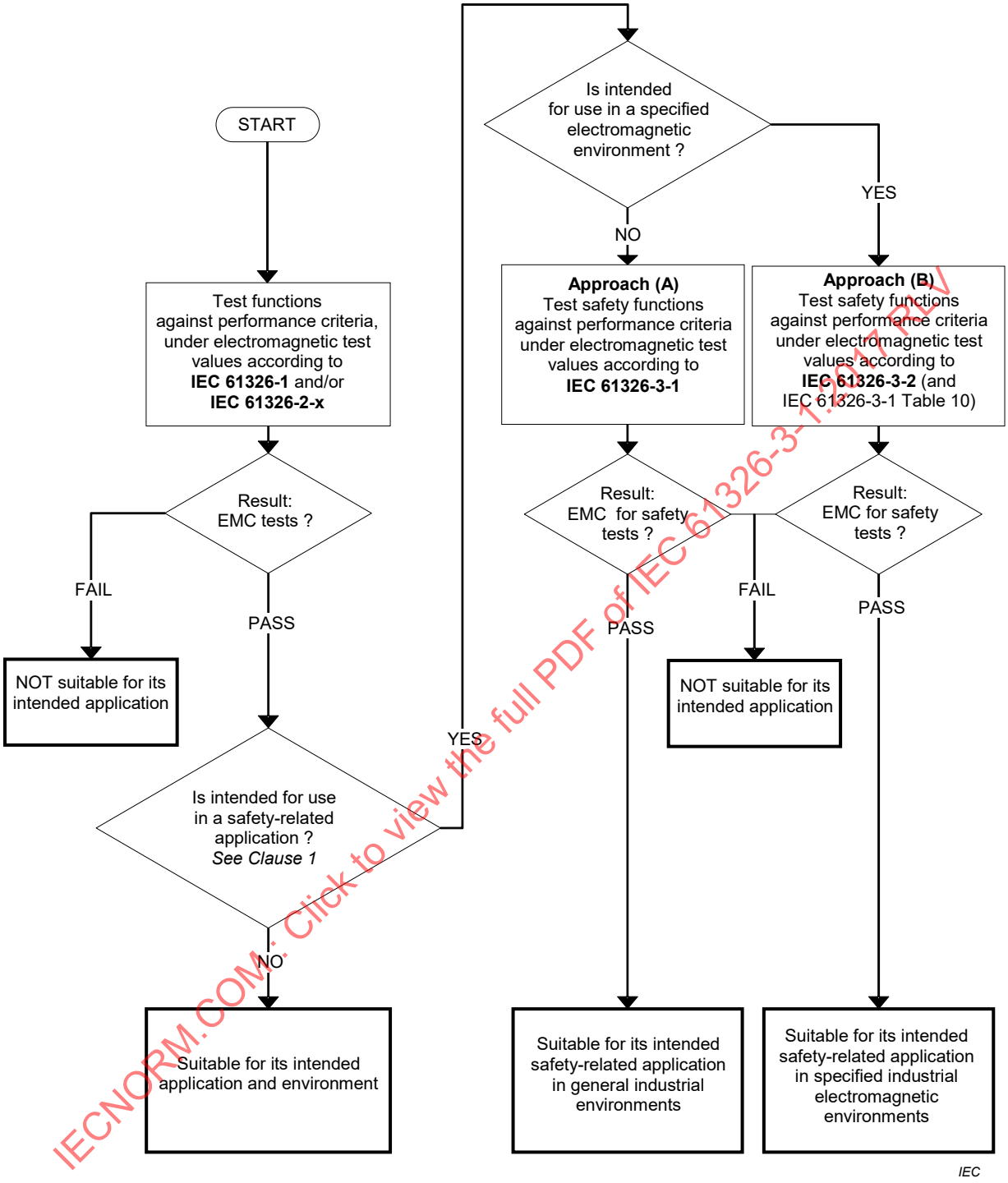
Following approach (a), this document gives specific electromagnetic immunity requirements that apply to safety-related systems and equipment intended to be used in safety-related systems. These requirements supplement certain requirements of IEC 61326-1, and the selected electromagnetic phenomena and 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 A.1.

The increased specified test levels in this document 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 shall take into account the required SIL and shall 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 document.

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.



NOTE This flowchart is not intended to give requirements about the sequence of test.

Figure A.1 – Correlation between the standards IEC 61326-1, IEC 61326-2-x, IEC 61326-3-1 and IEC 61326-3-2

Annex B
(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 TR 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 TR 61000-2-5. Well-known electromagnetic phenomena are described in IEC TR 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 B.1 (for further details, see IEC TR 61000-1-1 and IEC TR 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).

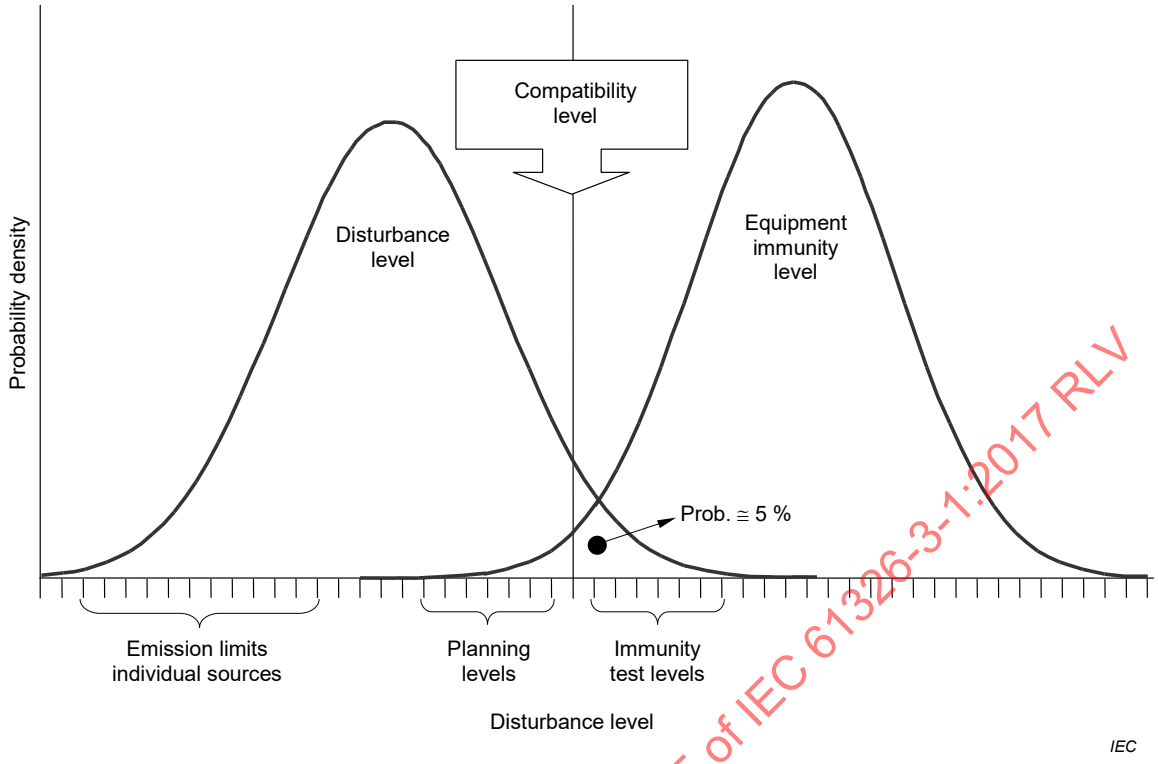


Figure B.1 – Emission/immunity levels and compatibility level, with an example of emission/immunity levels for a single emitter and susceptor, as a function of some independent variables (see IEC TR 61000-1-1)

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 TR 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 B.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 B.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 TR 61000-1-1.

The curves in Figure B.1 show the principal behaviour of the probability of disturbance levels and equipment immunity level, the ranges of planning levels and immunity test levels as well as the position of the compatibility level. 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 TR 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 B.1. The column “Different test level 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 TR 61000-2-5 in conjunction with engineering arguments.

Table B.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 to 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 to 2	
4	Surge	IEC 61000-4-5	Yes Factor 1 to 2	External protection devices are allowed to achieve the required immunity
5	Conducted RF	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
12	Voltage dips	IEC 61000-4-34	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related
13	Short interruptions	IEC 61000-4-34	No	To be decided case by case (dips, interruptions, voltage variations). Voltage variations are considered as functional aspects and not EMC related

Annex C
(informative)

Allowed effects during immunity tests

Tables C.1 and C.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 C.1 refers to the situation when equipment is concerned and Table C.2 refers to the situation when looking at the entire safety-related system.

These tables present the philosophy used in this document 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 C.1 – Allowed effects during immunity tests on functions of equipment *(1 of 2)*

		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** (DS 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 C.1 *(2 of 2)*

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

Table C.2 – Allowed effects during immunity tests on functions of a system *(1 of 2)*

		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** (DS 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 C.2 *(2 of 2)*

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

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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MATÉRIEL ÉLECTRIQUE DE MESURE, DE COMMANDE ET DE LABORATOIRE – EXIGENCES RELATIVES À LA CEM –

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La norme internationale IEC 61326-3-1 a été établie par le sous-comité 65A: Aspects systèmes, du comité d'études 65 de l'IEC: Mesure, commande et automation dans les processus industriels.

Cette deuxième édition annule et remplace la première édition parue en 2008. Cette édition constitue une révision technique. Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- extension de la plage de fréquences jusqu'à 6 GHz pour l'essai de champ électromagnétique à fréquences radioélectriques, conformément à l'IEC 61000-4-3,
- remplacement du critère de performance FS par DS, conformément à la norme générique IEC 61000-6-7,
- ajout du Tableau 1 – aspects à prendre en considération lors de l'application du critère de performance DS,
- intégration d'essais d'immunité pour les dispositifs ayant une consommation de courant > 16 A, conformément à l'IEC 61000-4-34,
- mise à jour du Tableau 8 – Plages de fréquences des émetteurs mobiles et des matériels ISM,
- mise à jour de la Figure A.1 et de la Figure 1 pour une meilleure lisibilité.

L'IEC 61326-3-1 doit être lue conjointement avec l'IEC 61236-1.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
65A/819/FDIS	65A/825/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61326, sous le titre général *Matériel électrique de mesure, de commande et de laboratoire – Exigences relatives à la CEM*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

- reconduite;
- supprimée;
- remplacée par une édition révisée, ou
- amendée.

IMPORTANT – Le logo *"colour inside"* qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

INTRODUCTION

La sécurité fonctionnelle est la partie de la sécurité du matériel commandé (EUC) et de son système de commande qui dépend du fonctionnement correct des systèmes électriques relatifs à la sécurité. Pour l'atteindre, toutes les entités du matériel du système relatif à la sécurité impliquées dans les performances des fonctions de sécurité doivent se comporter d'une manière spécifiée dans toutes les conditions pertinentes.

La publication IEC fondamentale pour la sécurité fonctionnelle des systèmes électriques/électroniques/électroniques programmables relatifs à la sécurité est l'IEC 61508. Elle établit les exigences globales pour l'atteinte de la sécurité fonctionnelle. L'immunité suffisante aux perturbations électromagnétiques est l'une de ces exigences.

Dans son concept, l'IEC 61508 distingue l'application et la conception des systèmes électriques et électroniques relatifs à la sécurité. La spécification globale des exigences de sécurité spécifie toutes les exigences pertinentes pour l'application prévue, comme suit:

a) définition des fonctions de sécurité, basée sur une appréciation du risque pour l'application prévue (quelles fonctions sont prévues pour réduire les risques);

b) niveau d'intégrité de sécurité (SIL) approprié pour chaque fonction de sécurité basée sur une appréciation du risque pour l'application prévue;

c) définition de l'environnement dans lequel le système est destiné à fonctionner, y compris l'environnement électromagnétique, tel qu'exigé par l'IEC 61508-2.

Les exigences relatives à chaque fonction de sécurité sont alors spécifiées dans une ou plusieurs spécifications des exigences de sécurité concernant les systèmes (SSRS). Ainsi, en ce qui concerne l'immunité aux phénomènes électromagnétiques, le point de départ essentiel est le fait que l'environnement électromagnétique et ses phénomènes sont pris en compte dans la SSRS, tel qu'exigé dans l'IEC 61508. Le système relatif à la sécurité destiné à mettre en œuvre la fonction de sécurité spécifiée doit être conforme à la SSRS et les exigences d'immunité correspondantes doivent en découler pour les entités du matériel, ce qui se traduit par une spécification des exigences pour le matériel. Pour ce qui concerne l'environnement électromagnétique, il convient que la SSRS et la spécification des exigences pour le matériel soient fondées sur une évaluation pertinente des menaces électromagnétiques prévisibles dans l'environnement réel sur la totalité de la durée d'exploitation du matériel. Ainsi, les exigences d'immunité pour le matériel dépendent des caractéristiques de l'environnement électromagnétique dans lequel le matériel est destiné à fonctionner.

Le fabricant de matériel doit donc prouver que le matériel est conforme aux exigences qui lui sont applicables et l'intégrateur du système doit prouver que le système est conforme à la SSRS. Des preuves doivent être apportées en appliquant des méthodes appropriées. Il n'est pas nécessaire de tenir compte des autres aspects de l'application, par exemple, les risques associés à toute défaillance du système relatif à la sécurité. L'objectif est que tout matériel du système soit conforme aux critères particuliers de performance, par la prise en compte des aspects de sécurité fonctionnelle (par exemple, le critère de performance DS) jusqu'aux niveaux spécifiés dans la SSRS indépendamment du niveau d'intégrité de sécurité (SIL) exigé.

Pour des approches sur la manière d'appliquer la série IEC 61326-3, voir l'Annexe A.

Il existe également la norme CEM générique IEC 61000-6-7, qui traite des aspects de la sécurité fonctionnelle dans les environnements industriels. Les normes CEM génériques sont conçues pour s'appliquer dans un environnement électromagnétique défini à des produits pour lesquels il n'existe aucune norme CEM de produit/de famille de produits dédiée. Cependant, concernant les matériels qui relèvent du domaine d'application du présent document, il a été jugé que les informations fournies dans la norme CEM générique ne sont pas suffisantes. Des informations et des spécifications plus détaillées se sont avérées nécessaires, par exemple, des montages d'essai spécifiques, la prise en considération d'accès par la borne de terre fonctionnelle ou la différentiation délibérée entre les types

d'environnements électromagnétiques applicables aux matériels qui relèvent du domaine d'application du présent document.

Même si, historiquement, la présente norme de produit a été élaborée quelques années avant la publication de la norme CEM générique, cette deuxième édition tient compte des informations fournies dans la norme CEM générique et les applique selon le cas.

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

1 Domaine d'application

La présente partie de l'IEC 61326 couvre tous les matériels qui relèvent du domaine d'application de l'IEC 61326-1, mais est limitée aux systèmes et matériels pour applications industrielles destinés à réaliser des fonctions de sécurité telles que définies dans l'IEC 61508, avec un niveau d'intégrité de sécurité (SIL) 1-3.

Les environnements électromagnétiques couverts par la présente norme de famille de produits sont des environnements industriels, à la fois à l'intérieur et à l'extérieur, tels que décrits pour les sites industriels dans l'IEC 61000-6-2 ou définis en 3.8 de l'IEC 61326-1. Les matériels et les systèmes pour une utilisation dans d'autres environnements électromagnétiques, par exemple dans l'industrie de processus ou dans des environnements avec des atmosphères potentiellement explosives, sont exclus du domaine d'application du présent document.

Les matériels et systèmes considérés comme «éprouvés par une utilisation antérieure», conformément à l'IEC 61508, ou «utilisation préalable», conformément à l'IEC 61511, sont exclus du domaine d'application du présent document.

Les systèmes d'alarme incendie et les systèmes d'alarme de sécurité destinés à la protection des bâtiments sont exclus du domaine d'application du présent document.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-161, *Vocabulaire Électrotechnique International – Partie 161: Compatibilité électromagnétique* (disponible sur <http://www.electropedia.org/)

IEC 61000-4-2:2008, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

IEC 61000-4-3:2006, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:2012, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essais d'immunité aux transitoires électriques rapides en salves*

IEC 61000-4-5:2014, *Compatibilité électromagnétique (CEM) – Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc*

IEC 61000-4-6:2013, *Compatibilité électromagnétique (CEM) – Partie 4-6: Techniques d'essai et de mesure – Immunité aux perturbations conduites, induites par les champs radioélectriques*

IEC 61000-4-8:2009, *Compatibilité électromagnétique (CEM) – Partie 4-8: Techniques d'essai et de mesure – Essai d'immunité au champ magnétique à la fréquence du réseau*

IEC 61000-4-11:2004, *Compatibilité électromagnétique (CEM) – Partie 4-11: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension*

IEC 61000-4-16:2015, *Compatibilité électromagnétique (CEM) – Partie 4-16: Techniques d'essai et de mesure – Essai d'immunité aux perturbations conduites en mode commun dans la plage de fréquences de 0 Hz à 150 kHz*

IEC 61000-4-29:2000, *Compatibilité électromagnétique (CEM) – Partie 4-29: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension sur les accès d'alimentation en courant continu*

IEC 61000-4-34:2005, *Compatibilité électromagnétique (CEM) – Partie 4-34: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension pour matériel ayant un courant appelé de plus de 16 A par phase*
IEC 61000-4-34:2005/AMD1:2009

IEC 61000-6-2:2016, *Compatibilité électromagnétique (CEM) – Partie 6-2: Normes génériques – Norme d'immunité pour les environnements industriels*

IEC 61326-1:2012, *Matériel électrique de mesure, de commande et de laboratoire – Exigences relatives à la CEM – Partie 1: Exigences générales*

IEC 61326-3-2:___[1], *Matériel électrique de mesure, de commande et de laboratoire – Exigences relatives à la CEM – Partie 3-2: 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 dont l'environnement électromagnétique est spécifié*

IEC 61508-2:2010, *Sécurité fonctionnelle des systèmes électriques/électroniques/électroniques programmables relatifs à la sécurité – Partie 2: Exigences pour les systèmes électriques/électroniques/électroniques programmables relatifs à la sécurité*

3 Termes, définitions et abréviations

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 61326-1 et de l'IEC 60050-161, ainsi que les suivants, s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/

[1] En préparation. Stade au moment de la publication: IEC/DIS 61326-3-2:2016.

- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

NOTE D'autres définitions, qui ne se trouvent ni dans l'IEC 60050-161, ni dans le présent document, mais qui sont néanmoins nécessaires à l'application des différents essais, sont données dans les publications fondamentales en CEM de la série IEC 61000.

3.1.1
défaillance dangereuse
défaillance d'un élément et/ou sous-système et/ou système ayant une influence sur la mise en œuvre de la fonction de sécurité qui:

a) empêche le fonctionnement nécessaire de la fonction de sécurité (mode de sollicitation) ou provoque la défaillance d'une fonction de sécurité (mode continu) de sorte que l'EUC est mis dans un état dangereux ou potentiellement dangereux, ou

b) diminue la probabilité que la fonction de sécurité fonctionne correctement lorsque c'est nécessaire

[SOURCE: IEC 61508-4:2010, 3.6.7]

3.1.2
matériel
sous-systèmes, matériels, appareils et autres ensembles de produits

3.1.3
matériel commandé
EUC
équipement, machine, appareil ou installation utilisés pour les activités de fabrication, de traitement, de transport, médicales ou d'autres activités

Note 1 à l'article: Le système de commande de l'EUC est séparé et distinct de l'EUC.

Note 2 à l'article: L'abréviation «EUC» est dérivée du terme anglais développé correspondant «equipment under control».

[SOURCE: IEC 61508-4:2010, 3.2.1]

3.1.4
sécurité fonctionnelle
sous-ensemble de la sécurité globale se rapportant à l'EUC et au système de commande de l'EUC qui dépend du fonctionnement correct des systèmes E/E/PE relatifs à la sécurité et des dispositifs externes de réduction de risque

[SOURCE: IEC 61508-4:2010, 3.1.12]

3.1.5
dommage
blessure physique ou atteinte à la santé des personnes, ou atteinte aux biens ou à l'environnement

[SOURCE: Guide ISO/IEC 51:2014, 3.1, modifiée – "physique" a été ajouté]

3.1.6
danger
phénomène dangereux
source potentielle de dommage

Note 1 à l'article: Le terme inclut les dangers à court terme ou immédiats (tels que les incendies ou les explosions) et ceux qui ont des effets à long terme sur la santé (tels que le dégagement de substances toxiques).

[SOURCE: Guide ISO/IEC 51:2014, 3.2, modifiée – la note à l'article a été ajoutée]

3.1.7
défaillance en sécurité
défaillance d'un élément et/ou sous-système et/ou système ayant une influence sur la mise en œuvre de la fonction de sécurité qui:

a) conduit au fonctionnement parasite de la fonction de sécurité avec la potentialité de mettre l'EUC (ou une partie de celui-ci) dans un état de sécurité ou de maintenir un état de sécurité, ou

b) augmente la probabilité du fonctionnement parasite de la fonction de sécurité avec potentialité de mettre l'EUC (ou une partie de celui-ci) dans un état de sécurité ou de maintenir un état de sécurité

[SOURCE: IEC 61508-4:2010, 3.6.8]

3.1.8
fonction de sécurité
fonction à réaliser par un système E/E/PE relatif à la sécurité ou par un dispositif externe de réduction de risque, prévue pour assurer ou maintenir un état de sécurité de l'EUC par rapport à un événement dangereux spécifique

EXEMPLE Des exemples de fonctions de sécurité comprennent:

– les fonctions devant être réalisées en tant qu'actions positives pour éviter des situations dangereuses (par exemple, arrêt d'un moteur) et

– les fonctions de prévention de réalisation d'actions (par exemple, empêcher le démarrage d'un moteur).

[SOURCE: IEC 61508-4:2010, 3.5.1]

3.1.9
électronique programmable
PE
technologie basée sur l'informatique, pouvant comprendre du matériel, du logiciel, ainsi que les unités d'entrée et/ou de sortie

EXEMPLE Tous les dispositifs suivants sont des dispositifs électroniques programmables:

– microprocesseurs,

– microcontrôleurs,

– automates programmables,

– circuits intégrés à application spécifique (ASIC),

– automates logiques programmables (PLC),

– autres dispositifs basés sur la technologie informatique (par exemple, les capteurs intelligents, les transmetteurs, les actionneurs).

Note 1 à l'article: Ce terme recouvre les dispositifs microélectroniques basés sur une ou plusieurs unités centrales de traitement (CPU) associées à des mémoires, etc.

Note 2 à l'article: L'abréviation «PE» est dérivée du terme anglais développé correspondant «programmable electronic».

[SOURCE: IEC 61508-4:2010, 3.2.12]

3.1.10
électrique/électronique/électronique programmable
E/E/PE
technologie basée sur la technologie électrique (E), et/ou électronique (E) et/ou électronique programmable (PE)

EXEMPLE Les dispositifs électriques/électroniques/électroniques programmables comprennent

– les appareils électromécaniques (électriques);

– les appareils électroniques non programmables à circuits intégrés (électroniques);

– les appareils électroniques basés sur la technologie informatique (électroniques programmables); voir 3.2.5 de l'IEC 61326-1:2012.

Note 1 à l'article: Ce terme désigne l'ensemble des dispositifs ou systèmes fonctionnant selon les principes électriques.

[SOURCE: IEC 61508-4:2010, 3.2.13, modifiée – la référence indiquée dans le dernier tiret a été modifiée]

3.1.11
réseau de distribution à courant continu
réseau local à courant continu de distribution électrique dans l'infrastructure d'un site ou immeuble donné, destiné à la connexion de tout type de matériel

Note 1 à l'article: La connexion à des batteries locales ou à distance n'est pas considérée comme un réseau local de distribution à courant continu si une telle liaison n'est constituée que de l'alimentation pour un seul matériel.

3.1.12
système relatif à la sécurité
système désigné qui, à la fois

- met en œuvre les fonctions de sécurité requises pour atteindre ou maintenir un état de sécurité de l'EUC et
- est prévu pour atteindre, par lui-même ou grâce à d'autres systèmes E/E/PE relatifs à la sécurité, et aux dispositifs externes de réduction de risque, l'intégrité de sécurité nécessaire pour les fonctions de sécurité requises

Note 1 à l'article: Un système relatif à la sécurité recouvre l'ensemble des matériels, logiciels, ainsi que tous les équipements annexes (par exemple, alimentation) nécessaires pour exécuter la fonction de sécurité spécifiée (les capteurs, les autres dispositifs d'entrée, les éléments terminaux (actionneurs) ainsi que les autres dispositifs de sortie sont par conséquent compris dans le système relatif à la sécurité).

[SOURCE: IEC 61508-4:2010, 3.4.1, modifiée – les notes 1, 2, 3, 4, 5 et 7 ont été supprimées]

3.1.13
matériel en essai
EUT
matériel (dispositifs, appareils et systèmes) soumis aux essais d'immunité

Note 1 à l'article: L'abréviation «EUT» est dérivée du terme anglais développé correspondant «equipment under test».

3.1.14
matériel auxiliaire
AE
matériel nécessaire pour fournir au matériel en essai (EUT) les signaux exigés pour son fonctionnement normal et le matériel pour vérifier les performances de l'EUT

Note 1 à l'article: L'abréviation «AE» est dérivée du terme anglais développé correspondant «auxiliary equipment».

3.1.15
spécification des exigences de sécurité concernant les systèmes
SSRS
spécification qui contient les exigences concernant les fonctions de sécurité et leurs niveaux d'intégrité de sécurité associés

Note 1 à l'article: L'abréviation «SSRS» est dérivée du terme anglais développé correspondant «system safety requirements specification».

3.1.16
niveau d'intégrité de sécurité
SIL
niveau discret (parmi quatre possibles) correspondant à une gamme de valeurs d'intégrité de sécurité où le niveau 4 d'intégrité de sécurité possède le plus haut degré d'intégrité et le niveau 1 possède le plus bas

Note 1 à l'article: Les objectifs chiffrés de défaillance pour les quatre niveaux d'intégrité de sécurité sont indiqués dans les Tableaux 2 et 3 de l'IEC 61508-1:2010.

Note 2 à l'article: Les niveaux d'intégrité de sécurité sont utilisés pour spécifier les exigences concernant l'intégrité de sécurité des fonctions de sécurité à allouer aux systèmes E/E/PE relatifs à la sécurité.

Note 3 à l'article: Un niveau d'intégrité de sécurité (SIL) ne constitue pas une propriété d'un système, sous-système, élément ou composant. L'interprétation correcte de l'expression «Système relatif à la sécurité à SIL n» (où n est 1, 2, 3 ou 4) signifie que le système est potentiellement capable de prendre en charge les fonctions de sécurité avec un niveau d'intégrité de sécurité jusqu'à n.

Note 4 à l'article: L'abréviation «SIL» est dérivée du terme anglais développé correspondant «safety integrity level».

[SOURCE: IEC 61508-4:2010, 3.5.8, modifiée – la référence à 3.5.17 de l'IEC 61508-1 a été supprimée et sa date de publication a été ajoutée]

3.2 Abréviations

AE	auxiliary equipment (matériel auxiliaire)
DS	defined state (état défini)
E/E/PE	electrical/electronic/programmable electronic (électrique/électronique/électronique programmable)
EUC	equipment under control (matériel commandé)
EUT	equipment under test (matériel en essai)
ISM	industrial, scientific and medical (industriel, scientifique et médical)
PE	protective earth (terre de protection)
SIL	safety integrity level (niveau d'intégrité de sécurité)
SSRS	system safety requirements specification (spécification des exigences de sécurité concernant les systèmes)

4 Généralités

En complément des exigences de l'IEC 61326-1, la présente norme spécifie des exigences pour les systèmes et matériels pour applications industrielles destinés à réaliser des fonctions de sécurité en accord avec l'IEC 61508. Ces exigences ne s'appliquent pas aux fonctions du matériel ou du système qui ne sont pas relatives à la sécurité.

NOTE Le processus global de conception et les caractéristiques de conception nécessaires pour réaliser la sécurité fonctionnelle des systèmes électriques et électroniques sont définis dans l'IEC 61508. Cela inclut les exigences pour les caractéristiques de conception qui font que le système est tolérant (IEC 61508-2:2010, 7.4.7.1) aux perturbations électromagnétiques.

Les exigences d'immunité de l'IEC 61326-1 ont été sélectionnées pour garantir un niveau adéquat d'immunité pour le matériel utilisé dans des applications qui ne sont pas relatives à la sécurité, mais les niveaux d'immunité exigés ne couvrent pas les cas extrêmes qui peuvent survenir en tout emplacement mais avec une probabilité extrêmement faible.

Les niveaux d'essai d'immunité augmentés, comparés à ceux décrits dans l'IEC 61326-1, sont définis comme une mesure systématique pour empêcher des défaillances dangereuses provoquées par des phénomènes électromagnétiques. Il n'est donc pas nécessaire de prendre en compte les effets des phénomènes électromagnétiques dans la quantification du niveau d'intégrité de sécurité du matériel, par exemple la probabilité de défaillance en cas de

sollicitation. Des niveaux d'essai d'immunité augmentés sont définis quand cela est nécessaire.

Les niveaux d'essai d'immunité augmentés sont liés uniquement aux aspects de sécurité fonctionnelle. Ils ne sont pas applicables à l'évaluation des aspects de fiabilité et de disponibilité. Les niveaux d'essai d'immunité augmentés s'appliquent uniquement aux fonctions relatives à la sécurité ayant un critère de performance spécifique pour la sécurité fonctionnelle (critère de performance DS). Les niveaux d'essai d'immunité augmentés établissent les limites pour les valeurs d'essai maximales. La conformité à la présente norme n'exige pas d'autres essais avec des valeurs plus élevées.

5 Plan d'essai de CEM

5.1 Généralités

Avant d'effectuer les essais, un plan d'essai de CEM doit être établi. Ce plan doit contenir au minimum les éléments mentionnés de 5.2 à 5.6.

Si des essais quelconques sont considérés comme étant inutiles pour prouver la conformité à la présente norme, les justifications relatives à la non-réalisation de ces essais doivent être documentées dans le plan d'essai de CEM.

5.2 Instructions relatives aux essais

Les instructions relatives aux essais d'immunité dans le cadre de fonctions de sécurité doivent être fournies de façon détaillée et non ambiguë. Par conséquent, tous les détails pertinents relatifs à la réalisation d'une telle série d'essais d'immunité doivent être fournis dans le plan d'essai. Ledit plan d'essai doit comporter, au minimum, des informations concernant

- les accès d'entrée et de sortie pertinents pour les essais d'immunité,
- la configuration de l'EUT, y compris tout matériel auxiliaire et de surveillance nécessaire,
- le mode de fonctionnement des fonctions de sécurité,
- les niveaux relatifs à l'essai d'immunité,
- les critères de performance spécifiés, y compris le(s) état(s) défini(s),
- la surveillance du comportement de l'EUT,
- l'évaluation de la réaction de l'EUT face aux critères de performance spécifiés par les fabricants.

5.3 Configuration de l'EUT lors des essais

5.3.1 Généralités

Les matériels de mesure, de commande et de laboratoire consistent souvent en des systèmes dont la configuration n'est pas figée. Le type, le nombre et l'installation des différents sous-ensembles à l'intérieur du matériel peuvent donc varier d'un système à l'autre.

Afin de simuler de façon réaliste les conditions de CEM, les assemblages de matériels doivent représenter une installation type telle que celle spécifiée par le fabricant. Les essais de CEM doivent être effectués comme des essais de type dans des conditions normales telles que celles spécifiées par le fabricant.

Dans certains cas, des montages auxiliaires sont nécessaires afin de surveiller le fonctionnement correct de la fonction de sécurité lorsque des perturbations électromagnétiques ont un impact sur l'EUT.

5.3.2 Composition de l'EUT

Tous les dispositifs, baies, modules, cartes, etc. qui, potentiellement, relèvent de la CEM et appartiennent à l'EUT, doivent être documentés. Les justifications relatives à la composition de l'EUT choisi pour les essais doivent être documentées dans le plan d'essai de CEM.

5.3.3 Assemblage de l'EUT

Si un EUT a plusieurs configurations internes et externes possibles, les essais de type doivent être effectués avec la configuration la plus sensible, tel que prévu par le fabricant. Tous les types de modules doivent être soumis aux essais au moins une fois. Les justifications de ce choix doivent être documentées dans le plan d'essai de CEM. La possibilité de toute interaction électromagnétique entre des entités de matériels doit être prise en compte lors de la construction de la configuration la plus sensible. Les justifications de l'assemblage choisi pour les essais doivent être documentées dans le plan d'essai de CEM.

5.3.4 Accès d'entrée/sortie

Lorsqu'il y a plusieurs accès d'entrée/sortie de même type et de même fonction, la connexion d'un câble à un seul accès est suffisante à condition qu'il puisse être démontré que les câbles supplémentaires n'affecteront pas les résultats de façon significative. Les justifications de ce choix doivent être documentées dans le plan d'essai de CEM.

5.3.5 Matériel auxiliaire (AE)

Lorsqu'il est possible d'utiliser une variété d'entités de matériel auxiliaire (AE) avec l'EUT, au moins une entité de chaque type d'AE doit être choisie pour simuler les conditions réelles de fonctionnement. L'AE peut être simulé. Tout logiciel utilisé par l'AE doit être suffisamment documenté de manière à ce que l'essai soit reproductible.

Il est fortement recommandé que l'AE utilisé ne soit pas sensible aux perturbations électromagnétiques comme par exemple du matériel mécanique, afin de faciliter la détection et l'évaluation de la réaction de l'EUT.

5.3.6 Câblage et mise à la terre

Les câbles de mise à la terre doivent être raccordés à l'EUT conformément aux spécifications du fabricant. Il ne doit pas y avoir de raccordements supplémentaires à la terre.

5.4 Conditions de fonctionnement de l'EUT lors des essais

5.4.1 Modes de fonctionnement

Une sélection des modes de fonctionnement représentatifs doit être effectuée en considérant que seules les fonctions les plus typiques du matériel peuvent être soumises aux essais. Les modes de fonctionnement estimés, selon la spécification du matériel, comme étant les plus défavorables pour l'application prévue, doivent être sélectionnés.

NOTE Le mode de fonctionnement le plus défavorable est, par exemple, le mode de fonctionnement le plus sensible.

5.4.2 Conditions d'environnement

Les essais doivent être réalisés dans les plages environnementales de fonctionnement spécifiées par le fabricant (par exemple, température ambiante, humidité, pression atmosphérique) et dans les plages assignées pour la tension d'alimentation et la fréquence, sauf lorsque les exigences d'essai spécifiées sont différentes.

5.4.3 Logiciel de l'EUT durant l'essai

Le logiciel utilisé pour exercer les modes de fonctionnement sélectionnés doit être suffisamment documenté de manière à ce que l'essai soit reproductible.

5.5 Spécification des critères de performance

Les critères de performance pour chaque accès et chaque essai doivent être spécifiés, lorsque cela est possible, sous la forme de valeurs quantitatives.

5.6 Description de l'essai

Chaque essai à effectuer doit être spécifié dans le plan d'essai de CEM. La description des essais, les méthodes d'essai, les caractéristiques des essais et les montages d'essai sont indiqués dans les normes fondamentales mentionnées dans le Tableau 1. Il n'est pas nécessaire de reproduire le contenu de ces normes fondamentales dans le plan d'essai; toutefois, des informations complémentaires nécessaires à la mise en œuvre pratique des essais sont indiquées dans la présente norme. Dans certains cas, le plan d'essai de CEM doit détailler toute l'application.

NOTE Tous les phénomènes de perturbation connus n'ont pas été spécifiés pour les essais de la présente norme, mais seulement ceux considérés comme critiques. Pour plus d'informations, voir l'Annexe B.

6 Critères de performance

6.1 Critère de performance DS

Les critères de performance sont utilisés pour décrire et pour évaluer la réaction du matériel en essai quand il est exposé aux phénomènes électromagnétiques. Un critère particulier de performance DS doit être appliqué pour ce qui concerne la sécurité fonctionnelle. Le critère de performance DS implique ce qui suit.

a) Les fonctions de l'EUT destinées à une utilisation dans des applications de sécurité
   1) ne sont pas affectées hors de leur spécification, ou
   2) peuvent être affectées temporairement ou de façon permanente (même par destruction des composants) si l'EUT réagit à une perturbation de telle sorte que l'état ou les états détectables et définis de l'EUT sont
      i) maintenus, ou
      ii) atteints dans un temps établi.
b) Les fonctions non destinées à une utilisation dans des applications de sécurité peuvent être perturbées temporairement ou définitivement.

NOTE 1 Il est possible que l'état défini se trouve hors des limites de fonctionnement normal.

NOTE 2 L'édition 1 de la présente norme utilisait l'abréviation «FS» pour ce critère de performance. Conformément à la norme fondamentale IEC 61000-1-2 et à la norme générique IEC 61000-6-7, l'abréviation DS est désormais utilisée sans que le contenu technique n'ait été modifié.

6.2 Application du critère de performance DS

Le critère de performance DS est applicable uniquement aux fonctions de l'EUT destinées à des applications de sécurité. Il est pertinent pour tout phénomène. Il n'y a pas de différentiation exigée entre les phénomènes électromagnétiques continus et transitoires.

Le matériel réalisant ou destiné à réaliser des fonctions destinées à des applications de sécurité ou des parties de telles fonctions doit se comporter d'une manière spécifique, tel que spécifié par le critère de performance DS. Le comportement spécifié d'un système relatif à la sécurité est destiné à obtenir ou maintenir des conditions de sécurité du matériel et du matériel commandé. Pour cela, les fonctions de sécurité doivent être vérifiées avant, pendant et après l'essai d'immunité.

Lorsqu'une entité d'un matériel ou un système réalise à la fois des fonctions destinées à des applications de sécurité et des fonctions qui ne sont pas destinées à des applications de sécurité, les exigences relatives à la sécurité fonctionnelle s'appliquent uniquement dans le contexte des fonctions destinées à des applications de sécurité.

La nécessité d'évaluer les fonctions de sécurité selon le critère de performance DS requiert une surveillance précise de l'état technique de l'EUT. À cet effet, le critère de performance DS doit être indiqué de manière non ambiguë. Dans de nombreux cas, un matériel auxiliaire spécifique est nécessaire afin d'identifier de manière non ambiguë et de surveiller le fonctionnement correct de la fonction de sécurité à l'étude. Il doit être garanti que ledit matériel auxiliaire n'affecte pas le comportement de l'EUT au cours des essais d'immunité.

6.3 Aspects à prendre en considération lors de l'application du critère de performance DS

Si un EUT, en réaction à une perturbation, passe à l'état défini, il doit être vérifié que ce passage à l'état défini n'est pas seulement un résultat exceptionnel, mais que ce comportement est reproductible. Pour vérifier la reproductibilité, les règles définies au Tableau 1 doivent être appliquées au critère de performance DS.

Tableau 1 – Réaction de l'EUT au cours de l'essai

Essai	Réaction de l'EUT pendant l'essai	Comment poursuivre les essais
Transitoire [a]	L'EUT passe dans un état défini et une interaction avec l'utilisateur est nécessaire afin de poursuivre l'opération.	L'EUT doit être ramené à un fonctionnement normal et l'essai doit être répété 3 fois avec le même niveau d'essai et la même polarité et l'EUT doit réagir d'une façon conforme au critère de performance DS à chaque fois. Dans ce cas, l'essai doit être poursuivi avec le niveau d'essai suivant ou la polarité suivante, conformément à la norme fondamentale.
	L'EUT passe dans un état défini et est endommagé de manière permanente.	L'EUT doit être remplacé ou réparé et l'essai doit être répété 3 fois avec le même niveau d'essai et la même polarité et l'EUT doit réagir d'une façon conforme au critère de performance DS à chaque fois. Dans ce cas, l'essai doit être poursuivi avec le niveau d'essai suivant ou la polarité suivante, conformément à la norme fondamentale.
Continu [b]	L'EUT passe dans un état défini à une fréquence d'essai donnée tel que décrit en a) 2) de 6.1.	L'EUT doit être de nouveau soumis à l'essai 3 fois à la même fréquence et l'EUT doit réagir d'une façon conforme au critère de performance DS à chaque fois. Si l'EUT réagit à chaque fois de la même manière, les fréquences suivantes peuvent être soumises à l'essai seulement une fois par fréquence.
[a] Essais conformes aux normes IEC 61000-4-2, IEC 61000-4-4, IEC 61000-4-5, IEC 61000-4-11, IEC 61000-4-29, IEC 61000-4-34. [b] Essais conformes aux normes IEC 61000-4-3, IEC 61000-4-6, IEC 61000-4-8, IEC 61000-4-16.		

7 Exigences d'immunité

Les exigences d'immunité supplémentaires à celles données dans l'IEC 61326-1 sont données du Tableau 2 au Tableau 7. Le Tableau 10 donne une vue d'ensemble des effets admis des perturbations électromagnétiques sur les fonctions destinées à des applications de sécurité et sur les fonctions qui ne sont pas destinées à des applications de sécurité.

NOTE Certaines des valeurs d'essai indiquées du Tableau 2 au Tableau 7 sont moins sévères que les valeurs indiquées dans la norme CEM générique IEC 61000-6-7. Conformément au Guide IEC 107, lorsqu'une norme CEM de famille de produits ou de produit spécifie des valeurs/niveaux d'essai moins sévères pour un phénomène, ou si un phénomène n'est que partiellement couvert (par exemple, la norme CEM de famille de produits ou de produit ne couvre qu'une partie de la plage de fréquences recommandée), une justification ou une référence à l'exigence

applicable dans une autre norme CEM doit être donnée dans la norme CEM de famille de produits ou de produit. Une telle référence peut être faite à l'IEC 61326-3-1:2008, de laquelle ont été déduites les exigences de la présente norme et dont les exigences ont été éprouvées dans la pratique.

Certains des phénomènes électromagnétiques énumérés dans le Tableau 1 peuvent être reliés à un état du fonctionnement du matériel uniquement par une méthode statistique, par exemple, l'instant d'une impulsion par rapport à un état momentané d'un circuit numérique ou à l'émission d'un signal numérique. Afin d'augmenter le niveau de confiance par rapport à leur immunité aux perturbations électromagnétiques, pour les systèmes relatifs à la sécurité et les matériels prévus pour les SIL plus élevés, il est exigé de réaliser des essais d'immunité par rapport aux phénomènes électromagnétiques avec un nombre plus élevé d'impulsions, en comparaison des exigences de réalisation d'essai des normes fondamentales en CEM correspondantes. Cela peut être fait en utilisant des temps d'essai plus longs ou en appliquant plus d'impulsions d'essai (voir le texte du Tableau 1).

Tableau 2 – Exigences des essais d'immunité – Accès par l'enveloppe

	Phénomène	Norme fondamentale	Essai pour la fonction destinée à des applications de sécurité Valeur d'essai – Critère de performance	
1.1	Décharge électrostatique (DES)	IEC 61000-4-2	± 6 kV décharge au contact [a, b] ± 8 kV décharge dans l'air [a, b]	DS
1.2	Champ électromagnétique	IEC 61000-4-3	20 V/m (80 MHz à 1 GHz, 1 kHz (80 % AM)) [c] 10 V/m (1,4 GHz à 2 GHz, 1 kHz (80 % AM)) [c] 3 V/m (2,0 GHz à 6,0 GHz, 1 kHz (80 % AM)) [c]	DS
1.3	Champ magnétique à la fréquence du réseau	IEC 61000-4-8	30 A/m [d]	DS

[a] Ces valeurs doivent être appliquées conformément aux conditions d'environnement décrites dans l'IEC 61000-4-2, sur les parties qui peuvent être accessibles à des personnes autres que le personnel travaillant selon les procédures définies de contrôle des DES, mais pas au matériel dont l'accès est limité uniquement au personnel ayant été spécialement formé.

[b] Pour le matériel destiné à une application de SIL 3, le nombre de décharges au niveau le plus élevé doit être augmenté d'un facteur 3 par rapport au nombre donné dans la norme fondamentale.

[c] Ces valeurs d'essai doivent être appliquées dans les plages de fréquences données dans le Tableau 8. Les fréquences ISM doivent être prises en compte sur une base individuelle.

[d] Applicable uniquement pour le matériel contenant des dispositifs sensibles aux champs magnétiques.