UL 61131-2

STANDARD FOR SAFETY

Programmable Controllers – Part 2:
Equipment Requirements and Tests

UL Standard for Safety for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2

Second Edition, Dated June 5, 2008

Summary of Topics

This revision of ANSI/UL 61131-2 dated June 10, 2021 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated April 9, 2021.

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UL 61131-2

Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests

First Edition – Not Printed

Second Edition

June 5, 2008

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through June 10, 2021.

The most recent designation of ANSI/UL 61131-2 as a Reaffirmed American National Standard (ANS) occurred on June 10, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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Preface (UL)

This UL Standard is based on IEC Publication 61131-2: second edition Programmable Controllers – Part 2: Equipment Requirements and Tests, as revised by Corrigendum 1, March 2004. IEC publication 61131-2 is copyrighted by the IEC.

Efforts have been made to synchronize the UL edition number with that of the corresponding IEC standard with which this standard is harmonized. As a result, one or more UL edition numbers have been skipped to match that of the IEC edition number.

Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

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NATIONAL DIFFERENCES

GENERAL

National Differences from the text of International Electrotechnical Commission (IEC) Publication 61131-2, Programmable Controllers – Part 2: Equipment Requirements and Tests, copyright February 2003 as revised March 2004 are indicated by notations (differences) and are presented in bold text.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

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FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROGRAMMABLE CONTROLLERS – Part 2: Equipment requirements and tests

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61131-2 has been prepared by subcommittee 65B: Devices, of IEC technical committee 65: Industrial-process measurement and control.

This second edition of IEC 61131-2 cancels and replaces the first edition published in 1992 and constitutes a technical revision.

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

FDIS	Report on voting
65B/470A/FDIS	65B/481/RVD

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

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

IEC 61131 consists of the following parts under the general title *Programmable controllers*:

Part 1: General information

Part 2: Equipment requirements and tests

Part 3: Programming languages

Part 4: User guidelines

Part 5: Communications

Part 6: Reserved

Part 7: Fuzzy control programming

Part 8: Guidelines for the application and implementation of programming languages

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

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

A bilingual version of this standard may be issued at a later date.

101DV.1 DE *Addition to IEC Foreword notes:*

Annexes DVA, DVB, DVC, DVD, DVE, and DVF form an integral part of this standard.

INTRODUCTION

This part of IEC 61131 constitutes Part 2 of a series of standards on programmable controllers and the associated peripherals and should be read in conjunction with the other parts of the series.

Where a conflict exists between this and other IEC standards (except basic safety standards), the provisions of this standard should be considered to govern in the area of programmable controllers and their associated peripherals.

Compliance with Parts 1 and 2 of this standard cannot be claimed unless the requirements of 7.2 of this part are met.

Service and physical environment requirements are specified in Clause 4. Functional requirements are specified in Clause 5. Electromagnetic compatibility requirements are specified in Clause 8. Safety requirements are specified in Clause 11.

Terms of general use are defined in Part 1 of this standard. More specific terms are defined in each part.

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PROGRAMMABLE CONTROLLERS – Part 2: Equipment requirements and tests

1 General

1.1 Scope and object

This Part of IEC 61131 specifies requirements and related tests for programmable controllers (PLC) and their associated peripherals (for example, programming and debugging tools (PADTs), human-machine interfaces (HMIs), etc.) which have as their intended use the control and command of machines and industrial processes.

PLCs and their associated peripherals are intended to be used in an industrial environment and may be provided as open or enclosed equipment. If a PLC or its associated peripherals are intended for use in other environments, then the specific requirements, standards and installation practices for those other environments must be additionally applied to the PLC and its associated peripherals.

This standard also applies to any products performing the function of PLCs and/or their 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 mains supply voltage does not exceed a.c. 1 000 V r.m.s. (50/60 Hz), or d.c. 1 500 V. (If PLCs 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.)

1.1DV DR *Modification to Paragraph 4 of 1.1:*

Equipment operating at more than 600 V is considered as high voltage equipment with respect to the requirements in the National Electrical Code.

This standard does not deal with the functional safety or other aspects of the overall automated system. PLCs, their application programme and their associated peripherals are considered as components of a control system.

Since PLCs are component devices, safety considerations for the overall automated system including installation and application are beyond the scope of this standard. However, PLC safety as related to electric shock and fire hazards, electrical interference immunity and error detecting of the PLC-system operation (such as the use of parity checking, self-testing diagnostics, etc.), are addressed. Refer to IEC 60364 or applicable national/local regulations for electrical installation and guidelines.

The object of this standard is

– to establish the definitions and identify the principal characteristics relevant to the selection and application of PLCs and their associated peripherals;

– to specify the minimum requirements for functional, electrical, mechanical, environmental and construction characteristics, service conditions, safety, EMC, user programming and tests applicable to PLCs and the associated peripherals.

This Part also specifies

a) service, storage and transportation requirements for PLCs and their associated peripherals (Clause 4);

b) functional requirements for PLCs and their associated peripherals (Clause 5);

c) EMC requirements for PLCs and their associated peripherals (Clause 8);

d) safety requirements for PLCs and their associated peripherals (Clause 11);

e) information that the manufacturer is required to supply (Clauses 7, 10 and 14);

f) test methods and procedures that are to be used for the verification of compliance of PLCs and their associated peripherals with the requirements (Clauses 6, 9, and 12).

The tests are type tests or production routine tests, and not tests related to the ways PLC systems are applied.

1.101DV DR *Addition of the following to 1.1:*

This equipment is intended for installation in accordance with the National Electrical Code (NEC) for use in ordinary locations. Requirements based on the NEC are found in Annex DVA of this document.

1.2 Compliance with this standard

When compliance with this Part of IEC 61131 is indicated without qualification, compliance with all clauses, including all tests and verifications required in this part, must be verified. Moreover, the manufacturer's obligations expressed in this part are not waived if no type test is required, or if the test conditions are restricted for practical reasons.

When compliance with some portion of this Part of IEC 61131 is indicated, it is only necessary to verify compliance with those clauses against which the compliance claim is made. The manufacturer's obligations as indicated above are still applicable. The smallest unit of this part for compliance purposes shall be a clause, such as Clauses 5, 8 or 11.

Compliance with a portion of this Part of IEC 61131 is provided to facilitate efforts with respect to particular conformity assessment requirements (for example, Clause 8 as the compliance requirement for the EU electromagnetic compatibility directive or Clause 11 as the compliance requirement for the EU low-voltage directive).

Compliance with constructional requirements and with requirements for information to be provided by the manufacturer shall be verified by suitable examination, visual inspection and/or measurement.

All requirements not tested according to the clauses on tests and verifications shall be verifiable under a procedure to be agreed to by the manufacturer and the user.

It is the manufacturer's responsibility to ensure that delivered PLC equipment and associated peripherals are equivalent to the sample (s) which have been type-tested according to this Part of IEC 61131 and therefore that they comply with all requirements of this part.

Significant modifications shall be indicated through the use of suitable revision level indexes and markings (see 5.11 and 11.15) and shall comply with this Part of IEC 61131.

NOTE A new type test may be required to confirm compliance.

Where the manufacturer is allowed to select among several options, he shall clearly specify in his catalogues and/or datasheets those to which any portion of the PLC-system equipment complies. This applies to severity classes of voltage drops (i.e. PS1 or PS2) and types of digital inputs (i.e. Type 1 or Type 3).

1.2DV DR *Modification to Clause 1.2:*

This clause is considered informative.

1.3 Normative references

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

IEC 60068-2-1:1990,
Environmental testing – Part 2: Tests – Tests A: Cold

IEC 60068-2-2:1974,
Environmental testing – Part 2: Tests – Tests B: Dry heat

IEC 60068-2-6:1995,
Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)

IEC 60068-2-14:1984,
Environmental testing – Part 2: Tests – Test N: Change of temperature

IEC 60068-2-27:1987,
Environmental testing – Part 2: Tests – Test Ea and guidance: Shock

IEC 60068-2-30:1980,
Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)

IEC 60068-2-31:1969,
Environmental testing – Part 2: Tests – Test Ec: Drop and topple, primarily for equipment-type specimens

IEC 60068-2-32:1975,
Environmental testing – Part 2: Tests – Test Ed: Free fall (Procedure 1)

IEC 60364 (all parts),
Electrical installations of buildings

IEC 60417 (all parts),
Graphical symbols for use on equipment

IEC 60529:1989,
Degrees of protection provided by enclosures (IP Code)

IEC 60664-1:1992,
Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests

IEC 60664-3:1992,
Insulation coordination for equipment within low-voltage systems – Part 3: Use of coatings to achieve insulation coordination of printed board assemblies

IEC 60695-2-1 (all sheets),
Fire hazard testing – Part 2: Test methods – Section 1: Glow-wire test and methods

IEC 60707:1999,
Flammability of solid non-metallic materials when exposed to flame sources – List of test methods

IEC 60947-5-1:1997,
Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices

IEC 60947-7-1:2002,
Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors

IEC 60950-1:2001,
Information technology equipment – Safety – Part 1: General requirements

IEC 61000-4-2:1995,
Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test

IEC 61000-4-3:2002,
Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated radio-frequency electromagnetic field immunity test

IEC 61000-4-4:1995,
Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test

IEC 61000-4-5:1995,
Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test

IEC 61000-4-6:1996,
Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields

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

IEC 61000-4-12:1995,
Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Oscillatory waves immunity test

IEC 61010-1:2001,
Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements

CISPR 11:1999,
Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement

CISPR 16-1:1999,
Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus

CISPR 16-2:1999,
Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbances and immunity

1.102DV D2 *Additions to 1.3:*

1.102DV.1 A component of a product covered by this standard shall comply with the requirements for that component. See Annex DVB for a list of standards covering components used in the products covered by this standard.

1.102DV.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

1.102DV.3 A component shall be used in accordance with its rating established for the intended conditions of use.

1.102DV.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

1.102DV.5 See Annex DVC for Normative References that replace IEC Normative References.

2 Type tests

The object of this clause is to define how to verify compliance of the PLC and the associated peripherals with the requirements set forth in this part of IEC 61131. This compliance verification includes

– verification by type tests given in Clauses 6, 9 and 12,

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

These tests are qualification tests, and not tests related to the ways PLCs are employed. According to the scope of this standard, the above compliance verification may not cover the verification of the ability of the PLC-system to satisfy the intended automated system requirements. Where needed, special tests, not covered by this standard, shall be agreed to by the manufacturer and the user.

In addition, routine tests are specified in Clause 13.

NOTE Peripherals, used in the same environment as the PLC-system, must meet the same requirements as the PLC-system.

2DV D2 *Modification to Clause 2:*

This clause and all its subclauses are informative.

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

PLC-systems span the range from stand-alone products to modular designs; this leads to an infinite variety of user-built actual PLC-system configurations. For obvious practical reasons, in most cases type tests cannot be conducted on EUT identical to user-built PLC-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.

If an EUT representing a basic PLC or a remote I/Os (RIOS) is of modular structure, it shall fulfil the following minimum requirement.

All types of modules shall be represented in 1 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 may be appropriate to consider statistical criteria based on samples, for a large number of I/Os (for example, >100).

If there are too many families to be included into a single EUT, the manufacturer will define several EUTs.

– For the type test of a family with very similar modules (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 basic PLC-system only 1 arbitrarily chosen member of the family. If the type test is dependent on the differences between the modules, then a single family member may 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 PLC-system and if its maximum cable length cable is less than, or equal to, 3 m, it is considered to be an internal PLC bus. As such, it should not be considered a port for test.

– If a local bus extension is part of the PLC-system and is capable of driving cables with a length of >3 m, then only 1 end of the link is part of the EUT and it is considered as a communication port.

When new units/modules are introduced after initial release of a PLC-system 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.

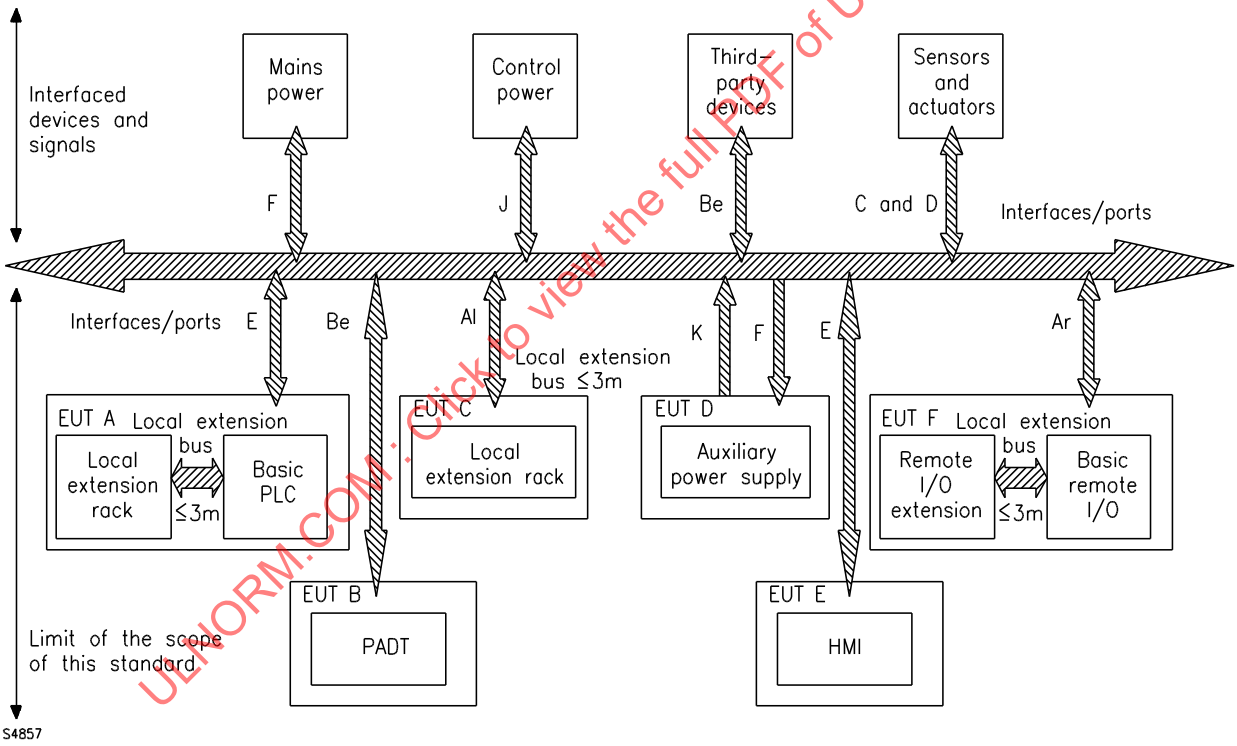
Unless otherwise specified in this standard, the manufacturer may elect either that each type test be conducted on a new EUT or that several type tests be performed successively on the same EUT.

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 must reflect this need. See specific test clauses for recommendations for EUTs.

2.2 Special features for immunity and EMC tests

Figure 1

EUT configurations



Each subpart of the PLC-system as shown in Figure 2 may constitute an EUT represented in Figure 1 as EUT A, B, C, D, E and/or F. To exercise the different ports of each EUT, the manufacturer may define subsystems and the different EUTs are tested in turn.

Only 1 subsystem is under test at any time, the others being considered as auxiliary equipment.

For instance, to achieve a given test on the EUT A, equipment of the other EUTs may be connected but are not in the test bed.

For example, to check the electrical interference immunity of the PLC-system, the manufacturer may choose between the following, as applicable:

– to build a single global EUT including the PADT/TE/RIOSs, and check the whole configuration; or

– to define a suite of simpler EUTs (for example, a PLC-system 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/RIOSs. For practical reasons, the manufacturer may elect to use actual PADTs/TEs/RIOSs to exercise the EUT ports.

At least 1 of each type or a representative number of I/O ports of the EUT must be connected and be functional.

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

2.3 Withstand test conditions

In general, the module which is in the manufacturer's catalogue should be tested alone, providing that mixing several modules does not affect the result of the test. Refer to those clauses dealing with withstand tests for specifics.

2.4 Verification procedure

Type tests shall be conducted on the EUT(s) defined in 2.1, unless otherwise specified.

For each test, the manufacturer shall

– specify how this configuration shall be installed and externally connected;

– provide the suitable test programmes which shall be run during the test;

– provide the proper operation verification procedure including the way to measure accuracy and temporary deviations of analogue I/Os.

The appropriate test programmes and proper functioning verification procedures provided by the manufacturer shall satisfy the requirements given in 2.5.

2.5 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, unless required by the test;

– 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 analogue I/Os out of the limits specified in item 4 of 7.10.2 and item 3 of 7.11.2.

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.

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

All external and internal product status information reporting means, such as displays, lamps, alarm signals, self-test result registers, shall be exercised. The test procedures shall include conditions to verify the related activities.

All various PLC-system operation modes significant for the user's implementation such as start-up and shut-down, cold/warm/hot restart, “normal run”, “normal stop”, “programme/monitor with PADTs”, etc., as applicable, shall be verified for performance and behaviour.

Initialization and reset conditions of all system components shall be checked for controlled start-up and shut-down. The various modes, such as “run”, “programme”, “monitor”, shall be verified for performance and behaviour.

Any special feature/performance not covered in this standard but necessary for the proper operation of the basic PLC-system shall be exercised and tested.

2.6 General 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 1, unless otherwise specified.

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

Table 1
General conditions for tests

	Test conditions
Mains power supply	Rated voltage and frequency
Temperature	15 °C to 35 °C
Relative humidity	≤75 %
Barometric pressure	86 kPa to 106 kPa (650 mm Hg to 800 mm Hg)
Output loads	Outputs loaded to rated load
Pollution	Pollution degree 2

3 Terms and definitions

For the purposes of this Part of IEC 61131, the following terms and definitions, in addition to those given in IEC 61131-1, apply.

3.1 **analogue input**: device which converts a continuous signal to a discretely valued multi-bit binary number, for use by the PLC-system

3.2 **analogue output**: device which converts a multi-bit binary number from the PLC-system to a continuous signal

3.3 **accessible**: able to be touched by the jointed test finger or test pin, when installed as intended. See 12.1.2, 12.1.3 and Annex C

3.4 **basic PLC (-system)**: configuration which consists, at a minimum, of a processing unit, power supply and I/O. See Figure 2.

3.5 **battery**: electrochemical energy source which may be rechargeable or non-rechargeable

3.6 **clearance**: shortest distance in air between two conductive parts

[IEC 60664-1]

3.7 **coating, protective**: covering of suitable insulating material that encloses the clearance and/or creepage distance of the printed wiring board and conforms to the surface of the board in such a manner that the environment is excluded and the clearance and/or creepage distance can withstand the required impulse and continuous potential

NOTE Coating is normally applied to exclude the effects of atmosphere and to increase the dielectric properties of the clearance and/or creepage distances that would not normally be adequate without coating. A less effective coating may exclude the atmosphere, but cannot be relied on to enhance the dielectric properties.

3.8 **comparative tracking index (CTI)**: numerical value of the maximum voltage at which a material withstands 50 drops of NH_4Cl solution (ammonia chloride) without tracking.

[IEC 60112]

3.9 **creepage distance**: shortest distance along the surface of the insulating material between two conductive parts

[IEV 60151-15-50]

3.10 **current sinking**: property of receiving current

3.11 **current sourcing**: property of supplying current.

3.12 **digital input, type 1**: device for sensing signals from mechanical contact switching devices, such as relay contacts, push-buttons, switches, etc. Converts an essentially two-state signal to a single-bit binary number

NOTE Type 1 digital inputs may not be suitable for use with solid-state devices such as sensors, proximity switches, etc.

3.13 **digital input, type 2**: device for sensing signals from solid-state switching devices such as 2-wire proximity switches. Converts an essentially 2-state signal to a single-bit binary number

NOTE 1 Two-wire proximity switches described here are designed to IEC 60947-5-2.

NOTE 2 This class could also be used for Type 1 or Type 3 applications.

3.14 **digital input, type 3**: device for sensing signals from solid-state switching devices such as 2-wire proximity switches. Converts an essentially 2-state signal to a single-bit binary number

NOTE 1 This class could also be used for Type 1 applications.

NOTE 2 Type 3 digital inputs offer lower power characteristics then Type 2 digital inputs. Generally, this allows much higher input channel densities per module or product. Type 3 differs from Type 2 in that it is compatible with those IEC 60947-5-2 devices that offer low current in the off state. See Table 7 for details of operating ranges. Proximity switch compatibility is such that a high percentage of proximity switches having Type 2 compatibility will also have Type 3 compatibility.

3.15 **digital output**: device which converts a single-bit binary number to a 2-state signal

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

3.17 **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

[IEV 60161-01-07]

3.18 **enclosed equipment**: equipment which is enclosed on all sides with the possible exception of its mounting surface to prevent personnel from accidentally touching live or moving parts contained therein and to protect the equipment against ingress of medium-size solid foreign bodies, and meeting requirements of mechanical strength, flammability, and stability (where applicable). Protection degree must be ≥ IP20

3.19 **enclosure**: housing affording the type and degree of protection suitable for the intended application

[IEV 60195-02-35]

3.20 **equipment class**: class numbers designate the means by which electric shock protection is maintained in normal condition and single-fault conditions of the installed equipment

[IEC 61140]

3.21 **equipment under test (EUT)**: representative configuration (s), as defined by the manufacturer, used for type tests (see Clause 2)

3.22 **external wiring**: wiring of the PLC-system equipment, which is installed by the user

3.23 **field wiring**: external wiring

3.24 **functional earthing conductor**: conductor that is in electrical contact with, for example, Earth, for purposes of interference immunity improvement

3.25 **hand-held equipment**: equipment which is intended to be held in one hand while being operated with the other hand

3.26 **hazardous live**: capable of rendering an electric shock or electric burn in normal condition or single-fault condition.

NOTE See 11.1.1.1 for values applicable to normal condition and 11.1.1.2 for the values applicable to single-fault condition.

3.27 **immunity (to a disturbance)**: ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 60161-01-20]

NOTE Not used exclusively to refer to EMC in this standard. It may also refer, for example, to vibration, humidity, etc.

3.28 **immunity type test (immunity test)**: type test verifying that the basic PLC-system operation is not altered by the application of specified influencing quantities that are intended to approximate normal operation

3.29 **insulation**:

NOTE 1 Insulation can be a solid, a liquid, a gas (for example, air), or any combination. [IEV 60151-03-30]

NOTE 2 (To) insulate – To prevent conduction between separate conductive bodies. [IEV 60151-03-28]

NOTE 3 (To) isolate – To disconnect completely a device or circuit from other devices or circuits.

To provide (by separation) a specified degree of protection from any live circuit. [IEV 60151-03-29]

3.29.1 **basic insulation**: insulation of hazardous live parts, which provides basic protection against electric shock under fault-free conditions

[IEV 60195-06-06 and IEV 60195-06-01]

NOTE This concept does not apply to insulation used exclusively for functional purposes. Such insulation is referred to as functional insulation.

3.29.2 **double insulation**: insulation comprising both basic insulation and supplementary insulation

[IEV 60195-06-08]

3.29.3 **reinforced insulation**: insulation of hazardous live parts which provides a degree of protection against electric shock equivalent to double insulation

NOTE Reinforced insulation may comprise several layers which cannot be tested singly as basic or supplementary insulation.

[IEV 60195-06-09]

3.29.4 **supplementary insulation**: independent insulation applied in addition to basic insulation, for fault protection

[IEV 60195-06-07]

3.30 **interface**: shared boundary between a considered system and another system, or between parts of a system, through which information or electrical energy is conveyed

3.31 **internal wiring**: wiring which is inside the PLC-system equipment, which is installed by the manufacturer

3.32 **isolated (devices, circuits)**: devices or circuits without galvanic connection between them

3.33 **live part**: conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

NOTE 1 This concept does not necessarily imply a risk of electric shock. [IEV 60195-02-19]

NOTE 2 PEN conductor – conductor combining the functions of both a protective earthing conductor and a neutral conductor. [IEV 60195-02-12]

NOTE 3 PEM conductor – conductor combining the functions of a protective earthing conductor and a mid-point conductor. [IEV 60195-02-13]

NOTE 4 PEL conductor – conductor combining the functions of both a protective earthing conductor and a line conductor. [IEV 60195-02-14]

[IEV 60195-02-19]

3.34 **mains power supply**: power from the conductors/mains of the permanent installation of the building at the supply voltage to the PLC-system

3.35 **material group**: classification of insulating materials in terms of comparative tracking index (CTI) range (see 11.4.3)

3.36 **micro-environment**: ambient conditions which surround the clearance or creepage distance being reviewed

NOTE The micro-environment of the clearance or creepage distance and not the environment of the equipment determines the effect of the insulation. The micro-environment may be better or worse than the environment of the equipment. It includes all factors influencing the insulation, such as climatic, electromagnetic, pollution, etc. (IEC 60664).

3.37 **module**: part of the PLC-system containing an identified function(s) (MPU, analogue input, etc.), which may plug into a backplane or base

3.38 **multi-channel module**: module containing multiple input and/or output signal interfaces. These signal interfaces could be isolated or not isolated from each other

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

NOTE Normal service conditions are stated in Clause 4.

3.40 **normal condition**: condition in which all means for protection against hazards are intact that is, a fault-free condition

3.41 **open equipment**: equipment that may have live electrical parts accessible, for example, a main processing unit. Open equipment is to be incorporated into other assemblies manufactured to provide safety

3.42 **operator**: person commanding and monitoring a machine or process through an HMI connected to the PLC. The operator does not change the PLC hardware configuration, software or the application programme. A PLC is not intended for use by untrained personnel. The operator is assumed to be aware of the general hazards in an industrial environment

3.43 **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.

[IEC 60664-1]

NOTE 1 In an electrical system, the transition from 1 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 Equipment covered in this standard is intended for use in overvoltage category II.

3.44 **permanent installation**: portion of the PLC-system which is required to perform the intended application function

NOTE See Annex A.

3.45 **pollution degree (in the micro-environment)**: for the purpose of evaluating clearances and creepage distances, 3 degrees of pollution in the micro-environment are established

NOTE 1 The conductivity of a polluted insulation is due to the deposition of foreign matter and moisture.

NOTE 2 The minimum clearances given for pollution degrees 2 and 3 are based on experience rather than on fundamental data.

3.45.1 **pollution degree 1**: no pollution or only dry, non-conductive pollution occurs. The pollution has no influence

3.45.2 **pollution degree 2**: normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected

3.45.3 **pollution degree 3**: conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation, which is expected

3.46 **port**: interface

NOTE Most commonly used with respect to EMC.

3.47 **portable equipment**: enclosed equipment that is moved while in operation or which can easily be moved from one place to another while connected to the supply

NOTE Examples are programming and debugging tools (PADTs) and test equipment (TE).

3.48 **protective conductor**: conductor provided for purposes of safety, for example, protection against electric shock

[IEV 60195-02-09]

3.49 **protective extra-low voltage (PELV) circuit**: electrical circuit in which the voltage cannot exceed a.c. 30 V r.m.s., 42,4 V peak or d.c. 60 V in normal and single-fault condition, except earth faults in other circuits.

A PELV circuit is similar to an SELV circuit that is connected to protective earth

3.50 **protective impedance**: single component regarded as fault-free, a combination of components, or a combination of basic insulation and a current- or voltage-limiting device, the impedance, construction and reliability of which are such that when connected between parts which are hazardous live and accessible conductive parts, it provides protection to the extent required by this standard in normal and single-fault condition

3.51 **recurring peak voltage**: peak value of a generated voltage whose characteristic is recurring at some specified period

3.52 **routine test**: conformity test made on each individual item during or after manufacture

[IEV 60151-16-17]

3.53 **safety extra-low voltage circuit (SELV circuit)**: electrical circuit in which the voltage cannot exceed a.c. 30 V r.m.s., 42,4 V peak or d.c. 60 V in normal and single-fault condition, including earth faults in other circuits.

An SELV circuit is not connected to protective earth

3.54 **service personnel**: person changing or repairing the PLC hardware configuration or the application programme

The service person may also install software updates provided by the manufacturer. They are assumed to be trained in the programming and operation of the PLC equipment and its use.

They are persons having the appropriate technical training and experiences necessary to be aware of hazards – in particular, electrical hazards – to which they are exposed in performing a task and of measures to minimize danger to themselves or to other persons or to the equipment.

3.55 **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 For a multi-channel module, the total output current is generally less than the sum of the output currents of the channels.

3.56 **type test**: conformity test made on one or more items representative of the production

[IEV 60151-16-16]

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

3.58 **withstand type test (withstand test)**: type test verifying that the application of more severe influencing quantities to the basic PLC system does not impair its ability to assume its intended mission

3.59 **working voltage**: highest value of the a.c. (r.m.s) or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage (U_e)

Transients are disregarded.

Both open-circuit conditions and normal use are taken into account.

4 Normal service conditions and requirements

It is the user's responsibility to ensure that the equipment service conditions are not exceeded. The PLC and PLC-system is intended to be used in an industrial environment.

The user must ensure the installation conditions match the environmental conditions given in this standard.

4.1 Climatic conditions and requirements

4.1.1 Operating ambient air temperature

The equipment shall be suitable for the operating temperature ranges given by the following Table 2.

Table 2
Operating ambient air temperature of PLC-systems

Temperature range	Type of limit	Enclosed equipment (ventilated/non-ventilated)		Open equipment
		Permanent installation	Non-permanent installation	Permanent installation
	Max.	40 °C	40 °C	55 °C
	Min.	5 °C	5 °C	5 °C
Average temperature over 24 h	Max.	35 °C	35 °C	50 °C

For enclosed non-ventilated equipment that is cooled by natural air convection, the equipment ambient air temperature is the room temperature 1 m away from the surface of the enclosure on a horizontal plane located at the vertical mid-point of the enclosure.

For enclosed ventilated equipment, the equipment ambient temperature is the temperature of the incoming air.

For open equipment, the ambient air temperature is the temperature of the incoming air immediately below the equipment.

No forced external cooling is assumed. Open peripherals, which are intended to be permanently installed as part of the PLC-system, shall meet the operating temperature range of the PLC.

Some types of equipment (for example, panel-mounted HMI, etc.) can use a combination of open and enclosed characteristics.

Requirements of this subclause are verified in accordance with 6.1.1 and 6.1.2.

4.1.1DV D2 *Modification to 4.1.1:*

The equipment shall be suitable for operating in a temperature range from 5°C to 25°C for both open and enclosed equipment and shall be marked in accordance with Table 11.15DV.1.1.

4.1.2 Relative humidity

The equipment shall be suitable for a relative humidity level from 10 % to 95 %, noncondensing.

Requirements of this subclause are verified in accordance with 6.1.3.

4.1.2DV D2 *Modification to 4.1.2:*

This clause is informative.

4.1.3 Altitude

The equipment shall be suitable for operation up to 2 000 m.

No test required.

4.1.4 Pollution degree

Where not otherwise specified by the manufacturer the equipment is designed for use in pollution degree 2.

4.2 Mechanical service conditions and requirements

Vibration, shock and free-fall conditions vary widely depending on the installation and environment and are very difficult to specify.

For the purpose of this standard, the service conditions are indirectly defined by the following requirements which apply to fixed equipment as well as to unpackaged portable and handheld equipment (see exceptions in 4.2.2). They do not apply to equipment containing assemblies other than PLC-systems and/or associated peripherals.

Experience shows that equipment meeting these requirements is suitable for industrial use on stationary installations.

Fixed equipment is that which is part of the permanent installation.

4.2DV D2 *Modification to 4.2:*

This clause and its subclauses are informative.

4.2.1 Vibrations

Immunity requirements are:

Table 3
Sinusoidal vibrations service conditions for PLC-systems

Frequency range Hz	Continuous	Occasional
$5 \le f < 9$	1,75 mm amplitude	3,5 mm amplitude
$9 \le f \le 150$	0,5 g constant acceleration	1,0 g constant acceleration

Vibration is applicable to each 3 mutually perpendicular axes.

The manufacturer shall specify the method of mounting portable and hand-held peripherals on the test equipment.

Requirements of this subclause are verified in accordance with 6.2.1.

4.2.2 Shock

Immunity requirements are occasional excursions to 15 g, 11 ms, half-sine, in each of 3 mutually perpendicular axes.

Devices containing CRTs are excluded from this requirement.

Electromechanical relays may temporarily respond to 15 g shocks. Temporary malfunctioning is allowed during the test, but equipment should be fully functional after the test.

Requirements of this subclause are verified in accordance with 6.2.2.

4.2.3 Free falls (portable and hand-held equipment)

Immunity requirements for free falls are:

Table 4
Free fall on concrete floor for portable and hand-held equipment

	Portable and hand-held (any weight) (withstand)	Hand-held (any weight) (immunity)	Normative items
Random drops	–	1 000 mm; 2 trials	(1), (2), (4)
Flat drops	100 mm; 2 trials	–	(1), (4)
Supported drops	30° or 100 mm; 2 trials	–	(1), (3), (4)
(1) Caution: temporary malfunctioning is allowed at the impact, but equipment shall be fully functional after the test. Therefore, if equipment is operating during the fall, erroneous operation could be introduced upon impact which may require operator correction. (2) From prescribed altitude (normal position of use) Table 17. (3) See Table 17. (4) Random drops are drops on any edge, surface or corner. Flat drops are only on surfaces. Supported drops are only on edges.			

Requirements of this subclause are verified in accordance with 6.2.3.

4.3 Transport and storage conditions and requirements

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

Transport and storage of unpackaged portable equipment should not exceed the requirements of 4.2.

When components are included in the equipment that have particular limitations (for example, CMOS components, batteries, etc.), the manufacturer shall specify the arrangements to be made for transport and storage.

4.3DV D2 *Modification to 4.3:*

This clause and its subclauses are informative.

4.3.1 Temperature

The allowable temperature range is -40 °C to +70 °C.

The temperature range -25 °C to +70 °C is acceptable, but is not recommended for future designs.

Requirements of this subclause are verified in accordance with 6.1.1.

The relative humidity range is 10 % to 95 %, non-condensing.

Requirements of this subclause are verified in accordance with 6.2.3.

4.3.2 Relative humidity

The relative humidity range is 10 % to 95 %, non-condensing.

Requirements of this subclause are verified in accordance with 6.1.3.

4.3.3 Altitude

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

No test required.

4.3.4 Free falls (PLC units in manufacturer's original packaging)

Withstand requirements for PLC units within manufacturer's original packaging are given in Table 5 below. After the test, they shall be fully functional and shall show no evidence of physical damage.

Table 5
Free fall on concrete floor in manufacturer's original packaging

Shipping weight with packaging kg	Random free-fall height mm		Number of falls
	With shipping package	With product package	
<10	1000	300	5
10 to 40	500	300	5
>40	250	250	5

Requirements of this subclause are verified in accordance with 6.2.4.

4.3.5 Other conditions

The user should reach agreement with the manufacturer for any mechanical conditions that are not specified in this standard. This may include items such as extra-low temperature storage, higher altitude transportation, etc.