भारतीय मानक
Indian Standard

IS 14254 (Part 2) : 2021
IEC 61131-2 : 2017

औद्योगिक प्रक्रम मापन नियंत्रण कार्य — प्रोग्राम योग्य नियंत्रक

भाग 2 उपस्कर सम्बन्धी अपेक्षाएं और परिक्षण

(दूसरा पुनरीक्षण)

Industrial-Process Measurement and Control — Programmable Controllers

Part 2 Equipment Requirements and Tests

(Second Revision)

ICS 25.040.40; 35.240.50

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in www.standardsbis.in

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CONTENTS

Industrial Process Measurement and Control Sectional Committee, ETD 18

NATIONAL FOREWORD

This Indian Standard (Part 2) (Second Revision) which is identical with IEC 61131-2 : 2017 'Industrial-process measurement and control — Programmable controllers — Part 2: Equipment requirements and tests' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on recommendation of the Industrial Process Measurement and Control Sectional Committee and approval of the Electrotechnical Division Council.

This Indian Standard was first published in 1992 which was identical to IEC Publication 1131-2 (1992). IS/IEC 1131 (Part 2) : 1992 was revised as IS 14254 (Part 2) to bring it in line with IEC 61131-2 : 2003. The second revision of this standard has been undertaken to align it with the latest version of IEC 61131-2 : 2017.

The major changes in this revision are as follows:

a) removal of safety requirements and instead pointing to IEC 61010-2-201;

b) addition of negative logic digital inputs and outputs;

c) addition of Type 3-d digital input;

d) addition of 2,7 GHz to 6 GHz requirement for Radio-frequency electro-magnetic amplitude modulated immunity;

e) clarification of temperature testing;

f) clarification of type testing;

g) deprecation of certain technologies;

h) general update of multiple aspects of functionality and EMC; and

j) reorganization of clauses to associate requirements and verifications more closely.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminologies and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60068-2-27 Environmental testing — Part 2: Tests — Test Ea and guidance: Shock	IS 9000 (Part 7/Sec 1) : 2018 Basic environmental testing procedures for electronic and electrical items: Part 7 Impact test, Section 1 Shock (Test Ea) (*second revision*)	Identical with IEC 60068-2-27 : 2008
IEC 60068-2-30 Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 + 12 h cycle)	IS 9000 (Part 5/Sec 2) : 1981 Basic environmental testing procedures for electronic and electrical items: Part 5 Damp heat (cyclic) test, Section 2 12 + 12 h cycle	Technically Equivalent

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60947-5-1 : 2016 Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements — Electromechanical control circuit devices	IS/IEC 60947-5-1 : 2009 Low-voltage switchgear and controlgear: Part 5 Control circuit devices and switching elements, Section 1 Electromechanical control circuit devices (*first revision*)	Identical with IEC 60947-5-1 : 2009
IEC 61000-4-2 : 2008 Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test	IS 14700 (Part 4/Sec 2) : 2018 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 2 Electrostatic discharge immunity test (*second revision*)	Identical with IEC 61000-4-2 : 2008
IEC 61000-4-3 : 2006 Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated radio-frequency electromagnetic field immunity test	IS 14700 (Part 4/Sec 3) : 2018 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 3 Radiated, radio frequency, electromagnetic field immunity test (*first revision*)	Identical with IEC 61000-4-3 : 2006
IEC 61000-4-4 : 2012 Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test	IS 14700 (Part 4/Sec 4) : 2018 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 4 Electrical fast transient/burst immunity test (*second revision*)	Identical with IEC 61000-4-4 : 2012
IEC 61000-4-5 : 2014 Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test	IS 14700 (Part 4/Sec 5) : 2012 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 5 Surge immunity test	Identical with IEC 61000-4-5 : 2005
IEC 61000-4-6 : 2013 Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances induced by radio-frequency fields	IS 14700 (Part 4/Sec 6) : 2016 Electromagnetic Compatibility (EMC): Part 4 Testing and measurement techniques, Section 6 Immunity to conducted disturbances, induced by radio-frequency fields	Identical with IEC 61000-4-6 : 2013
IEC 61000-4-8 : 2009 Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test	IS 14700 (Part 4/Sec 8) : 2018 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 8 Power frequency magnetic field immunity test (*second revision*)	Identical with IEC 61000-4-8 : 2009
IEC 61000-4-11 : 2004 Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity test	IS 14700 (Part 4/Sec 11) : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 11 Voltage dips, short interruptions and voltage variations immunity tests	Identical with IEC 61000-4-11 : 2004
IEC 61000-6-1 : 2016 Electromagnetic compatibility (EMC) — Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments	IS 14700 (Part 6/Sec 1) : 2008 Electromagnetic compatibility (EMC) : Part 6 Generic standards, Section 1 Immunity for residential, commercial and light-industrial environments	Identical with IEC 61000-6-1 : 2005

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61000-6-2 : 2016 Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments	IS 14700 (Part 6/Sec 2) : 2008 Electromagnetic compatibility (EMC): Part 6 Generic standards, Section 2 Immunity for industrial environments	Identical with IEC 61000-6-2 : 2005
IEC 61131-1 Programmable controllers — Part 1: General information	IS 14254 (Part 1) : 2006 Programmable controllers : Part 1 General information (*first revision*)	Identical with IEC 61131-1 (2003)

The technical committee has reviewed the provisions of the following International Standards referred to in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60068-2-1	Environmental testing — Part 2-1: Tests — Test A: Cold
IEC 60068-2-2	Environmental testing — Part 2: Tests — Tests B: Dry heat
IEC 60068-2-6	Environmental testing — Part 2: Tests — Test Fc: Vibration (sinusoidal)
IEC 60068-2-14	Environmental testing — Part 2: Tests — Test N: Change of temperature
IEC 60068-2-31	Environmental testing — Part 2: Tests — Test Ec: Drop and topple, primarily for equipment-type specimens
IEC 60417	Graphical symbols for use on equipment
IEC 60695-2-11 : 2000	Fire hazard testing — Part 2-11: Glowing/hot-wire based test methods — Glow-wire flammability test method for end-products
IEC 60695-11-10 : 1999	Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods
IEC 60947-7-1 : 2002	Low-voltage switchgear and controlgear — Part 7-1: Ancillary equipment — Terminal blocks for copper conductors
IEC 61000-4-18 : 2006	Electromagnetic compatibility (EMC) — Part 4-18: Testing and measurement techniques — Damped oscillatory waves immunity test
IEC 61000-6-4	Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments
IEC 61010-2-201	Safety requirements for electrical equipment for measurement, control, and laboratory use — Part 2-201: Particular requirements for control equipment
IEC 61131-3	Programmable controllers — Part 3: Programming languages
IEC 61131-9	Programmable controllers — Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)
IEC TR 61131-4 : 2004	Programmable controllers — Part 4: User guidelines
IEC 61158 (all parts)	Industrial communication networks — Fieldbus specifications
IEC 61784 (all parts)	Industrial communication networks — Profiles
ISO 7000	Graphical symbols for use on equipment — Registered symbols
ANSI/ISA-50.00.01-1975 – (R2012)	Compatibility of Analog Signals for Electronic Industrial Process Instruments
HCF_SPEC-13	HART (Highway Addressable Remote Transducer) Communication Protocol Specification, Rev 7.5

Only the English language text has been retained while adopting it in this Indian Standard, and as such, the page numbers given here are not the same as in the IEC Publication.

The standard also makes a reference to the BIS Certification Marking of the product. Details of which are given in National Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

INTRODUCTION

IEC 61131-2 is part of a series of standards on industrial control equipment, including programmable controllers, and their associated peripherals and should be read in conjunction with the other parts of the series. However, it can be read and applied alone.

Where a conflict exists between this and other IEC standards, the provisions of this standard should be considered to govern in the area of industrial control equipment, including programmable controllers, and their associated peripherals.

This standard defines for industrial control equipment the following:

- Testing and verifications methods (Clause 4);
- Operating conditions (5.2);
- Temperature and climatic tests (5.2.1);
- Mechanical requirements and tests (5.3);
- Functional requirements and tests for power supplies, I/Os and other components (Clause 6);
- EMC requirements and tests (Clause 7);
- Marking and documentation requirements (Clause 8).

Product safety requirements for PLC and the other types of industrial control equipment now in the scope of this standard are specified in IEC 61010-2-201, which replaces the requirements of Clauses 11 to 14 of IEC 61131-2:2007.

The operating conditions and the temperature derating for altitudes are aligned with IEC 61010-2-201:–[1].

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1 Under preparation. Stage at the time of publication: IEC /CDV 61010-2-201:2016.

Indian Standard

INDUSTRIAL-PROCESS MEASUREMENT AND CONTROL — PROGRAMMABLE CONTROLLERS

PART 2 EQUIPMENT REQUIREMENTS AND TESTS

(Second Revision)

1 Scope

This part of IEC 61131 specifies functional and electromagnetic compatibility requirements and related verification tests for industrial control equipment of the following types:

- programmable controllers (PLC);
- programmable automation controller (PAC);
- remote I/O;
- programming and debugging tools (PADTs);
- industrial PC (computers) and industrial panel PC;
- displays and human-machine Interfaces (HMI) for industrial use;
- distributed control system (DCS), and DCS components that are listed here in the scope;
- any product where the primary purpose is performing the function of industrial control equipment, including PLC and/or PAC, and/or their associated peripherals which have as their intended use the control and command of machines, automated manufacturing and industrial processes, e.g. discrete, batch and continuous control.

In this document “control equipment” is equivalent to “industrial control equipment” as are PLC and PAC.

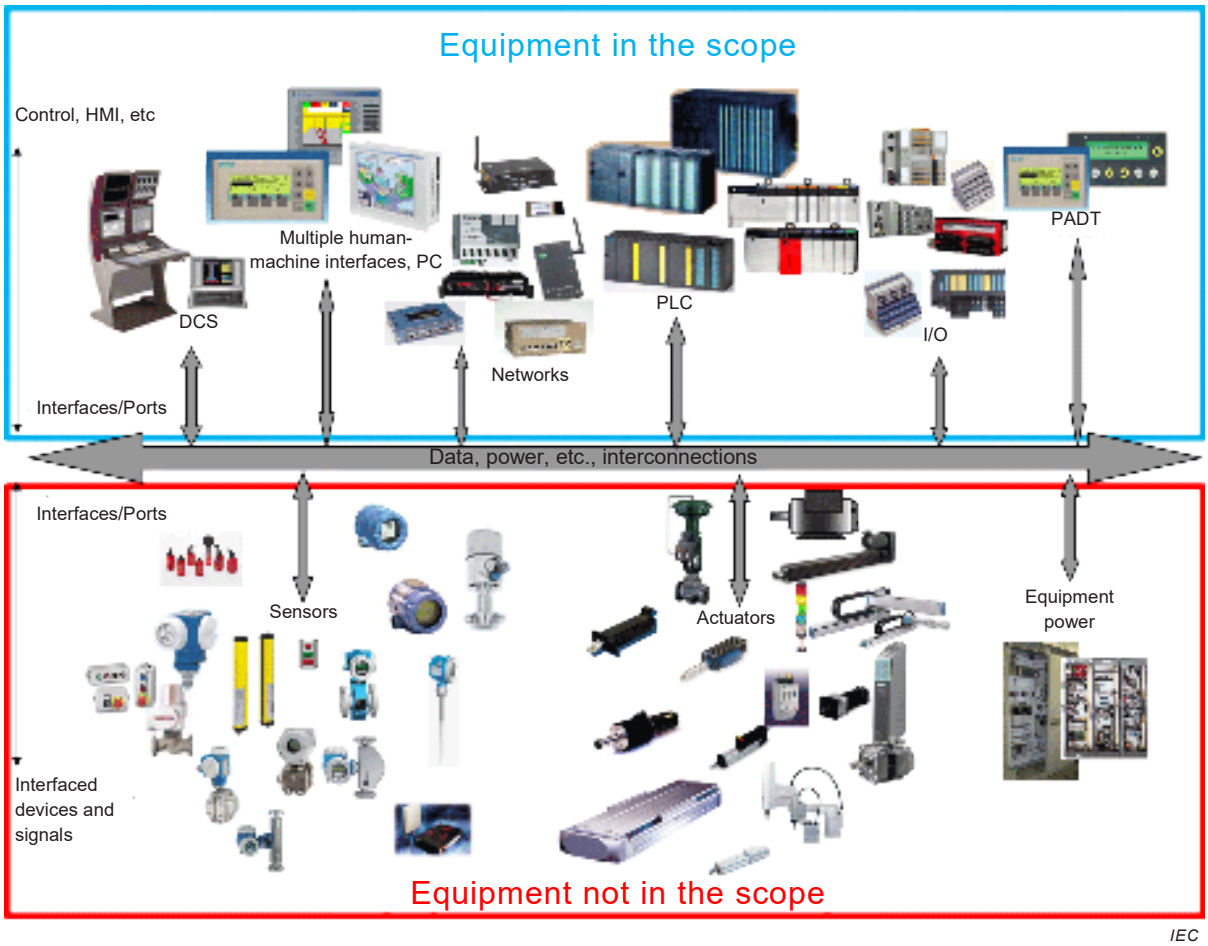

Figure 1 – Equipment in the scope and not in the scope

Components of the above named equipment (see Figure 1) included in the scope of this standard are:

- (auxiliary) stand-alone power supplies;
- peripherals such as digital and analog I/O;
- industrial network equipment.

Control equipment and their associated peripherals are intended to be used in an industrial environment and may be provided as open or enclosed equipment.

If control equipment or its associated peripherals are intended for use in other environments (light industrial, commercial, residential), then the specific requirements, standards and installation practices for those other environments shall be additionally applied to the control equipment and its associated peripherals.

Equipment covered in this standard is intended for use in overvoltage category II (IEC 60664-1) in low-voltage installations, where the rated equipment supply voltage does not exceed AC 1 000 V r.m.s. (50/60 Hz), or DC 1 000 V. If control equipment or their associated peripherals are applied in overvoltage category III installations, then additional analysis will be required to determine the suitability of the equipment for those applications.

The object of this standard is to establish the definitions and identify the principal characteristics relevant to the selection and application of control equipment and their associated peripherals.

This standard also specifies:

a) service (operating, storage and transportation) requirements for control equipment and their associated peripherals (Clause 5);

b) functional requirements for control equipment and their associated peripherals (Clause 6);

c) EMC requirements for control equipment and their associated peripherals (Clause 7);

d) information that the manufacturer is required to supply (Clause 8).

Safety requirements for control equipment and their associated peripherals are specified in IEC 61010-2-201.

The requirements of IEC Guide 106, “Guide for specifying environmental conditions for equipment performance rating”, and IEC Guide 107 “Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications,”are incorporated herein.

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 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12 h cycle)*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60417, *Graphical symbols for use on equipment* (available at http://www.graphical-symbols.info/equipment)

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

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 61000-4-4:2012, *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 61000-4-18:2006, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory waves immunity test*

IEC 61000-6-1:2016, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

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

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

IEC 61010-2-201:–[2], *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-201: Particular requirements for control equipment*

IEC 61131-1, *Programmable controllers – Part 1: General information*

IEC 61131-3, *Programmable controllers – Part 3: Programming languages*

IEC 61131-9, *Programmable controllers – Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)*

IEC TR 61131-4, *Programmable controllers – Part 4: User guidelines*

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61784 (all parts), *Industrial communication networks – Profiles*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols* (available at http://www.iso.org/obp)

ANSI/ISA-50.00.01-1975 – (R2012), *Compatibility of Analog Signals for Electronic Industrial Process Instruments*

HCF_SPEC-13, *HART (Highway Addressable Remote Transducer) Communication Protocol Specification, Rev 7.5*

3 Terms, definitions, abbreviated terms, acronyms, conventions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61131-1 and the following apply.

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2 Under preparation. Stage at the time of publication: IEC/ADIS 61010-2-201:2016.

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

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

3.1.1
ambient temperature
temperature, determined under prescribed conditions, of the air surrounding the equipment

3.1.2
analog input
device which converts a continuous signal to a discretely valued multi-bit binary number, for use by the control equipment

3.1.3
analog output
device which converts a multi-bit binary number from the control equipment to a continuous signal

3.1.4
battery
electrochemical energy source which can be rechargeable or non-rechargeable

3.1.5
current sinking
property of receiving current

3.1.6
current sourcing
property of supplying current

3.1.7
d.c. power network
local direct current electricity supply network in the infrastructure of a site or building intended for use by one or more different types of equipment and providing power supply independently from the conditions of the public mains network

Note 1 to entry: Examples of a d.c. power network are 125 Vd.c. and 400 Vd.c. power networks utilized in applications such as utility power plants, airport radar UPS, telecom UPS etc. Low voltages such as e.g. 24 V d.c., 48 V d.c., are not suitable for distribution, due to high voltage drop losses. As such these low voltage power sources are not considered d.c. power networks.

3.1.8
digital input
device which converts an essentially two-state signal to a single-bit binary number

3.1.9
digital output
device which converts a single-bit binary number to a two-state signal

3.1.10
earth
conducting mass of the Earth, whose electric potential at any point is conventionally taken as zero

[SOURCE: IEC 60050-195:1998, 195-01-01]

3.1.11
EMC
electromagnetic compatibility
ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

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

3.1.12
enclosed equipment
equipment which includes an enclosure, having safety capability, or combination of an enclosure, having safety capability, and installation provisions enclosing on all sides, with the possible exception of its mounting surface, to prevent personnel from accidentally touching hazardous live, hot or moving parts contained therein and meeting requirements of mechanical strength, flammability, and stability (where applicable)

Note 1 to entry: Examples are portable and hand-held equipment.

[SOURCE: IEC 61010-2-201:–, 3.102]

3.1.13
enclosure
housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.1.14
equipment under test
EUT
representative configuration(s), as defined by the manufacturer, used for type tests (see 4.2)

Note 1 to entry: This note applies to the French language only.

3.1.15
field wiring
wiring of the control equipment, which is not installed in the control equipment manufacturer's facility

Note 1 to entry: Examples of field wiring are power supply, digital and analogue input and output wiring.

Note 2 to entry: Control equipment manufacturer’s, e.g. pre-assembled or molded cabling is not considered field wiring.

[SOURCE: IEC 61010-2-201:–, 3.105]

3.1.16
fixed equipment
electric equipment fastened to a support, or otherwise secured in a specific location

[SOURCE: IEC 60050-826:2004, 826-16-07]

3.1.17
functional earth
point or points in a system, an installation or in equipment for connection to earth, for purposes other than electrical safety

3.1.18
hand-held equipment
electric equipment intended to be held in the hand during normal use

[SOURCE: IEC 60050-826:2004, 826-16-05]

3.1.19
immunity, <to a disturbance>
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

Note 1 to entry: Not used exclusively to refer to EMC in this standard. It may also refer, for example, to vibration, humidity, etc.

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

3.1.20
immunity type test
immunity test
type test verifying that the equipment operation is not altered by the application of specified influencing quantities that are intended to approximate normal operation

3.1.21
interface
shared boundary between one control equipment and another control equipment, or between parts of a control equipment, through which information or electrical energy is conveyed

3.1.22
isolated, <devices, circuits>
devices or circuits without galvanic connection between them

3.1.23
module
part of the control equipment containing (an) identified function(s) processing unit, analog input, etc.), which may plug into a backplane or base

3.1.24
multi-channel module
module containing multiple input and/or output signal interfaces which could be isolated or not isolated from each other

3.1.25
normal use
operation, including stand-by, according to the instructions for use or for the obvious intended purpose

Note 1 to entry: Normal service conditions are stated in Clause 5.

3.1.26
open equipment
equipment which does not protect personnel from accidentally touching hazardous live or moving parts contained therein nor meet requirements of mechanical strength, flammability and stability (where applicable)

[SOURCE: IEC 61010-2-201:–, 3.107]

3.1.27
operator
person commanding and monitoring a machine or process through an HMI connected to the control equipment

Note 1 to entry: The operator does not change the control equipment hardware configuration, software or the application programme. Control equipment is not intended for use by untrained personnel.

Note 2 to entry: The operator is assumed to be aware of the general hazards in an industrial environment.

3.1.28
overvoltage category, <of a circuit or within an electrical system>
classification based on limiting (or controlling) the values of prospective transient overvoltages occurring in a circuit (or within an electrical system having different nominal voltages) and depending upon the means employed to influence the overvoltages

Note 1 to entry: In an electrical system, the transition from one overvoltage category to another of lower category is obtained through appropriate means complying with interface requirements. These interface requirements may be an overvoltage protective device or a series-shunt impedance arrangement capable of dissipating, absorbing, or diverting the energy in the associated surge current, to lower the transient overvoltage value to that of the desired lower overvoltage category.

Note 2 to entry: Equipment covered in this standard is intended for use in overvoltage category II.

3.1.29
permanent installation
portion of the control equipment that can only be connected to or disconnected from the control equipment by the use of a tool

3.1.30
port
access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

Note 1 to entry: Most commonly used with respect to EMC.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified – Note 1 to entry has been modified.]

3.1.31
portable equipment
equipment intended to be carried by hand and not fixed during normal use

3.1.32
public mains
power from the conductors/mains of the public utility distribution system

3.1.33
total output current, <of an output module>
current that a multi-channel module operating at the most adverse combination of normal operation can supply without any part of it (insulation, terminals, exposed conductive parts, etc.) exceeding the specified temperature limits

Note 1 to entry: For a multi-channel module, the total output current is generally less than the sum of the output currents of the channels.

3.1.34
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.1.35
unit
integral assembly (which may consist of modules plugged in or otherwise connected within the assembly) connected to other units within the control equipment by means of cables for permanently installed units and cables or other means for portable units

3.1.36
withstand type test
withstand test
type test verifying that the application of more severe influencing quantities to the equipment does not impair its ability to assume its intended mission

3.2 Abbreviated terms, acronyms, conventions and symbols

Acronym	Description
a.c.	or "AC" or "alternating current" are all equivalent
BCD	Binary-Coded Decimal
BIOS	Basic Input/Output System
CDN	Coupling/Decoupling Network
CISPR	Comité International Spécial des Perturbations Radioélectriques (CISPR; English: Special International Committee On Radio Interference)
CMRR	Common-Mode Rejection Ratio
CMV	Common-Mode Voltage
d.c.	or "DC" or "direct current" are all equivalent
DCS	Distributed Control System
DIN	Deutsches Institut für Normung
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
EU	European Union
EUT	Equipment Under Test
FDIS	Final Draft International Standard
FF	Foundation Fieldbus
HART	Highway Addressable Remote Transducer
HMI	Human Machine Interface
I/O	Input/Output
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEV	International Electrotechnical Vocabulary
ISO	International Organization for Standardization
LSB	Least Significant Bit
MOV	Metal Oxide Varistor
MTBF	Mean Time Between Failures
NC	Normally Closed
ND	Not Defined
NO	Normally Open
ODVA	ODVA, Inc. (formerly “Open DeviceNet Vendor’s Association”)
OS	Operating System
OTH	Operating Temperature & Humidity
PAC	Programmable Automation Controller
PADT	Programming and Debugging Tool
PAS	Publicly Available Specification

PC	Personal Computer
PELV	Protected Extra-Low Voltage
PFVP	Proper Functioning Verification Procedures
PLC	Programmable Logic Controller
PNO	Profibus Nutzer (User) Organization
PS	Power Supply
RC	Resistor Capacitor
RIOS	Remote Input/Output Station
RMS	Root Mean Square
RTD	Resistive Temperature Device
SC	Subcommittee
SDCI	Single-drop Digital Communication Interface
SDL	Shut Down Limit
SELV	Safety Extra-Low Voltage
STH	Storage Temperature & Humidity
TC	Thermocouple
TE	Test Equipment
TTH	Transportation Temperature & Humidity
TM	Thermal Module
USB	Universal Serial Bus

4 Compliance and type tests

4.1 Compliance with this standard

Compliance to this standard can be claimed in a number of ways.

1) Complete compliance to this standard:

   “compliant to IEC 61131-2”

   This means the equipment complies with all clauses.

2) Compliance to a clause or clause(s) statement, for example:

   “Compliant to IEC 61131-2:-, Clause 9” or

   “Compliant to IEC 61131-2:-, subclause 6.2 and Clause 9”

   This means the equipment complies with only the clauses/subclauses stated.

3) Compliance to functionality statement, for example:

   “Functionality: Digital Input Type 3 according to IEC 61131-2” and/or

   “Ambient temperature range: 0 ºC to 60 ºC according to IEC 61131-2”

   This means the equipment complies with the functionality item stated as defined in this standard.

One exception is Clause 7, Electromagnetic compatibility (EMC) requirements. It is mandatory all equipment complies with this clause.

Where the manufacturer is allowed to select among several options for normal service conditions, catalogues and/or datasheets shall clearly specify which option the equipment has been evaluated against. This applies to e.g. ambient temperature ranges, severity classes of voltage dips (e.g. PS1 or PS2), and types of digital inputs (e.g. Type 1 or Type 3).

4.2 Type tests

4.2.1 General

The objective of 4.2 is to define how to verify compliance of the control equipment and the associated peripherals with the requirements set forth in this standard. This compliance verification includes:

a) verification by type tests given in appropriate clauses;

b) verification by suitable examination, visual inspection or/and measurement.

These tests are qualification tests and not tests related to the ways control equipment is employed. According to the scope of this standard, the above compliance verification may not cover the verification of the ability of the control equipment to satisfy the intended automated control equipment requirements.

NOTE Peripherals, not in the scope of this standard, used in the same environment as the control equipment, can be evaluated to the same requirements as the control equipment.

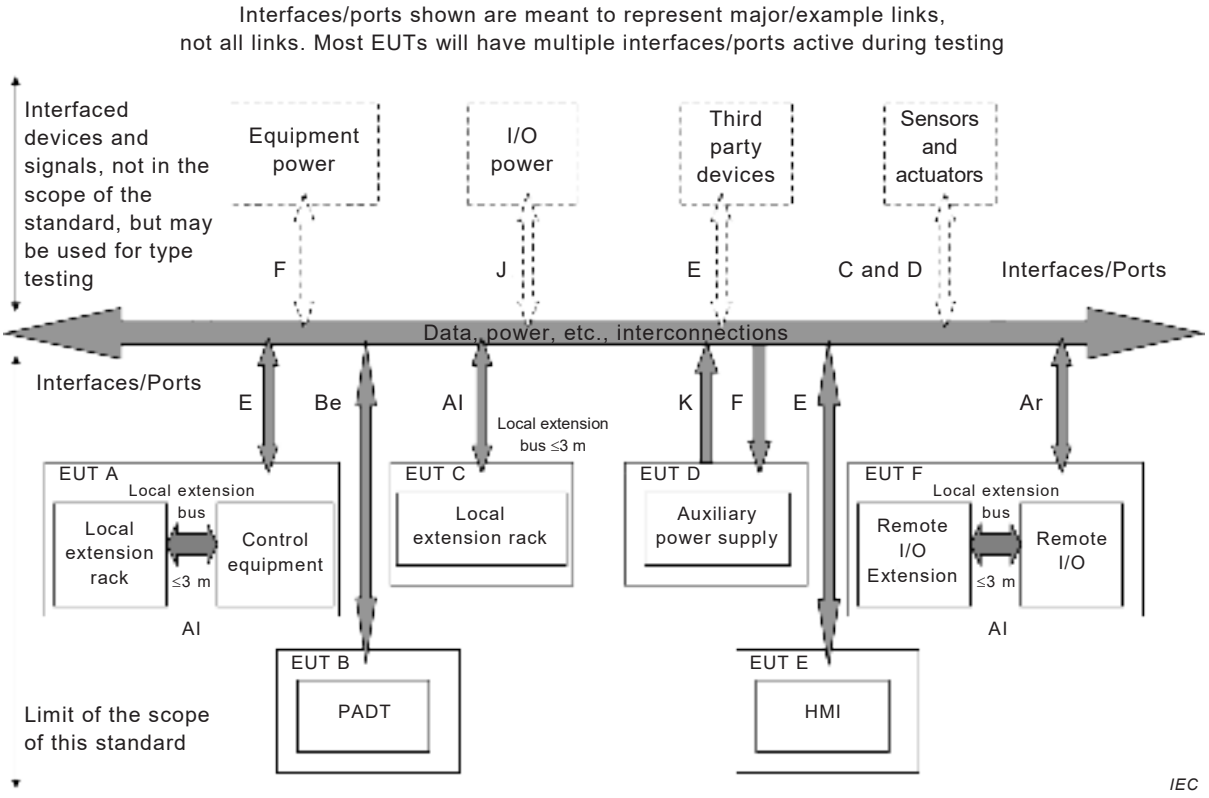
It shall be kept in mind a type test is meant to test a target device, the EUT. But in the type test context EUT can mean the EUT, the single target device, e.g. a module alone or this same single target device as part of a test EUT, e.g. a module, a power supply, a communication module and a rack.

4.2.2 Equipment to be tested (equipment under test/EUT)

Control equipment in the scope of this standard is used in a wide variety of applications. The modular designs of most control equipment and the wide range of combinable remote I/O, industrial PCs and HMI lead to an extremely wide variety of system configurations. For obvious practical reasons, in most cases type tests cannot be conducted on EUT identical to user-built systems, and engineering judgement is necessary. Therefore, the manufacturer is required to define the EUTs and document the corresponding test plan and test programmes to meet the following principles.

Combination of tests/EUTs/test programmes shall be such that one may reasonably think that any configuration built by the user according to the manufacturer's specifications and installation instructions would pass satisfactorily the same tests, and will properly function in normal operation, which these tests are intended to reflect.

Unless otherwise specified in this standard, the manufacturer may elect to use various EUTs to achieve the objectives of a given type test.



NOTE Letters used in Figure 2 (e.g. E, F, Be) are defined in the Key of Figure 7.

Figure 2 – Example EUT configurations

Each subpart of the EUT as shown in Figure 2 may constitute an EUT represented as EUT A, B, C, D, E and/or F. To exercise different characteristics, capabilities, ports, etc of each EUT, the manufacturer may define subsystems and the different EUTs are tested in turn.

Only one subsystem is under test at any time, the others being considered as auxiliary equipment.

Examples:

a) to test vibration immunity of the EUT A, equipment of the other EUTs may be connected but are not in the test bed.

b) to check the electrical interference immunity of the EUT, the manufacturer may choose between the following, as applicable:

   1) to build a single global EUT including the PADT/TE/RIOS, and check the whole configuration; or

   2) to define a suite of simpler EUTs (for example, a EUT without any PADT/TE/RIOS, and a single PADT and a single RIOS and a single PADT and a single TE, or any other suite of partial combinations of them which make sense) but correspondingly exercise the appropriate ports of each EUT with an equipment part of the test bed (the laboratory equipment necessary to test the EUT) as would do the missing PADT/TE/RIOS. For practical reasons, the manufacturer may elect to use actual PADTs/TEs/RIOS to exercise the EUT ports.

If there are too many families to be included into a single EUT, the manufacturer shall define several EUTs as follows:

– For the type test of a family with very similar modules (family, i.e. modules using the same schematic and basic manufacturing and differing mainly by, for example, the number of

inputs and outputs), the manufacturer may elect to include in the EUT only one arbitrarily chosen member of the family. If the type test is dependent on the differences between the modules, then a single family member shall not be used.

– Appropriate catalogued options, such as power supply units, application memory(ies), processing unit(s) etc. shall be used to build the relevant EUT(s).
– If a local bus extension is part of the EUT and if its maximum cable length cable is less than, or equal to, 3 m, it is considered to be an internal equipment bus. As such, it shall not be considered a port for test.
– If a local bus extension is part of the EUT and is capable of driving cables with a length of > 3 m, then only one end of the link is part of the EUT and it is considered as a communication port.

If an EUT representing a control equipment or a remote I/Os (RIOS) is of modular structure, it shall fulfil the following minimum requirements:

– All types of modules shall be represented in one or several EUT configurations in which any mix of modules is permissible.
– All types of modules shall be configured in the EUTs and tested at least once.

NOTE It can be appropriate to consider statistical criteria based on samples for a large number of I/Os (for example, >100).

At least one of each type or a representative number of I/O ports of the EUT shall be connected and be functional.

A selection of the representative functional modes shall be made considering that only the most typical functions of the equipment can be tested.

The EUT shall be tested according to the manufacturer's installation guideline.

All tests shall be conducted in a well-defined and reproducible manner.

The EUT is located in the specified test e.g. chamber, building, site and any test support equipment shall be located outside the influence of the test environment.

All input/output cables shall be normally looped back for monitoring and testing and/or shall be terminated with a load.

For multi-channel I/O EUT's, the circuit design shall be reviewed to determine the worst case situation for testing. On and off states and the range of allowed loads shall be tested.

Certain tests can be easily targeted at a single item, others are more appropriate to a set of items configured together. Equipment to be tested shall reflect this need. See specific test clauses for recommendations on EUTs.

When new units/modules are introduced after initial release of a control equipment catalogue, which has already been satisfactorily tested according to this standard, EUT(s) simpler than those originally used can be defined. This is only permissible if such EUTs and the associated test programmes provided by the manufacturer allow proper verification as if these new units/modules had been tested within the originally tested EUTs.

Unless otherwise specified in this standard, the manufacturer may elect either that each type test be conducted on a new EUT or that several type tests be performed successively on the same EUT.

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, it is required that the decision and justification not to test is recorded in the test report.

4.2.3 Special features for EMC tests

Communication ports are to be connected as in normal use for ESD testing.

Pass-fail criteria are located in Table 1.

4.2.4 Withstand test conditions

In general, a module should be tested alone. Those clauses dealing with withstand tests should be referred to for specifics. See 5.2.1, 5.3.4, 5.4.4, 6.2.2.6, 6.3.2.1, 6.3.2.3, 6.4.4.5.3, 6.4.5.10.4, 6.4.6.10.4 and 6.5.6.6.

4.2.5 Climatic tests

Tests are performed on unpackaged equipment.

Temperature-sensitive components that are normally serviced and removed by the service personel may be removed, if so requested by the manufacturer.

The climatic testing is made on the basis of the applicable standards of the IEC 60068 series.

4.2.6 Functionality verification with temperature

4.2.6.1 General method

This test method is utilized for verification of equipment functionality with temperature; e.g. analog I/O characteristics.

It is not required to perform this if it can be proved and documented that temperature range does not have any impact on the equipment.

The equipment shall be mounted in its least favorable position/orientation in an ambient temperature equal to its maximum or minimum rated ambient temperature.

The EUT shall be configured so it is generating its least favorable heat dissipation. It shall be noted that least favorable can be both a hot or cold situation (i.e. highest dissipation or lowest dissipation). This dissipation may be caused by some combination of load current, input voltage, input frequency, I/O duty cycle, etc.

The EUT wiring shall be the smallest size suitable for the maximum current rating of the EUT according to the manufacturer’s instructions.

The test room/chamber/box (size is not a test criterion) environment surrounding the EUT shall not be subject to air movement caused by sources not part of the EUT, i.e. it shall be a natural convection environment. See Figure 3.

NOTE 1 To reduce and block forced air movement in a test room or in a climatic chamber around the EUT, the EUT can be placed in a partially or completely closed test box allowing air movement / natural convection only caused by the EUT. Or barriers made of any suitable material could be used around the EUT, to block air movement.

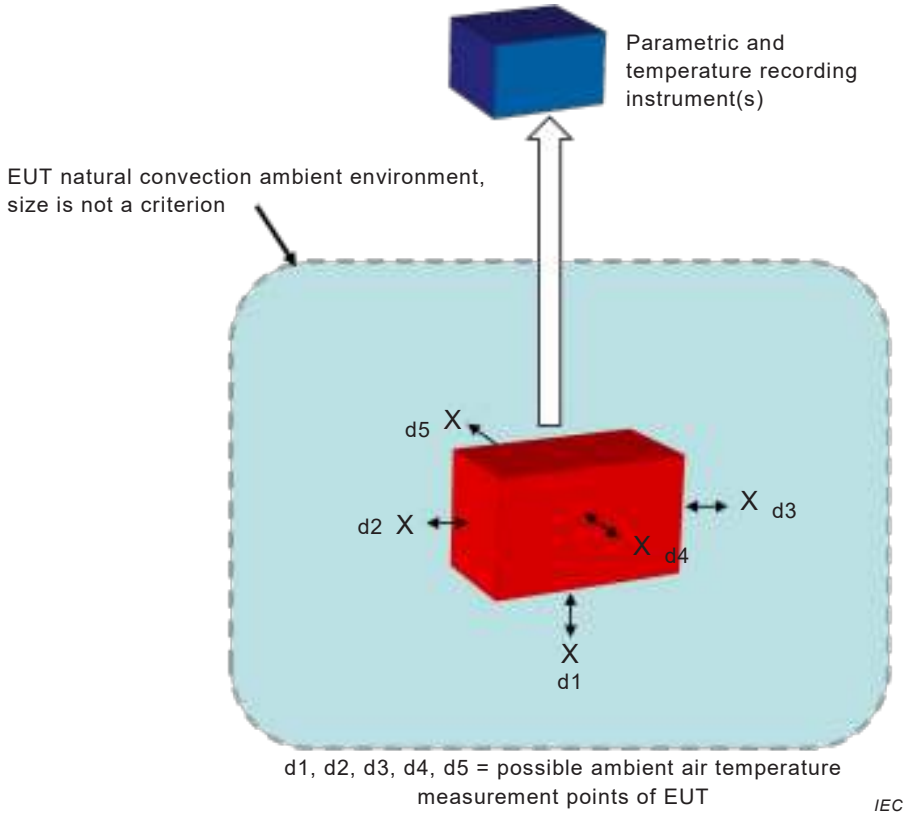


Figure 3 – General temperature test environment

Temperatures are measured when steady state has been reached.

If the EUT is meant to function as a standalone unit it shall be tested standalone, e.g. a standalone HMI or communications switch/router. See 4.2.

If the EUT is not meant to function as a standalone unit, e.g. I/O module of a modular equipment system, then a representative EUT shall be utilized for testing. This EUT shall represent a practical least favourable combination of conditions for the EUT. See 4.2.

NOTE 2 Practical least favourable combination of conditions means a realistic situation the EUT can be utilized for in a real world application, not a theoretical combination which would never be used in practice.

This practical least favourable combination shall be, at a minimum, the items necessary for the EUT to function, e.g. power supply, communication module (TM's in Figure 4) and EUT. The EUT shall be surrounded, as permitted by manufacturer's documentation, on both sides with real modules or "simulation module" (thermally representative module, TMs in Figure 4) representing the worst case thermal environment for the EUT, i.e. adding more modules around the EUT does not cause further temperature increase of the EUT. A justification of the configuration for the test shall be provided in the test report.

NOTE 3 An example configuration for testing an I/O module EUT, of a modular system, might be:

- the EUT (I/O module),
- a power supply,
- communication module,
- three of the same type I/O module operating at full load to the left of the EUT,
- three of the same type I/O module operating at full load to the right of the EUT, and
- adding more I/O modules left or right does not cause the EUT's temperature to change.

For vented equipment, cooled by natural air convection, the ambient temperature is the incoming air temperature at a point not more than 50 mm and not less than 25 mm away from the plane of the equipment's air flow entry point. See Figure 4. The points d1, d2 and d3, in Figure 4, are the possible measurement points. The point with the lowest temperature should be utilized as the ambient temperature.

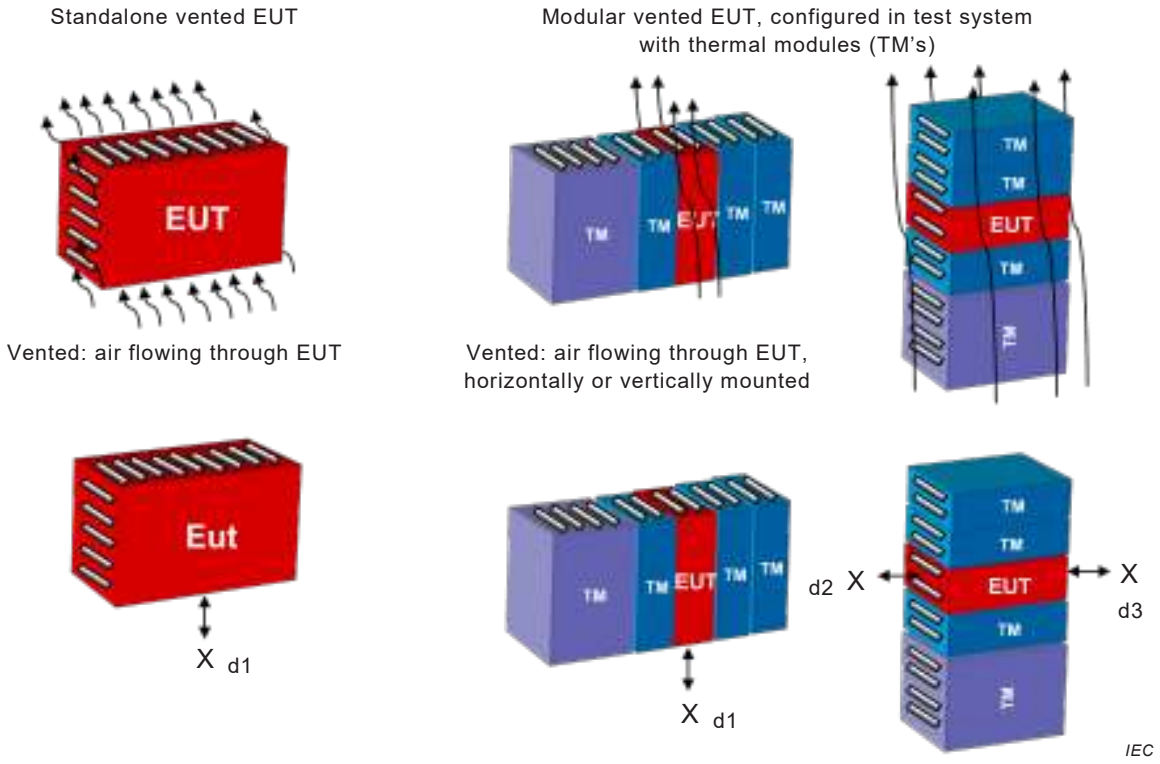


Figure 4 – Vented equipment

NOTE 4 Vents are purposeful air openings intended to allow air to pass through the equipment for the purpose of cooling, not incidental vents, e.g. switch shaft or communication jack openings.

For non-vented equipment, cooled by natural air convection, the ambient temperature is the air temperature at a point not more than 50 mm and not less than 25 mm away from the equipment, on a horizontal plane located at the vertical mid-point of the equipment. See Figure 5. The points d2-d5, in Figure 5, are the possible measurement points. The point with the lowest temperature should be utilized as the ambient temperature.

Due to mounting requirements, some of the measurement points may not be practical to utilize.

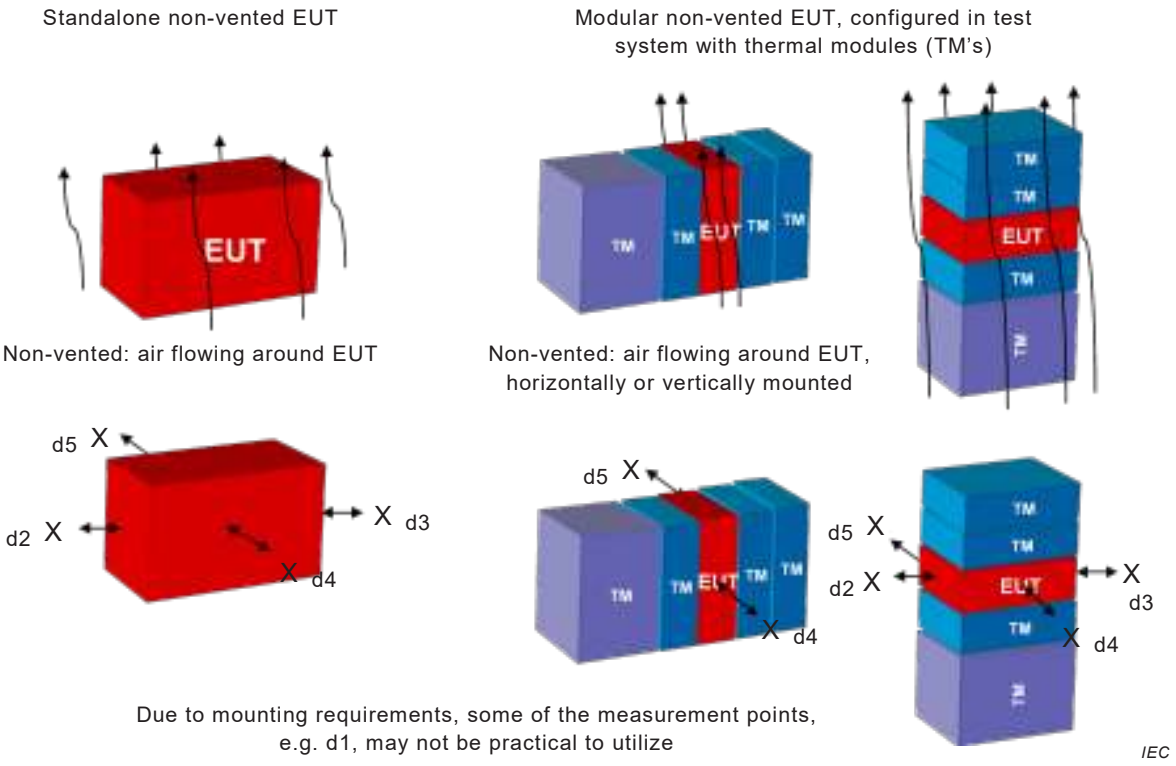


Figure 5 – Non-vented equipment

4.2.6.2 Special method, panel mounted equipment

Panel mounted equipment presents some special considerations, see Figure 6.

In this case part of the equipment (EUT_a) may be in one ambient environment, e.g. ambient environment #1 and the rest of the equipment (EUT_b) may be in another ambient environment, e.g. ambient environment #2. The equipment construction techniques can be quite different, e.g. (referring to Figure 6) open/vented in ambient environment #1 and enclosed/non-vented in ambient environment #2.

It should be kept in mind, it may be necessary that these two different environments be applied simultaneously, to ensure least favourable conditions.

Each part of the equipment (EUT_a and EUT_b) shall be evaluated separately according to its own environment.

The general method described in 4.2.6.1 with regard to test conditions and least favourable EUT configuration, orientation, etc. shall be followed.

Three special methods for testing panel mounted equipment are provided:

a) The equipment shall be mounted such that the two portions (EUT_a and EUT_b) of the EUT are subjected to their specific environments.

NOTE 1 This provides the most accurate results, but is the most difficult to create for a test.

b) The total EUT (EUT_a + EUT_b) shall be mounted in a single environment, which shall be the highest of the two, and the temperatures of the lower temperature EUT portion are corrected by the difference between the EUT's maximum rated ambient temperature and the actual test ambient temperature.

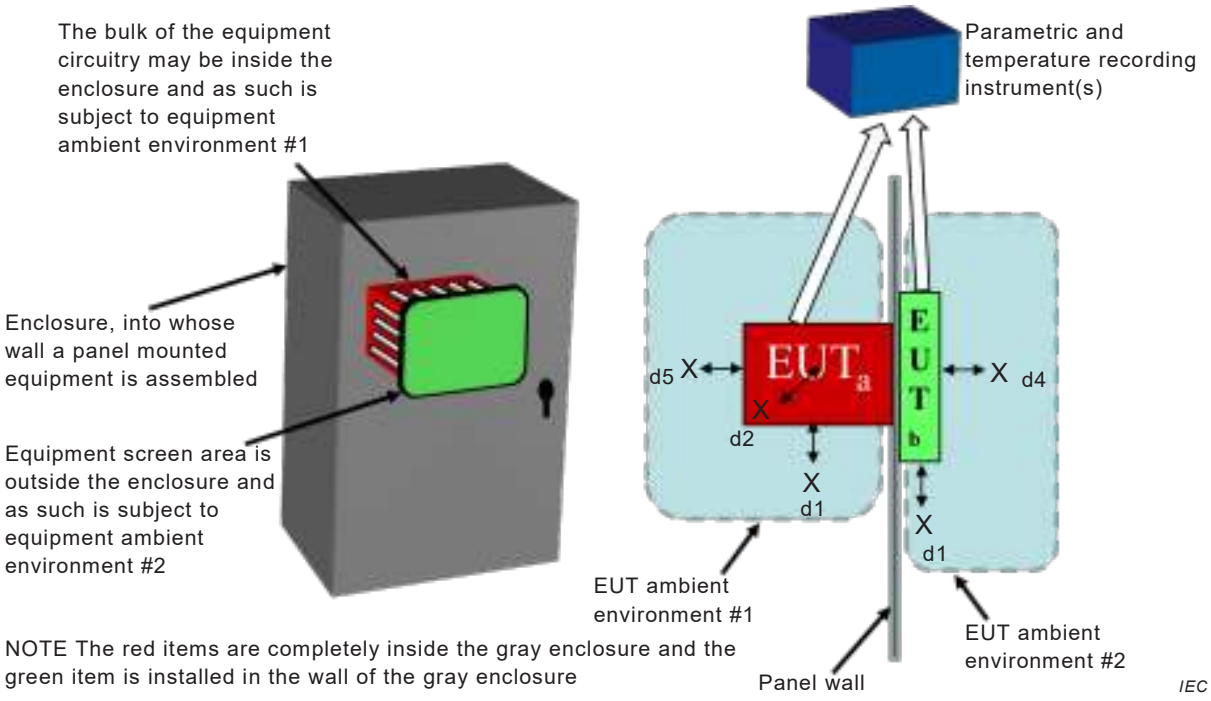
EXAMPLE 1 If EUT_a's maximum rated ambient temperature = 60 ºC and EUT_b's maximum rated ambient temperature = 50 ºC, the test will be run with a test ambient temperature = 60 ºC. Temperatures taken for EUT_b would be corrected by –10 ºC (50 ºC-60 ºC).

NOTE 2 This method is not as accurate as a) but will yield conservative results compared to c).

c) The total EUT (EUT_a + EUT_b) shall be mounted in a single environment, which shall be the lower of the two, and the temperatures of the higher temperature EUT portion are corrected by the difference between the EUT's maximum rated ambient temperature and the actual test ambient temperature.

EXAMPLE 2 If EUT_a's maximum rated ambient temperature = 60 ºC and EUT_b's maximum rated ambient temperature = 50 ºC, the test will be run with a test ambient temperature = 50 ºC. Temperatures taken for EUT_a would be corrected by +10 ºC (60 ºC-50 ºC).

NOTE 3 This method is not as accurate as a) and will not yield conservative results compared to b).



NOTE The red items are completely inside the gray enclosure and the green item is installed in the wall of the gray enclosure

Figure 6 – Panel mounted equipment extending through the wall of a cabinet

4.2.6.3 Special method, large or heavy equipment

Equipment too large or too heavy can be tested at room ambient temperature, if the measured temperatures are corrected by the difference between the EUT's maximum rated ambient temperature and the actual test room ambient temperature.

Where this method is applied, rationale shall be provided in the test report.

4.2.7 Verification procedure

Type tests shall be conducted on the EUT(s) defined in 4.2.2 and 4.2.3, unless otherwise specified in this document.

For each test, the manufacturer shall:

- specify the configuration, its arrangement and its external connections;
- provide the test programmes which shall be run during the test;
- provide the proper operation verification procedure, e.g. including the way to measure accuracy and temporary deviations of analog I/Os.

The appropriate test programmes and proper functioning verification procedures provided by the manufacturer shall satisfy the requirements given in 4.2.8.

4.2.8 Requirements for test programmes and proper functioning verification procedures (PFVPs) to be provided by the manufacturer

During the type tests, there shall be no:

- destruction of hardware;
- modification of the operating system and test programmes and/or alteration of their execution;
- unintended modification of system and application data stored or exchanged;
- erratic or unintended behaviour of the EUT;
- deviation of the analog I/Os out of the limits specified in item 4 of Table 48 and item 3 of Table 52.

All relevant functions and parts of the EUT (i.e. units and modules) shall be functioning in such a way that the information paths to/from these functions and parts are exercised.

All the I/O and communication channels of the EUT shall be exercised.

It is acceptable to apply statistical criteria based on samples, for large number of I/Os, etc. (for example, >100).

The type test is not meant to test every possible operating mode or capability of an EUT. The intent of the type test is to exercise the EUT, at the boundaries of its operating mode(s) and/or capability(ies). Therefore engineering judgement is necessary to define both the configuration of the test and verification, to prove the overall capability. This is without actually testing all possibilities, i.e. a practical set of tests and results.

The following non-exhaustive list contains example items to consider in defining the type tests, with regard to exercise of the EUT.

a) Configuration of the EUT:
   - external and internal status information reporting means;
   - displays;
   - alarm signals,;
   - self-test result registers;
   - I/O;
   - test program length;
   - operation modes, e.g. start-up, shut-down, cold/warm/hot restart, normal run;
   - performance.

b) The type test shall focus on the least favourable conditions for the EUT, to test its boundaries. Therefore different test set-ups might be needed for testing the EUT boundaries under, for example EMC conditions, climatic conditions.

c) For every EUT there shall be a specification of how and where the limits of proper function can be identified.

4.2.9 EMC Performance criteria

Verification test method performance criteria.

Table 1 – Criteria to prove the performance of an EUT against EMC disturbances

Performance criterion		
Criterion	**Operation**	
	During test	**After test**
A	The EUT shall continue to operate as intended. No loss of function or performance, according to PFVPs (4.2.8)	The EUT shall continue to operate as intended
B	Degradation of performance accepted Examples: analog values vary within manufacturer-specified limits[a], communication delay times vary within manufacturer-specified limits, flickering on HMI display, etc. No change of operating mode Examples: loss of data or uncorrected errors in communication, unintentional state changes of digital I/O which are seen by the EUT or test set-up, etc. No irreversible loss of stored data, according to PFVPs (4.2.8)	The EUT shall continue to operate as intended. Temporary degradation of performance shall be self-recoverable
C	Loss of functions accepted, but no destruction of hardware or software (programme or data)	The EUT shall continue to operate as intended automatically, after manual restart or power off/power on
[a] See Table 48, item 4) and Table 52, item 3).		

4.2.10 General facility/laboratory conditions for tests

The tests shall be carried out in accordance with the appropriate test procedure.

The tests shall be carried out under the general test conditions given in Table 2, except for the tests specified with other conditions in this standard, e.g. climatic tests or EMC tests for voltage interruptions.

Unless otherwise specified, no sequence is imposed for type tests.

Table 2 – General facility/laboratory conditions for tests

Test condition	Range
Temperature	15 °C to 35 °C
Relative humidity	≤ 75 %
Barometric pressure	86 kPa to 106 kPa (650 mmHg to 800 mmHg)

4.3 Test report

A test report shall be used to document conformity to this standard or to specific clauses or subclauses within this standard (see 4.1).

The test report shall reference this standard and each clause and/or subclause and their titles, to which conformity is claimed and testing was done.

Where applicable the various tests in a clause and/or subclause and values to which the equipment was tested and/or the measured values shall be identified.

The test report shall contain all necessary information to reproduce the test. At a minimum, the following shall be recorded:

- identification of EUT hardware and any associated equipment (eg. modular parts, cabling, etc.) including versions and/or serial number;
- identification of EUT system software (eg. BIOS), operating system (OS) including versions and/or serial number;
- identification of test equipment including model number, brand, and calibration details;
- climatic conditions including temperature, humidity, and atmospheric pressure;
- rationale for using this combination of hardware and software;
- test results including pass/fail, effects on EUT during/after test;
- any specific conditions required to achieve compliance (e.g. enclosure, shielding, earthing, deratings, etc.).

5 Normal service conditions and requirements

5.1 General

The equipment is intended to be used in an industrial environment.

Service conditions encompass operating, transport and storage.

5.2 Operating conditions and requirements

5.2.1 Ambient temperature and relative humidity

Table 3 provides a recommended set of operating environments for equipment in the scope.

At a miniumum, PLC/PAC, if enclosed equipment, shall be suitable for ambient temperature and relative humidity ranges stated as operating environment OTH2 (green highlight in Table 3) and OTH3, if open equipment (blue highlight in Table 3).

Table 3 – Operating environments, ambient temperature and relative humidity

Operating environment	Equipment Type	Minimum ambient temperature	Maximum ambient temperature	Minimum relative humidity	Maximum relative humidity[a]	Comment on application
OTH1	Enclosed	20 °C	25 °C	20 %	75 %	e.g fully air conditioned, DCS
OTH2	Enclosed	5 °C	40 °C	5 %	85 %	e.g. industrial PC
OTH3	Open	5 °C	55 °C	5 %	85 %	e.g. HMI, PLC, PAC
OTH4	Open	0 °C	60 °C	10 %	95 %	e.g. PLC
OTH5	Open	-25 °C	70 °C	10 %	100 %	e.g PLC, field devices
OTH6	Enclosed	-40 °C	70 °C	10 %	100 %	

Air pressure absolute min. 79,5 kPa to max. 101,3 kPA.

NOTE 1 Table based on guidance from IEC 60721-3-3 and historical experience.

NOTE 2 A closely related topic is surface temperature limits. These are specified in 10.1 of IEC 61010-2-201:–.

[a] Under normal operation equipment is not intended to operate with condensation.

Equipment may also be suitable for extended operating environments. Refer to Table 3, for additonal environments.

Equipment style (open or enclosed) is not limited to just those operating environments listed, e.g. enclosed = OTH2, open = OTH3. They can be designed for other ranges also, e.g. enclosed = OTH3.

The requirements of 5.2.1 are verified in accordance with the immunity test requirements of Table 4, Table 5, Table 6 and Table 7.

Table 4 – Dry-heat withstand and immunity tests

	Withstand	**Immunity (Not normative: informative / optional)**
Reference test	IEC 60068-2-2, test Bb	IEC 60068-2-2, test Be
Preconditioning	According to manufacturer's specifications	
Initial measurement	According to PFVP, see 4.2.8	
Conditioning	Power supply unconnected	Power connected and in operation
Ambient temperature[b]	Maximum of STH1, STH2, STH3, STH4 or STH5 °C ± 2 K[d] TTH1, TTH2, TTH3 or TTH4 °C ± 2 K[e]	Maximum of OTH1, OTH2, OTH3, OTH4, OTH5 or OTH6 °C ± 2 K[c]
Duration of exposure	16 h ± 1 h	16 h ± 1 h
Measuring and/or loading during conditioning	None	Yes
Details of mounting/support	None	See 4.2.6
Recovery procedure		
Time	1 h minimum	-
Climatic conditions	See 4.2.5 and 4.2.9[a]	
Special caution	No condensation[a]	
Power supply	Power connected and in operation	
Final measurements	According to PFVP, see 4.2.8	

[a] All external and internal condensation shall be removed by airflow, prior to connecting again the EUT to a power supply.

[b] Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.

[c] See Table 3

[d] See Table 13

[e] See Table 14

Table 5 – Cold withstand and immunity tests

	Withstand	**Immunity (Not normative: informative / optional)**
Reference test	IEC 60068-2-1, test Ab	IEC 60068-2-1, test Ae
Preconditioning	According to manufacturer's specifications	
Initial measurement	According to PFVP, see 4.2.8	
Conditioning	Power supply unconnected	Power connected and in operation
Ambient temperature[b]	Minimum of STH1, STH2, STH3, STH4 or STH5 °C ± 3 K[d] TTH1, TTH2, TTH3 or TTH4 °C ± 3 K[e]	Minimum of OTH1, OTH2, OTH3, OTH4, OTH5 or OTH6 °C ± 2 K[c]
Duration of exposure	16 h ± 1 h	16 h ± 1 h
Measuring and/or loading during conditioning	None	Yes
Details of mounting/support	None	See 4.2.6
Recovery procedure		
Time	1 h minimum	-
Climatic conditions	See 4.2.5 and 4.2.9[a]	
Special caution	No condensation[a]	
Power supply	Power connected and in operation	
Final measurements	According to PFVP, see 4.2.8	

[a] All external and internal condensation shall be removed by airflow, prior to connecting again the EUT to a power supply.

[b] Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.

[c] See Table 3

[d] See Table 13

[e] See Table 14

Table 6 – Change of temperature, withstand and immunity tests

<table>
<tr><th colspan="2"></th><th>Withstand test</th><th>Immunity test</th></tr>
<tr><td colspan="2">Reference test</td><td>IEC 60068-2-14, test Na</td><td>IEC 60068-2-14, test Nb</td></tr>
<tr><td colspan="2">Preconditioning</td><td colspan="2">According to manufacturer’s specification</td></tr>
<tr><td colspan="2">Initial measurements</td><td colspan="2">According to PFVP, see 4.2.8</td></tr>
<tr><td colspan="2">Conditioning</td><td>Power supply unconnected</td><td>Power connected and in operation</td></tr>
<tr><td colspan="2">Measurement and/or loading during conditioning</td><td>None</td><td>Yes[c]</td></tr>
<tr><td colspan="2">Details of mounting/support</td><td>None</td><td>See 4.2.6</td></tr>
<tr><td rowspan="2">Minimum ambient temperature[f]</td><td>Open equipment</td><td rowspan="2">STH1, STH2, STH3, STH4 or STH5 °C ± 3 K[g]
TTH1, TTH2, TTH3 or TTH4 °C ± 3 K[h]</td><td>OTH3, OTH4, OTH5 °C ± 3 K[f]</td></tr>
<tr><td>Enclosed equipment</td><td>OTH1, OTH2, OTH6 °C ± 3 K[f]</td></tr>
<tr><td rowspan="2">Maximum ambient temperature[e]</td><td>Open equipment</td><td rowspan="2">STH1, STH2, STH3, STH4 or STH5 °C ± 2 K[g]
TTH1, TTH2, TTH3 or TTH4 °C ± 2 K[h]</td><td>OTH3, OTH4, OTH5 °C ± 3 K[f]</td></tr>
<tr><td>Enclosed equipment</td><td>OTH1, OTH2, OTH6 °C ± 3 K[f]</td></tr>
<tr><td colspan="2">Exposure time at each temperature</td><td colspan="2">3 h ± 30 min</td></tr>
<tr><td colspan="2">Transport time</td><td>Less than 3 min</td><td>Not applicable</td></tr>
<tr><td colspan="2">Temperature variation speed</td><td>Not applicable</td><td>3 K/min. ± 0,6 K/min.</td></tr>
<tr><td colspan="2">Number of cycles</td><td>5</td><td>2</td></tr>
<tr><td colspan="4">Recovery procedure</td></tr>
<tr><td colspan="2">Time</td><td>Less than 2 h</td><td>Not applicable</td></tr>
<tr><td colspan="2">Climatic conditions</td><td>See 4.2.5 and 4.2.10[d]</td><td>Not applicable</td></tr>
<tr><td colspan="2">Power supply</td><td colspan="2">Power connected and in operation</td></tr>
<tr><td colspan="2">Final measurements</td><td>[a]</td><td>[b]</td></tr>
</table>

[a] PFVP according to 4.2.8 performed after recovery.

[b] PFVP according to 4.2.8 performed during test.

[c] Loading per product specifications, including any derating.

[d] All external and internal condensation shall be removed by airflow, prior to connecting again the EUT to a power supply.

[e] Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.

[f] See Table 3

[g] See Table 13

[h] See Table 14

Table 7 – Cyclic (12 + 12) damp-heat withstand test

	Withstand test	Immunity test (Not normative: informative / optional)
Reference test	IEC 60068-2-30, test Db Variant 2	IEC 60068-2-78, test Cab
Preconditioning	According to manufacturer's specifications	
Initial measurements	According to PFVP, see 4.2.8	
Conditioning	Power supply unconnected and without packaging container EUT at 25 °C ± 3 K stabilized before test starts	Power connected and in operation
Measurement and/or loading during conditioning	None	Yes
Details of mounting/support	None	See 4.2.6
Ambient temperature[b, f]	Maximum[f] of STH1, STH2 °C ± 2 K[d] TTH1, TTH2 °C ± 2 K[e] or Temp. 55°C ± 2 K Rel. Humidity 95%	Maximum of OTH1, OTH2, OTH3 °C ± 2 K[c] or Temp. 30°C ± 2 K Rel. Humidity 93%
Number of cycles / time	2 / (12 + 12)h	1 / 16h
Recovery procedure time		
Climatic conditions	Under controlled conditions prescribed in IEC 60068-2-30[a]	Under controlled conditions prescribed in IEC 60068-2-78[a]
Power supply	After recovery: Power connected and in operation	
Final measurements	According to PFVP, see 4.2.8, performed within 30 min after recovery	

[a] All external and internal condensation shall be removed by airflow, prior to reconnecting the EUT to a power supply.

[b] Ambient temperature is monitored for ventilated or non-ventilated equipment as described in 4.2.6.1.

[c] See Table 3

[d] See Table 13

[e] See Table 14

[f] IEC 60068-2-30, test Db specifies two test temperatures. The upper temperature shall be achieved in a period of 3 h ± 30 min.

5.2.2 Altitude

The equipment shall be suitable for operation up to 2 000 m, see green highlight in Table 8 (minimum 79,5 kPa absolute).

NOTE A closely related topic is clearance distance. This is specified in 6.7.1.2 of IEC 61010-1:2010.

If the equipment is rated for an altitude greater than 2 000 m, the manufacturer shall provide altitude derating information similar to that in Table 8. If the manufacturer does not, Table 8 is applicable.

Table 8 – Multiplication factors for equipment ambient temperature of operation at altitudes up to 5 000 m

Altitude m	Derating ratio for temperature[a]
0 to 2 000[b]	1,0
3 000	0,9
4 000	0,8
5 000	0,7
Linear interpolation is allowed between altitudes. NOTE These factors compensate for the reduction in cooling capacity of air at higher altitudes, due to lower density. [a] Equipment ambient temperature rating at 2 000 m [b] Atmospheric pressure and air density increases with decreasing altitude. Therefore utilization of the derating factor for 0 m to 2 000 m for altitudes below sea level is considered conservative.	

EXAMPLE 1 If the operating ambient temperature of the equipment is 25 ºC at 2 000 m, its operating ambient temperature at 5 000 m = 25 ºC * 0,7 = 17,5 ºC.

EXAMPLE 2 If the operating ambient temperature of the equipment is 70 ºC at 2 000 m, its operating ambient temperature at 3 000 m = 70 ºC * 0,9 = 63 ºC.

The requirements of 5.2.2 are verified by the temperatures tests of Table 4 and by inspection of the equipment manuals for deratings according to Table 8.

5.3 Mechanical operating conditions and requirements

5.3.1 General

Experience shows that equipment meeting these requirements are suitable for industrial use.

For the purpose of this standard, the operating conditions are indirectly defined by the following requirements which apply to fixed equipment as well as to unpackaged portable and hand-held equipment. They do not apply to equipment containing assemblies outside the scope of this standard. Fixed equipment is equipment which is part of the permanent installation.

5.3.2 Vibrations

Vibration immunity requirements for equipment in the scope of this document are shown in Table 9.

Table 9 – Sinusoidal vibration conditions

Displacement	3,5 mm constant displacement, $5 \leq f < 8{,}4$ Hz
Acceleration	10 m/s^2 (1 g) constant acceleration, $8{,}4 \leq f \leq 150$ Hz
All amplitude figures are peak values. The break point frequency shall be adjusted to yield a smooth cross-over without discontinuity from the constant amplitude displacement requirement to the constant amplitude acceleration requirement. NOTE 1 g = 10 m/s^2	

Vibration is applicable to each 3 mutually perpendicular axes.

The requirements of 5.3.2 are verified in accordance with Table 10.

Table 10 – Immunity vibration test

Reference test	IEC 60068-2-6, test Fc
Preconditioning	According to manufacturer's specifications
Initial measurements	According to PFVP, see 4.2.8
Details of mounting/support	According to manufacturer's specifications
Motion	Sinusoidal
Vibration amplitude/acceleration	
5 Hz $\leq f <$ 8,4 Hz	3,5 mm_{peak} constant displacement
8,4 Hz $\leq f \leq$ 150 Hz	10 $m/s^2{}_{peak}$ constant acceleration
Vibration type	Sweeping, at a rate of 1 octave/min (± 10 %)
Vibration duration	10 sweep cycles per axis on each of 3 mutually perpendicular axes
Measurement and verification during test	According to PFVP, see 4.2.8
Verification after tests	According to PFVP, see 4.2.8
The break point frequency shall be adjusted to yield a smooth cross-over without discontinuity from the constant amplitude displacement requirement to the constant amplitude acceleration requirement.	

5.3.3 Shock

Shock immunity requirements for equipment in the scope of this document are occasional excursions to 150 m/s^2 (15 g), 11 ms, half-sine, in each of 3 mutually perpendicular axes.

Electromechanical relays may temporarily respond to 150 m/s^2 (15 g) shocks. Temporary malfunctioning is allowed during the test, but equipment should be fully functional after the test.

The requirements of 5.3.3 are verified in accordance with Table 11.

Table 11 – Immunity shock test

Reference test	IEC 60068-2-27, test Ea
Preconditioning	According to manufacturer's specifications
Initial measurements	According to PFVP, see 4.2.8
Details of mounting/support	According to manufacturer's specifications
Type of shock	Half-sine
Shock severity	150 m/s^2 (15 g) peak, 11 ms duration
Application	Three shocks in each direction per axis, on 3 mutually perpendicular axes (total of 18 shocks)
Measurement and verification during test	According to PFVP, see 4.2.8
Verification after tests	According to PFVP, see 4.2.8

5.3.4 Free falls (portable and hand-held equipment)

Immunity (during operation) and withstand (non-operational) requirements for falls are as shown in Table 12.

Fall type tests may be combined with the safety evaluation according to IEC 61010-2-201.

Fall test is for hand-held and portable equipment only. Fixed equipment does not require testing.

The reference standard is IEC 60068-2-31, free fall, procedure 1.

The EUT shall be equipped with manufacturer's standard cable(s) (if any).

Free falls can be on any edge, surface or corner. For free falls the least favourable edge, surface or corner shall be selected for the test.

Table 12 – Free fall on concrete floor for portable and hand-held equipment

	Portable and hand-held (<10kg) (withstand)	**Hand-held (<1kg) (immunity)**
Free falls	100 mm; 2 falls	1 000 mm; 2 falls
Dropping onto an edge or a corner	30° or 100 mm; 2 falls	

The requirements of 5.3.4 are verified, after testing the EUT to Table 12, according to PFVP, see 4.2.8.

The EUT may show signs of physical damage after each test, but shall be fully functional.

With the EUT operating during the fall, erroneous operation can be introduced upon impact. Operator correction/reset is allowed after impact.

It is permitted to use a new sample for each fall.

5.4 Transport and storage conditions and requirements

5.4.1 General

The following requirements apply to control equipment units placed within manufacturer's original packaging.

Transport and storage of unpackaged portable equipment shall not exceed the requirements of 5.4.

When components are included in the equipment, which have particular limitations, e.g. batteries, the manufacturer shall specify the arrangements to be made for transport and storage.

5.4.2 Ambient temperature and relative humidity

Table 13 provides a recommended set of storage environments for equipment in the scope.

Table 13 – Storage environments, ambient temperature and relative humidity

Storage environment	Equipment Type	Minimum ambient temperature	Maximum ambient temperature	Minimum relative humidity	Maximum relative humidity[a]	Comment on application
STH1	Enclosed/ Open	20 °C	25 °C	20 %	75 %	e.g. DCS
STH2	Enclosed/ Open	5 °C	40 °C	5 %	85 %	e.g. industrial PC, DCS
STH3	Enclosed/ Open	-5 °C	60 °C	5 %	95 %	e.g. HMI, industrial PC
STH4	Enclosed/ Open	-25 °C	70 °C	10 %	95 %	e.g. PLC/PAC (not recommended for new designs)
STH5	Enclosed/ Open	-40 °C	70 °C	10 %	100 %	e.g. PLC/PAC (recommended for new designs)

NOTE Table based on guidance from IEC 60721-3-1 and historical experience.

[a] Non-condensing

At a minimum, PLC/PAC equipment shall be suitable for ambient temperature and relative humidity ranges stated as storage environment STH4 (enclosed/open equipment, green highlight in Table 13).

Table 14 provides a recommended set of transportation environments for equipment in the scope.

Table 14 – Transportation environments, ambient temperature and humidity

Transportation environment	Equipment Type	Minimum ambient temperature	Maximum ambient temperature	Minimum relative humidity	Maximum relative humidity[a]	Comment on application
TTH1	Enclosed/ Open	5 °C	40 °C	20 %	75 %	e.g. DCS
TTH2	Enclosed/ Open	-25 °C	60 °C	30 %	75 %	e.g. HMI, industrial PC, DCS
TTH3	Enclosed/ Open	-25 °C	70 °C	40 %	95 %	e.g. PLC/PAC (not recommended for new designs)
TTH4	Enclosed/ Open	-40 °C	70 °C	45 %	95 %	e.g. PLC/PAC (recommended for new designs)

NOTE Table based on guidance from IEC 60721-3-2 and historical experience.

[a] Non-condensing

At a miniumum, PLC/PAC equipment shall be suitable for ambient temperature and relative humidity ranges stated as transportation environment TTH3 (enclosed/open equipment, green highlight in Table 14).

Equipment may also be suitable for extended storage environments. Refer to Table 13 and Table 14, for additonal environments.

The requirements of 5.4.2 are verified in accordance with the withstand test requirements of Table 4, Table 5, Table 6 and Table 7.

5.4.3 Altitude

The design atmospheric pressure for transportation shall be equivalent to 0 m to 3 000 m altitude (minimum 70 kPa absolute).

No verification required.

5.4.4 Free falls (in manufacturer's original packaging)

Withstand requirements for control equipment units within manufacturer's original packaging are given in Table 15.

The reference standard is IEC 60068-2-31, procedure 1.

The test is made with each type of manufacturer’s original packaging with the heaviest unit using it.

NOTE 1 There are no requirements on the packaging such as e.g. dimensions, material, form, thickness, this test is only to qualify the robustness of the EUT when packaged.

If the EUT is shipped with any manufacturer’s standard cable(s) installed and any accessories and documentation in the same package, the test has to be made with the complete filled package.

Table 15 – Free fall on concrete floor in manufacturer’s original packaging

Shipping weight with packaging kg	**Random free-fall drop height** mm	
	With shipping package	**With product package**
< 10	1 000	300
10 – 40	500	300
> 40	250	250
Number of falls [a, b]	Once on each face, edge and corner (e.g. for rectangular package, 6 faces, 12 edges and 8 corners)	

[a] The number and type of falls (face, edge or corner) may be limited depending on handling, shipping and transportation requirements / limitations defined by the manufacturer. If the number is limited, it shall be justified in the test report.

[b] Multiple samples are permitted during test execution.

These requirements of 5.4.4 are verified by testing the EUT to Table 15. After unpacking the EUT shall not show evidence of physical damage and by testing the EUT according to PFVP to 4.2.8.

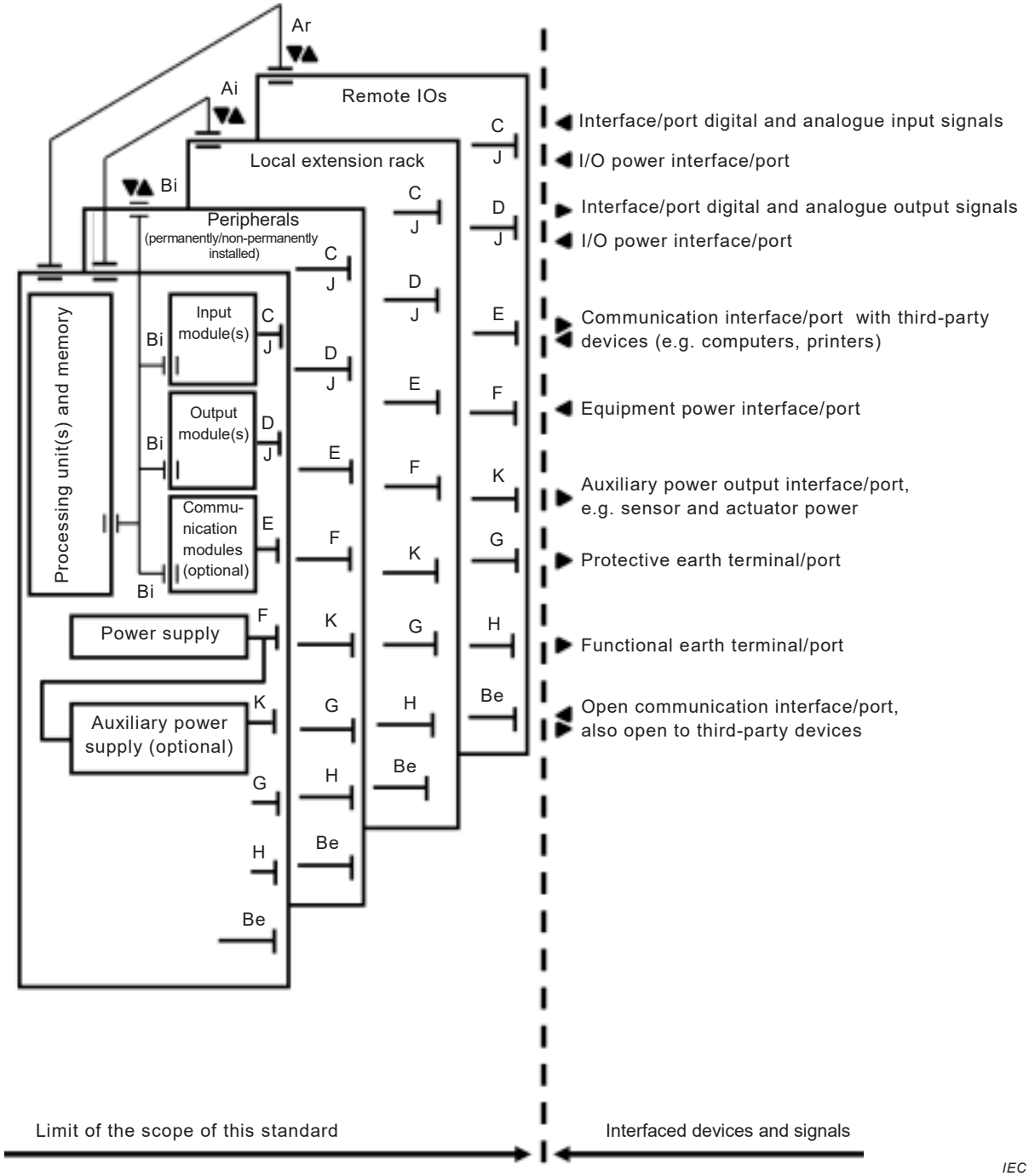
When accessories are to be carried in the same package, they shall be in the package during the fall tests and they shall be checked for damage after unpacking.

Measurement is not required. Vibration sensors may be used at damageable parts or components (e.g. hard disks) to verify compliance with the limits of its data sheet.

6 Functional requirements

6.1 General

A typical modular control equipment and its interfaces / ports is shown in Figure 7. This type of control equipment provides all types of interfaces and ports that are common for the equipment in the scope of this standard.



Key

Al Communication interface/port for local extension rack

Ar Communication interface/port for remote I/O station, control network, fieldbus

Be Open communication interface/port, open to third-party devices; e.g. PADT, personal computer used for programming

Bi Internal communication interface/port, e.g. backplane bus

C Interface/port for digital and analog input signals

D Interface/port for digital and analog output signals

E Serial or parallel communication interfaces/ports for data communication with third-party devices; e.g. computers, printers

F Equipment power interface/port. Devices with F ports have requirements on keeping downstream devices intelligent during power up, power down and power interruptions.

G Protective earth port

H Functional earth port

J I/O power interface/port

K Auxiliary power output interface/port, e.g. sensor and actuators power

Figure 7 – Typical interface/port diagram of a modular control equipment

6.2 Power input ports

NOTE Power input ports are equipment power port (port F, Figure 7).

6.2.1 Requirements

6.2.1.1 Rated values and operating ranges

Incoming power supplies to the control equipment and to the externally powered I/O modules shall be as shown in Table 16.

Table 16 – Rated values and operating ranges of incoming power supply

Voltage		Frequency		Recommended use (R)		Normative items and note[c]
Rated U_e	Tolerance min./max.	Rated f_n	Tolerance min./max.	Power supply	I/0 signals	
d.c. 24 V	–15 %/+20 %			R	R	[a, b]
d.c. 48 V				R	R	[a]
d.c. 125 V						
a.c. 24 V r.m.s.	–15 %/+10 %	50 Hz or 60 Hz	–6 %/+4 %			(NOTE)
a.c. 48 V r.m.s.						(NOTE)
a.c. 100 V r.m.s.				R	R	
a.c. 110 V r.m.s.				R	R	
a.c. 120 V r.m.s.				R	R	(NOTE)
a.c. 200 V r.m.s.				R	R	
a.c. 230 V r.m.s.				R	R	(NOTE)
a.c. 240 V r.m.s.				R	R	
a.c. 400 V r.m.s.				R		[d],(NOTE)

NOTE The rated voltages are derived from IEC 60038.

[a] In addition to the voltage tolerances, a total a.c. component having a peak value of 5 % of the rated voltage is allowed. The absolute limits are d.c. 30/19,2 V for d.c. 24 V and d.c. 60/38,4 V for d.c. 48 V.

[b] See footnote e) of Table 24 if Type 2 digital inputs are likely to be used.

[c] For incoming voltages other than those given in the table such as d.c. 110 V etc., the tolerances given in the table and its note apply. These voltage tolerances shall be used to calculate the input limits of Table 24, using the equations in Annex B.

[d] Three-phase supply.

The requirements of 6.2.1.1 are verified in accordance with 6.2.2.1, 6.2.2.2, 6.2.2.3, 6.2.2.4 and 6.2.2.5.

6.2.1.2 Improper equipment power supply connection

Equipment shall be designed to withstand a reversal of power supply polarity.

The requirements of 6.2.1.2 are verified in accordance with 6.2.2.6.

6.2.1.3 Voltage interruptions power ports

These limits apply to the equipment power interface/port (F) in Figure 7.

For short disturbances of the supply as defined in Table 17, the EUT (including RIOS (see 6.8) and non-permanently installed peripherals) shall maintain normal operation.

For interruptions longer than the maximum interruption time of the supply(ies), the EUT shall either maintain normal operation or go to a predefined state and have a clearly specified behaviour until normal operation is resumed.

NOTE Outputs and fast responding inputs energized by the same supply(ies) can respond to these power supply variations.

Table 17 – Voltage interruptions (functional requirements)

Supply type[e]	Severity level	Maximum interruption time	Low voltage, $U_{e\ min}$ to % U_e[b]
d.c.	PS1[c]	1 ms	0 %
d.c.	PS2[d]	10 ms	0 %
a.c.	PS2[d]	0,5 period[a]	0 %

NOTE See Annex E.

[a] Any arbitrary phase angle, f_n = 50 Hz or 60 Hz (see 6.2.2.7).

[b] $U_{e\ min}$ is the U_e at minimum tolerance in Table 16.

[c] PS1 applies to control equipment energized by battery or d.c. supplies which fulfil PS2.

[d] PS2 applies to control equipment energized from a.c. supplies, rectified a.c. supplies and d.c. supplies (with more severe interruption than PS1).

[e] Voltage interruptions are from $U_{e\ min}$.

The requirements of 6.2.1.3 are verified in accordance with 6.2.2.7.

6.2.2 Verification of power input ports (a.c. or d.c.)

6.2.2.1 Verification test method for voltage range, voltage ripple and frequency

The test method for voltage range, voltage ripple and frequency is shown in Table 18.

Table 18 – Voltage ripple and frequency range immunity test

Reference test	None	
EUT configuration	According to manufacturer's specifications	
Initial measurements	According to PFVP, see 4.2.8	
Test description[a]	Minimum operational voltage	Maximum operational voltage
a.c. voltage (k × U_e)[b]	k = 0,85	k = 1,10
a.c. frequency (k × f_n)[b]	k = 0,94	k = 1,04
d.c. voltage (k × U_e)[b]	k = 0,85	k = 1,20
Ripple continuous (k × U_e)[b]	k = 0,05	k = 0,05
Test duration	30 min	30 min
Measurement and verification during tests	According to PFVP, see 4.2.8	
Verification after tests	According to PFVP, see 4.2.8	
Performance criteria	A	

[a] If there are separate equipment power supplies to the EUT, the tests may be carried out on each supply separately.

[b] See precise definitions in Table 16.

6.2.2.2 Shut-down test (sudden supply interruption)

Test description: during shut-down due to the supply interruption, the EUT behaviour shall be observed. The test is repeated twice.

Performance criteria: The requirement given above shall be met. In addition, from the start of interruption to shut-down, there shall be no change not caused by the normal test programme and no erratic or unintended condition of any kind.

The proper functional verification procedure (PFVP) of 4.2.8 shall be performed during tests.

6.2.2.3 Start-up test

When the external supply is applied for a time specified by the manufacturer, the EUT shall start again according to the specifications of the manufacturer (automatic or manual restart, initialization sequence, etc.). During the start-up, there shall be no erratic or unintended condition.

The proper functional verification procedure (PFVP) of 4.2.8 shall be performed during tests.

6.2.2.4 Gradual shut-down/start-up test

Verification test method for gradual shut-down/start-up requirements are shown in Table 19.

Table 19 – Gradual shut-down/start-up test

Reference test	None
EUT configuration	According to manufacture's specifications
Initial measurements	According to PFVP, see 4.2.8
Test description	Gradual shut-down/start-up (see Figure 8)
Initial/final conditions	Power supply at rated values (U_e, f_n), no ripple
Lowest voltage (V)	0 (zero)
Waiting time at lowest voltage(s)	10 s ± 20 %
Number of trials	3
Time interval between trials	1 s < time interval ≤ 10 s
Measurement and verification during test	According to PFVP, see 4.2.8
Voltage shut-down limit (SDL)	The voltage at which the EUT starts the manufacturer's specified shut-down sequence or initiates a behaviour not in accordance with the PFVP during the decreasing voltage sequence
Average SDL (SDL_{av})	The average of 3 measured SDL

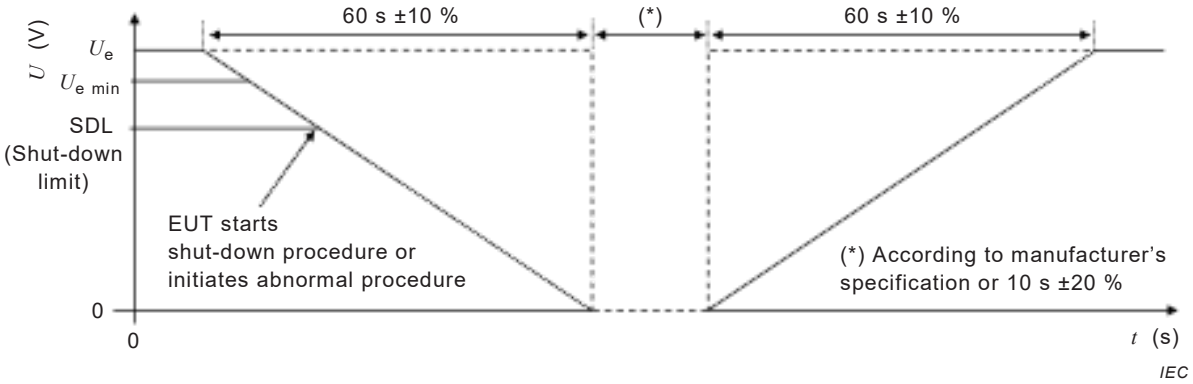


Figure 8 – Gradual shut-down/start-up test

6.2.2.5 Supply voltage variation tests

Verification test method for supply voltage variation requirements are shown in Table 20.

Table 20 – Supply voltage variation tests

Reference test	None	
EUT configuration	According to manufacture's specifications	
Initial measurements	According to PFVP, see 4.2.8	
Test descriptions	Fast supply voltage variation (See Figure 9)	Slow supply voltage variation (See Figure 10)
Initial/final conditions	Power supply at rated values ($U_{e\ min}$, f_n), no ripple	
Lowest voltage (U)	0 (zero)	0,9 SDL_{av} ± 10 % [a]
Waiting time at lowest voltage(s)	0 (zero)	0 (zero)
Number of trials	3	3
Time interval between trials	1 s < time interval ≤ 5 s	
Measurement and verification during tests	According to PFVP, see 4.2.8	
[a] SDL_{av} is a result of the gradual shut-down test (see 6.2.2.4).		

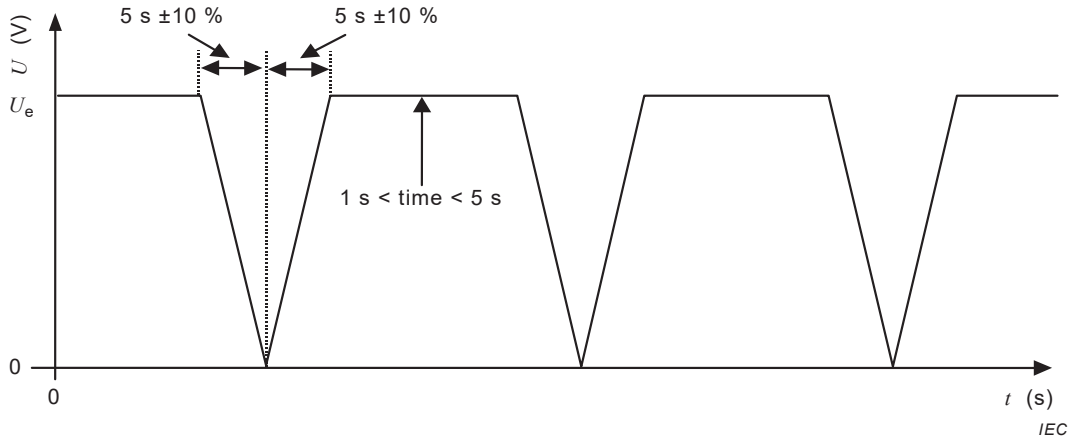


Figure 9 – Fast supply voltage variation test

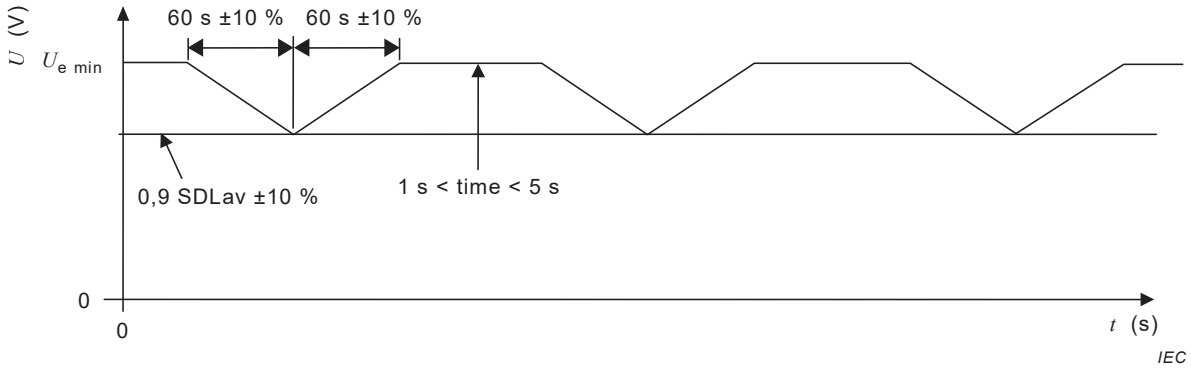


Figure 10 – Slow supply voltage variation test

6.2.2.6 Reversal of d.c. power supply polarity

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of power polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated voltage, of reverse polarity, shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8) after the test.

6.2.2.7 Voltage interruptions verification method

Power ports are equipment power input port, port F, Figure 7. Verification test method for voltage interruptions are shown in Table 21.

Table 21 – Voltage interruptions immunity test (Functional tests)

Reference test	IEC 61000-4-11[f]	IEC 61000-4-29	
EUT configuration	According to manufacturer's specifications		
Initial measurements	According to PFVP, see 4.2.8		
Supply voltage and frequency	$U_{e\ min}$, f_n [e]	$U_{e\ min}$ [e]	
	a.c. supply interruption	d.c. supply interruption	
Duration	0,5 period, starting at zero-crossing[a, b]	PS1: ≥ 1 ms[b]	PS2: ≥ 10 ms[b]
$U_{e\ min}$ to %$U_{e\ min}$ [e]	0 (zero) %	0 (zero) %	0 (zero) %
Performance criteria	The EUT shall continue to operate as intended. No loss of function or performance[d]		
Number of trials	20		
Time interval between trials	1 s < time interval < 10 s		
Measurement and verification during tests	Normal operation shall be maintained[c] According to PFVP, see 4.2.8		
Verification after tests	The EUT shall continue to operate as intended. According to PFVP, see 4.2.8		

[a] Optionally, the manufacturer may elect to interrupt supply at a random phase angle.

[b] The manufacturer may state longer interruptions.

[c] Outputs and fast responding inputs energized by the same power supply may be affected temporarily during the disturbance but shall resume normal operation after the disturbance.

[d] These criteria are synonymous with Table 1, Criteria A.

[e] $U_{e\ min}$ is the U_e at minimum tolerance in Table 16.

[f] This test is the same as one portion of the test in 7.3.2, Table 46. A single test may be used to satisfy both requirements..

6.3 Memory power back-up

6.3.1 Requirements

Power back-up for volatile memories shall be capable of maintaining stored information for at least 300 h under normal use, and 1 000 h at an ambient temperature not greater than 25 °C when the energy source is at rated capacity. (For power back-up needing replacement, the rated capacity is the value used to designate the procedure and time interval for replacement.)

The manufacturer shall specify storage time information relative to volatile memory if different from stated durations.

It shall be possible to change or refresh power back-up without loss of data in the backed-up portions of memory. (See also 5.4, 8.3.5 item h) and 8.3.12 item d).)

Equipment shall be designed to withstand a reversal of memory power back-up polarity.

If a memory back-up battery is provided, a warning of "low battery voltage" shall be provided.

The requirements of 6.3.1 are verified in accordance with 6.3.2.

6.3.2 Verification of memory power back-up requirements

6.3.2.1 Back-up duration withstand test

Verification test method for back-up duration requirements.

Table 22 – Back-up duration withstand test

Reference test	None	
EUT configuration	According to PFVP, see 4.2.8	
Duration of preparation	According to manufacturer's specifications (energy source may require time to be fully charged)	
Tests to be performed	Either Test A or Test B defined below	
Test descriptions	Test A	Test B
Initial conditions	Energy source fully charged; external energy supply disconnected	
Ambient temperature	Open equipment 55 °C Enclosed equipment 40 °C	General conditions (4.2.9)
Duration	300 h	1 000 h
Verification after the test	According to PFVP, see 4.2.8. The EUT shall be fully operational. No loss of retentive data is allowed.	

6.3.2.2 Verification of manufacturer's method of changing the energy source

Verification test method for energy storage changing requirements.

The energy source shall be replaced, according to the manufacturer's instructions.

Table 23 – Change of energy source test

Reference test	None
EUT configuration	According to PFVP, see 4.2.8
Replacement of energy source	According to the manufacturer's specifications (energy source may require time to be fully charged).
Verification after the tests	According to PFVP, see 4.2.8. The EUT shall be fully operational. No loss of retentive information is allowed.

No loss of data shall occur.

6.3.2.3 Verification of reversal of memory power back-up polarity

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of power polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated voltage, of reverse polarity, shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8).

6.3.2.4 Verification of low battery voltage warning requirements

The required warning of "low battery voltage" shall be checked. The energy source shall be removed and the proper controlled voltage shall be applied in place of the energy source.

The low battery voltage warning, as specified by the manufacturer, e.g. LED, software tag, shall change state at or above (above means there is more energy available than necessary) the specified level.

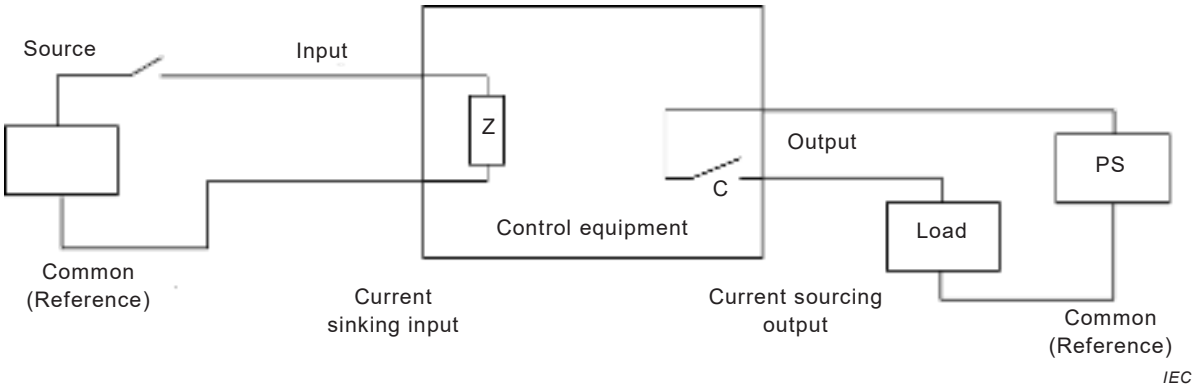
6.4 Digital I/Os

6.4.1 General

Ports C is the interface/port for digital input signals. Port D is the interface/port for digital output signals. See Figure 7.

6.4.2 Positive logic digital I/Os (sinking inputs / sourcing outputs)

Figure 11 gives an illustration of definitions for positive logic I/O parameters.



Key

C Output: Mechanical or static contact (e.g. dry relay contact, triac, transistor or equivalent)

Z Input: Input impedance

PS External power supplies

NOTE Some applications may use only one PS common to inputs, outputs and control equipment.

Figure 11 – Positive logic (sinking inputs / sourcing outputs)

Digital inputs shall comply with the requirements of the standard voltage ratings given in 6.4.4.2. Non-standard voltage digital inputs shall be in accordance with the design equation given in Annex B.

Digital outputs shall comply with the requirements of the standard ratings given in 6.4.5.1 for a.c. or 6.4.6.1 for d.c.

It shall be possible to interconnect inputs and outputs by means of a correct selection of the above digital I/Os, resulting in proper control equipment operation. Additional external load shall be specified by the manufacturer if necessary.

It shall be possible to feed isolated per channel, multi-channel, modules from different voltage sources. In this case the channels shall comply with the maximum voltage difference occurring between the voltage sources. Example: An a.c. input module having channels attached to different phases of the line. The channels shall then comply with the maximum voltage difference occuring between phases.

6.4.3 Negative logic digital I/Os (sourcing inputs / sinking outputs)

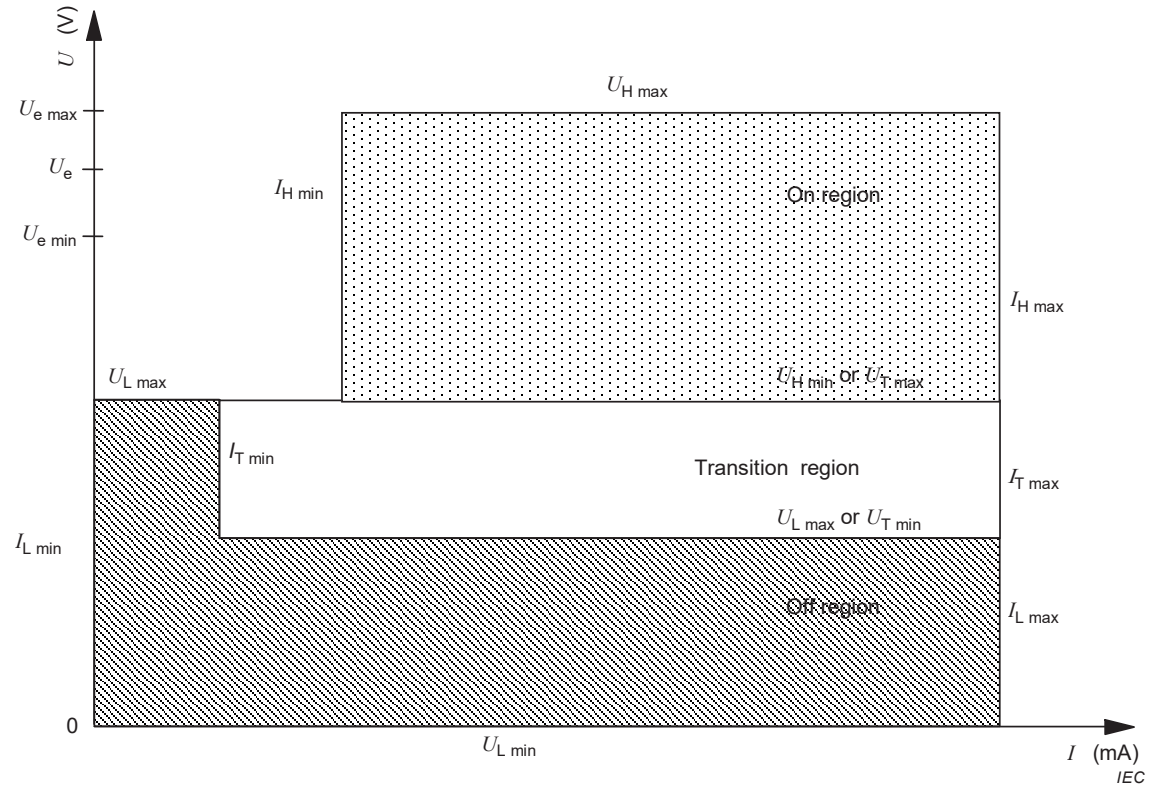
Current-sourcing inputs and current-sinking outputs which may be required for certain applications are covered in this standard. See Annex F.

6.4.4 Digital inputs (positive logic, current sinking)

6.4.4.1 *U*/*I* operation regions

Figure 12 represents graphically the limits and operating ranges which are used herein to characterize current sinking digital input circuits.

The operating region consists of “on region”, “transition region” and “off region”. It is necessary to exceed both $U_{T\ min}$ and $I_{T\ min}$ to leave the “off region”, and to exceed both $I_{H\ min}$ and $U_{H\ min}$ to enter the “on region”. All input U-I curves shall remain within these boundary conditions. The region below zero volt is a valid part of the “off region” for d.c. inputs only.



U_{Hmax} and U_{Hmin} are the voltage limits for the on conditions (state 1)

I_{Hmax} and I_{Hmin} are the current limits for the on conditions (state 1)

U_{Tmax} and U_{Tmin} are the voltage limits for the transition state (on or off)

I_{Tmax} and I_{Tmin} are the current limits for the transition state (on or off)

U_{Lmax} and U_{Lmin} are the voltage limits for the off conditions (state 0)

I_{Lmax} and I_{Lmin} are the current limits for the off conditions (state 0)

U_{Lmax} equals U_{Hmin} to I_{Tmin} and equals U_{Tmin} above I_{Tmin}

U_e, $U_{e\ max}$ and $U_{e\ min}$ are the rated voltage and its limits for the external power supply voltage

Figure 12 – U-I operation regions of current-sinking inputs

6.4.4.2 Operating ranges for digital inputs (current sinking)

Current-sinking digital inputs shall operate within the limits presented in Table 24. See Annex B.

Table 24 – Operating ranges for digital inputs (current sinking)

			Input style												
			Type 1 limits						Type 3 limits, (Note)						
			State 0		Transition		State 1		State 0		Transition		State 1		
Rated voltage U_e	Rated frequency $f_{n\ Hz}$	Type of limit	UL V	IL mA	UT V	IT mA	UH V	IH mA	UL V	IL mA	UT V	IT mA	UH V	IH mA	Normative items
d.c. 24 V		Max.	15/5	15	15	15	30	15	11/5	15	11	15	30	15	a, b,d, e
		Min.	–3	ND	5	0,5	15	2	–3	ND	5	1,5	11	2	
d.c. 48 V		Max.	34/10	15	34	15	60	15	30/10	15	30	15	60	15	a, b, d
		Min.	–6	ND	10	0,5	34	2	–6	ND	10	1,5	30	2	
a.c. 24 V r.m.s.	50/60	Max.	14/5	15	14	15	27	15	10/5	15	10	15	27	15	a, c
		Min.	0	0	5	1	14	2	0	0	5	2	10	5	
a.c. 48 V r.m.s.	50/60	Max.	34/10	15	34	15	53	15	30/10	15	30	15	53	15	a, c
		Min.	0	0	10	1	34	2	0	0	10	2	30	5	
a.c. 100 V r.m.s. a.c. 110 V r.m.s. a.c. 120 V r.m.s.	50/60	Max.	79/20	15	79	15	1,1 U_e	15	74/20	15	74	15	1,1 U_e	15	a, c, d, e
		Min.	0	0	20	1	79	2	0	0	20	2,5	74	5	
a.c. 200 V r.m.s. a.c. 230 V r.m.s. a.c. 240 V r.m.s.	50/60	Max.	164/40	15	164	15	1,1 U_e	15	159/40	15	159	15	1,1 U_e	15	a, c, d, e
		Min.	0	0	40	2	164	3	0	0	40	2,5	159	5	

NOTE Compatibility with 2-wire proximity switches according to IEC 60947-5-2 is possible with Type 3. See also c) above.

[a] All logic signals are in positive logic. Open inputs shall be interpreted as state 0 signal. See Annex B for equations and assumptions used in developing values in this table and for additional comments.

[b] The given voltage limits include all alternating voltages components.

[c] Static switches may affect the total r.m.s. content of true harmonics of the input signals and therefore affect the compatibility of the input interface with proximity switches. See 6.2.1 for requirements.

[d] Recommended for common usage and future designs.

[e] As allowed by current technology, and to encourage the design of single input modules compatible with all commonly used rated voltages, limits are absolute and independent of rated voltage (except $U_{H\ max}$) and based on equations given in Annex B and respectively a.c. 100 V r.m.s. and a.c. 200 V r.m.s.

ND = Not defined

6.4.4.3 Input Type 3-d (Type 3 with diagnostics)

Input Type 3-d, diagnostic type, shall provide the characteristics shown in Figure 13. These characteristics are compatible with non-diagnostic input Type 3.

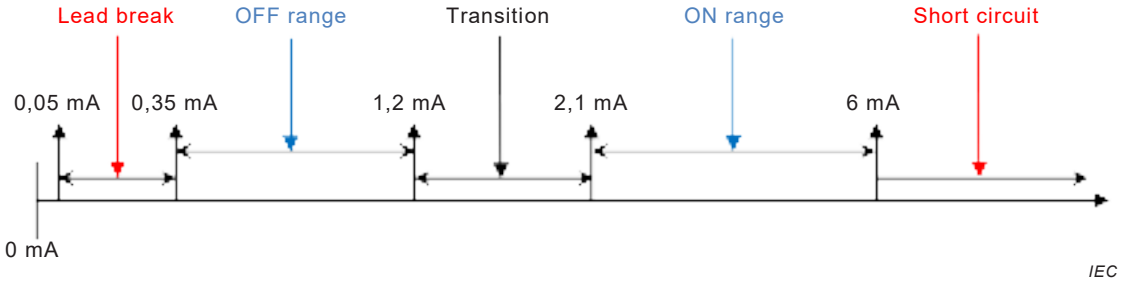


Figure 13 – Input Type 3 Diagnostic

Lead break/wire off = 0,05 mA ≤ I ≤ 0,35 mA

OFF = I ≤ 1,2 mA

ON = I ≥ 2,1 mA

$I_{hysteresis}$ = 0,1-0,3 mA

Lead/wire short circuit = I ≥ 6 mA

NOTE This characteristic is compatible with IEC 60947-5-6 and NAMUR DIN 19234, for resistive inputs.

The requirements of this 6.4.4.3 are verified in accordance with 6.4.4.5.

6.4.4.4 Input indication requirements

Each input channel shall be provided with either a software or hardware indicator to indicate the state 1 condition, i.e. state 1 = ON.

These requirements are verified by inspection.

6.4.4.5 Verification of digital inputs

6.4.4.5.1 General

Unless otherwise specified in 6.4.4.5.1, all tests shall be carried out twice on the same I/O channel(s).

- First test: at minimum ambient temperature (T_{min}), i.e. T_{min} given in Table 3.
- Second test: at maximum ambient temperature (T_{max}), i.e. T_{max} given in Table 3.

It is not required to test more than 1 digital input channel of each type, but all different types which are represented in the EUT shall be tested.

However, tests where module maximum capability is tested shall be performed on all channels of multi-channel modules, e.g. module current capacity, power dissipation, temperature.

6.4.4.5.2 Operating range test

It shall be verified that all requirements, of the input type specified per 6.4.4, are met.

6.4.4.5.3 Reversal of signal polarity test

Protective devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of signal polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated signal, of reverse polarity, for digital inputs shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8).

6.4.5 Digital outputs for alternating currents (positive logic, current sourcing)

6.4.5.1 Rated values and operating ranges (a.c.)

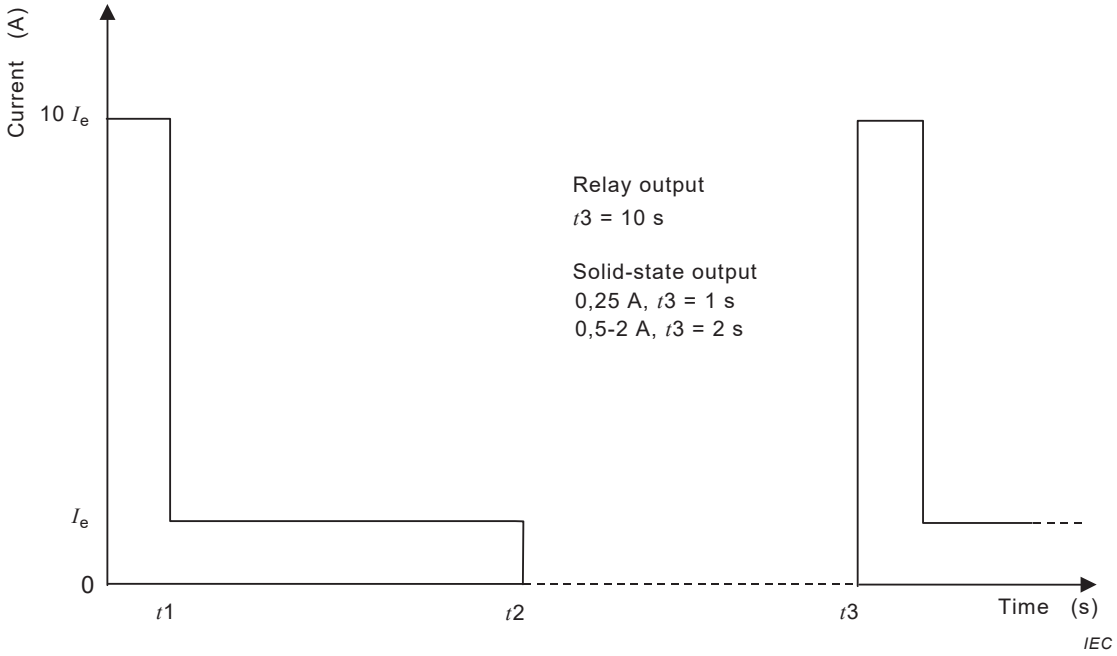
Digital a.c. outputs shall comply with the ratings given in Table 25, at the output voltage(s) stated by the manufacturer according to 6.2.1.

Table 25 – Rated values and operating ranges for current sourcing digital a.c. outputs

			a.c. output style				
			Type 0,25	**Type 0,5**	**Type 1**	**Type 2**	
Rated current (state 1)		I_e A	**0,25**	**0,5**	**1**	**2**	**Normative items**
Current range for state 1		Min. (mA)	10 [5]	20	100	100	a, b
(continuous at max. voltage)		Max. (A)	0,28	0,55	1,1	2,2	a
Voltage drop, U_d for state 1	Non protected output	Max. (V)	3	3	3	3	a
	Protected and short-circuit proof	Max. (V)	5	5	5	5	a
Leakage current for state 0	Solid-state outputs	Max. (mA)	5 [3]	10	10	10	a, b
	Electromechanical outputs	Max. (mA)	2,5	2,5	2,5	2,5	a
Operating cycle time repetition rate for temporary overload, (see Figure 14)	Solid-state outputs	Max. (s)	1	2	2	2	
	Relay-based outputs	Max. (s)	10	10	10	10	

[a] RMS currents and voltages.

[b] Figures in square brackets apply to a module not equipped with RC network or equivalent surge suppressers. All other values apply to modules with suppression.



t1: 2 cycles at fn (fn = rated line frequency)

t2: ON time

t3 – t2: OFF time (OFF time = ON time)

t3: Operation time

Figure 14 – Temporary overload waveform for digital a.c. outputs

6.4.5.2 Output indication requirements

Each output channel shall be provided with either a software or hardware indicator to indicate the state 1 condition, i.e. state 1 = ON.

These requirements are verified by inspection.

6.4.5.3 Protected outputs requirements

For outputs stated by the manufacturer to be protected,

a) the output shall either withstand and/or the associated protective device shall operate to protect the output for all steady-state values of output current greater than 1,1 times the rated value;

b) after resetting or replacement of the protective device alone, as applicable, the control equipment shall return to normal operation;

c) optional restart capabilities shall be selected among the 3 following types:

   1) automated restart protected output: a protected output which automatically recovers after the overload is removed;

   2) controlled restart protected output: a protected output which is reset through signals (for example, for remote control);

   3) manual restart protected output: a protected output which implies a human action to recover (the protection may be fuses, electronic interlocks, etc.).

These requirements are verified in accordance with 6.4.5.10.3.

NOTE 1 Operation under overload condition for an extended period of time can affect the operating life of the module.

NOTE 2 The protected outputs will not necessarily protect the field wiring.

6.4.5.4 Short-circuit-proof outputs requirements

For outputs stated by the manufacturer to be short-circuit-proof:

a) for all output currents greater than $I_{e\ max.}$ and up to 2 times the rated value I_e, the output shall operate and withstand temporary overload(s). Such temporary overload(s) shall be specified by the manufacturer.

b) for all output currents prospectively above 20 times the rated value, the protective device shall operate. After resetting or replacement of the protective device alone, the control equipment shall return to normal operation.

c) for output currents in the range of 2 times to 20 times I_e, or for temporary overload(s) beyond the limits specified by the manufacturer (item a) above), the module may require repair or replacement.

These requirements are verified in accordance with 6.4.5.10.3.

6.4.5.5 Externally-protected outputs requirements

For outputs stated by the manufacturer to be externally-protected, the manufacturer shall recommend an external protection device. The outputs shall meet all the requirements stated for the short-circuit-proof outputs (6.4.5.4), when the external protection device is installed.

6.4.5.6 Electromechanical relay outputs requirements

Electromechanical relay outputs shall be capable of performing a number of operations, as specified by the manufacturer, with the load specified for AC-15 utilization category according to IEC 60947-5-1:2016, Annex C.

Overload and endurance type tests are not required if the relay components have been shown to comply with the requirements of IEC 60947-5-1.

NOTE The overload and endurance type test can be combined with the safety evaluation according to IEC 61010-2-201.

6.4.5.7 Discrete semiconductor outputs requirements

Discrete semiconductor outputs shall be capable of performing at least 3 million operations with the load specified for AC-15 utilization category (durability class 3) according to IEC 60947-5-1:2016, Annex C.

NOTE The overload and endurance type tests can be combined with the safety evaluation according to IEC 61010-2-201.

6.4.5.8 Overload test requirements

Switching devices shall close and open a test circuit having the current, voltage, and power factor values given in Table 26. Fifty cycles, each consisting of 1 closing and 1 opening, shall be completed using a timing of 1 s ON, 9 s OFF. After completion of the 50 cycles, the equipment shall be subjected to the endurance test in 6.4.5.9.

Table 26 – Overload test circuit values

Intended load	Current	Voltage	Power factor
AC general use	1,5 × RATED	RATED	0,75 to 0,80
DC general use	1,5 × RATED	RATED	-
AC resistance	1,5 × RATED	RATED	1,0
DC resistance	1,5 × RATED	RATED	-
AC pilot duty [a]	RATED [a]	1,1 × RATED [b]	<0,35
DC pilot duty [a]	RATED [a]	1,1 × RATED [b]	-

NOTE 1 Source IEC 60947-5-1.

NOTE 2 Pilot duty = rating assigned to a relay or switch that controls the coil of another relay or switch.

[a] Unless otherwise specified, the inrush current shall be 10 times the steady-state current.

[b] Set up the EUT at its RATED voltage and current and then increase the voltage by 10 % without further adjustment of the load.

Verification: After test completion the device shall pass the PFVP (see 4.2.8).

6.4.5.9 Endurance test requirements

After completion of the overload test in 6.4.5.8, the switching device is to close and open a test circuit having the current, voltage, and power factor values given in Table 27. A total of 6 000 cycles, consisting of 1 closing and 1 opening, shall be completed. The cycle timing shall be 1 s ON and 9 s OFF, except for the first 1 000 cycles of the pilot duty test. The first 1 000 cycles of the pilot duty test shall be at a rate of 1 cycle per second except that the first 10 to 12 cycles are to be as fast as possible.

The endurance test need not be conducted on solid-state output devices for general or resistive use.

Table 27 – Endurance test circuit values

Intended load	Current	Voltage	Power factor
AC general use	RATED	RATED	0,75 to 0,80
DC general use	RATED	RATED	-
AC resistance	RATED	RATED	1,0
DC resistance	RATED	RATED	-
AC pilot duty [a]	RATED	RATED	<0,35
DC pilot duty [a]	RATED	RATED	-

NOTE 1 Source IEC60947-5-1.

NOTE 2 Pilot duty = rating assigned to a relay or switch that controls the coil of another relay or switch.

[a] The test circuit is identical to the overload test circuit except that the voltage is the RATED voltage.

Verification: After test completion the device shall pass the PFVP (see 4.2.8).

6.4.5.10 Verification of digital a.c. outputs

6.4.5.10.1 General

Unless otherwise specified in 6.4.5.10.1, all tests shall be carried out twice on the same I/O channel(s).

- First test: at minimum ambient temperature (T_{min}), i.e. T_{min} given in Table 3.
- Second test: at maximum ambient temperature (T_{max}), i.e. T_{max} given in Table 3.

It is not required to test more than 1 digital a.c. output channel of each type, but all different types which are represented in the control equipment shall be tested.

However, tests where module maximum capability is tested shall be performed on all channels of multi-channel modules, e.g. module current capacity, power dissipation, temperature.

6.4.5.10.2 Operating range test

It shall be verified that all requirements, of the output type specified per 6.4.5 are met.

Test procedures:

- Current range: Tested at minimum, mid-range and maximum value of Output Type.
- Leakage current: If external devices/circuits intended for output protection are specified in the user manual (see Clause 8) they shall be installed.
- Temporary overload: According to IEC 60947-5-1, (AC-15). For short-circuit proof outputs, the current values shall be respectively 2 I_e to 20 I_e (as given in 6.4.5.4).

6.4.5.10.3 Test of protected, not-protected, and short-circuit proof outputs

Verification test method for overload and short circuit requirements is given in Table 28.

Table 28 – Overload and short-circuit tests for digital outputs

Reference test	**None**				
EUT configuration	According to manufacturer's specifications				
Details of mounting/support	According to manufacturer's specifications				
Loading	It is sufficient to check one I/O channel of each type under test				
Initial measurements	According to PFVP, see 4.2.8				
Description of the tests	A	B	C	D	E
Prospective currents (k × I_e)	1,2/1,3[a]	1,5	2	5	21
Duration of test (min)	5	5	5	5	5
Order of trials					
First series (at T_{min})	1	2	3	4	5
Second series (at T_{max})	6	7	8	9	10
Time intervals between tests	10 min ≤ time intervals ≤ 60 min				
Application of the test protected outputs	Yes	Yes	Yes	Yes	Yes
Short-circuit proof outputs	No	No	Yes[b]	No	Yes[d]
Not-protected outputs[c]	No	No	Yes[b]	No	Yes[d]
Measurement and verification	See requirements in 6.4.5.3 or 6.4.5.4				
during the overload	According to PFVP, see 4.2.8				
immediately after overload	According to PFVP, see 4.2.8				
after overload and proper resetting	According to PFVP, see 4.2.8				

[a] 1,2 for a.c. outputs.

[b] For currents in the range of 2 times to 20 times I_e, the module may require repair or replacement.

[c] Protective device(s) to be provided or specified by the manufacturer shall be installed.

[d] Protective device(s) shall operate. They shall be reset or replaced as applicable for the following test.

6.4.5.10.4 Reversal of signal polarity test

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of signal polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated signal, of reverse polarity, shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8).

6.4.6 Digital outputs for direct current (current sourcing)

6.4.6.1 Rated values and operating ranges (d.c.)

Digital outputs shall comply with the ratings given in Table 29, at the output voltage(s) stated by the manufacturer according to 6.2.1.

Table 29 – Rated values and operating ranges (d.c.) for current-sourcing digital d.c. outputs

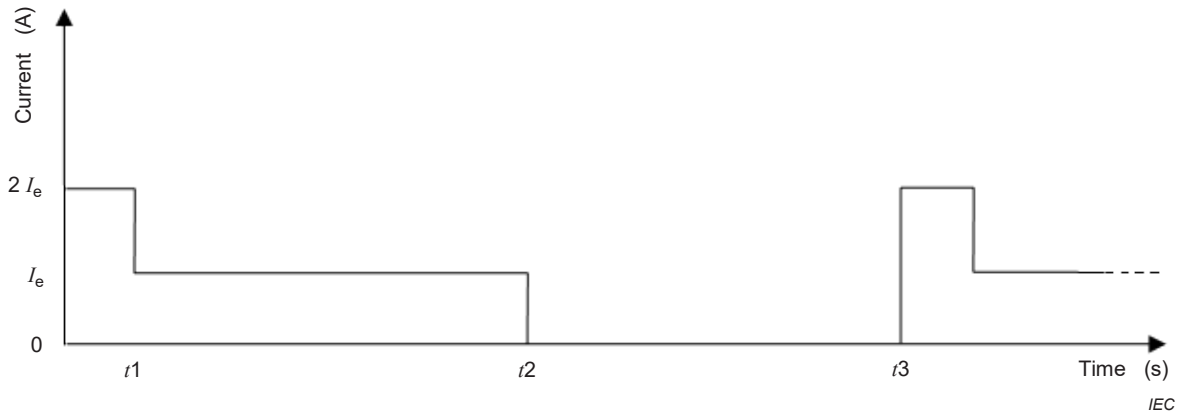
			d.c. output style					
			Type 0,1	**Type 0,25**	**Type 0,5**	**Type 1**	**Type 2**	
Rated current for state 1		**I_e (A)**	**0,1**	**0,25**	**0,5**	**1**	**2**	**Norma-tive items**
Current range for state 1 at maximum voltage (continuous)		Max. (A)	0,12	0,3	0,6	1,2	2,4	
Voltage drop, U_d	Non-protected output	Max. (V)	3	3	3	3	3	
	Protected and short-circuit-proof	Max. (V)	3	3	3	3	3	[a]
Leakage current for state 0		Max. (mA)	0,1	0,5	0,5	1	1	[b, c]
Temporary overload		Max. (A)	See Figure 15 or as specified by manufacturer					

[a] For 1 A and 2 A rated currents, if reverse polarity protection is provided, a 5 V drop is allowed. This makes the output incompatible with a type 1 input of the same voltage rating.

[b] The resulting compatibility between d.c. outputs and d.c. inputs, without additional external load, is as follows:

	Output Type 0,1	Output Type 0,25	Output Type 0,5	Output Type 1	Output Type 2
Input Type 1:	yes	yes	yes	no	no
Input Type 3:	yes	yes	yes	yes	yes

[c] With adequate external load, all d.c. outputs may become compatible with all Type 1 and Type 3 d.c. inputs.



$t1$ = surge time = 10 ms

$t2$ = ON time

$t3 - t2$ = OFF time (OFF time = ON time)

$t3$ = operation time = 1 s

Figure 15 – Temporary overload waveform for digital d.c. outputs

6.4.6.2 Output indication requirements

Each output channel shall be provided with either a software or hardware indicator to indicate the state 1 condition, i.e. state 1 = ON.

These requirements are verified by inspection.

6.4.6.3 Protected outputs requirements

For outputs stated by the manufacturer to be protected,

a) the output shall either withstand and/or the associated protective device shall operate to protect the output for all steady-state values of output current greater than 1,2 times the rated value;

b) after resetting or replacement of the protective device alone, as applicable, the control equipment shall return to normal operation;

c) optional restart capabilities shall be selected among the 3 following types:

   1) automated restart protected output: a protected output which automatically recovers after the overload is removed;

   2) controlled restart protected output: a protected output which is reset through signals (for example, for remote control);

   3) manual restart protected output: a protected output which implies a human action to recover (the protection may be fuses, electronic interlocks, etc.).

The requirements of 6.4.6.3 are verified in accordance with 6.4.6.10.3.

NOTE 1 Operation under overload condition for an extended period of time can affect the operating life of the module.

NOTE 2 The protected outputs will not necessarily protect the field wiring.

6.4.6.4 Short-circuit-proof outputs requirements

For outputs stated by the manufacturer to be short-circuit-proof:

a) for all output currents greater than $I_{e\ max.}$ and up to 2 times the rated value I_e, the output shall operate and withstand temporary overload(s). Such temporary overload(s) shall be specified by the manufacturer.

b) for all output currents prospectively above 20 times the rated value, the protective device shall operate. After resetting or replacement of the protective device alone, the control equipment shall return to normal operation.

c) for output currents in the range of 2 times to 20 times I_e, or for temporary overload(s) beyond the limits specified by the manufacturer (item a) above), the module may require repair or replacement.

The requirements of 6.4.6.4 are verified in accordance with 6.4.6.10.3.

6.4.6.5 Externally-protected outputs requirements

For outputs stated by the manufacturer to be externally-protected, the manufacturer shall recommend an external protection device. The outputs shall meet all the requirements stated for the short-circuit-proof outputs (6.4.5.4), when the external protection device is installed.

6.4.6.6 Electromechanical relay outputs requirements

Electromechanical relay outputs shall be capable of performing a number of operations, as specified by the manufacturer, with the load specified for DC-13 utilization category according to IEC 60947-5-1:2016, Annex C.

Overload and endurance type tests are not required if the relay components have been shown to comply with the requirements of IEC 60947-5-1.

NOTE The overload and endurance type test can be combined with the safety evaluation according to IEC 61010-2-201.

6.4.6.7 Discrete semiconductor outputs requirements

Discrete semiconductor outputs shall be capable of performing at least 3 million operations with the load specified for DC-13 utilization category (durability class 3) according to IEC 60947-5-1:2016, Annex C.

NOTE The overload and endurance type test can be combined with the safety evaluation according to IEC 61010-2-201.

6.4.6.8 Overload test requirements

See 6.4.5.8.

6.4.6.9 Endurance test requirements

See 6.4.5.9.

6.4.6.10 Verification of digital d.c. outputs

6.4.6.10.1 General

Unless otherwise specified in 6.4.6.10.1, all tests shall be carried out twice on the same I/O channel(s).

- First test: at minimum ambient temperature (T_{min}), i.e. T_{min} given in Table 3.
- Second test: at maximum ambient temperature (T_{max}), i.e. T_{max} given in Table 3.

It is not required to test more than 1 digital d.c. output channel of each type, but all different types which are represented in the EUT shall be tested.

However, tests where module maximum capability is tested shall be performed on all channels of multi-channel modules, e.g. module current capacity, power dissipation, temperature.

6.4.6.10.2 Operating range test

It shall be verified that all requirements, of the output type specified per 6.4.6 are met.

Test procedures:

- Current range: Tested at minimum, mid-range and maximum value of Output Type.
- Leakage current: If external devices/circuits intended for output protection are specified in the user manual (see Clause 8) they shall be installed.
- Temporary overload: According to IEC 60947-5-1, (DC-13). For short-circuit proof outputs, the current values shall be respectively 2 I_e to 20 I_e (as given in 6.4.6.4).

6.4.6.10.3 Test of protected, not-protected, and short-circuit proof outputs

Verification test method for overload and short circuit requirements.

Table 30 – Overload and short-circuit tests for digital outputs

Reference test	None				
EUT configuration	According to manufacturer's specifications				
Details of mounting/support	According to manufacturer's specifications				
Loading	It is sufficient to check one I/O channel of each type under test				
Initial measurements	According to PFVP, see 4.2.8				
Description of the tests	A	B	C	D	E
Prospective currents (k × I_e)	1,2/1,3[a]	1,5	2	5	21
Duration of test (min)	5	5	5	5	5
Order of trials					
First series (at T_{min})	1	2	3	4	5
Second series (at T_{max})	6	7	8	9	10
Time intervals between tests	10 min ≤ time intervals ≤ 60 min				
Application of the test protected outputs	Yes	Yes	Yes	Yes	Yes
Short-circuit proof outputs	No	No	Yes[b]	No	Yes[d]
Not-protected outputs[c]	No	No	Yes[b]	No	Yes[d]
Measurement and verification	See requirements in 6.4.6.3 or 6.4.6.4				
during the overload	According to PFVP, see 4.2.8				
immediately after overload	According to PFVP, see 4.2.8				
after overload and proper resetting	According to PFVP, see 4.2.8				

[a] 1,3 for d.c. outputs.

[b] For currents in the range of 2 times to 20 times I_e, the module may require repair or replacement.

[c] Protective device(s) to be provided or specified by the manufacturer shall be installed.

[d] Protective device(s) shall operate. They shall be reset or replaced as applicable for the following test.

6.4.6.10.4 Reversal of signal polarity test

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of signal polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated signal, of reverse polarity, shall be applied for 10 s.

After the test, the device shall pass the PFVP (see 4.2.8).

6.4.7 Requirements for discrete channel compatibility with IEC 61131-9 SDCI

If a channel utilizes single-drop digital communication interface for small sensors and actuators (SDCI), it shall comply with the requirements of IEC 61131-9.

6.4.8 Special digital I/O interfaces

A control equipment may be offered with digital I/O interfaces that are not covered in this standard, e.g. high power contactor drivers. In such a case, the manufacturer's data shall give all relevant information for its utilization.

The requirements of 6.4.8 are verified in accordance with procedures defined by the manufacturer. These procedures shall be documented in the test report, see 4.3.

6.5 Analog I/Os

6.5.1 General

Ports C is the interface/port for analog input signals. Port D is the interface/port for analog output signals. See Figure 7.

Utilize ANSI/ISA-50.00.01-1975 as source for analog ranges.

6.5.2 Analog inputs

Rated values of signal range and impedance for analog inputs to control equipments shall be as specified in Table 31.

Table 31 – Rated values and impedance limits for analog inputs

Signal range	Input impedance limits	Normative items
± 10 V	≥ 10 kΩ	
0-10 V	≥ 10 kΩ	
1-5 V	≥ 5 kΩ	
4 mA to 20 mA	≤ 300 Ω	

6.5.3 Analog outputs

Rated values of signals range and load impedance for analog outputs of control equipment shall be as specified in Table 32.

Table 32 – Rated values and impedance limits for analog outputs

Signal range	Load impedance limits	Normative items
± 10 V	≥ 1 000 Ω	[a]
0-10 V	≥ 1 000 Ω	[a]
1-5 V	≥ 500 Ω	[a]
4 mA to 20 mA	≤ 600 Ω	[a]
[a] Outputs shall withstand any overload from open circuit to short circuit.		

6.5.4 Analog temperature inputs

Analog inputs may be designed to be compatible with standard thermocouples or standard resistive temperature devices (RTDs) such as PT100 sensors.

Thermocouple analog inputs shall provide a method for cold-junction compensation.

6.5.5 Requirements for analog channel compatibility with HART® (Highway Addressable Remote Transducer)

6.5.5.1 General

If a channel utilizes HART®, it shall comply with the requirements of HART® (Highway Addressable Remote Transducer) Communication Protocol Specification, 7.5, HCF_SPEC-13.

The requirements of 6.5.5.1 are verified in accordance with 6.5.5.2.

6.5.5.2 Verification of HART® communication interface requirements

Manufacturer shall verify performance capability. This may be by internal testing or e.g. by external organization providing a certification.

If the communication port is specified by an open protocol e.g. HART®, it shall be tested to the requirements of those standards. These verification / test requirements are generally supplied by the fieldbus or technology provider organizations (e.g. HART® Foundation).

6.5.6 Verification of analog I/Os

6.5.6.1 General

Unless otherwise specified in 6.5.6.1, all tests shall be carried out twice on the same I/O channel(s).

- First test: at minimum ambient temperature (T_{min}), i.e. T_{min} given in Table 3.
- Second test: at maximum ambient temperature (T_{max}), i.e. T_{max} given in Table 3.

It is not required to test more than 1 analog input channel and 1 analog output channel of each type, but all different types which are represented in the EUT shall be tested.

However, tests where module maximum capability is tested shall be performed on all channels of multi-channel modules, e.g. module current capacity, power dissipation, temperature.

6.5.6.2 Operating range tests

Verify that all requirements are met. It is acknowledged that analog I/O offer a more or less infinite set of verification possibilities. A simple practical subset shall be tested, which addresses the basic or most important capability of analog I/O. This simplified test is not meant to eliminate the requirement that a specified parameter meets its specified rating, it is simply an acknowledgement of a practical subset of type tests.

Example of a simple practical subset, test procedure:

All range types offered in the manufacturer's datasheet (e.g. ± 10 V, 4 mA to 20 mA) shall be verified.

Test all range types for resolution and accuracy. Test 11 points in the range (0, to 100 % every 10 % of range). Test at minimum operating temperature, maximum operating temperature and 25 °C. Test one sample at each condition 3 times.

The results shall be in accordance with the equipment datasheet.

NOTE This verification can be combined with the temperature type tests.

All parametric specifications defined in the manufacturers datasheet shall be verified and recorded in the test report. See 4.3.

The temperature testing methodology shall be according to 4.2.6.

6.5.6.3 Analog output overload immunity test

Measurement and verification shall be conducted in accordance with Table 33.

Table 33 – Analog output overload immunity test

Reference test	None
EUT configuration	According to manufacturer's specifications
Initial condition	The load is applied until temperature(s) of any affected part(s) of the EUT stabilize (3 temperature readings, of the affected part(s)
Applied load	According specified maximum (resistive, capacitive or inductive) overload, specified by the manufacturer.
Number of reading	3 times at the affected part(s)
Reading interval	2 minutes apart until not changing by more than 1 K
Pass / fail	No physical damage or change in performance, other than specified in manufactures datasheet, shall be detected.
After the test	The accuracy shall be verified for the minimal and the maximum value of the range according to PFVP, see 4.2.8.

6.5.6.4 Short-circuit and open-circuit test

When the short circuit or the open circuit is applied, no physical damage or abnormal phenomenon shall be detected. After the test, perform the PFVP of 4.2.8.

6.5.6.5 Voltage supply variation test

This test shall be performed when the analog I/O modules are externally energized by an independent power supply (i.e. independent from the other I/O modules power supply(ies) of the EUT).

The power supply is replaced by a variable power source. The voltage is adjusted to the extreme values of the specified range of voltage supply, the PFVP and the output variations shall be inside the specified range, see 4.2.8.

6.5.6.6 Reversal of signal polarity test

Protection devices such as fuses may be reset prior to verification.

If the equipment is mechanically designed to prevent reversal of signal polarity, a test is not necessary and can be replaced by visual inspection.

The maximum rated signal, of reverse polarity for unipolar analog inputs, shall be applied for 10 s.

The results shall be as stated by the manufacturer. After the test, the device shall pass the PFVP, see 4.2.8.

6.6 Communication interface requirements

6.6.1 General

The configuration tested according to Clause 4.2 of this standard shall be equipped with communication interface modules where applicable and with communication links specified by the manufacturer.

Communication is done through port types AI, Ar, Be and Bi. See Figure 7.

AI Communication interface/port for local extension rack

Ar Communication interface/port for remote I/O station, control network, fieldbus

Be Open communication interface/port, open to third-party devices; e.g. PADT, personal computer used for programming

Bi Internal communication interface/port, e.g. backplane bus

Two general types of communication interfaces are available:

a) Proprietary protocol

b) Open protocol

Normally communication port Ar is an open protocol fieldbus port. If any port utilizes an open protocol per e.g. IEC 61158, IEC 61784, Fieldbus Foundation, it shall comply with the requirements of those standards.

The requirements of 6.6.1 are verified in accordance with 6.6.2.

6.6.2 Verification of communication interface requirements

Manufacturer shall verify performance capability. This may be by internal testing or e.g. by external organization providing a certification.

If the communication port is specified by an open protocol e.g. IEC 61158, IEC 61784, HART, it shall be tested to the requirements of those standards. These verification/test requirements are generally supplied by the fieldbus or technology provider organizations (e.g. FF, PNO, ODVA).

6.7 Main processing unit(s) and memory(ies) requirements

6.7.1 General

This 6.7.1 shall be read in conjunction with IEC 61131-1 and with 6.8 and 6.9 of this standard (respectively, RIOS and peripherals).

See Figure 7 for the definition and illustration of the control equipment, the main processing unit , the main memory and other terms used in this 6.7.1.

Main processing unit(s) and memory(ies) are part of the permanent control equipment installation and therefore tested accordingly.

The requirements of this 6.7.1 are verified in accordance with 6.7.2.

6.7.2 Verification of processing unit requirements

Manufacturer shall be able to provide verification of any published performance statements e.g:

- Language support;

- Instruction execution speed;
- Memory capacity.

6.8 Remote input/output station (RIOS) requirements

6.8.1 General

RIOS are part of the permanent control equipment installation and therefore to be tested accordingly. However, for ease of testing, isolated RIOS may be tested separately where appropriate.

Requirements for voltage dips and interruption of the power supply(ies) fully apply to RIOS. These requirements are shown in 6.2.

In case of loss of communication with the processing unit application programme, RIOS shall be able to fix the states of their outputs to specified values, within specified delays and without passing through unspecified states and be capable of providing a fault indication signal.

Control equipment provided fault states:

a) Hold-Last value (Use example: remain at the level or state just before the loss, e.g. to hold a vessel of molten glass at the same temperature). Applicable to digital and analog channels.
b) OFF (Use example: when the de-energized state is the best fault state, generally in discrete control applications). Applicable to digital and analog channels.
c) Programmed value (Use example: this level or value is known to the application designer and is set at application development, or possibly under some program control, this is used if the best condition is to ramp to some slow feedrate or to gently allow the process to move to a set level). Applicable to analog channels.

The processing unit control equipment shall provide the user's application programme with relevant information on the current status of RIOS.

The requirements of 6.8.1 are verified in accordance with 6.8.2.

6.8.2 Verification of local and remote I/O stations

6.8.2.1 General

Manufacturer shall be able to provide verification of any published performance statements.

6.8.2.2 Response time test

This test verifies the effect on transfer time(s) introduced to provide local and/or remote input information and RIOS status to the application programme and to transmit its logical decisions to remote outputs.

Procedure: An application test programme consisting of copying input status to outputs is run in 4 similar configurations:

- local inputs to local outputs,
- remote inputs to local outputs,
- local inputs to remote outputs and
- remote inputs to remote outputs.

Pass/fail criteria: The total EUT response times and the subsequent variations of transfer time(s) shall conform to the manufacturer's datasheet.

6.8.2.3 Loss of communication test

Procedure: The test is performed by disconnecting a) the communication cable, b) the RIOS external power supply, and observing the behaviour of the EUT (i.e. of the processing unit as well as of the RIOS and of their outputs).

Pass/fail criteria: When communication fails or is lost, outputs shall assume a manufacturer's specified state within a manufacturer's specified interval without erratic or unintended behaviour, and the communication error shall be signalled to the user interface.

6.9 Peripherals (PADTs, TEs, HMIs) requirements

6.9.1 General

Peripherals which are not a permanent part of the control equipment shall cause no malfunction of the control equipment when making or breaking communication with an operating system.

The requirements of 6.9.1 are verified in accordance with Table 34.

Table 34 – Insertion/withdrawal of removable units

Reference test	None
Description of the test for permanently installed units (e.g. modules in backplanes, pre-assembled or molded cable connectors, connectors for field wiring)	50 insertions/withdrawals are performed without power; then the equipment shall pass the PFVP, see 4.2.8
Description of the test for non-permanently installed unitsand peripherals E.g. USB , network ports, memory cards (see Figure 7)	500 insertions/withdrawals are performed while the EUT is performing functional test programmes as required for PFVP, see 4.2.8 Insertions and withdrawals shall not affect the proper operation of the EUT Communication on the physical link during the test is not required

Connectors for the peripherals shall be polarized to prevent improper connection, or the control equipment shall be so designed that no malfunction occurs if a connection is improper.

The control equipment consisting of the peripheral and the control equipment shall be designed to ensure that the edited programme executing in the control equipment is functionally identical to the edited programme displayed on the peripheral.

If on-line modification of the application programme and/or the modes of operation of the control equipment by a peripheral is possible (i.e. when the control equipment is in active control of a machine or industrial process), then:

a) the peripheral shall automatically give clear warnings equivalent to “during on-line modification, programme display may differ from application programme, control of the machine/ process may be interrupted during... ms, etc.”, as applicable;

b) the peripheral shall ask the operator “Do you really want to carry out this action?” or some similar words and execute the command only after a positive reply has been given by the operator;

c) it shall be possible to upload the new application programme to the manufacturer's supplied data media and verify, on line, that the record is functionally equivalent to it;

d) means shall be provided to prevent unauthorized use of these functions (hardware or software).

HMI, PADTs and TEs utilizing Ports Be and E (See Figure 7) are encouraged to comply with open standards.

The requirements of 6.9.1 are verified in accordance with 6.9.2.

6.9.2 Verification of peripheral (PADTs, TEs, HMIs) requirements

Manufacturer shall be able to provide verification of any published performance statements, e.g.:

- HMI screen size, resolution, number of colors;
- HMI screen update speed;
- Touchscreen accuracy;
- Gesture support;
- Communication port protocol support (see 6.6);
- Memory capacity;
- Cleanability.

6.10 Self-tests and diagnostics requirements

6.10.1 General

The manufacturer shall provide means for self-tests and diagnostics of the operation. Such means shall be built-in services of the equipment and/or recommended ways to implement the intended application.

The following shall be provided:

- a means for monitoring the user's application programme (i.e. watchdog timer, etc.);
- a hardware or software means to check the memory integrity;
- a means to check the validity of the data exchanged between memory(ies), processing unit(s) and I/O modules (e.g. application loop-back test);
- a means to check that the power supply unit(s) do(es) not exceed the current and voltage limits allowed by the hardware design;
- a means to monitor the status of processing unit.

The equipment shall be capable of operating an alarm signal with a software or hardware alarm output. When the control equipment is monitored and “functioning correctly”, this alarm output shall be in a predetermined state. When not “functioning correctly” it shall go to the opposite state. The manufacturer shall specify the conditions of the “correct functioning state” and the self-tests which are executed to drive this alarm output.

RIOS shall be capable of operating an alarm signal on an alarm output (e.g. through a digital output module) in the event of loss of power or loss of normal communication with the processing unit and go to a predetermined state (see 6.8).

The requirements of 6.10.1 are verified in accordance with 6.10.2.

6.10.2 Verification of self-tests and diagnostics

Manufacturer shall be able to provide verification of any published performance statements, e.g.:

- application programme monitor and update speed;
- memory integrity check completeness and speed;
- alarm signals for HW, FW or SW failure.

6.11 Functional earth

Functional earth terminals are for EMC immunity/emission protection/control. There are no constructional requirements.

The terminals shall be marked.

The marking requirements of 6.12 are in accordance with 8.2.3.

6.12 Requirements for information on normal service and function

Information on normal service and function shall be provided by the manufacturer, in accordance with the requirements of Clause 8.

The requirements of 6.12 are verified by inspection.

7 Electromagnetic compatibility (EMC) requirements

7.1 General

Industrial control equipment is designed for the industrial environment, covered by IEC 61000-6-2 and 61000-6-4, unless otherwise indicated by manufacturer’s information.

This Clause 7 specifies electromagnetic compatibility (EMC) requirements for industrial control equipment.

As potential radiating equipment, the installed control equipment and other devices may emit conducted and radiated electromagnetic interference.

As potential receiving equipment the control equipment may be affected by externally generated conducted interference, radiated electromagnetic fields and electrostatic discharges. Table 35 provides some considerations.

The picture shown in Figure 16 is meant to describe the EMC radiation and interference coupling mechanisms in a factory environment. Zone separation is determined by power distribution, installation practices and control wiring practices.

Zone C = Factory mains distribution. It is generally characterized by such practices as; e.g. isolation from public mains by dedicated transformer, primary surge protection and severe interference coupling. With regard to EMC, Zone C can be described as a somewhat more severe environment than the general industrial environment.

Zone B = Dedicated power distribution. This zone is within/surrounded by the factory mains industrial environment (Zone C). It is generally characterized by such practices as; e.g. isolatation from factory mains by dedicated transformer, secondary surge protection, dedicated d.c. power network, and moderate industrial interference coupling. With regard to EMC, Zone B can be described as the general industrial environment.

Zone A = Local power distribution. This zone is within/surrounded by the dedicated power distrubution industrial environment (Zone B). It is generally characterized by such practices as; e.g. shorter wiring, well protected power supplies (SELV/PELV, see IEC 61010-2-201 for definitions), I/O impedance limiting, installation of protection networks, a.c./d.c. converters, isolation transformers, surge suppressers, local d.c. power, tertiary protection and low

industrial interference coupling. With regard to EMC, Zone A can be described as a somewhat less severe environment than the general industrial environment.

Control equipment is designed for Zone B, unless otherwise indicated by manufacturer's information. Zone B encompasses Zone A.

If a product is to be used in multiple zones, then it shall be designed and tested to the most severe combination of requirements for its intended zones.

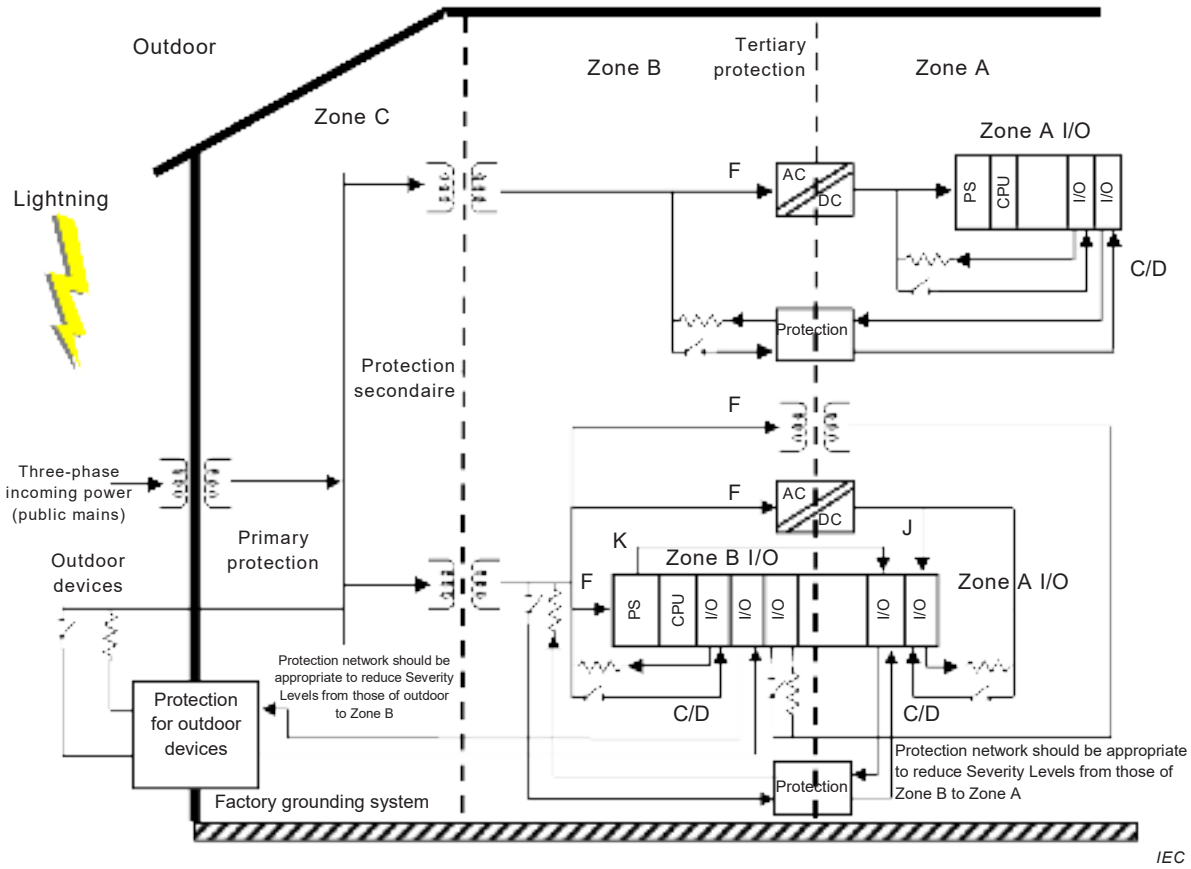


Figure 16 – EMC zones

Dotted lines in Figure 16 are not meant to indicate physical separation or segregation. The letters referred to in Figure 16 (F, K, C, D, etc.) correspond to those referred to in Figure 7. They describe interface/ports.

Table 35 – EMC zones & ptotection considerations

Zones	Protection considerations			
Zone C	Factory mains distribution >300 V rated voltage (line to neutral)	Primary surge protection	Severe voltage surge coupling 4 000 V	Overvoltage category III[a]
Zone B	Dedicated power distribution ≤300 V rated voltage (line to neutral)	Secondary surge protection I/O impedance limiting	Moderate voltage surge coupling 2 000 V	Overvoltage category II[a]
Zone A	Local power distribution ≤120 V rated voltage ≤100 V rated voltage ≤50 V rated voltage (line to neutral)	Tertiary surge protection I/O impedance limiting	Low-voltage surge coupling 1 000 V 800 V 500 V	Overvoltage category I[a]
[a] overvoltage categories as defined in IEC 60664-1				

For Zone B, the nature of the installation shall be such that overvoltage category II conditions shall not be exceeded.

Transient overvoltages at the point of connection to the equipment power supply shall be controlled not to exceed overvoltage category II, i.e. not higher than the impulse voltage corresponding to the rated voltage for basic insulation. The equipment or the transient suppression means shall be capable of absorbing the energy in the transient.

In the Zone B industrial environment, non-periodic overvoltage peaks may appear on equipment power supply lines as a result of power interruptions to high-energy equipment (for example, blown fuse on one branch in a 3-phase system). This will cause high current pulses at relatively low voltage levels, (approximately $2 \times U_{\text{peak}}$).

The requirements of 7.2 and 7.3 are intended to characterize the EMC performance of the control equipment and are the responsibility of the manufacturer.

Since the control equipment is only a component of the overall automated system, this standard does not deal with the EMC of the overall automated system.

If an EMC enclosure (e.g. cabinet) or other protection device (e.g. filter) is specified by the manufacturer it shall be included as part of the equipment under test (EUT). These protection devices may be specified by either manufacturer's type / model or by electrical characteristics.

The EMC enclosure port is the physical boundary of the EUT through which electromagnetic fields may radiate or impinge. See definition 3.1.30.

7.2 Emission requirements

Control equipment, defined in this document, is designed for the industrial environment, unless otherwise indicated by manufacturer's information.

Emissions requirements and verifications are given in IEC 61000-6-4.

Control equipment is not connected to the public mains, as such, there is no emission requirement up to 150 kHz.

If the control equipment is designed e.g. for other environments, for public mains connection, then other requirements may be required e.g. IEC 61000-6-3, IEC 61000-3-2, IEC 61000-3-3.

7.3 EMC immunity requirements

7.3.1 Immunity levels

Immunity requirements for Zone A and B enclosure ports are defined in Table 36.

Table 36 – Enclosure port tests, Zones A and B

Environmental phenomenon	Basic standard	Test		Test level	Test set-up	Normative items	Performance criteria
Electrostatic discharge	IEC 61000-4-2	Contact		± 4kV	Table 39	[a]	B
		Air		± 8kV			
Radio-frequency Electro-magnetic field Amplitude modulated	IEC 61000-4-3	80 % AM, 1 kHz Sinusoidal	80 MHz to 1 000 MHz	10 V/m	Table 40	[d]	A
			1,4 GHz to 2,0 GHz	3 V/m			
			2,0 GHz to 2,7 GHz	3 V/m			
			2,7 GHz to 6,0 GHz	3 V/m			
Power frequency magnetic fields	IEC 61000-4-8	60 Hz		30 A/m	Table 41	[b, c]	A
		50 Hz		30 A/m			

[a] The ESD test shall be applied to

a) operator accessible devices (for example, HMI, PADT and TE);

b) enclosure ports;

c) service accessible parts (for example, switches, keyboards, protective/functional earth, module housing, communications ports with connectors in place and metal connectors) which are not protected from casual access.

The ESD test shall not be applied to communications ports without connectors in place, I/O ports or power ports.

[b] This test is meant to test equipment sensitivity to magnetic fields normally occurring on the factory floor. The test is only applicable to equipment containing devices susceptible to magnetic fields, such as Hall effect devices, disk drives, magnetic memories and similar equipment. Control equipment does not normally contain such devices; however, other devices, such as HMI, may. The test is not meant to simulate high-intensity magnetic fields such as those, for example, associated with welding and induction heating processes. This requirement may be satisfied by the test being applied to the sensitive device at the device manufacturer. Also see Clause D.6.

[c] See Clause D.6.

[d] This level does not represent the field emitted by a transceiver in close proximity to the EUT.

Zone B levels are the most typical industrial environmental levels.

Conducted immunity requirements for Zone B are contained in Table 37.

Table 37 – Conducted immunity tests, Zone B

	Environmental phenomenon	Fast transient burst	High energy surge	Radiofrequency interference	
	Basic standard	IEC 61000-4-4	IEC 61000-4-5	IEC 61000-4-6	
	Test set-up	Table 42	Table 43	Table 44	
	Performance criteria	B	B	A	
Interface/Port Figure 7 (designation)	**Specific interface/port**	**Test level**	**Test level**	**Test level**	**Values derived from**
Data communication (AI and Ar for I/O racks; Be, Bi and E for peripherals)	Shielded cable	1 kV[d]	1 kV line-to-earth[b]	10 V[d]	IEC 61000-6-2:2016 Table 2
	Unshielded cable	1 kV[d]	1 kV line-to-earth[b]	10 V[d]	
Digital and analog I/Os (C and D)	a.c. I/O and a.c. rated relay (unshielded)	2 kV[d]	2 kV line-to-earth[b] 1 kV line-to-line[b]	10 V[d]	IEC 61000-6-2:2016 Table 4
	Analog or d.c. I/O and d.c. rated relay (unshielded)	1 kV[d]	1 kV line-to-earth[b]	10 V[d]	IEC 61000-6-2:2016 Table 2
	All shielded lines (to earth)	1 kV[d]	1 kV line-to-earth[b]	10 V[d]	IEC 61000-6-2:2016 Table 2
Equipment power (F)[e]	a.c. power	2 kV	2 kV line-to-earth 1 kV line-to-line	10 V	IEC 61000-6-2:2016 Table 4
	d.c. power	2 kV[a,d]	0,5 kV line-to-earth[a,b,c] 0,5 kV line-to-line[a,b,c]	10 V	IEC 61000-6-2:2016 Table 3
I/O power (J) and auxiliary power output (K)	a.c. I/O and a.c. auxiliary power	2 kV[d]	2 kV line-to-b 1 kV line-to-line[b]	10 V	IEC 61000-6-2:2016 Table 4
	d.c. I/O and d.c. auxiliary power	2 kV[a, d]	0,5 kV line-to-earth[a,b,c] 0,5 kV line-to-line[a,b,c]	10 V	IEC 61000-6-2:2016 Table 3

[a] No test is required if:

1) ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging, or

2) ports intended for use with an a.c.-d.c. power adaptor. (In this case: Test shall be performed on the a.c. power input of the a.c.-d.c. power adaptor specified by the manufacturer or, where none is so specified, using a typical a.c.- d.c. power adaptor) .

[b] For ports with cables specified ≤30 m, no test is needed.

[c] No test is required for ports not intended to be connected to a d.c. power network.

[d] For ports with cables specified ≤3 m, no test is needed.

[e] Equipment power (F) ports for connection to < 60 V d.c. or a.c. (nominal) shall be tested as I/O power (J) ports. These low voltage sources cannot be considered d.c. or a.c. power networks, as voltage drop practicalities prevent their distribution.

Zone A levels apply where installation practices reduce industrial environmental levels below those of Zone B. Referring to Figure 16, these practices may include shorter wiring, well protected power supplies (SELV/PELV, see IEC 61010-2-201 for definitions), I/O impedance

limiting, installation of protection networks, a.c./d.c. converters, isolation transformers, surge suppressers, local d.c. power, tertiary protection.

Conducted immunity requirements for Zone A are contained in Table 38.

Table 38 – Conducted immunity tests, zone A

	Environmental phenomenon	Fast transient burst	High energy surge	Radiofrequency interference	
	Basic standard	IEC 61000-4-4	IEC 61000-4-5	IEC 61000-4-6	
	Test set-up	Table 42	Table 43	Table 44	
	Performance criteria	B	B	A	
Interface/Port Figure 7 (designation)	**Specific interface/port**	**Test level**	**Test level**	**Test level**	**Values derived from**
Data communication (AI and Ar for I/O racks; Be, Bi and E for peripherals)	Shielded cable	0,5 kV[d]	No test	3 V[d]	IEC 61000-6-1:2016 Table 2
	Unshielded cable	0,5 kV[d]	No test	3 V[d]	
Digital and analog I/Os (C and D)	a.c. I/O (unshielded)	1 kV[d]	2 kV line-to-earth[b] 1 kV line-to-line[b]	3 V[d]	IEC 61000-6-1:2016 Table 4
	Analog or d.c. I/O (unshielded)	0,5 kV[d]	No test	3 V[d]	IEC 61000-6-1:2016 Table 2
	All shielded lines (to earth)	0,5 kV[d]	No test	3 V[d]	IEC 61000-6-1:2016 Table 2
Equipment power (F)[e]	a.c. power	1 kV	2 kV line-to-earth 1 kV line-to-line	3 V	IEC 61000-6-1:2016 Table 4
	d.c. power	0,5 kV[a,d]	0,5 kV line-to-earth[a,b,c] 0,5 kV line-to-line[a,b,c]	3 V	IEC 61000-6-1:2016 Table 3
I/O power (J) and auxiliary power output (K)	a.c. I/O and a.c. auxiliary power	1 kV[d]	2 kV line-to-earth[b] 1 kV line-to-line[b]	3 V	IEC 61000-6-1:2016 Table 4
	d.c. I/O and d.c. auxiliary power	0,5 kV[a, d]	0,5 kV line-to-earth[a,b,c] 0,5 kV line-to-line[a,b,c]	3 V	IEC 61000-6-1:2016 Table 3

[a] No test is required if:

1) ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging, or

2) ports intended for use with an a.c.-d.c. power adaptor. (In this case: Test shall be performed on the a.c. power input of the a.c.-d.c. power adaptor specified by the manufacturer or, where none is so specified, using a typical a.c.- d.c. power adaptor) .

[b] For ports with cables specified ≤ 30 m, no test is needed.

[c] No test is required for ports not intended to be connected to a d.c. power network.

[d] For ports with cables specified ≤ 3 m, no test is needed.

[e] Equipment power (F) ports for connection to < 60 V d.c. or a.c. (nominal) shall be tested as I/O power (J) ports. These low voltage sources cannot be considered d.c. or a.c. power networks, as voltage drop practicalities prevent their distribution.

Conditions of use may require installation in Zone C. The manufacturer may elect to provide equipment for this installation by utilizing the levels given in Annex C.

The requirements of 7.3.1 are verified in accordance with Table 39, Table 40, Table 41, Table 42, Table 43, and Table 44.

Table 39 – Electrostatic discharge immunity test

Reference test	IEC 61000-4-2
EUT configuration	According to manufacturer's specifications
Initial measurements	PFVP; see 4.2.8
Details of mounting/support	According to manufacturer's specifications and IEC 61000-4-2 provisions
Selection of application points	The ESD test shall be applied to: a) operator-accessible devices (for example, HMI, PADT and TE); b) enclosure ports; c) parts accessible during service not protected from casual access. Examples: 1) switches; 2) keyboards; 3) protective/functional earth; 4) module packaging/housing; 5) ports with connectorsor covers in place; 6) metal connectors). The ESD test shall not be applied to: i) Communication ports without the mating connector in place; ii) I/O ports; iii) Power ports; iv) Ports with an ESD warning marking.[b]
Test application	
Contact discharge	EUT, horizontal and vertical coupling planes
Air discharge	EUT
Test levels	Table 36 or Table C.1
Time between two discharges	≥ 1 s
Number of discharges on each selected point	Ten discharges after the equipment is discharged to earth
Measurement and verification during loading	PFVP; see 4.2.8
Performance criteria	Table 36 or Table C.1[a]

[a] If the EUT deviates only once during the test, a second trial of 10 discharges shall be performed; if more non allowed deviations are observed, failure of the ESD test shall be declared.

[b] To identify a port that has not been tested for immunity to electrostatic discharge. Use electrostatic sensitive devices (ESD) warning symbol, IEC 60417-5134:2003-04.

Table 40 – Radiated electromagnetic field immunity test

Reference test	IEC 61000-4-3
EUT configuration	According to manufacture's specifications
Initial measurements	PFVP; see 4.2.8
Details of mounting/support	The EUT is placed in the calibrated test field
Frequency range to be swept	Table 36 or Table C.1 (see note below)
Modulation	Table 36 or Table C.1
Test field strength	Table 36 or Table C.1
Measurement and verification during loading	PFVP; see 4.2.8
Performance criteria	Table 36 or Table C.1
NOTE See also Annex H, IEC 61000-4-3:2006.	

Table 41 – Power-frequency magnetic field immunity test

Reference test	IEC 61000-4-8
EUT configuration	According to manufacture's specifications
Initial measurements	PFVP; see 4.2.8
Details of mounting/support	The EUT is immersed in the magnetic field of a 1 m × 1 m induction coil.
Frequency (power line)	Table 36 or Table C.1
Test condition	Immersion method in continuous field
Test field strength	Table 36 or Table C.1
Measurement and verification during loading	PFVP; see 4.2.8
Performance criteria	Table 36 or Table C.1[a]
[a] See Clause D.6.	

Table 42 – Fast transient burst immunity test

Reference test	IEC 61000-4-4
EUT configuration	According to manufacturer's specifications
Initial measurements	PFVP; 4.2.8
Details of mounting/support	The EUT shall be such as to eliminate the radiated EMI received on I/O wiring by the specified capacitive coupling
Severity level at rated voltage	Table 37, Table 38 or Table C.2
Duration	≥ 1 minute
Application ports	**Application methods**
Communication (Al, Ar, Be, Bi, and E), I/O (C and D), I/O Power (J) and auxiliary power output (K)	50 pF-200 pF capacitive clamp coupling
Equipment power (F)[a]	33 nF direct coupling
Measurement and verification during loading	PFVP; 4.2.8
Performance criteria	Table 37, Table 38 or Table C.2
NOTE The repeatability of this test is closely related to the number and relative position of wires within the capacitive coupling clamp.	
[a] Equipment power (F) ports for connection to < 60 V d.c. or a.c. (nominal) shall be tested as I/O power (J) ports. These low voltage sources cannot be considered d.c. or a.c. power networks, as voltage drop practicalities prevent their distribution.	

Table 43 – High-energy surge immunity test

Reference test	IEC 61000-4-5
EUT configuration	According to manufacturer's specifications
Initial measurements	PFVP; 4.2.8
Details of mounting/support	According to manufacturer's specifications
Severity level at rated voltage	Table 37, Table 38 or Table C.2
Number of discharges	5 each in positive and negative polarities
Repetition rate	≤ 1 surge/minute
Application ports	**Application methods**
Shielded communication (Al, Ar, Be, Bi, and E) and shielded I/O (C and D)	2 Ω/10 nF between shield and reference earth
Unshielded communication (Al, Ar, Be, Bi, and E), unshielded I/O (C and D), I/O Power (J) and auxiliary power output (K)	42 Ω/0,5 μF line-to-earth 42 Ω/0,5 μF line-to-line
Equipment power (F)[a]	12 Ω/9 μF line-to-earth 2Ω/18μF line-to-line
Measurement and verification during loading	PFVP; 4.2.8
Performance criteria	Table 37, Table 38 or Table C.2
[a] Equipment power (F) ports for connection to < 60 V d.c. or a.c. (nominal) shall be tested as I/O power (J) ports. These low voltage sources cannot be considered d.c. or a.c. power networks, as voltage drop practicalities prevent their distribution.	

Table 44 – Conducted r.f. immunity test

Reference test	IEC 61000-4-6
EUT configuration	According to manufacturer's specifications
Initial measurements	PFVP; 4.2.8
Details of mounting/support	The EUT shall be such as to eliminate the radiated EMI received on I/O wiring by the specified magnetic coupling
Severity level at rated voltage	Table 37, Table 38 or Table C.2
Frequency range to be swept	150 kHz-80 MHz
Modulation	80 % AM by a 1 kHz sinusoidal
Test level (unmodulated)	Table 37, Table 38 or Table C.2
Application ports	**Application method (all cable between EUT and clamp or CDN is as short as possible)**
Communication (Al, Ar, Be, Bi, and E), I/O (C and D), Equipment power (F), Functional earth (H), I/O power (J) and auxiliary power output (K)	CDN (preferred), EM or current coupling clamp
Measurement and verification during loading	PFVP; 4.2.8
Performance criteria	Table 37, Table 38 or Table C.2

7.3.2 Voltage dips and interruptions power ports

These limits apply to the equipment power interface/port (F) in Figure 7.

For disturbances lasting 0,5 period as defined in Table 45, the EUT (including RIOS (see 6.8) and non-permanently installed peripherals) shall maintain normal operation.

For disturbances lasting 10 or more periods, the EUT shall either maintain normal operation or go to a predefined state and have a clearly specified behaviour until normal operation is resumed.

NOTE 1 Outputs and fast or slow responding inputs energized by the same supply(ies) can respond to these power supply variations.

Table 45 – Voltage dips and interruptions (EMC requirements)

Supply type[d]	Severity level[c]	Maximum dip and interruption time	Low voltage	Performance criteria[f]
a.c.	PS2	0,5 period[a]	U_e to 0% U_e[b]	A
		250 at 50 Hz / 300 at 60 Hz periods[e]	U_e to 0% U_e[b]	C
		10 at 50 Hz / 12 at 60 Hz periods[e]	U_e to 40% U_e[b]	C
		25 at 50 Hz / 30 at 60 Hz periods[e]	U_e to 70% U_e[b]	C

[a] Any arbitrary phase angle, f_n = 50 Hz or 60 Hz (see Table 46).

[b] U_e at nominal voltage in Table 16.

[c] PS2 applies to EUTs energized from a.c. supplies.

[d] Voltage interruptions are from U_e

[e] f_n = 50 Hz/60 Hz

[f] See Table 1.

NOTE 2 The limits of Table 45 differ somewhat from the requirements for voltage interruptions in IEC 61000-6-2. Rationale: The requirements for voltage interruptions are derived from this standard. Further, IEC 61000-6-2 specifies Performance Criteria B which is not useful in the application of systems. Specifically applications require Performance Criteria A for voltage interruptions of 0,5 period minimum. Experience with the installed systems demonstrates the requirements of the industrial environment are fulfilled by the above requirements.

The requirements of 7.3.2 are verified in accordance with Table 46.

Table 46 – Voltage dips and interruptions immunity test (EMC tests)[f]

Reference test	IEC 61000-4-11			
EUT configuration	According to manufacturer's specifications			
Initial measurements	PFVP; 4.2.8			
Supply voltage and frequency	U_e, f_n [e]			
Duration	0,5 period, starting at zero-crossing[a, b]	250 at 50 Hz / 300 at 60 Hz periods[d]	10 at 50 Hz / 12 at 60 Hz periods[d]	25 at 50 Hz / 30 at 60 Hz periods[d]
U_e to %U_e [e]	0 (zero) %	0 (zero) %	40 %	70 %
Performance criteria	Table 45			
Number of trials	3			
Time interval between trials	1 second < time interval < 10 seconds			
Measurement and verification during test	PFVP, 4.2.8 Normal operation shall be maintained[c]			
Verification after tests	PFVP, 4.2.8			

[a] Optionally, the manufacturer may elect to interrupt supply at a random phase angle.

[b] The manufacturer may state longer interruptions.

[c] Outputs and fast or slow responding inputs energized by the same power supply may be affected temporarily during the disturbance but shall resume normal operation after the disturbance.

[d] f_n = 50 Hz/60 Hz

[e] U_e at nominal voltage in Table 16.

[f] Applied to power ports which are equipment power input port, port F, Figure 7.

7.4 Requirements for information on EMC installation

Information on EMC installation shall be provided by the manufacturer, in accordance with 8.4.

8 Marking requirements and information to be provided by the manufacturer

8.1 Verification

The requirements of Clause 8 shall be verified by inspection to ensure well documented content.

8.2 General marking requirements

8.2.1 Minimum marking requirement

For all equipment, as a minimum, the information marked on the device shall identify the manufacturer (the company bringing the product to market) and the device.

The marking requirements for product safety shall be in conformity with IEC 61010-2-201.

The following information shall be provided by the manufacturer:

- manufacturer’s name, trade mark or other identification;
- model/catalogue number, type designation or name;
- software serial number and/or revision level, where applicable;
- hardware serial number or series and/or revision level, and date code or equivalent.

The requirements of this 8.2.1 are verified by inspection.

8.2.2 Functional identifications

All equipment operator switches, indicator lamps, and connectors shall be identified or have provisions for identification.

The requirements of this 8.2.2 are verified by inspection.

8.2.3 Functional earth terminals markings

Functional earth terminals (i.e. used for non-safety purposes such as interference immunity improvement) shall be marked with one of the following symbols:

IEC 60417-5018 (2011-07) or

IEC 60417-5017 (2006-08)

NOTE For proper dimensioning, information can be found in IEC 60417-5018 (2011-07) or IEC 60417-5017 (2006-08).

The requirements of 8.2.3 are verified by inspection.

8.2.4 Documentation markings

Where the documentation is provided by electronic media, the following symbol shall be provided on the product, along with the location of the documentation, e.g. URL, QRcode, on the product, packaging or printed information with the product:

ISO 7000-0434B:2004-01

ISO 7000-1641:2004-01

8.3 Information format and content

8.3.1 Information format

This information shall be provided in any of the following documents:

- catalogues;
- datasheets;
- user's manuals;
- technical documentation.

NOTE Information on the preparation of the instructions can be found in IEC 82079-1 and IEC 61506.

Additional documentation may be required to satisfy other standards to which the EUT is specified, e.g. safety to IEC 61010-2-201.

Information shall be available in either printed or electronic format (e.g. .pdf, cloud, web). If information is provided in electronic form, use the marking shown in 8.2.4 to indicate this.

8.3.2 Information content

The manufacturer shall provide information required for the application, installation, commission, operation, maintenance and disposal of the equipment.

These documents shall contain the following:

- the information on safety that is required by the IEC 61010-2-201, e.g. safety warnings, mounting requirements, temperature and ventilation, connection to the supply;
- description and the specifications of the product and its associated peripherals;
- relevant information to aid in understanding the application and use of these products;
- equipment configuration rules;
- normal service conditions;
- physical dimensions and weights;
- list compliance with standards and certifications;
- installation and commissioning instructions;
- programming and troubleshooting instructions;
- operating and maintenance requirements;
- accessory and spare parts lists (for example, fuses).

8.3.3 Information on compliance with this standard

The manufacturer shall provide information on compliance with this standard, which shall be claimed on one of three levels.

a) Complete compliance to this standard

   This means the equipment complies with all clauses.

b) Compliance to a clause or clause(s) statement

   This means the equipment complies with only the clauses stated.

c) Compliance to functionality statement

   This means the equipment complies with the functionality item stated as defined in this standard.

One exception is Clause 7, Electromagnetic compatibility (EMC) requirements. All equipment shall comply with this clause.

See 4.1 for details of method.

8.3.4 Information on shipping and storage

The manufacturer shall provide shipping and storage instructions.

8.3.5 Information on a.c. and d.c. power supply

The manufacturer shall provide the following information.

a) Data to allow selection of a suitable power distribution network to provide specified voltage at each power utilization point. This information includes peak inrush (at cold start and warm restart), repetitive peak and steady-state r.m.s. input currents under full-load conditions.

b) External terminal identification for power supply interfaces.

c) Typical example(s) for power supply control equipment(s).

d) Special supply installation requirements, if any, for products energized through multiple power supplies or supply voltages and frequencies not included in 6.2.1.

e) The effect of the following incorrect connections of power to the supply(ies):

- reverse polarity;
- improper voltage level and/or frequency;
- improper lead connection.

f) Complete information on control equipment behaviour for typical power up/down sequences.

g) Data to allow evaluation of the maximum values of interruption time which do not affect the normal operation of any control equipment configuration; PS class (PS-1 or PS-2) of d.c. supplied devices.

h) Memory back-up time with respect to temperature and maintenance requirements.

i) Recommended time interval between replacement of energy sources, if applicable, and recommended procedure and subsequent effects on the control equipment.

j) Recommended fuse size and opening characteristics.

8.3.6 Information on digital inputs (current sinking)

The manufacturer shall provide the following information:

- volt-ampere curve over the full operating range, with tolerances or equivalent;
- digital input delay time for 0 to 1 and 1 to 0 transitions;
- existence of common points between channels;
- effect of incorrect input terminal connection;
- isolation potentials between channel and other circuits (including earth) and between channels under normal operation;
- type of input (Input Type 1 or Input Type 3);
- monitoring point and binary state of visual indicator;
- effects when withdrawing/inserting input module under power;
- additional external load when interconnecting inputs and outputs, if needed;
- explanation of signal evaluation (for example, static/dynamic evaluation, interrupt release, etc.);
- recommended cable and cord lengths depending on cable type and electromagnetic compatibility;
- terminal arrangements;
- typical example(s) of external connections.

8.3.7 Information on digital outputs for alternating currents (current sourcing)

The manufacturer shall provide the following information with respect to digital outputs for a.c. operation:

- type of output (Output Type 0,25, Output Type 0,5 Output Type 1 or Output Type 2);
- type of protection (i.e. protected, short-circuit-proof, non-protected output), and
  - for protected outputs: operating characteristics beyond 1,1 I_e including the current(s) level(s) at which the protecting device energizes, the current behaviour beyond, and the time(s) involved;
  - for short-circuit-proof outputs: information for replacement or resetting the protective device as required;

  - for non-protected outputs: specification for protective device to be provided by the user, as required;
- output delay time for state 0 to state 1 and state 1 to state 0 transitions;
- commutation characteristics and turn-on voltage with respect to zero-voltage crossing;
- existence of common points between channels;
- terminal arrangements;
- typical example(s) of external connections;
- number and type of outputs (for example, NO/NC contacts, solid state, individually isolated channels, etc.);
- for electromechanical relays, the rated current and voltage complying with 6.4.5.6;
- output ratings for the other loads such as incandescent lamps;
- total output current for multi-channel modules (see definition 3.1.24);
- characteristics of suppresser networks incorporated into the output circuit against voltage peaks due to inductive kickback;
- type of external protective networks, if required;
- effects of incorrect output terminal connection;
- isolation potentials between channel and other circuits (including earth) and between channels under normal operation;
- monitoring points of visual indicators in the channel (for example, processing unit side/load side);
- recommended procedures for changing output modules;
- output behaviour during interruptions of processing unit control, voltage dips and interruptions and power up/down sequences (see also 6.8);
- way of operation (i.e. latching/non-latching type);
- effects of multiple overloads on isolated multi-channel modules.

8.3.8 Information on digital outputs for direct current (current sourcing)

Information to be provided by the manufacturer for digital outputs for d.c. shall be the same as for digital outputs for a.c., as defined in 8.3.7. However, the specification of commutation for zero-voltage crossing does not apply, and with regard to electromechanical relay outputs, AC-15 is replaced by DC-13 in 6.4.5.6.

Also five types of output (Output Type 0,1, Output Type 0,25, Output Type 0,5 Output Type 1 or Output Type 2) are available.

8.3.9 Information on analog inputs

8.3.9.1 Information on analog input static characteristics

The manufacturer shall provide the appropriate information from Table 47, with respect to analog inputs.

Table 47 – Analog input static characteristics

Static characteristics		Units and examples
1) Input type		e.g. current, voltage, RTD, TC
2) Input range		e.g. 4 mA to 20 mA, 0-5 V
3) Input impedance in signal range (manufacturer shall specify if this is in the on or off state)		Ω
4) Analog input error:	temperature coefficient	± % of full scale/K
	maximum error at 25 °C	± % of full scale (which scale)
5) Maximum error over full temperature range		± % of full scale (which scale)
6) Digital resolution		Number of bits
7) Data format returned of the application programme		Binary, BCD, etc
8) Value of a LSB (least significant bit)		mV, mA
9) Maximum permanent allowed overload (no damage)		V, mA
10) Overload indication		For example, flag
11) Type of input		For example, differential
12) Common-mode characteristics (d.c., a.c. 50 Hz, a.c. 60 Hz) if applicable		CMRR-dB, CMV-V
13) For other inputs (thermocouples, RTD, etc):	type(s) sensor(s)	J, K, T, etc.: Pt, 100, etc.
	measurement range(s)	Min. °C to max. °C
	linearization method	Internal or configurable

8.3.9.2 Information on analog input dynamic characteristics

The manufacturer shall provide the appropriate information from Table 48, with respect to analog inputs.

Table 48 – Analog input dynamic characteristics

Dynamic characteristics		Units and examples
1) Sample duration time (including setting time)		ms
2) Sample repetition time		ms
3) Input filter characteristics:	order	First, second, etc.
	transition frequency	Hz
4) Maximum temporary deviation during each specified electrical interference test (see Table 1, criteria B)		± % of full scale

8.3.9.3 Information on analog input general characteristics

The manufacturer shall provide the appropriate information from Table 49, with respect to analog inputs.

Table 49 – Analog input general characteristics

General characteristics	Units and examples
1) Operating modes	Trig, self-scan, etc.
2) Type of protection	RC, opto-isolator, MOVs, etc.
3) Isolation potentials under normal operation between channel and a) other circuits (including earth), b) between channels, c) power supply(ies) and d) interface(s)	V
4) External power supply data, if required	
5) Common points between channel if any	Technical data
6) Type, length of cable, installation rules recommended to provide interference immunity	Twisted pair, 50 m max
7) Calibration or verification to maintain rated accuracy	Month, years
8) Terminal arrangements	
9) Typical example(s) of external connections	
10) Effect of incorrect input terminal connection	

8.3.9.4 Information on analog input miscellaneous characteristics

The manufacturer shall provide the appropriate information from Table 50, with respect to analog inputs.

Table 50 – Analog input miscellaneous characteristics

Miscellaneous characteristics	Units and examples
1) Monotonicity with no missing codes	Yes, no
2) Crosstalk between channels at d.c., a.c. 50 Hz and a.c. 60 Hz	dB
3) Non-linearity	% of full scale
4) Repeatability at fixed temperature after specified stabilization time	% of full scale
5) Lifetime of electromagnetic relay multiplexers, if applicable	Number of cycles, of hours

8.3.10 Information on analog outputs

8.3.10.1 Information on analog output static characteristics

The manufacturer shall provide the appropriate information from Table 51, with respect to analog outputs.

Table 51 – Analog output static characteristics

Static characteristics		Units and examples
1) Output type		e.g. current, voltage
2) Output range		e.g. 4 mA to 20 mA, 0-5 V
3) Output impedance in signal range (manufacturer shall specify if this is in the on or off state)		Ω
4) Analog output error:	maximum error at 25 °C	± % of full scale (which scale)
	temperature coefficient	± % of full scale/K
5) Maximum error over full temperature range		± % of full scale (which scale)
6) Digital resolution		Number of bits
7) Data format returned of the application programme		Binary, BCD, etc
8) Value of a LSB (least significant bit)		mV, mA

8.3.10.2 Information on analog output dynamic characteristics

The manufacturer shall provide the appropriate information from Table 52, with respect to analog outputs.

Table 52 – Analog output dynamic characteristics

Dynamic characteristics	Units and examples
1) Settling time for full-range change	ms
2) Overshoot	% of full scale
3) Maximum temporary deviation during each specified electrical interference test (see Table 1, criteria B)	± % of full scale

8.3.10.3 Information on analog output general characteristics

The manufacturer shall provide the appropriate information from Table 53, with respect to analog outputs.

Table 53 – Analog output general characteristics

General characteristics	Units and examples
1) Type of protection	Opto-isolator, etc.
2) Isolation potentials between channel and other circuits (including earth) and between channels under normal operation	V
3) External power supply data, if required	Technical data
4) For current outputs with external supply, the maximum and minimum voltage drop across the output terminals in the full output range	V
5) Type, length of cable, installation rules recommended to provide interference immunity	Twisted pair, 50 m max.
6) Calibration or verification to maintain rated accuracy	Month, years
7) Terminal arrangements	
8) Common points between channels, if any	
9) Allowed type(s) of loads	Floating, earthed
10) Maximum capacitive load (for voltage outputs)	pF
11) Maximum inductive load (for current outputs)	mH
12) Typical example(s) of external connections	
13) Output response at power up and power down	
14) Effect of incorrect output terminal connection	

8.3.10.4 Information on analog output miscellaneous characteristics

The manufacturer shall provide the appropriate information from Table 54, with respect to analog outputs.

Table 54 – Analog output miscellaneous characteristics

Miscellaneous characteristics	Units and examples
1) Monotonicity	Yes, no
2) Crosstalk between channels at d.c., a.c. 50 Hz and a.c. 60 Hz	dB
3) Non-linearity	% of full scale
4) Repeatability at fixed temperature after specified stabilization time	% of full scale
5) Output ripple	% of full scale

8.3.11 Information on communication interfaces

If the manufacturer provides communication interfaces to other than his own equipment, he shall provide the necessary information for correct operation. This may be achieved by referencing a specific standard or specification together with details of any options such as baud rate, type of cable to be used, etc.

8.3.12 Information on main processing unit(s) and memory(ies)

Information to be provided by the manufacturer for main processing unit(s) and memory(ies) shall be a selection of the following:

a) organization, capacity of programme memory;

b) organization, capacity of data memory and number of bits per word;

c) memory type(s) (e.g. size in MB or Mb etc.) available;

d) memory back-up functionality and servicing requirements if any;

e) data, constraints and procedures to determine a desired configuration (racks, cables, bus expanders, power supply unit, maximum number of I/Os per type, maximum number of I/O modules, etc.);

f) description of the programming languages supported by the control equipment (combination of the PADT and the main processing unit(s);

g) to what extent the languages defined in IEC 61131-3 are supported, including the differences if any (objects, instructions, semantic and syntactic rules, etc.);

h) calculation methods to determine every memory utilization (user's application programme and data, firmware programme and data where applicable) and average values of every relevant time (scan time(s), control equipment response time(s), transfer time(s), execution time(s));

i) mechanisms in which I/Os are processed (i.e. use of I/O image registers periodically refreshed by the control equipment, immediate “get/put” type instructions, interrupt and event-driven programmes, etc.) and their effect on the following subjects:

   - control equipment response time(s);
   - restart capabilities (i.e. cold, warm, hot restart);
   - detailed times for inputs, outputs, processing, etc.

j) effect of non-permanently installed peripherals on every relevant time (see item h) of this 8.3.12) when they are plugged/unplugged, connected/disconnected to their control equipment interface;

k) Status information concerning cold, warm and hot restart if applicable. Description and usage of programmable timers usable to determine the process-dependent difference between warm and hot restart;

l) self-test and diagnostic functions implemented (see 6.10).

8.3.13 Information on remote input/output station (RIOS)

The manufacturer shall provide the following information:

- specifications for the selection of adequate cables and other devices needed for the communication link;
- specifications for proper installation of the whole system (including proper selection of power source(s));
- type of I/O communication network (point-to-point, star, multi-drop, ring, etc.);
- principles, procedures and transmission speeds used on the communication link and their capability to transfer data from and to the RIOS with respect to error coding/detection and to the delays of transmission in the best, most likely and worst cases;

- effect on transfer time(s) introduced to provide remote input information and RIOS status to the user's application programme and to transmit its logical decisions to remote outputs;
- specified values and delays according to 6.8;
- configuration related data: maximum number of RIOS in a configuration, minimum/maximum size of each;
- which I/O modules of the total I/O system may not be used in RIOS and/or which of their functions are altered if any;
- type, architecture and characteristics of redundancy if provided;
- modems/repeaters if applicable. Maximum distance with or without repeaters;
- terminating devices if required;
- physical characteristics of the communication interface including isolation characteristics, maximum acceptable common mode voltage, built-in short-circuit protections, etc.;
- type of standard link interface (i.e. RS 232, RS 422, RS 485, RS 511, etc.);
- functional and safety earth specifications;
- procedures for making/breaking logical and physical connection of a RIOS to a control equipment (for example, “on line”).

8.3.14 Information on peripherals (PADTs, TEs, HMIs)

The manufacturer shall provide the following information through convenient documentation:

– clear warnings and precautions to be observed when using functions enabling alteration of control conditions such as control equipment status modification, changing of data or programmes in the memory, forcing input or output signal, etc.;
– usability of peripherals at RIOS;
– service conditions for peripherals which are intended for use in an environment less severe than stated in Clause 5 (such peripherals may need to be remotely connected to the rest of the control equipment through communication lines);
– specifications for the selection of adequate cables and other devices needed for the communication link;
– specifications for proper installation of the whole system (including proper selection of energy source(s));
– type of communication network (point-to-point, star, multi-drop, ring, etc.);
– principles, procedures and transmission speeds used on the communication link and their capability to transfer data from and to the RIOS with respect to error coding/detection and to the delays of transmission in the best, most likely and worst cases;
– terminating devices if required;
– physical characteristics of the communication interface including isolation characteristics, maximum acceptable common mode voltage, built-in short-circuit protections, etc.;
– type of standard link interface (i.e. RS 232, RS 422, RS 485, etc.);
– functional earth requirements.

8.3.15 Information on self-tests and diagnostics

The manufacturer shall provide the following information through convenient documentation and marking:

– description of tests and diagnostics which are implemented and when they are executed (i.e. permanently, periodically, upon user's application programme request, during start-up procedure, etc.);
– correct functioning state and driving conditions of the alarm output(s) (see 6.10).

8.4 Information on EMC installation

General rules of installation are noted in IEC TR 61131-4. Additions or deviations from these shall be provided. If special EMC measures are necessary to fufill the required limits specified in this standard, they shall be clearly stated in the manufacturer's information. These may include:

– use of shielded or special cables;
– termination of shielding connections;
– maximum cable lengths;
– cable seperation;
– use of external devices such as filters;
– correct bonding to functional or earth ground.

If different devices or connections as noted above apply in different EMC Zones or environments, this shall also be provided by the manufacturer.

If the manufacturer has specified a minimum performance level, or a permissible performance loss (see 7.3), then the related performance level shall be described in the instructions for use.

Manufacturer shall also indicate the intended EMC Zone for which the EUT has met the required EMC test limits.

8.5 Information on reliability

If the manufacturer provides values of the mean time between failures (MTBF) of any subassembly or module, and of the type-test configuration(s) (control equipment(s)) under normal operating conditions the manufacturer shall also explain the method used to determine it.

Annex A
(informative)

Temperature derating for altitude

A.1 Standard atmosphere modelling

A.1.1 Ambient temperature

The temperature decreases with altitude at the temperature lapse rate up to the tropopause. Equation (A.1) gives ambient temperature at altitude h (m).

$$T_h = T_0 - Lh \quad \text{(A.1)}$$

Where:

T_h is ambient temperature at altitude, h m,

T_0 is ambient temperature at altitude, 0 m, 298,15 K

L is temperature lapse rate, = g/cp, 0,006 5 K/m

h is altitude.

NOTE Equation (A.1) gives accurate values up to 8 000 m.

A.1.2 Aerostatics equation

The pressure variations for the international standard atmosphere can be calculated by using the hydrostatic Equation (A.2), perfect gas law and the temperature lapse rate equation. The hydrostatic equation for a column of air (see Figure A.1) is the following:

$$dP = -\rho \times g \times dh \quad \text{(A.2)}$$

Where:

P is pressure,

ρ is air density,

g is gravity factor.

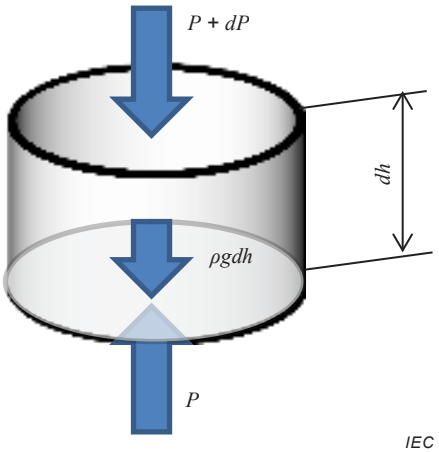


Figure A.1 – A small atmosphere element

The equation of the state of the perfect gas is Equation (A.3).

$$P = \rho \times \frac{R}{M} T \tag{A.3}$$

Where:

R is the ideal gas constant,

M molar mass of dry air.

Equations (A.2) and (A.3) give the hydrostatic Equation (A.4):

$$\frac{dP}{P} = -\frac{\rho g M dh}{\rho R T} = -\left(\frac{gM}{RT}\right) dh \tag{A.4}$$

The integrating Equation (A.3) between sea level (h_0) and altitude: h(m) gives the pressure P_h at altitude h(m).

$$\int_{P_0}^{P} \frac{dP}{P} = -\frac{gM}{R} \int_{h_0}^{h} \frac{dh}{T_0 - Lh} \tag{A.5}$$

The above integration gives Equation (A.6).

$$P_h = P_0 \times \left(1 - \frac{L \cdot h}{t_0}\right)^{\frac{g \cdot M}{R \cdot L}} \tag{A.6}$$

NOTE Equation (A.6) gives good value up to 11 000 m.

A.1.3 Air density

The perfect gas Equation (A.3) gives air density ρ Kg/m^3 at altitude h(m) as shown in Equation (A.7):

$$\rho = \frac{M \cdot P_h}{R \cdot T_h} \tag{A.7}$$

A.1.4 Radiation

The product of the specific heat at the constant pressure, the air volume (the product of the ventilation and the air density) and the temperature differential give the radiation amount Q_V Equation (A.8).

$$Q_V = C_P \times \rho \times V_V \times \Delta \tag{A.8}$$

Where:

C_P is the specific heat at constant pressure, 1 007 J/Kg·K,

V_V is ventilation (m^3/s),

Δ is the temperature differential (K).

A.1.5 Derating ratio

Equation (A.9) gives the derating D_h at altitude h (m) based on the reference altitude h_{ref} (m).

$$
\begin{aligned}
D_h &= Q_{v,h} \Big/ Q_{v,href} \\
&= C_{P,h} \times \rho_h \times V_V \times \Delta \Big/ C_P \times \rho_{href} \times V_V \times \Delta \\
&= \rho_h \Big/ \rho_{href} \\
&= \left(P_h / T_h\right) \Big/ \left(P_{ref} / T_{ref}\right) \\
&= P_h \cdot T_{ref} \Big/ P_{ref} \cdot T_h \\
&= \left(1 - \frac{L \cdot h}{T_0}\right)^{\frac{gM}{RL}} \cdot \left(T_0 - L \cdot h_{ref}\right) \Bigg/ \left(1 - \frac{L \cdot h_{ref}}{T_0}\right)^{\frac{gM}{RL}} \cdot \left(t_0 - L \cdot h\right)
\end{aligned}
\qquad \text{(A.9)}
$$

Table A.1 is calculated utilizing 2 000 m as the reference altitude, and 298,15 K as sea level standard temperature.

Table A.1 – Component temperature derating with altitude, 2 000 m as reference

Altitude m	Derating ratio at 25 °C	Derating ratio at 40 °C	Derating ratio at 55 °C	Derating ratio at 60 °C	Derating ratio at 70 °C
0 to 2 000	1,000	1,000	1,000	1,000	1,000
3 000	0,910	0,915	0,918	0,920	0,922
4 000	0,827	0,835	0,842	0,844	0,848
5 000	0,750	0,761	0,770	0,774	0,780
NOTE 298,15 K is the temperature at sea level.					

A.1.6 Comparison with IEEE1613

Table A.2 is a comparison between this method and IEEE 1613 standard, when the reference altitude is 1 500 m, and 20 °C at the sea level standard temperature. It demonstrates correspondence with IEEE 1613.

Table A.2 – Component temperature derating with altitude, 1 500 m as reference, and 20 °C at the sea level standard temperature

Altitude m	Derating ratio - this method	Derating ratio - IEEE method
0 to 1 500	1,00	1,00
2 000	0,95	0,96
3 000	0,86	0,87
4 000	0,78	0,78
5 000	0,70	0,69

References:

a) Dr. D. I. Benn, *Course material of the climate and weather systems*, University of St. Andrews, 2003.

b) Airbus customer services, *Getting to grips with aircraft performance monitoring*, 2002.

Annex B
(informative)

Digital input standard operating range equations

The following equations were used to generate Table 24 and Table D.1 (with some exceptions explained in the footnotes).

d.c. equations	**a.c. equations**	
$U_{H\ max}$ = 1,25 U_e	$U_{H\ max}$ ≈ 1,1 U_e	
$U_{H\ min}$ ≈ 0,8 U_e – $U_{d\ –}$ 1V	$U_{H\ min}$ ≈ 0,85 U_e – $U_{d\ –}$ 1V	(1), (2)
$U_{T\ max}$ = $U_{H\ min}$	$U_{T\ max}$ = $U_{H\ min}$	
$U_{L\ max}$ = $U_{H\ min}$ for $I \leq I_{T\ min}$	$U_{L\ max}$ = $U_{H\ min}$ for $I \leq I_{T\ min}$	
$U_{T\ min}$ ≈ 0,2 U_e	$U_{T\ min}$ ≈ 0,2 U_e	(1)
$U_{L\ max}$ = $U_{T\ min}$ for $I > I_{T\ min}$	$U_{L\ max}$ = $U_{T\ min}$ for $I > I_{T\ min}$	
$U_{L\ min}$ = -3 V (d.c. 24 V)	$U_{L\ min}$ = 0	
$U_{L\ min}$ = -6 V (d.c. 48 V)		
$I_{L\ min}$ = ND (Not defined)	$I_{L\ min}$ = 0	
Type 1 inputs:	**Type 1 inputs:**	
$I_{H\ max}$ = $I_{T\ max}$ = $I_{L\ max}$ = 15 mA	$I_{H\ max}$ = $I_{T\ max}$ = $I_{L\ max}$ = 15 mA	
$I_{H\ min}$ ≈ $I_{T\ min}$ + 1 mA	$I_{H\ min}$ ≈ $I_{T\ min}$ + 1 mA ($U_e \leq$ 120 V r.m.s.) or	
	$I_{H\ min}$ ≈ $I_{T\ min}$ + 2 mA ($U_e >$ 120 V r.m.s.)	
$I_{T\ min}$ ≈ $U_{H\ max}$/Z	$I_{T\ min}$ ≈ $U_{H\ max}$/Z	(5)
U_d = 3 V (Table 29)	U_d = 5 V (Table 25)	(3)
Type 2 inputs:	**Type 2 inputs:**	
$I_{H\ max}$ = $I_{T\ max}$ = $I_{L\ max}$ = 30 mA	$I_{H\ max}$ = $I_{T\ max}$ = $I_{L\ max}$ = 30 mA	
$I_{H\ min}$ ≈ I_m +1mA = 6 mA	$I_{H\ min}$ ≈ I_m + 1mA = 6 mA	
$I_{T\ min}$ ≈ I_r = 1,5 mA	$I_{T\ min}$ ≈ I_r = 3 mA	(4)
U_d = d.c. 8 V	U_d = a.c. 10 V r.m.s.	(4)
Type 3 inputs:	**Type 3 inputs:**	
$I_{H\ max}$ = $I_{T\ max}$ = $I_{L\ max}$ = 15 mA	$I_{H\ max}$ = $I_{T\ max}$ = $I_{L\ max}$ = 15 mA	
$U_{H\ max}$/Z ≤ $I_{H\ min}$ ≤ I_m = 5 mA	$I_{H\ min}$ ≈ I_m = 5 mA	
$I_{T\ min}$ ≈ I_r = 1,5 mA	$I_{T\ min}$ ≈ I_r = 3 mA	(4)
U_d = d.c. 8 V	U_d = a.c. 10 V r.m.s.	(4)

(1) For all a.c. 100/110/120 V r.m.s. and all a.c. 200/220/230/240 V r.m.s. inputs, U_e has been respectively selected as a.c. 100 V r.m.s. and a.c. 200 V r.m.s., in order to allow compatibility of a single module with various supply voltages.

(2) 1 V drop (a.c. or d.c.) is assumed for the connecting leads.

(3) Maximum values of voltage drops, U_d, of digital outputs for d.c. and a.c.

(4) These values of and I_r, U_d and I_m correspond to those adopted in IEC 60947-5-2.

(5) Z = Empirical worst-case relay contact, open-contact impedance = 100 kΩ.

Annex C
(normative)

Zone C – EMC immunity levels

When higher interference levels are encountered than Zone B, the following levels, associated with Zone C, may be appropriate.

Table C.1 – Enclosure port tests, Zone C

Environmental phenomenon	Basic standard	Test		Test level	Test set-up	Normative items	Performance criteria
Electrostatic discharge	IEC 61000-4-2	Contact		± 4 kV	Table 39	[a]	B
		Air		± 8 kV			
Radio-frequency Electro-magnetic field Amplitude modulated	IEC 61000-4-3	80 % AM, 1 kHz Sinusoidal	2,7 GHz to 6,0 GHz	3 V/m	Table 40	[d]	A
			2,0 GHz to 2,7 GHz	3 V/m			
			1,4 GHz to 2,0 GHz	3 V/m			
			80 MHz to 1 000 MHz	10 V/m			
Power frequency magnetic fields	IEC 61000-4-8	60 Hz		30 A/m	Table 41	[b, c]	A
		50 Hz		30 A/m			

[a] The ESD test shall be applied to:

a) operator accessible devices (for example, HMI, PADT and TE);

b) enclosure ports;

c) service accessible parts (for example, switches, keyboards, protective/functional earth, module housing, communications ports with connectors in place and metal connectors) which are not protected from casual access.

The ESD test shall not be applied to communications ports without connectors in place, I/O ports or power ports.

[b] This test is meant to test equipment sensitivity to magnetic fields normally occurring on the factory floor. The test is only applicable to equipment containing devices susceptible to magnetic fields, such as Hall effect devices, disk drives, magnetic memories and similar equipment. Control equipment does not normally contain such devices; however, other devices, such as HMI, may. The test is not meant to simulate high-intensity magnetic fields such as those, for example, associated with welding and induction heating processes. This requirement may be satisfied by the test being applied to the sensitive device at the device manufacturer. Also see Clause D.6.

[c] See Clause D.6.

[d] This level does not represent the field emitted by a transceiver in close proximity to the EUT.

Table C.2 – Conducted immunity tests, Zone C

	Environmental phenomenon	Fast transient burst	High energy surge	Radio-frequency interference	Damped oscillatory wave
	Basic standard	**IEC 61000-4-4**	**IEC 61000-4-5**	**IEC 61000-4-6**	**IEC 61000-4-18**
	Test set-up	Table 42	Table 43	Table 44	Table C.3
	Performance criteria	**B**	**B**	**A**	**B**
Interface/Port **Figure 7 (designation)**	**Specific interface/port**	**Test level**	**Test level**	**Test level**	**Test level**
Data communication (AI and Ar for I/O racks; Be, Bi and E for peripherals)	Shielded cable	1 kV[d]	2 kV line-to-earth[b]	10 V[d]	0,5 kV line-to-earth
	Unshielded cable	1 kV[d]	2 kV line-to-earth[b]	10 V[d]	No test
Digital and analog I/Os (C & D)	a.c. I/O (unshielded)	2 kV[d]	2 kV line-to-earth[b] 1 kV line-to-line[b]	10 V[d]	2,5 kV line-to-earth 1 kV line-to-line
	Analog or d.c. I/O (unshielded)	2 kV[d]	1 kV line-to-earth[b]	10 V[d]	1 kV line-to-earth 0,5 kV line-to-line
	All shielded lines (to earth)	2 kV[d]	2 kV line-to-earth[b]	10 V[d]	0,5 kV line-to-earth
Equipment power (F)[e]	a.c. power	4 kV	4 kV line-to-earth 2 kV line-to-line	10 V	2,5 kV line-to-earth 1 kV line-to-line
	d.c. power	2 kV[a,d]	1 kV line-to-earth[a,b,c] 1 kV line-to-line[a,b,c]	10 V	2,5 kV line-to-earth[a] 1 kV line-to-line[a]
I/O power (J) and auxiliary power output (K)	a.c. I/O and a.c. auxiliary power	4 kV[d]	4 kV line-to-earth[b] 2 kV line-to-line[b]	10 V	2,5 kV line-to-earth 1 kV line-to-line
	d.c. I/O and d.c. auxiliary power	2 kV [a, d]	1 kV line-to-earth[a,b,c] 1 kV line-to-line[a,b,c]	10 V	2,5 kV line-to-earth[a] 1 kV line-to-line[a]

[a] No test is required if:

1) ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging, or

2) ports intended for use with an a.c.-d.c. power adaptor. (In this case: Test shall be performed on the a.c. power input of the a.c.-d.c. power adaptor specified by the manufacturer or, where none is so specified, using a typical a.c.- d.c. power adaptor) .

[b] For ports with cables specified ≤ 30 m, no test is needed.

[c] No test is required for ports not intended to be connected to a d.c. power network.

[d] For ports with cables specified ≤ 3 m, no test is needed.

[e] Equipment power (F) ports for connection to < 60 V d.c. or a.c. (nominal) shall be tested as I/O power (J) ports. These low voltage sources cannot be considered d.c. or a.c. power networks, as voltage drop practicalities prevent their distribution.

The requirements of this subclause are verified in accordance with Table 39, Table 40, Table 41, Table 42, Table 43, Table 44 and Table C.3.

Table C.3 – Damped oscillatory wave immunity test

Reference test	**IEC 61000-4-18**
EUT configuration	According to manufacturer's specifications
Initial measurements	PFVP; 4.2.8
Details of mounting/support	According to manufacturer's specifications
Waveform	Damped oscillating wave the envelope of which reaches 50 % of the initial peak value after 3 to 6 cycles (verify the sinusoidal shape of the wave)
Frequency	1 MHz ± 10 %
Source impedance	200 Ω ± 10 % unshielded
Repetition rate	400/second
Test duration	≥ 2 s
Length to connection	≤ 2 m
Severity level at rated voltage	Table C.2
Application ports	**Application method**
I/O (C and D), Equipment power (F), I/O power (J) and auxiliary power output (K)	line-to-earth, line-to-line
Measurement and verification during loading	PFVP; 4.2.8
Performance criteria	Table C.2

Annex D
(normative)

Legacy techniques that are out-dated and not recommended for new design

D.1 Background

As technology changes and moves forward some concepts, while perfectly acceptable in earlier times, become or start to become obsolete.

Due to this recognition certain items are removed to this Annex D from the main body. This shall be interpreted that while these items may still be available in control equipment, they shall be discouraged from being offered in new design control equipment.

If however they are still offered, and there could be special application reasons or reasons of compatibility with installed equipment to do this, those e.g. interfaces shall still conform to the original requirements as defined in this document. As such, Annex D is normative.

D.2 Ambient temperature

The ambient temperature range –25 °C to +70 °C is acceptable, but is not recommended for future designs.

See also 5.4.2.

The requirements of Clause D.2 are verified in accordance with Table 4.

D.3 Type 2 digital input

D.3.1 Definition

digital input, type 2
device for sensing signals from solid-state switching devices such as 2-wire proximity switches. Converts an essentially two-state signal to a single-bit binary number

Note 1 to entry: Two-wire proximity switches described here are designed to IEC 60947-5-2.

Note 2 to entry: This class could also be used for Type 1 or Type 3 applications.

D.3.2 Background

Type 2 digital inputs were originally designed, specified and put into use to allow for compatibility between control euipment inputs and field sensors, e.g. proximity switches. This input type significantly reduced the problems associated with field sensor and control equipment input installation compatibility problems.

However, this input type did consume a considerable amount of power. As modules with higher densities of inputs but smaller in size were demanded by customers, significant difficulties were encountered due to heating.

The Type 3 input style was created by cooperative effort between IEC Subcommittees 65B and 121A. A lower power proximity switch type was created along with a lower power input style which preserved the high compatibility, but at a significant power savings. This allowed for high density, small size and lower power on both sides, i.e. interface and sensor.

The Type 3 development and field introduction limited the need for the Type 2 digital input.

Table D.1 – Standard operating ranges for Type 2 digital inputs (current sinking)

Rated voltage U_e	Rated frequency $f_{n\ Hz}$	Type of limit	Type 2 limits [g], (Note)						Normative items
			State 0		Transition		State 1		
			UL	IL	UT	IT	UH	IH	
			V	mA	V	mA	V	mA	
d.c. 24 V		Max.	11/5	30	11	30	30	30	a, b, d, e
		Min.	–3	ND	5	2	11	6	
d.c. 48 V		Max.	30/10	30	30	30	60	30	a, b, d
		Min.	–6	ND	10	2	30	6	
a.c. 24 V r.m.s.	50/60	Max.	10/5	30	10	30	27	30	a, c
		Min.	0	0	5	4	10	6	
a.c. 48 V r.m.s.	50/60	Max.	29/10	30	29	30	53	30	a, c
		Min.	0	0	10	4	29	6	
a.c. 100 V r.m.s. a.c. 110 V r.m.s. a.c. 120 V r.m.s.	50/60	Max.	74/20	30	74	30	1,1 U_e	30	a, c, d, f
		Min.	0	0	20	4	74	6	
a.c. 200 V r.m.s. a.c. 230 V r.m.s. a.c. 240 V r.m.s.	50/60	Max.	159/40	30	159	30	1,1 U_e	30	a, c, d, f
		Min.	0	0	40	5	159	7	

NOTE Compatibility with 2-wire proximity switches according to IEC 60947-5-2 is possible with Type 2. See also c) below.

[a] All logic signals are in positive logic. Open inputs shall be interpreted as state 0 signal. See Annex B for equations and assumptions used in developing values in this table and for additional comments.

[b] The given voltage limits include all alternating voltages components.

[c] Static switches may affect the total r.m.s. content of true harmonics of the input signals and therefore affect the compatibility of the input interface with proximity switches, especially for Type 2, a.c. 24 V r.m.s. See 6.2.1 for requirements.

[d] Recommended for common usage.

[e] The minimum external power supply voltage for Type 2, d.c. 24 V inputs connected to 2-wire proximity switches shall be higher than d.c. 20 V or $U_{H\ min}$ lower than d.c. 11 V to allow sufficient safety margin.

[f] As allowed by current technology, and to encourage the design of single input modules compatible with all commonly used rated voltages, limits are absolute and independent of rated voltage (except $U_{H\ max}$) and based on equations given in Annex B and respectively a.c. 100 V r.m.s. and a.c. 200 V r.m.s.

[g] See definitions in D.3.1.

ND = Not defined

D.4 Analog inputs

Approximately eighty percent of analog loops installed are 4 mA to 20 mA loops. The remaining loops are divided among the votage and current ranges. This leaves a quite small percentage which are 0 mA to 20 mA loops.

As such the 0 mA to 20 mA signal range analog input is not recommended for new designs.

If this style input is offered the rated values of signal range and impedance for analog inputs to control equipment shall be as specified in Table D.2.

Table D.2 – Rated values and impedance limits for analog inputs

Signal range	Input impedance limits	Normative items
0 mA to 20 mA	≤ 300 Ω	[a]
[a] Not recommended for future designs.		

See also 6.5.2.

D.5 Analog outputs

Approximately eighty percent of analog loops installed are 4 mA to 20 mA loops. The remaining loops are divided among the voltage and current ranges. This leaves a quite small percentage which are 0 mA to 20 mA loops.

As such the 0 mA to 20 mA signal range analog output is not recommended for new designs.

If this style output is offered the rated values of signals range and load impedance for analog outputs of control equipment shall be as specified in Table D.3.

Table D.3 – Rated values and impedance limits for analog outputs

Signal range	Load impedance limits	Normative items
0 mA to 20 mA	≤ 600 Ω	[a, b]
[a] Outputs shall withstand any overload from open circuit to short circuit.		
[b] Not recommended for future designs.		

See also 6.5.3.

D.6 CRT displays

With the rapid development, high quality, large size, low cost, etc of flat panel displays, CRT displays are essentially a thing of the past for most applications.

These devices are not recommended for new designs.

If they are employed, they shall meet the requirements of 7.3.1 and Annex C and the footnotes of Table 36 and Table C.1 are modified as follows:

[a] The ESD test shall be applied to

a) operator accessible devices (for example, HMI, PADT and TE);

b) enclosure ports;

c) service accessible parts (for example, switches, keyboards, protective/functional earth, module housing, communications ports with connectors in place and metal connectors) which are not protected from casual access.

The ESD test shall not be applied to communications ports without connectors in place, I/O ports or power ports.

[b] This test is meant to test equipment sensitivity to magnetic fields normally occurring on the factory floor. The test is only applicable to equipment containing devices susceptible to magnetic fields, such as Hall effect devices, CRT displays, disk drives, magnetic memories and similar equipment. Control equipment does not normally contain such devices; however, other devices, such as HMI, may. The test is not meant to simulate

high-intensity magnetic fields such as those, for example, associated with welding and induction heating processes. This requirement may be satisfied by the test being applied to the sensitive device at the device manufacturer.

[c] There shall be no deviation up to 3 A/m. Above 3 A/m the manufacturer shall specify the allowed deviation for CRT display interfaces.

[d] This level does not represent the field emitted by a transceiver in close proximity to the EUT.

The footnote of Table 41 is modified as follows:

[a] For CRTs, the performance criteria are B if the field is ≥ 3 A/m.

The requirements of Clause D.6 are verified in accordance with Table 39, Table 40, Table 41, Table 42, Table 43, and Table 44.

Annex E
(informative)

Application reasoning for a.c. and d.c. interruptions

Figure E.1 depicts two different d.c. bus scenarios.

On the right is depicted a local d.c. distribution bus (e.g. 24 V d.c.). Multiple process control items receive power from this bus. Each is equiped with an overload protection device e.g. circuit breaker or fuse to isolate it from the distribution bus upon fault. Alternately, this device may be used to temporarily disconnect or power down a function.

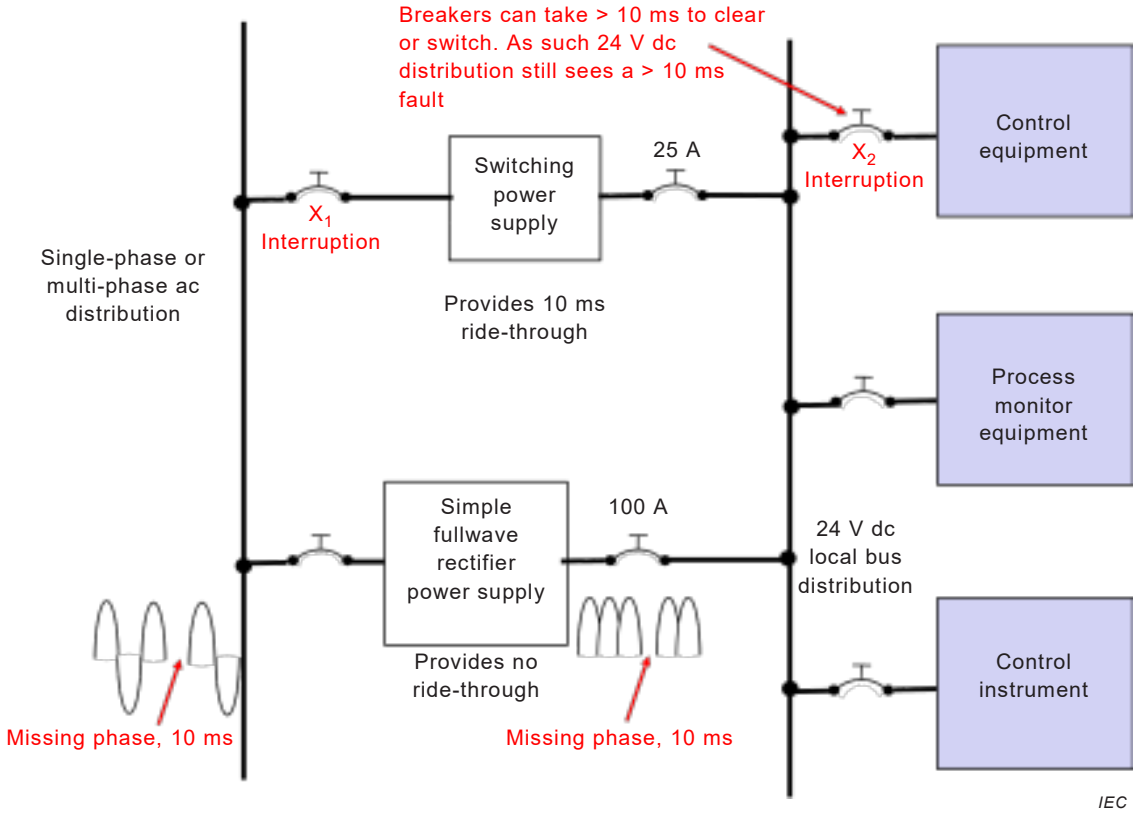


Figure E.1 – d.c. distribution to control equipment and faults

Table 17 offers a set of voltage interruption requirements. Years of experience have shown equipment designed to withstand the PS2 specification, either for a.c. or d.c. supply type, will offer reasonable protection of control equipment elements from disturbance caused by a.c. or d.c. distribution bus interruptions.

Control equipment should provide for its own level of disturbance protection, (e.g. Table 17 PS2 level). This will provide for both disturbances which will be passed through by a simple transformer rectifier or a d.c. distribution circuit breaker trip (X_2 shown in Figure E.1).

Table 17 PS1 interruption level capability relies on having a very robust power distribution system. The power distribution system provides the ride-through and a high degree of certitude that no disturbance will reach the control equipment, at least from the a.c. distribution bus. However, the d.c. distribution circuit breaker trip (X_2 shown in Figure E.1) is still not protected against.

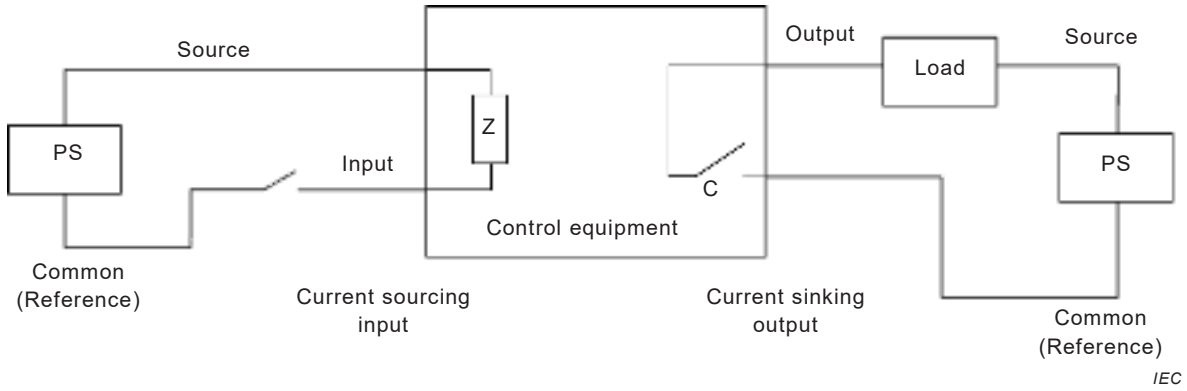
Annex F
(normative)

Digital I/O: Current-sourcing input and current-sinking output

F.1 Digital I/O (negative logic)

Negative logic, current-sourcing inputs and current-sinking outputs may be required for certain applications (Figure F.1). However, they are not recommended by this standard for general application and/or as the preferred style.

Special care must be exercised in their use.



Key

C Output: Mechanical or static contact (e.g. dry relay contact, triac, transistor or equivalent)

Z Input: Input impedance

PS External power supplies

NOTE Some applications can use only one PS common to inputs, outputs and control equipment

Figure F.1 – Negative logic (sourcing inputs / sinking outputs)

Where positive logic, current-sinking inputs and current-sourcing outputs are used (see Figure F.2), any short-circuit (e.g. due to probable application wear of cabling) to the reference potential or wire-breakage is interpreted by the inputs and loads as the “off state”. This yields safe conditions for the control equipment, i.e. loads become de-energized and inputs indicate OFF.

Red ellipse with arrow indicates probable cabling wear shorts in the following Figure F.2 and Figure F.3.

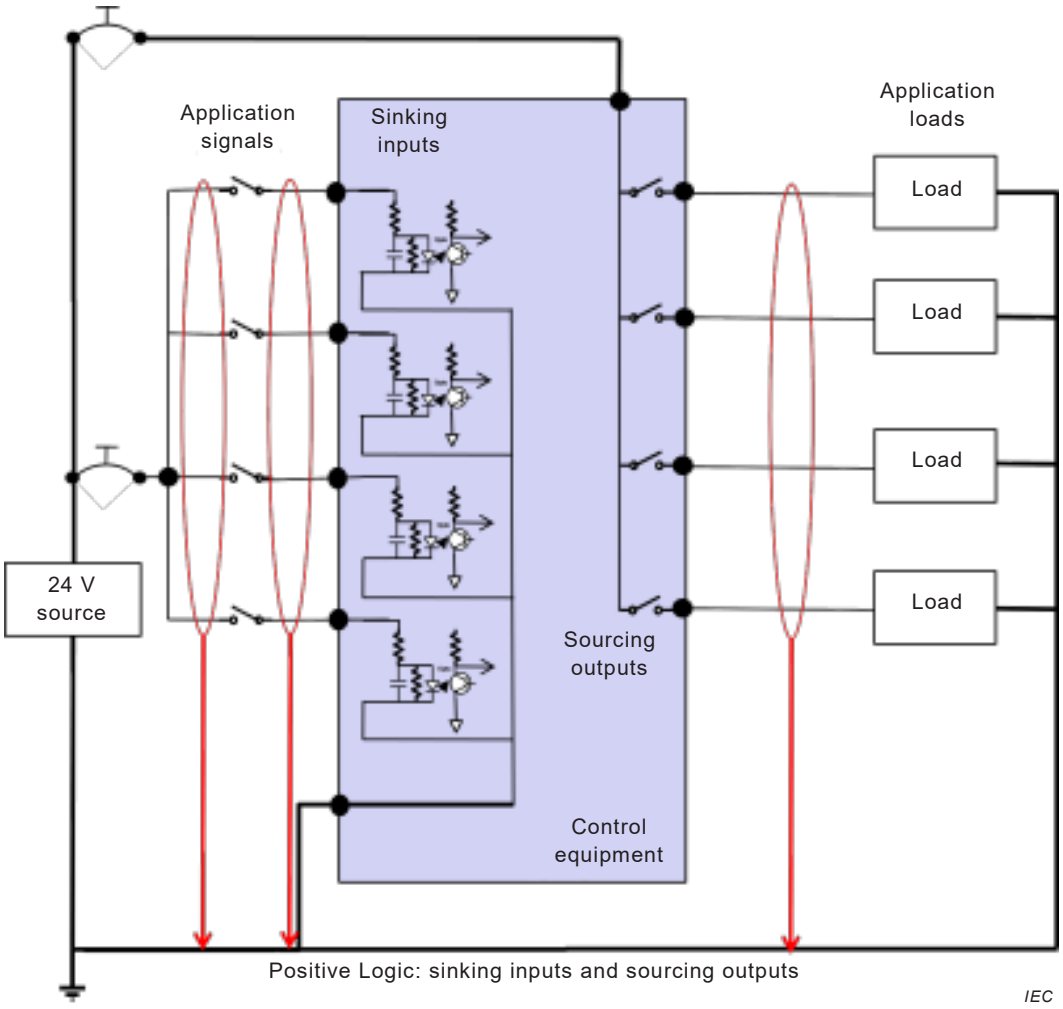


Figure F.2 – Positive logic with faults

Where negative logic, current-sourcing inputs and current-sinking outputs are used (see Figure F.3), any short-circuit (e.g. due to probable application wear of cabling) to the reference potential or earth faults are interpreted by the inputs and loads as the “on state”. This yields unsafe conditions for the control equipment, i.e. loads become energized and inputs indicate ON.

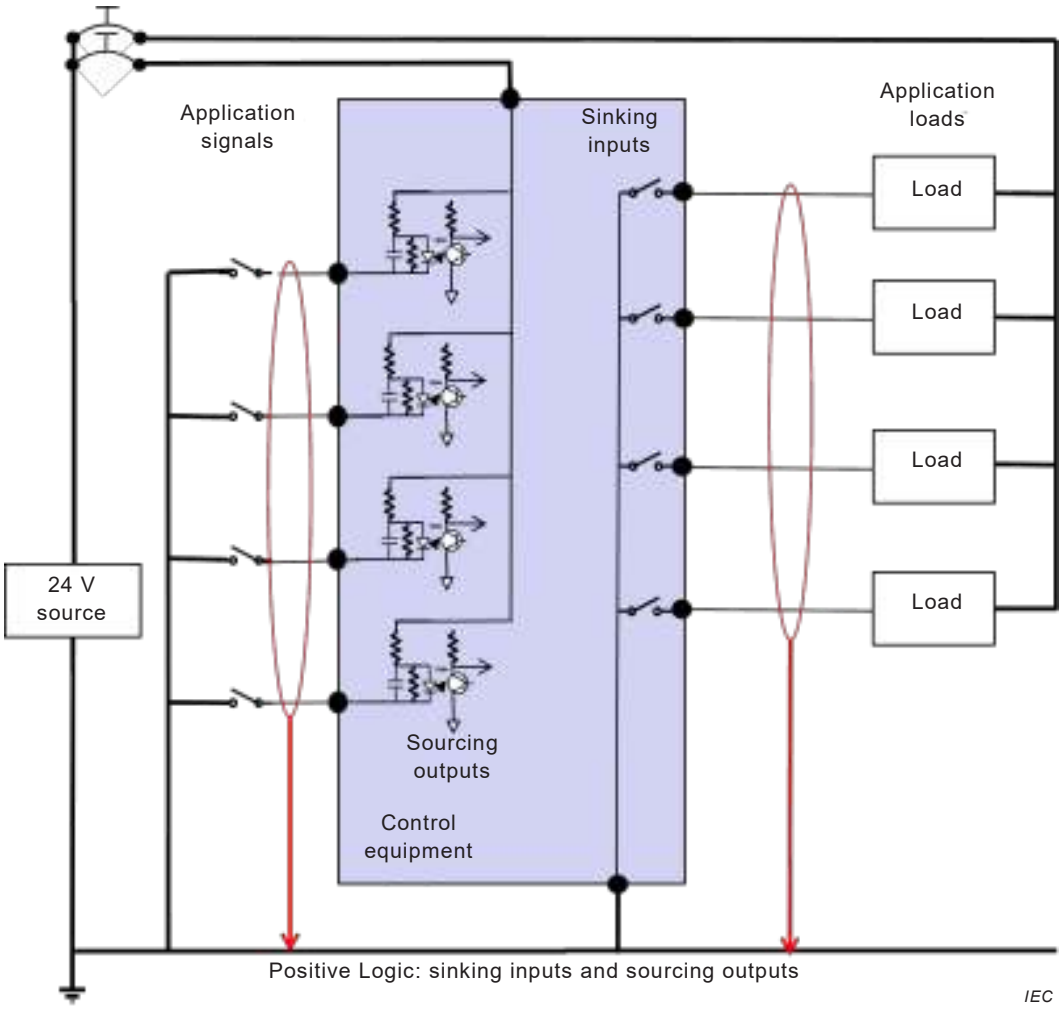


Figure F.3 – Negative logic with faults

Special care is necessary for this negative logic application to prevent earth faults, such as the external power source floated from common earth or extra high wear cabling.

F.2 Function and verification

Functionality and verification of negative logic digital I/O shall be according to 6.4. The sense of the input or output is opposite, but the values and function are the same.

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IEC 60947-5-2, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 60947-5-6, *Low-voltage switchgear and controlgear – Part 5-6: Control circuit devices and switching elements – DC interface for proximity sensors and switching amplifiers (NAMUR)*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

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National Annex A

(*National Foreword*)

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Northern : Plot No. 4-A, Sector 27-B, Madhya Marg, CHANDIGARH 160019 — 265 0206, 265 0290

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