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INTERNATIONAL STANDARD

colour inside

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 61326-3-2:2017-05 RLV(en)

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CONTENTS

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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

FOREWORD

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International Standard IEC 61326-3-2 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 Figure A.1 and Figure 1 for better readability,
- adding tests according to IEC 61000-4-16 to replace the tests according to IEC 61000-4-6 in the frequency range between 10 kHz and 150 kHz.

IEC 61326-3-2 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/820/FDIS	65A/826/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 ~~integrated~~ 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 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – Industrial applications with specified electromagnetic environment

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 within a specified electromagnetic environment and 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 they can be found in industrial applications with an electromagnetic environment having specified characteristics (for example, process industry)~~, and based on the requirements of the process industry, specifically chemical/petrochemical/pharmaceutical manufacturing plants using the mitigation measures given in Annex C. The difference between the electromagnetic environment covered by this document compared to the general industrial environment (see IEC 61326-3-1) is due to the mitigation measures employed against electromagnetic phenomena leading to a specified electromagnetic environment with test values that have been proven in practice.

The environment of industrial application with a specified electromagnetic environment typically includes the following characteristics:

- industrial area with limited access;
- limited use of mobile transmitters;
- dedicated cables for power supply and control, signal or communication lines;
- separation between power supply and control, signal or communication cables;
- factory building mostly consisting of metal construction;
- overvoltage/lightning protection by appropriate measures (for example, metal construction of the building or use of protection devices);
- pipe heating systems driven by AC main power ~~may be present~~;
- no high-voltage substation close to sensitive areas;
- presence of CISPR 11 Group 2 ISM equipment using ISM frequencies only with low power;
- competent staff;
- periodical maintenance of equipment and systems;
- mounting and installation guidelines for equipment and systems.

~~A more detailed description of the above-mentioned typical characteristics is given in Annex B.~~

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 61000-4-16:2015, *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 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*~~

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

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 61326-3-1:~~2008~~ [2], *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety functions (functional safety) – General industrial applications*

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*

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

~~IEC 61511-1:2003, *Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and software requirements*~~

~~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 of 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:

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

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

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

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, modifed – "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 equipment.

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

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

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

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

~~[IEC 61508-4, 3.4.1, modified]~~

3.1.12
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 with a specified electromagnetic environment intended to perform safety functions as defined in the IEC 61508 series. These ~~additional~~ requirements do not apply to the normal (non-safety-related) functions of the equipment and/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 is also not considered on a statistical basis.~~ Therefore, it is needed to control the environment (for example, defining installation requirements, limited use of mobile transmitters) or to generally increase immunity test levels 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.

In addition to the immunity requirements of IEC 61326-1, the experience with this type of electromagnetic environment is used to specify adequate levels of immunity and adequate performance criteria.

NOTE 2 For the determination of adequate levels and performance criteria, data related to the occurrence of faults have been collected and analysed. For the evaluation, more than 20 000 units in safety applications are analysed annually on the occurrence of failures whereas it has been shown that the failure rates meet the SIL requirements. These units are in compliance with specified EMC requirements applicable for their normal functions within the process industry (see Annex C).

NOTE 3 The requirements for a safety-related system intended to implement the specified function ~~should~~ and to fulfil the SSRS ~~as required~~ are described in IEC 61508. The SSRS specifies all relevant requirements of the intended application. According to IEC 61508, equipment intended for use in that system ~~has to~~ fulfils the relevant requirements derived from the SSRS.

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 instruction 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. Such 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 and external configurations, the type tests shall be made with the most susceptible configuration, as expected by the manufacturer. All types of module 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 ~~electronic~~ equipment can be tested. The estimated worst-case operating modes within the specification of the equipment for the intended application shall be selected.

NOTE The worst-case operating modes are those most susceptible to electromagnetic phenomena.

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 that are considered as most critical. For further information, see Annex B.

6 Performance criteria

6.1 General

Performance criteria are used to describe and to assess the reaction of the equipment under test when being exposed to electromagnetic phenomena.

6.2 Performance criteria A, B and C

Performance ~~criteria~~ criterion A~~, B and C are~~ is defined in IEC 61326-1 and is as follows:

The equipment shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.

Performance criteria B and C are not appropriate for functional safety~~; instead, a performance criterion FS is defined taking into account functional safety aspects~~.

6.3 Performance criterion ~~FS~~ DS

6.3.1 Definition of performance criterion DS

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.

6.3.2 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 safety 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.

~~In the SRS of a system both the undisturbed function and the required behaviour in case of a 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 and 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 safety functions 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.

6.3.3 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 6.3.1.	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 list the immunity test requirements.

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 61326-3-2:2008 from which the requirements in this standard were derived and which requirements have been proven in practice.

Table 2 – Immunity test requirements ~~for equipment intended for use in industrial locations with specified electromagnetic environment~~ – 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] ± 8 kV air discharge [a]	A
1.2	Electromagnetic field	IEC 61000-4-3	10 V/m (80 MHz to 1 GHz, 1 kHz (80 % AM)) ~~[b]~~ 10 V/m (1,4 GHz to 2 GHz, 1 kHz (80 % AM)) 3 V/m (2,0 GHz to 2,7 GHz, 1 kHz (80 % AM)) 3 V/m (2,7 GHz to 6,0 GHz, 1 kHz (80 % AM)) [b]	A
1.3	Rated power frequency magnetic field	IEC 61000-4-8	100 A/m [c]	A

[a] ~~Levels~~ These values shall be ~~chosen~~ applied in accordance with the environmental conditions described in ~~Annex A of~~ IEC 61000-4-2 ~~and applied~~ 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] Except for the ITU broadcast frequency bands 87 MHz to 108 MHz, 174 MHz to 230 MHz, and 470 MHz to 790 MHz, where the level shall be 3 V/m.~~

[b] Testing in this frequency range shall be performed if it is required by the application.

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

Table 3 – Immunity test requirements ~~for equipment intended for use in industrial locations with specified electromagnetic environment~~ – 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	2 kV (5/50 ns, 5 kHz)	A
2.2	Surge	IEC 61000-4-5	1 kV (line to line) 2 kV (line to ground)	A
2.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) ~~c~~	A~~d~~
2.4	Voltage dips	IEC 61000-4-11 or IEC 61000-4-34	0 % during 1 cycle 40 % during 10/12 cycles [a] 70 % during 25/30 cycles [a]	A ~~FS~~ DS ~~FS~~ DS
2.5	Short interruptions	IEC 61000-4-11 or IEC 61000-4-34	0 % during 250/300 cycles [a]	~~FS~~ DS
2.6	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A

~~a Line to line.~~

~~b Line to ground.~~

~~c In the frequency range 10 kHz up to 150 kHz the impedance of the CDN has to comply with the asymmetric impedance requirements of IEC 61000-4-6 at 150 kHz. Calibration shall be performed in accordance with IEC 61000-4-6. Sufficient decoupling can be demonstrated if the impedance criterion is met both with the AE port short-circuited and then open-circuited.~~

~~d For signals characterized by an accuracy of <1 % specified by the manufacturer, and, if not otherwise required by applicable standards or agreed specifications, the permitted deviation may be increased up to ±1 % for disturbing signals with U_o >3 V.~~

[a] "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 with specified electromagnetic environment~~ – 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	2 kV (5/50 ns, 5 kHz)	A
3.2	Surge	IEC 61000-4-5	0,5 kV (line to line) 1 kV (line to ground)	A
3.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) ~~c~~	A~~d~~
3.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A
3.5	Voltage dips	IEC 61000-4-29	40 % U_T for 1 000 ms 0 % U_T for 1 000 ms	~~FS~~ DS ~~FS~~ DS
3.6	Short interruptions	IEC 61000-4-29	0 % U_T for 20 ms	A
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 or 6).				

~~a Line to line.~~

~~b Line to ground.~~

~~c In the frequency range 10 kHz up to 150 kHz the impedance of the CDN has to comply with the asymmetric impedance requirements of IEC 61000-4-6 at 150 kHz. Calibration shall be performed in accordance with IEC 61000-4-6. Sufficient decoupling can be demonstrated if the impedance criterion is met both with the AE port short-circuited and then open-circuited.~~

~~d For signals characterized by an accuracy of <1 % specified by the manufacturer and if not otherwise required by applicable standards or agreed specifications, the permitted deviation may be increased up to ± 1 % for disturbing signals with U_e > 3 V.~~

Table 5 – Immunity test requirements ~~for equipment intended for use in industrial locations with specified electromagnetic environment~~ – 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	1 kV (5/50 ns, 5 kHz)[a]	A
4.2	Surge	IEC 61000-4-5	1 kV (line to ground) [b]	~~FS~~ DS
4.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) [a]~~, c~~	A~~d~~
4.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz) [a]	A

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

~~b Line to ground.~~

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

~~d For signals characterized by an accuracy of <1 % specified by the manufacturer and if not otherwise required by applicable standards or agreed specifications, the permitted deviation may be increased up to ± 1 % for disturbing signals with U_e >3 V.~~

~~e In the frequency range 10 kHz up to 150 kHz the impedance of the CDN has to comply with the asymmetric impedance requirements of IEC 61000-4-6 at 150 kHz. Calibration is to be performed in accordance with IEC 61000-4-6. Sufficient decoupling can be demonstrated if the impedance criterion is met both with the AE port short-circuited and then open-circuited.~~

Table 6 – Immunity test requirements ~~for equipment intended for use in industrial locations with specified electromagnetic environment~~ – I/O signal/control ports connected directly 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	2 kV (5/50 ns, 5 kHz)	A
5.2	Surge	IEC 61000-4-5	1 kV (line to line) 2 kV (line to ground)	A
5.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) ~~c~~	A ~~d~~
5.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A

~~a Line to line.~~

~~b Line to ground.~~

~~c In the frequency range 10 kHz up to 150 kHz the impedance of the CDN has to comply with the asymmetric impedance requirements of IEC 61000-4-6 at 150 kHz. Calibration shall be performed in accordance with IEC 61000-4-6. Sufficient decoupling can be demonstrated if the impedance criterion is met both with the AE port short-circuited and then open-circuited.~~

~~d For signals characterized by an accuracy of <1 % specified by the manufacturer and if not otherwise required by applicable standards or agreed specifications, the permitted deviation may be increased up to ±1 % for disturbing signals with U_e > 3 V.~~

Table 7 – Immunity test requirements ~~for equipment intended for use in industrial locations with specified electromagnetic environment~~ – 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]	A
6.2	Surge	IEC 61000-4-5	1 kV (line to ground) [b]	~~FS~~ DS
6.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) ~~d~~	A
6.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A

[a] Only in case lines > 3 m.

~~b Line to ground.~~

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

~~d In the frequency range 10 kHz up to 150 kHz the impedance of the CDN has to comply with the asymmetric impedance requirements of IEC 61000-4-6 at 150 kHz. Calibration shall be performed in accordance with IEC 61000-4-6. Sufficient decoupling can be demonstrated if the impedance criterion is met both with the AE port short-circuited and then open-circuited.~~

8 Test set-up and test philosophy for EUT 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 it is described in 8.2.

In case of physically small safety-related systems, corresponding immunity tests can be applied to entire safety-related systems as 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. ~~To allow this~~ 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 shall 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.

NOTE The general approach of applying performance criteria for the different types of functions is shown in Table 10 of IEC 61326-3-1:__[3].

~~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).

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

The performance criteria for functional safety place additional requirements on the equipment that is intended for use in safety-related applications. ~~In this case both apply the normal criteria within their associated limits and the additional requirements for functional safety.~~

~~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~~ shall 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,

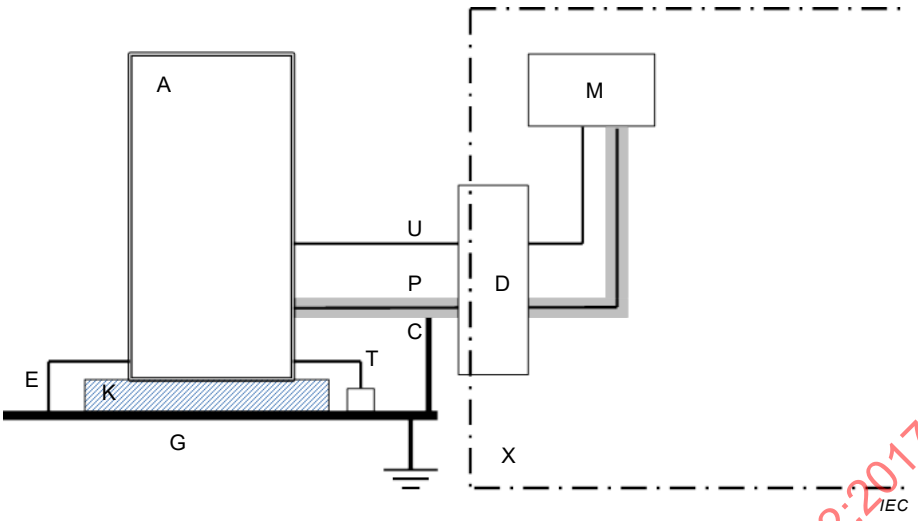
- the data communication between the EUT and the devices, which are necessary for the function of the EUT and for performing the function intended for safety application; and
- the status of the safety outputs whose functions are intended for safety applications.

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)

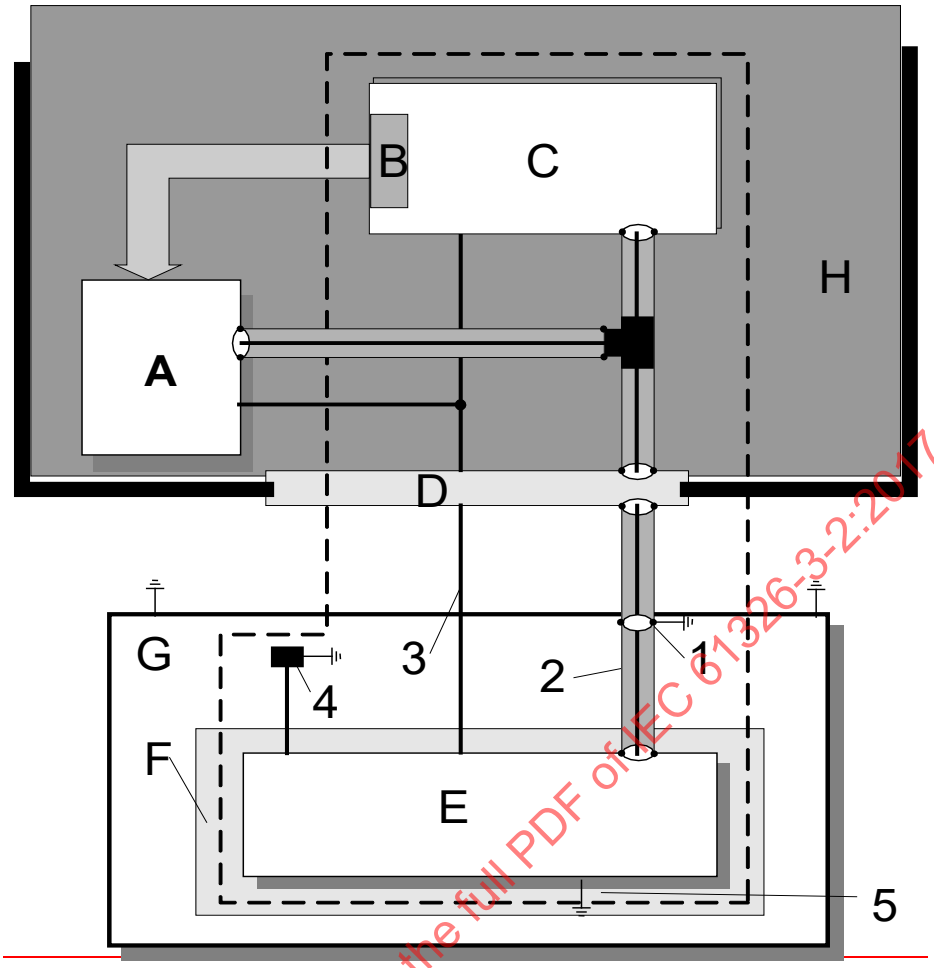
K insulated support

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

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

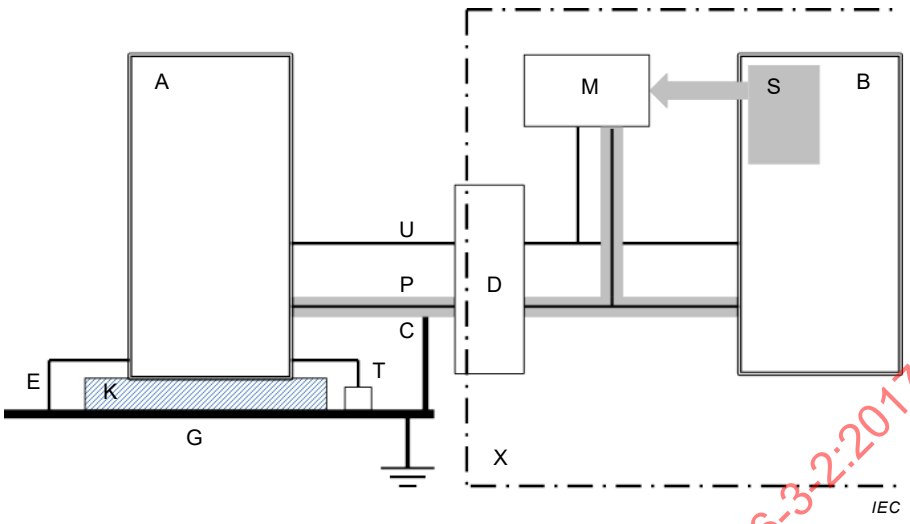
X electromagnetically decoupled environment

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



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) (any necessary, and all safety-related functions)

K insulated support

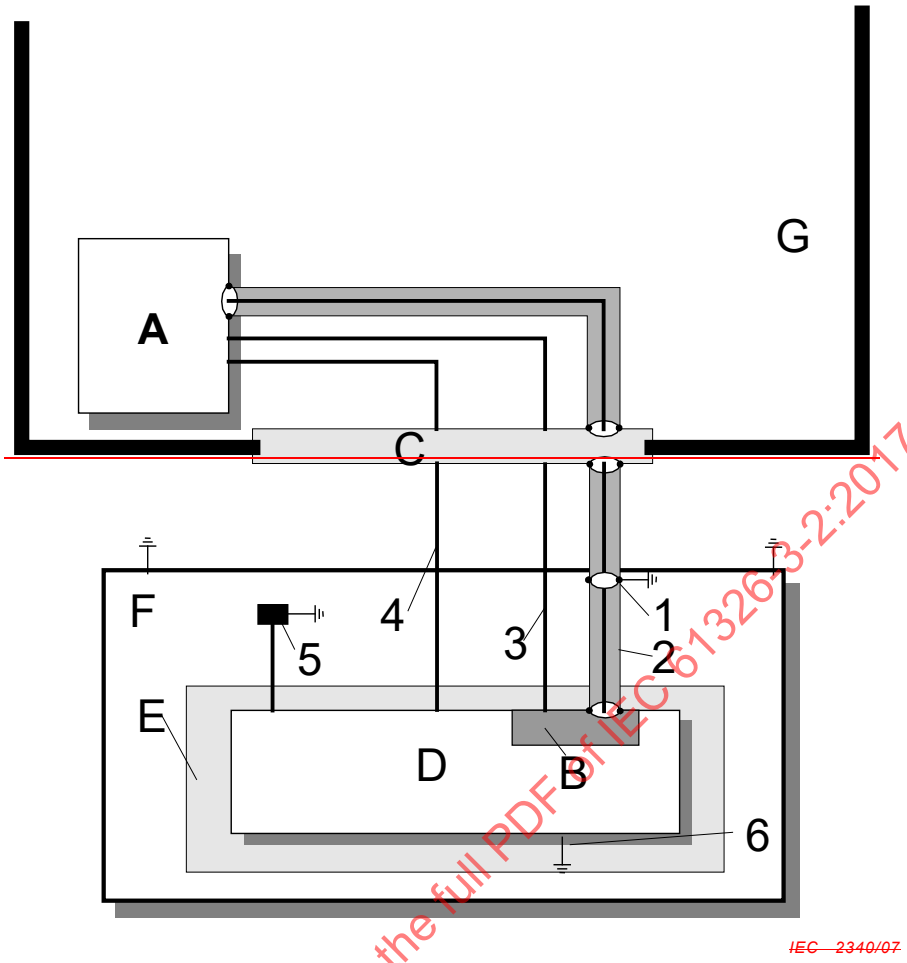
S safety-related system output – monitored

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

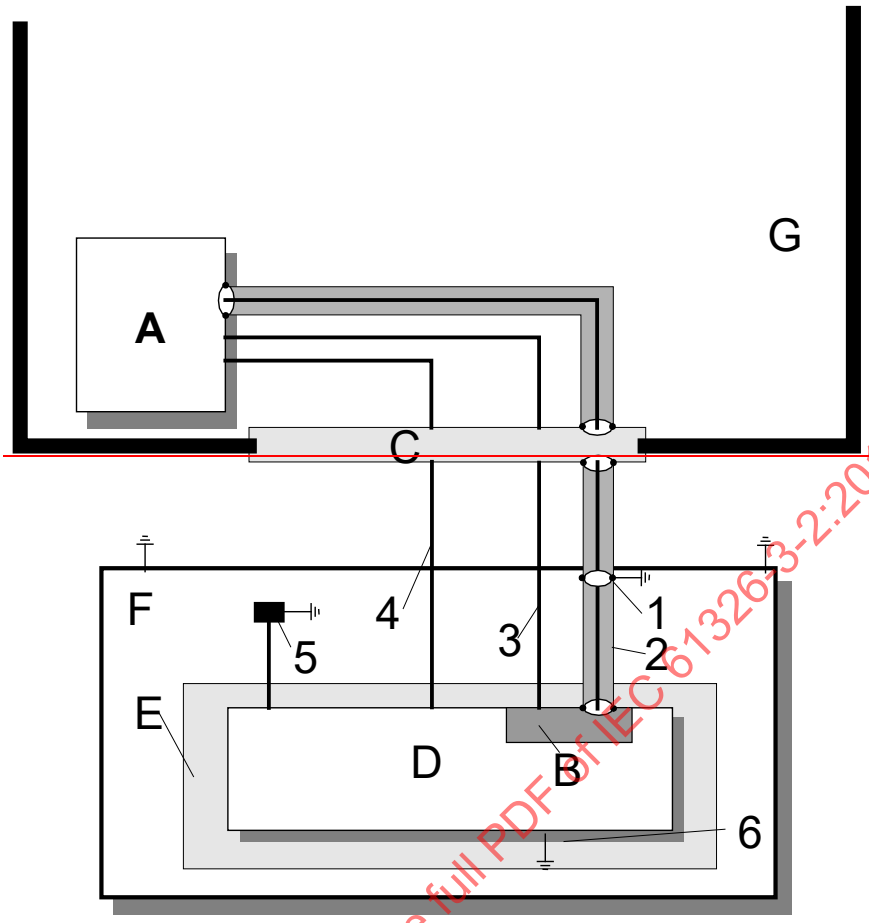
Figure 2 – Typical test set-up for equipment intended for use in a safety-related system integrated into a representative safety-related system during test



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 a 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 – 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 this document.

Applying approach (b) results in the fact that there is a specified electromagnetic environment due to the strict observation of particular installation and mitigation practices. In addition, however, appropriate knowledge is required concerning the electromagnetic phenomena and the amplitudes to be expected in this specified electromagnetic environment. This has been achieved by taking into account statistical data on faults in safety applications of the process industry. For this evaluation more than 20 000 units in safety applications are annually analysed on the occurrence of failures; from this data it has been shown that the failure rates meet the requirements connected to the safety integrity level (SIL). These units are in compliance with particular EMC requirements of the process industry.

Following approach (b), IEC 61326-3-2 gives specific electromagnetic immunity requirements that apply to safety-related systems and equipment intended to be used in safety-related systems. These requirements supplement some requirements of IEC 61326-1 (or of comparable EMC requirements of the process industry) and the selected electromagnetic phenomena and defined immunity test levels are expected to match with the environmental conditions of the specified industrial applications as defined in the scope of this standard.

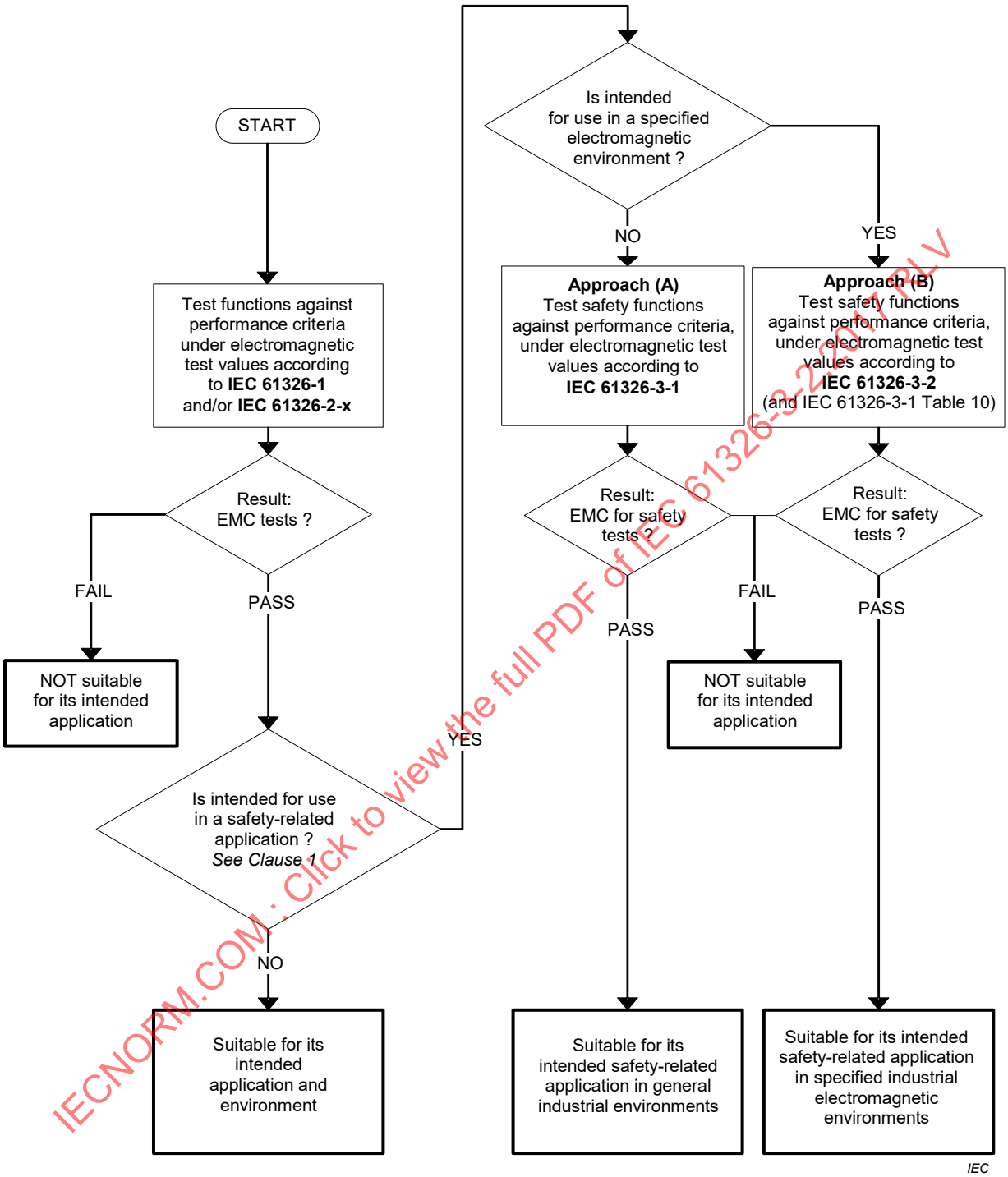
The correlation between the standards IEC 61326-1, IEC 61326-2-X, IEC 61326-3-1 and IEC 61326-3-2 is described in Figure A.1.

The specified test levels in this document are derived from the highest levels to be expected in the specified environment of industrial applications. These 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 be based only on extensive discussions between the parties involved. Some IEC standards and technical specifications or 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.

NOTE The test levels in this standard are based on statistical evaluations of the NAMUR (User association for automation in process industry; www.namur.de). Their evaluation includes more than 23 000 units (2003) that are used in safety instrument applications. According to this evaluation the devices meet the requirement of SIL 2 and 3 safety instrument applications. The corresponding test levels are given in Annex C.

A proposal of deriving immunity levels taking into account the knowledge of experts for electromagnetic compatibility as well as the various electromagnetic phenomena field is given in Table B.1 together with a comparison to those immunity levels used in IEC 61326-1 for industrial applications.

Table B.1 – General considerations for the application of electromagnetic phenomena for functional safety in industrial applications with specified electromagnetic environment (examples)

No	Phenomena	Basic standard	Increased level[a]	Comments
1	Electrostatic discharge (ESD)	IEC 61000-4-2	Yes next level of IEC 61000-4-2 No	Levels shall be applied in accordance with the environmental conditions described in IEC 61000-4-2 on parts which may be touched by persons other than staff working in accordance with defined procedures for the control of ESD Access to equipment is limited to appropriately trained personnel only
2	Electromagnetic field	IEC 61000-4-3	Yes, depending on frequency range	Increased levels 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 have to be taken into account on an individual basis
3	Burst	IEC 61000-4-4	No	Because of use of dedicated cables for power, I/O and communication and the separation of this cable this phenomena is limited to normal levels
4	Surge	IEC 61000-4-5	No	Because of overvoltage and lightning protection by appropriate measures (for example, metal construction of the building or the use of protection devices) this phenomenon is limited to normal levels
5	Conducted RF	IEC 61000-4-6	Yes, with expanded frequency range	Taking into account the growing use of frequency-driven motors and switching-mode power supplies, which cause low-frequency disturbances, a higher test level and an expanded frequency range is needed
6	Power frequency magnetic field	IEC 61000-4-8	Yes	According to the use of high currents produced by (pipe) heating systems driven by AC mains a higher test level is needed
7	Voltage dips	IEC 61000-4-11	No	
8	Short interruptions	IEC 61000-4-11	No	
9	Conducted common mode voltages	IEC 61000-4-16	No	
10	Voltage dips	IEC 61000-4-29	Yes	According to the use of DC power distribution networks in the process industry, tests are needed
11	Short interruptions	IEC 61000-4-29	Yes	According to the use of DC power distribution networks in the process industry, tests are needed
12	Voltage dips	IEC 61000-4-34	No	
13	Short interruptions	IEC 61000-4-34	No	

[a] "Increased level" compared to the test levels of IEC 61326-1 for industrial applications.

Annex C
(~~informative~~ normative)

~~Details of the~~ Specified electromagnetic environment

C.1 General

~~The aim of this annex is to give more detailed information on characteristics of the industrial environment which is mentioned in the scope of this standard.~~

Use of this standard requires that the electromagnetic environment at the industrial installation location be controlled. The application of particular mitigation measures results in the specified electromagnetic environment. Annex C specifies the particular mitigation measures that shall be applied. To fulfil the definition of the specified environment, all applicable measures given in Annex C shall be applied.

NOTE These ~~details~~ mitigation measures are taken from NAMUR Recommendation 98 (installation requirements for achieving EMC in production sites). NAMUR (User association for automation in process industries; www.namur.de) is an association of users of process control technology. Manufacturers of process control technology, hardware and software are not eligible as members.

C.2 Industrial area with limited access

The access to the industrial plant (area) ~~is~~ shall be limited by an access regulation. All employees and visitors ~~are~~ shall be well informed on access limitations, use of mobile transmitters and other important rules to protect the environment against electromagnetic phenomena.

C.3 Limited use of mobile transmitters

The use of mobile transmitters in sensitive areas ~~is~~ shall be limited by access rules. The access rules ~~are~~ shall be chosen by calculation of the minimum protective distances for sensitive equipment. For low power devices at frequencies above 2 GHz (typically below 100 m W_{ERP}), the access ~~is~~ need not to be limited.

The protective distances, assuming to have field strength levels below 10 V/m, are typically:

- for GSM telephones approx. ~~1,2~~ 1,0 m (max P_{ERP} = 2 W)
- for DECT telephones approx. ~~0,4~~ 0,35 m (P_{ERP} = 0,25 W)
- for mobile radio devices approx. ~~1,8~~ 1,6 m (P_{ERP} = 5 W)

To calculate these distances, the following expression is used:

$$d = 2 \cdot \frac{k\sqrt{P}}{E}$$

~~where~~

~~d is the protective distance from the transmission antenna in m;~~

~~P is the transmission output in W;~~

~~k is constant~~

~~k = 3,9 if P_{ERP} is utilized;~~

~~k = 1,7 if the antenna supply output is utilized;~~

~~E is the test field strength for calculation is 10 V/m.~~

$$E = \frac{\sqrt{30 \cdot G_a \cdot P}}{d}$$

where

d is the distance from the transmission antenna in m;

P is the input power (ERP) to the transmitting antenna in W;

E is the electric field strength in V/m under far field conditions.

G_a is the absolute gain of the antenna; for a half-wavelength dipole antenna the gain G_a is 1,64 (2,15 dB).

The calculation is done assuming a half-wavelength dipole antenna. Reflective and absorbent objects in the near vicinity can amplify or weaken the electromagnetic field by a factor of 2.

More detailed information for determination of field strengths in near field and far field can be found in Annex B of IEC TR 61000-2-5:2011.

C.4 Dedicated cables for power supply and control, signal or communication lines

With regard to their potential in emitting or receiving disturbances, cable connections are divided into three different categories.

- Signal/control cables (< 110 V)
  For example, signal cables for PLC/PCS, measurement signal cables 4 mA to 20 mA, communication cables, cables for field bus/system bus and intrinsically safe circuits. It is recommended that pairs of twisted wires are used for low-level signals.
- Low-voltage (LV) power cables (up to 1 kV)
  DC power cables (even < 110 V) and low-voltage power cables (for example, for lighting systems, sockets, motors, magnetic valves, heat tracing systems).
- High-voltage (HV) power cables (> 1 kV)
  Power cables and other cables carrying medium or high voltage.

These cable categories ~~are~~ shall be physically separated, see Clause C.5.

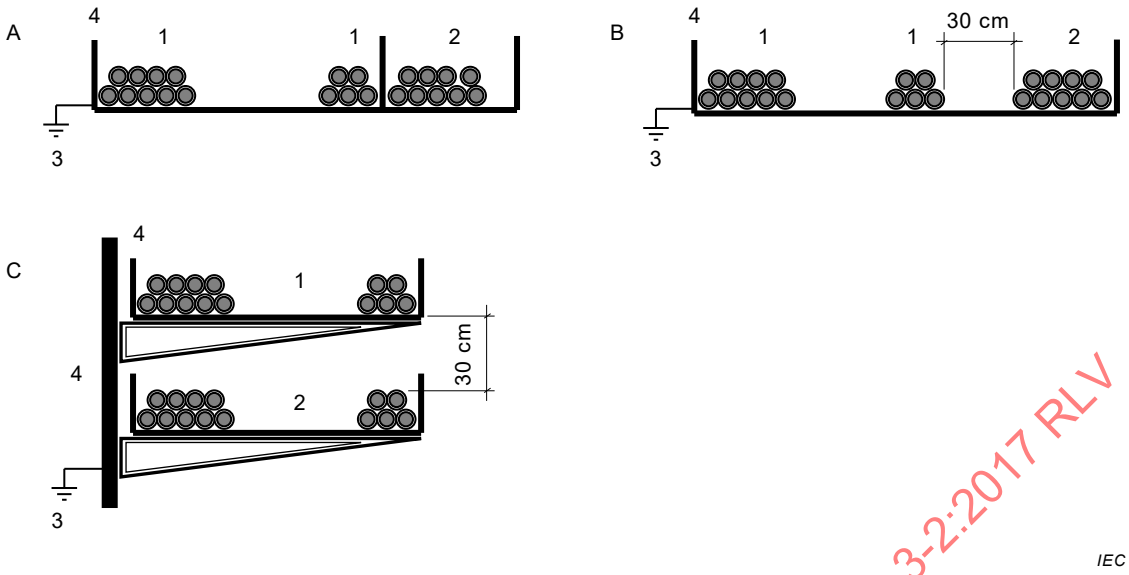
C.5 Separation between power supply and control, signal or communication cables

Different categories of cable ~~are~~ shall be laid separately. The separation distance is a minimum of 30 cm, or a metallic separating ~~web~~ septum is used in the cable duct/tray. Particularly high-voltage power cables ~~are~~ shall not be laid together with other cable categories.

Wire pairs that belong together functionally ~~are~~ shall be laid in the same cable to reduce coupling of symmetric signals. Cables for auxiliary power supplies ~~should, wherever possible,~~ shall be laid separately from control cables.

Control cables ~~are~~ shall be separated from bus bars and power transformers.

Figure C.1 shows the recommended cable layouts for different categories.



Key

1	signal cable	A	different categories of cables separated by metallic separation web
2	low-voltage power cable	B	different categories of cables separated by distance between them
3	earth connection	C	different categories of cables separated by using different metallic cable trays or by distance if not metallic
4	steel structure, equipotential bonding		

Figure C.1 – Recommended cable layouts for different categories

C.6 Factory building mostly consisting of metal construction

The buildings of the factory consist of reinforced concrete or metal construction.

Metal construction and reinforcement of concrete ~~are~~ shall be welded or bonded together to improve the equipotential bonding effect.

C.7 Overvoltage/lightning protection by appropriate measures

For the factory/plant, an overvoltage/lightning protection concept shall exist (for example, metal construction of the building or the use of protection devices). The installed overvoltage/lightning protection system shall limit~~s~~ the overvoltages caused by lightning or switching actions between all conductors and the ground potential and shall limit~~s~~ the overvoltages to a defined and safe voltage level.

The EMC-orientated lighting protection concept divides the building system into lightning protection zones in direct relation to the interference sensitivity of individual system areas:

- Zone 1/Class B, lightning conductor (formerly rough protection),
- Zone 2/Class C, overvoltage protector (formerly medium protection),
- Zone 3/Class D, overvoltage protector (formerly fine protection).

The external lightning protection consists of an interception device, conductors and earthing system. The internal lightning protection consists of equipotential bonding, surge arrestors, cable shielding, potential equalization and/or signal balancing.

A low-impedance connection between the lightning protection system and the building/electrical system earth electrode and adjacent building earths, metallic structures, pipe bridges, pipelines and rail systems ~~is~~ shall be installed. The connection is typically by copper shield braiding ≥16 mm^2, grounding cables 70 mm^2 to 300 mm^2 or steel strips ≥3,5 mm × 30 mm.

C.8 Pipe heating systems driven by AC mains ~~may be present~~

Pipe heating systems are present in many parts of the factory. These heating systems which are driven by AC mains generate high magnetic fields.

C.9 No high-voltage substations close to sensitive areas

High-voltage substations ~~are~~ shall be located outside sensitive areas to prevent extreme high magnetic fields or electric fields.

C.10 Presence of low-power devices using ISM frequencies according to CISPR 11

If CISPR 11 Group 2 ISM equipment using ISM frequencies are present, they shall either transmit only with low radio frequency power or ~~— tantamount —~~ shall be placed at sufficient distance, for example calculated according to Clause C.3.

C.11 Competent staff

All work on the installation of the plant ~~is~~ shall be done by ~~competent~~ trained staff. The staff ~~is~~ shall be informed about the installation guidelines for equipment and systems to prevent faulty workmanship.

C.12 Periodic maintenance of equipment and systems

All installations (for example, cables, instruments, construction of earth bonding system) ~~are~~ shall be under periodic maintenance to prevent corrosion of cable shields/earth bonding system or faulty workmanship. The maintenance ~~is~~ shall be done according to a maintenance plan.

C.13 Installation guidelines for equipment and systems

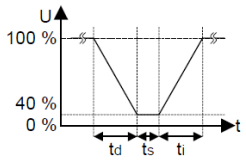
All installations (before placing into operation and during maintenance/replacement operations) ~~are~~ shall be implemented according to installation guidelines for the plant. The guidelines explain in detail the installation process, shielding, earth bonding, etc.

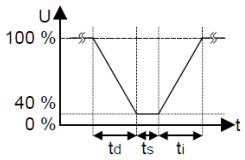
Annex D
(informative)

Example of immunity levels in the process industry

Table D.1 lists ~~exemplary~~ the immunity requirements ~~as~~ used in the process industry (Reference: NAMUR Recommendation NE 21:2012).

Table D.1 – Immunity test requirements for equipment intended for use in industrial locations with a specified electromagnetic environment according to NE 21

Port	Phenomenon	Basic standard	Normal function Test value – Performance criterion	
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	6 kV/8 kV contact/air	A
	Electromagnetic field	IEC 61000-4-3	~~10 V/m (80 MHz-1 GHz)[a]~~ ~~10 V/m (1,4 GHz-2 GHz)~~ 10 V/m (80 MHz to 2 GHz)	A
			3 V/m (2 GHz to 2,7 GHz)	A
	Rated power frequency magnetic field [a]	IEC 61000-4-8	100 A/m[b]	A
AC power	Burst	IEC 61000-4-4	2 kV[d]	A
	Surge	IEC 61000-4-5	1 kV[e b] /2 kV[d c]	A
	Conducted RF	IEC 61000-4-6	10 V (10 kHz to 80 MHz)	A[e]
	Voltage dips	~~IEC 61000-4-11~~	~~0 % during 1 cycle~~ ~~40 % during 50 cycles~~ ~~100 % during 50 cycles~~	~~A~~ B ~~C~~ ~~C~~
			 cycle a) and b): a) 100 % – 0 % – 100 % b) 100 % – 40 % – 100 % t_d = t_i = 2 s; t_s = 1 s repeat 10 cycles	
	Voltage variations		+ 10 % / –15 % U_n	A
	Voltage interruptions		0 % 20 ms	A

DC power	Burst	IEC 61000-4-4	2 kV[d]	A
	Surge	IEC 61000-4-5	0,5 kV[c b] /1 kV[d c]	A
	Conducted RF	IEC 61000-4-6	10 V (10 kHz to 80 MHz)	A[e]
	Voltage dips	~~IEC 61000-4-29~~	~~40 % U_T for 1 000 ms~~ ~~0 % U_T for 1 000 ms~~	~~C~~ ~~C~~
				~~A~~ B
			cycle a) and b): a) 100 % – 0 % – 100 % b) 100 % – 40 % – 100 % t_d = t_i = 2 s; t_s = 1 s repeat 10 cycles	
	Voltage variations		+ 20 % / –20 % U_n	A
	~~Short~~ Voltage interruptions	~~IEC 61000-4-29~~	0% U_T for 20 ms	A
I/O signal/ control	Burst	IEC 61000-4-4	1 kV	A
	Surge	IEC 61000-4-5	1 kV[d c]	B
	Conducted RF	IEC 61000-4-6	10 V (10 kHz to 80 MHz)	A[e]

~~a Except for the ITU broadcast frequency bands 87 MHz to 108 MHz, 174 MHz to 230 MHz, and 470 MHz to 790 MHz, where the level shall be 3 V/m.~~

a Only to magnetically sensitive equipment.

b Line to line.

c Line to ground.

d Additional test with 100 kHz repetition frequency (informative).

~~e For signals characterized by an accuracy of <1 % specified by the manufacturer and if not otherwise required by applicable standards or agreed specifications, the permitted deviation may be increased up to ±1 % for disturbing signals with Uo > 3 V.~~

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IEC 61326-3-2

Edition 2.0 2017-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

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 61326-3-2:2017-05(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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

FOREWORD

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International Standard IEC 61326-3-2 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 Figure A.1 and Figure 1 for better readability,
- adding tests according to IEC 61000-4-16 to replace the tests according to IEC 61000-4-6 in the frequency range between 10 kHz and 150 kHz.

IEC 61326-3-2 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/820/FDIS	65A/826/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 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – Industrial applications with specified electromagnetic environment

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 within a specified electromagnetic environment and 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, and based on the requirements of the process industry, specifically chemical/petrochemical/pharmaceutical manufacturing plants using the mitigation measures given in Annex C. The difference between the electromagnetic environment covered by this document compared to the general industrial environment (see IEC 61326-3-1) is due to the mitigation measures employed against electromagnetic phenomena leading to a specified electromagnetic environment with test values that have been proven in practice.

The environment of industrial application with a specified electromagnetic environment typically includes the following characteristics:

- industrial area with limited access;
- limited use of mobile transmitters;
- dedicated cables for power supply and control, signal or communication lines;
- separation between power supply and control, signal or communication cables;
- factory building mostly consisting of metal construction;
- overvoltage/lightning protection by appropriate measures (for example, metal construction of the building or use of protection devices);
- pipe heating systems driven by AC main power;
- no high-voltage substation close to sensitive areas;
- presence of CISPR 11 Group 2 ISM equipment using ISM frequencies only with low power;
- competent staff;
- periodical maintenance of equipment and systems;
- mounting and installation guidelines for equipment and systems.

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

IEC 61326-3-1:__[1], *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 functions (functional safety) – General industrial applications*

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*

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions of 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 browing platform: available at http://www.iso.org/obp

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

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, modifed – "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 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 with a specified electromagnetic environment intended to perform safety functions as defined in the IEC 61508 series. These requirements do not apply to the normal (non-safety-related) functions of the equipment and/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 61508-2:2010, 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.

Therefore, it is needed to control the environment (for example, defining installation requirements, limited use of mobile transmitters) or to generally increase immunity test levels 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.

In addition to the immunity requirements of IEC 61326-1, the experience with this type of electromagnetic environment is used to specify adequate levels of immunity and adequate performance criteria.

NOTE 2 For the determination of adequate levels and performance criteria, data related to the occurrence of faults have been collected and analysed. For the evaluation, more than 20 000 units in safety applications are analysed annually on the occurrence of failures whereas it has been shown that the failure rates meet the SIL requirements. These units are in compliance with specified EMC requirements applicable for their normal functions within the process industry (see Annex C).

NOTE 3 The requirements for a safety-related system intended to implement the specified function and to fulfil the SSRS are described in IEC 61508. The SSRS specifies all relevant requirements of the intended application. According to IEC 61508, equipment intended for use in that system fulfils the relevant requirements derived from the SSRS.

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 instruction 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. Such 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 and external configurations, the type tests shall be made with the most susceptible configuration, as expected by the manufacturer. All types of module 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 The worst-case operating modes are those most susceptible to electromagnetic phenomena.

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 that are considered as most critical. For further information, see Annex B.

6 Performance criteria

6.1 General

Performance criteria are used to describe and to assess the reaction of the equipment under test when being exposed to electromagnetic phenomena.

6.2 Performance criteria A, B and C

Performance criterion A is defined in IEC 61326-1 and is as follows:

The equipment shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.

Performance criteria B and C are not appropriate for functional safety.

6.3 Performance criterion DS

6.3.1 Definition of performance criterion DS

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.

6.3.2 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 safety 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.

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 safety functions 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.

6.3.3 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 6.3.1.	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 list the immunity test requirements.

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 61326-3-2:2008 from which the requirements in this standard were derived and which requirements have been proven in practice.

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] ± 8 kV air discharge [a]	A
1.2	Electromagnetic field	IEC 61000-4-3	10 V/m (80 MHz to 1 GHz, 1 kHz (80 % AM)) 10 V/m (1,4 GHz to 2 GHz, 1 kHz (80 % AM)) 3 V/m (2,0 GHz to 2,7 GHz, 1 kHz (80 % AM)) 3 V/m (2,7 GHz to 6,0 GHz, 1 kHz (80 % AM)) [b]	A
1.3	Rated power frequency magnetic field	IEC 61000-4-8	100 A/m [c]	A

[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] Testing in this frequency range shall be performed if it is required by the application.

[c] 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	2 kV (5/50 ns, 5 kHz)	A
2.2	Surge	IEC 61000-4-5	1 kV (line to line) 2 kV (line to ground)	A
2.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))	A
2.4	Voltage dips	IEC 61000-4-11 or IEC 61000-4-34	0 % during 1 cycle 40 % during 10/12 cycles [a] 70 % during 25/30 cycles [a]	A DS DS
2.5	Short interruptions	IEC 61000-4-11 or IEC 61000-4-34	0 % during 250/300 cycles [a]	DS
2.6	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A

[a] "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	2 kV (5/50 ns, 5 kHz)	A
3.2	Surge	IEC 61000-4-5	0,5 kV (line to line) 1 kV (line to ground)	A
3.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))	A
3.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A
3.5	Voltage dips	IEC 61000-4-29	40 % U_T for 1 000 ms 0 % U_T for 1 000 ms	DS DS
3.6	Short interruptions	IEC 61000-4-29	0 % U_T for 20 ms	A
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 or 6).				

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	1 kV (5/50 ns, 5 kHz) [a]	A
4.2	Surge	IEC 61000-4-5	1 kV (line to ground) [b]	DS
4.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM)) [a]	A
4.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz) [a]	A
[a] Only in case of lines > 3 m. [b] Only in case of long distance lines (see 3.10 of IEC 61326-1:2012).				

Table 6 – Immunity test requirements – I/O signal/control ports connected directly 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	2 kV (5/50 ns, 5 kHz)	A
5.2	Surge	IEC 61000-4-5	1 kV (line to line) 2 kV (line to ground)	A
5.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))	A
5.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A

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]	A
6.2	Surge	IEC 61000-4-5	1 kV (line to ground) [b]	DS
6.3	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz, 1 kHz (80 % AM))	A
6.4	Conducted common mode voltage	IEC 61000-4-16	10 V (10 kHz to 150 kHz)	A

[a] Only in case lines > 3 m.

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

8 Test set-up and test philosophy for EUT 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 it is described in 8.2.

In case of physically small safety-related systems, corresponding immunity tests can be applied to entire safety-related systems as 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 shall 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.

NOTE The general approach of applying performance criteria for the different types of functions is shown in Table 10 of IEC 61326-3-1:__[2].

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

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 the equipment that is intended for use in safety-related applications.

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 shall 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,

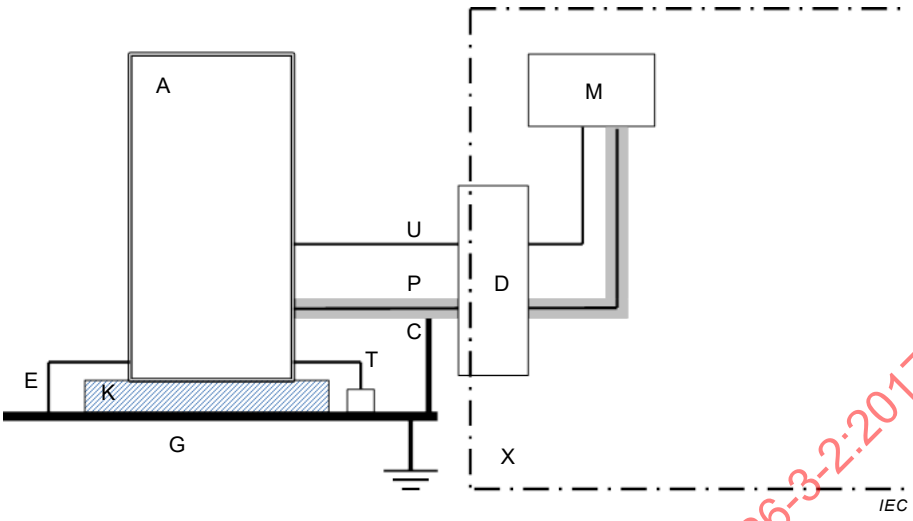
- the data communication between the EUT and the devices, which are necessary for the function of the EUT and for performing the function intended for safety application; and
- the status of the safety outputs whose functions are intended for safety applications.

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)

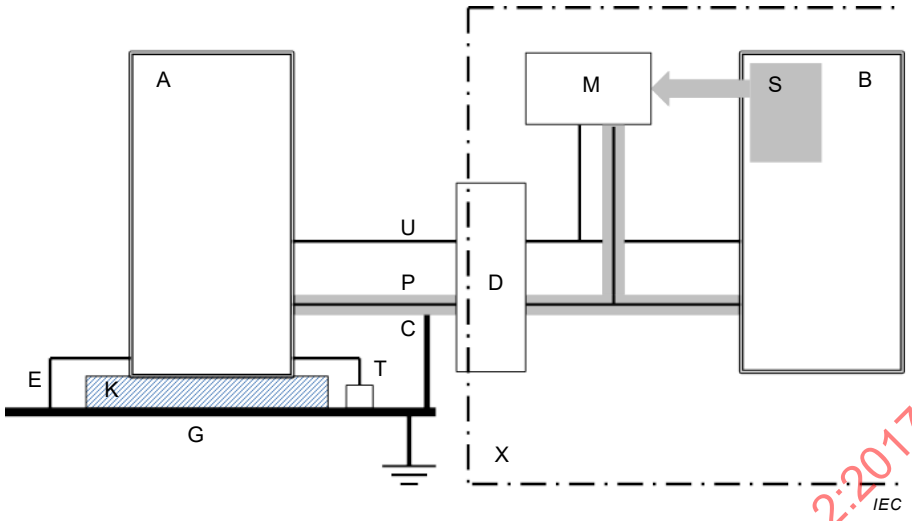
K insulated support

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) (any necessary, and 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 this document.

Applying approach (b) results in the fact that there is a specified electromagnetic environment due to the strict observation of particular installation and mitigation practices. In addition, however, appropriate knowledge is required concerning the electromagnetic phenomena and the amplitudes to be expected in this specified electromagnetic environment. This has been achieved by taking into account statistical data on faults in safety applications of the process industry. For this evaluation more than 20 000 units in safety applications are annually analysed on the occurrence of failures; from this data it has been shown that the failure rates meet the requirements connected to the safety integrity level (SIL). These units are in compliance with particular EMC requirements of the process industry.

Following approach (b), IEC 61326-3-2 gives specific electromagnetic immunity requirements that apply to safety-related systems and equipment intended to be used in safety-related systems. These requirements supplement some requirements of IEC 61326-1 (or of comparable EMC requirements of the process industry) and the selected electromagnetic phenomena and defined immunity test levels are expected to match with the environmental conditions of the specified industrial applications as defined in the scope of this standard.

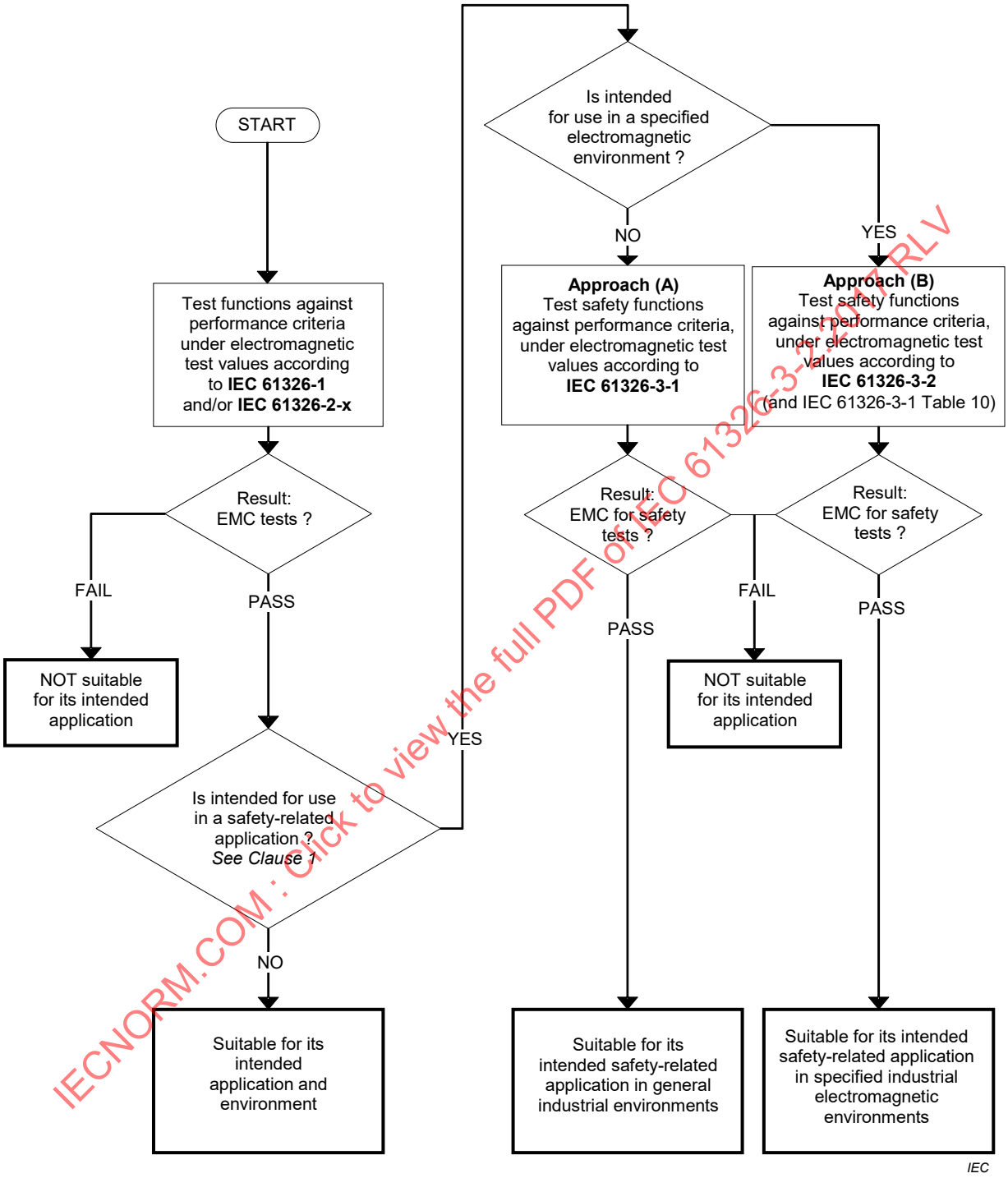
The correlation between the standards IEC 61326-1, IEC 61326-2-X, IEC 61326-3-1 and IEC 61326-3-2 is described in Figure A.1.

The specified test levels in this document are derived from the highest levels to be expected in the specified environment of industrial applications. These 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 be based only on extensive discussions between the parties involved. Some IEC standards and technical specifications or 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.

NOTE The test levels in this standard are based on statistical evaluations of the NAMUR (User association for automation in process industry; www.namur.de). Their evaluation includes more than 23 000 units (2003) that are used in safety instrument applications. According to this evaluation the devices meet the requirement of SIL 2 and 3 safety instrument applications. The corresponding test levels are given in Annex C.

A proposal of deriving immunity levels taking into account the knowledge of experts for electromagnetic compatibility as well as the various electromagnetic phenomena field is given in Table B.1 together with a comparison to those immunity levels used in IEC 61326-1 for industrial applications.

Table B.1 – General considerations for the application of electromagnetic phenomena for functional safety in industrial applications with specified electromagnetic environment (examples)

No	Phenomena	Basic standard	Increased level[a]	Comments
1	Electrostatic discharge (ESD)	IEC 61000-4-2	Yes next level of IEC 61000-4-2 No	Levels shall be applied in accordance with the environmental conditions described in IEC 61000-4-2 on parts which may be touched by persons other than staff working in accordance with defined procedures for the control of ESD Access to equipment is limited to appropriately trained personnel only
2	Electromagnetic field	IEC 61000-4-3	Yes, depending on frequency range	Increased levels 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 have to be taken into account on an individual basis
3	Burst	IEC 61000-4-4	No	Because of use of dedicated cables for power, I/O and communication and the separation of this cable this phenomena is limited to normal levels
4	Surge	IEC 61000-4-5	No	Because of overvoltage and lightning protection by appropriate measures (for example, metal construction of the building or the use of protection devices) this phenomenon is limited to normal levels
5	Conducted RF	IEC 61000-4-6	Yes, with expanded frequency range	Taking into account the growing use of frequency-driven motors and switching-mode power supplies, which cause low-frequency disturbances, a higher test level and an expanded frequency range is needed
6	Power frequency magnetic field	IEC 61000-4-8	Yes	According to the use of high currents produced by (pipe) heating systems driven by AC mains a higher test level is needed
7	Voltage dips	IEC 61000-4-11	No	
8	Short interruptions	IEC 61000-4-11	No	
9	Conducted common mode voltages	IEC 61000-4-16	No	
10	Voltage dips	IEC 61000-4-29	Yes	According to the use of DC power distribution networks in the process industry, tests are needed
11	Short interruptions	IEC 61000-4-29	Yes	According to the use of DC power distribution networks in the process industry, tests are needed
12	Voltage dips	IEC 61000-4-34	No	
13	Short interruptions	IEC 61000-4-34	No	
[a] "Increased level" compared to the test levels of IEC 61326-1 for industrial applications.				

Annex C
(normative)

Specified electromagnetic environment

C.1 General

Use of this standard requires that the electromagnetic environment at the industrial installation location be controlled. The application of particular mitigation measures results in the specified electromagnetic environment. Annex C specifies the particular mitigation measures that shall be applied. To fulfil the definition of the specified environment, all applicable measures given in Annex C shall be applied.

NOTE These mitigation measures are taken from NAMUR Recommendation 98 (installation requirements for achieving EMC in production sites). NAMUR (User association for automation in process industries; www.namur.de) is an association of users of process control technology. Manufacturers of process control technology, hardware and software are not eligible as members.

C.2 Industrial area with limited access

The access to the industrial plant (area) shall be limited by an access regulation. All employees and visitors shall be well informed on access limitations, use of mobile transmitters and other important rules to protect the environment against electromagnetic phenomena.

C.3 Limited use of mobile transmitters

The use of mobile transmitters in sensitive areas shall be limited by access rules. The access rules shall be chosen by calculation of the minimum protective distances for sensitive equipment. For low power devices at frequencies above 2 GHz (typically below 100 m W_{ERP}), the access need not to be limited.

The protective distances, assuming to have field strength levels below 10 V/m, are typically:

- for GSM telephones approx. 1,0 m (max P_{ERP} = 2 W)
- for DECT telephones approx. 0,35 m (P_{ERP} = 0,25 W)
- for mobile radio devices approx. 1,6 m (P_{ERP} = 5 W)

To calculate these distances, the following expression is used:

$$E = \frac{\sqrt{30 \cdot G_a \cdot P}}{d}$$

where

d is the distance from the transmission antenna in m;

P is the input power (ERP) to the transmitting antenna in W;

E is the electric field strength in V/m under far field conditions.

G_a is the absolute gain of the antenna; for a half-wavelength dipole antenna the gain G_a is 1,64 (2,15 dB).

The calculation is done assuming a half-wavelength dipole antenna. Reflective and absorbent objects in the near vicinity can amplify or weaken the electromagnetic field by a factor of 2.

More detailed information for determination of field strengths in near field and far field can be found in Annex B of IEC TR 61000-2-5:2011.

C.4 Dedicated cables for power supply and control, signal or communication lines

With regard to their potential in emitting or receiving disturbances, cable connections are divided into three different categories.

- Signal/control cables (< 110 V)
  For example, signal cables for PLC/PCS, measurement signal cables 4 mA to 20 mA, communication cables, cables for field bus/system bus and intrinsically safe circuits. It is recommended that pairs of twisted wires are used for low-level signals.
- Low-voltage (LV) power cables (up to 1 kV)
  DC power cables (even < 110 V) and low-voltage power cables (for example, for lighting systems, sockets, motors, magnetic valves, heat tracing systems).
- High-voltage (HV) power cables (> 1 kV)
  Power cables and other cables carrying medium or high voltage.

These cable categories shall be physically separated, see Clause C.5.

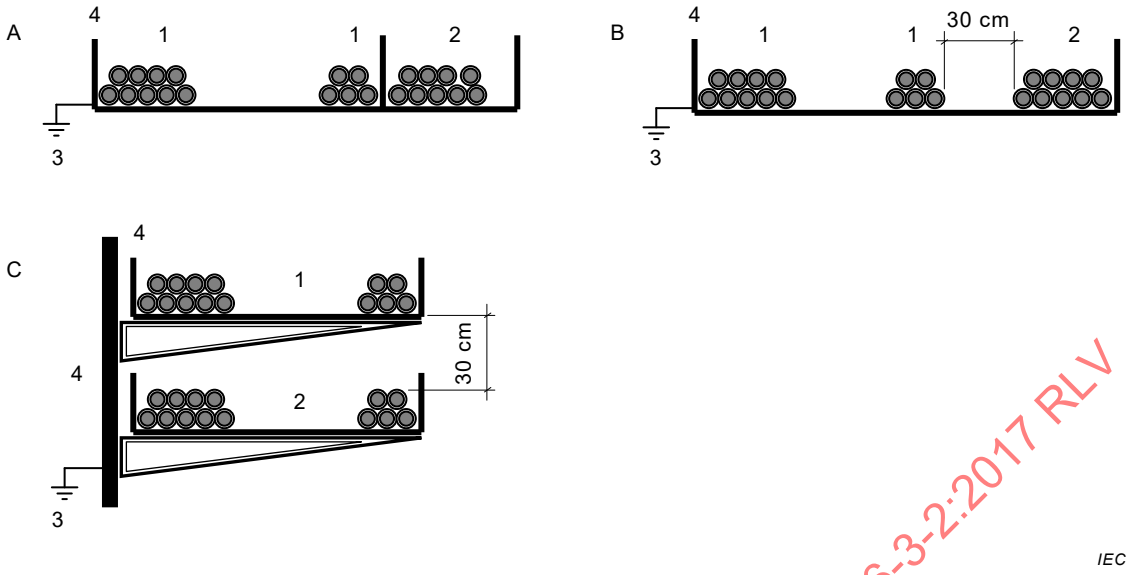
C.5 Separation between power supply and control, signal or communication cables

Different categories of cable shall be laid separately. The separation distance is a minimum of 30 cm, or a metallic separating septum is used in the cable duct/tray. Particularly high-voltage power cables shall not be laid together with other cable categories.

Wire pairs that belong together functionally shall be laid in the same cable to reduce coupling of symmetric signals. Cables for auxiliary power supplies shall be laid separately from control cables.

Control cables shall be separated from bus bars and power transformers.

Figure C.1 shows the recommended cable layouts for different categories.



Key

1 signal cable
2 low-voltage power cable
3 earth connection
4 steel structure, equipotential bonding

A different categories of cables separated by metallic separation web
B different categories of cables separated by distance between them
C different categories of cables separated by using different metallic cable trays or by distance if not metallic

Figure C.1 – Recommended cable layouts for different categories

C.6 Factory building mostly consisting of metal construction

The buildings of the factory consist of reinforced concrete or metal construction.

Metal construction and reinforcement of concrete shall be welded or bonded together to improve the equipotential bonding effect.

C.7 Overvoltage/lightning protection by appropriate measures

For the factory/plant, an overvoltage/lightning protection concept shall exist (for example, metal construction of the building or the use of protection devices). The installed overvoltage/lightning protection system shall limit the overvoltages caused by lightning or switching actions between all conductors and the ground potential and shall limit the overvoltages to a defined and safe voltage level.

The EMC-orientated lighting protection concept divides the building system into lightning protection zones in direct relation to the interference sensitivity of individual system areas:

- Zone 1/Class B, lightning conductor (formerly rough protection),
- Zone 2/Class C, overvoltage protector (formerly medium protection),
- Zone 3/Class D, overvoltage protector (formerly fine protection).

The external lightning protection consists of an interception device, conductors and earthing system. The internal lightning protection consists of equipotential bonding, surge arrestors, cable shielding, potential equalization and/or signal balancing.

A low-impedance connection between the lightning protection system and the building/electrical system earth electrode and adjacent building earths, metallic structures, pipe bridges, pipelines and rail systems shall be installed. The connection is typically by copper shield braiding ≥16 mm^2, grounding cables 70 mm^2 to 300 mm^2 or steel strips ≥3,5 mm × 30 mm.

C.8 Pipe heating systems driven by AC mains

Pipe heating systems are present in many parts of the factory. These heating systems which are driven by AC mains generate high magnetic fields.

C.9 No high-voltage substations close to sensitive areas

High-voltage substations shall be located outside sensitive areas to prevent extreme high magnetic fields or electric fields.

C.10 Presence of low-power devices using ISM frequencies according to CISPR 11

If CISPR 11 Group 2 ISM equipment using ISM frequencies are present, they shall either transmit only with low radio frequency power or shall be placed at sufficient distance, for example calculated according to Clause C.3.

C.11 Competent staff

All work on the installation of the plant shall be done by trained staff. The staff shall be informed about the installation guidelines for equipment and systems to prevent faulty workmanship.

C.12 Periodic maintenance of equipment and systems

All installations (for example, cables, instruments, construction of earth bonding system) shall be under periodic maintenance to prevent corrosion of cable shields/earth bonding system or faulty workmanship. The maintenance shall be done according to a maintenance plan.

C.13 Installation guidelines for equipment and systems

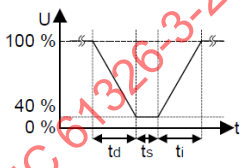
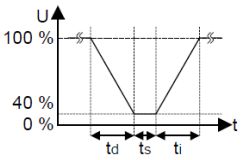
All installations (before placing into operation and during maintenance/replacement operations) shall be implemented according to installation guidelines for the plant. The guidelines explain in detail the installation process, shielding, earth bonding, etc.

Annex D
(informative)

Example of immunity levels in the process industry

Table D.1 lists the immunity requirements used in the process industry (Reference: NAMUR Recommendation NE 21:2012).

Table D.1 – Immunity test requirements for equipment intended for use in industrial locations with a specified electromagnetic environment according to NE 21

Port	Phenomenon	Basic standard	Normal function Test value – Performance criterion	
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	6 kV/8 kV contact/air	A
	Electromagnetic field	IEC 61000-4-3	10 V/m (80 MHz to 2 GHz)	A
			3 V/m (2 GHz to 2,7 GHz)	A
	Rated power frequency magnetic field [a]	IEC 61000-4-8	100 A/m	A
AC power	Burst	IEC 61000-4-4	2 kV[d]	A
	Surge	IEC 61000-4-5	1 kV [b] / 2 kV[c]	A
	Conducted RF	IEC 61000-4-6	10 V (10 kHz to 80 MHz)	A
	Voltage dips		 cycle a) and b): a) 100 % – 0 % – 100 % b) 100 % – 40 % – 100 % t_d = t_i = 2 s; t_s = 1 s repeat 10 cycles	B
	Voltage variations		+ 10 % / –15 % U_n	A
	Voltage interruptions		0 % 20 ms	A
DC power	Burst	IEC 61000-4-4	2 kV[d]	A
	Surge	IEC 61000-4-5	0,5 kV[b] /1 kV[c]	A
	Conducted RF	IEC 61000-4-6	10 V (10 kHz to 80 MHz)	A
	Voltage dips		 cycle a) and b): a) 100 % – 0 % – 100 % b) 100 % – 40 % – 100 % t_d = t_i = 2 s; t_s = 1 s repeat 10 cycles	B
	Voltage variations		+ 20 % / –20 % U_n	A
	Voltage interruptions		0 % 20 ms	A
I/O signal/ control	Burst	IEC 61000-4-4	1 kV[d]	A
	Surge	IEC 61000-4-5	1 kV[c]	B
	Conducted RF	IEC 61000-4-6	10 V (10 kHz to 80 MHz)	A

[a] Only to magnetically sensitive equipment.

[b] Line to line.

[c] Line to ground.

[d] Additional test with 100 kHz repetition frequency (informative).

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

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

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La Norme internationale IEC 61326-3-2 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 fréquence radioélectrique, 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 de la Figure A.1 et de la Figure 1 pour une meilleure lisibilité,
- ajouts d'essais conformes à l'IEC 61000-4-16 afin de remplacer les essais conformes à l'IEC 61000-4-6 dans la plage de fréquences comprises entre 10 kHz et 150 kHz.

L'IEC 61326-3-2 doit être lue conjointement avec l'IEC 61326-1.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
65A/820/FDIS	65A/826/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, publiées 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 ces 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 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 3-2: 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

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 dans un environnement électromagnétique spécifié et 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, et conformes aux exigences relatives à l'industrie de transformation, en particulier les usines de fabrication de produits chimiques/pétrochimiques/pharmaceutiques qui utilisent les mesures d'atténuation décrites à l'Annexe C. Par rapport à l'environnement industriel général (voir l'IEC 61326-3-1), la différence de l'environnement électromagnétique couvert par le présent document résulte des mesures d'atténuation employées contre les phénomènes électromagnétiques conduisant à un environnement électromagnétique spécifié dont les valeurs d'essai ont été prouvées dans la pratique.

L'environnement d'application industrielle ayant un environnement électromagnétique spécifié comprend généralement les caractéristiques suivantes:

– emplacement industriel à accès limité;
– utilisation restreinte des émetteurs mobiles;
– câbles dédiés pour l'alimentation électrique et pour les lignes de commande, de signal et de communication;
– séparation entre les câbles d'alimentation électrique, de commande, de signal et de communication;
– bâtiment d'usine de structure principalement métallique;
– protection contre les surtensions et la foudre par des mesures appropriées (par exemple, construction métallique de bâtiment ou utilisation de dispositifs de protection);
– des systèmes de chauffage de canalisation alimentés par le réseau principal d'alimentation en courant alternatif
– absence de poste à haute tension à proximité des emplacements sensibles;
– présence de dispositifs de faible puissance uniquement, utilisant des fréquences ISM en accord avec le Groupe 2 du CISPR 11;
– personnel compétent;
– maintenance périodique du matériel et des systèmes;
– lignes directrices de montage et d'installation pour les matériels et les systèmes.

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

IEC 61326-3-1:__[1], *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*

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/
- 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 la présente norme, 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 ou 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».

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

[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 dont l'environnement électromagnétique est spécifié et qui sont destinés à réaliser des fonctions de sécurité en accord avec la série IEC 61508. Ces exigences ne s'appliquent pas aux fonctions normales (non relatives à la sécurité) du matériel et/ou du système.

NOTE 1 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.

En conséquence, il est nécessaire de maîtriser l'environnement (par exemple, en définissant des exigences d'installation, de restriction d'utilisation d'émetteurs mobiles) ou d'augmenter de manière générale les niveaux d'essai d'immunité comme mesure systématique destinée à 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.

En plus des exigences d'immunité de l'IEC 61326-1, l'expérience dans ce type d'environnement électromagnétique est utilisée pour spécifier les niveaux adéquats d'immunité et les critères de performance adéquats.

NOTE 2 Pour la détermination des niveaux et des critères de performance adéquats, des données relatives à l'apparition de pannes ont été recueillies et analysées. Pour cette évaluation, plus de 20 000 cas d'applications de sécurité sont analysés annuellement dès l'apparition de pannes; à partir de ces données, il a été observé que les taux de défaillances respectaient les exigences de niveau d'intégrité de sécurité (SIL). Ces cas sont en conformité avec les exigences de CEM applicables à leurs fonctions normales dans l'industrie de transformation (voir Annexe C).

NOTE 3 Les exigences relatives à un système relatif à la sécurité destiné à mettre en œuvre la fonction spécifiée et satisfaire à la SSRS sont décrites dans l'IEC 61508. La SSRS spécifie toutes les exigences pertinentes de l'application prévue. Conformément à l'IEC 61508, le matériel destiné à une utilisation dans un tel système satisfait aux exigences applicables de la SSRS.

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. De tels essais 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, telle que prévue 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