



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 3502 : 2004
(JEMA/JSA)

**Programmable controllers—
Equipment requirements and tests**

ICS 25.040.40; 35.240.50

Reference number : JIS B 3502 : 2004 (E)

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee, as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Electrical Manufacturers' Association (JEMA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 3502 : 1997** is replaced with this Standard.

This Standard has been made based on **IEC/FDIS 61131-2 Programmable controllers—Equipment requirements and tests** for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

Date of Establishment: 1993-07-01

Date of Revision: 2004-06-20

Date of Public Notice in Official Gazette: 2004-06-21

Investigated by: Japanese Industrial Standards Committee
Standards Board
Technical Committee on Industrial
Automation

JIS B 3502:2004, First English edition published in 2005-06

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

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Programmable controllers— Equipment requirements and tests

Introduction This Japanese Industrial Standard has been prepared based on IEC/**FDIS 61131-2** *Programmable controllers—Equipment requirements and tests* registered in 2003 as FDIS with some modifications of the technical contents.

Portions given sidelines or dotted underlines are the matters modified from the original International Standard. A list of modification with the explanations is given in annex 1 (informative).

1 General

1.1 Scope This Standard specifies requirements and related tests for programmable controllers (PLCs) 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 (see **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.)

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 **JIS C 0364** series or applicable national/local regulations for electrical installation and guidelines.

The object of this Standard groups⁽¹⁾ is as follows:

Note (1) Standard groups refer to **JIS B 3501**, **JIS B 3502**, **JIS B 3503**, **IEC/TR3 61131-4**, **IEC 61131-5**, **IEC 61131-7** and **IEC 61131-8**.

- a) to establish the definitions and identify the principal characteristics relevant to the selection and application of PLCs and their associated peripherals;
- b) 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 Standard also specifies

- 1) service, storage and transportation requirements for PLCs and their associated peripherals (clause 4);
- 2) functional requirements for PLCs and their associated peripherals (clause 5);
- 3) EMC requirements for PLCs and their associated peripherals (clause 8);
- 4) safety requirements for PLCs and their associated peripherals (clause 11);
- 5) information that the manufacturer is required to supply (clauses 7, 10 and 14);
- 6) test methods and procedures that are to be used for the verification of compliance of PLCs and their associated peripherals with the requirements (5.12, 8.4, 11.16 and 11.17).

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

1.2 Compliance with this Standard When compliance with this Standard is indicated without qualification, compliance with all clauses, including all tests and verifications required in this Standard, must be verified. Moreover, the manufacturer's obligations expressed in this Standard 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 Standard 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 Standard for compliance purposes shall be a clause, such as clauses 5, 8 or 11.

Compliance with a portion of this Standard 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.

The manufacturer shall provide, on request, compliance verification information for all requirements referenced in the claims of compliance with all or a portion of this Standard.

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 Standard and therefore that they comply with all requirements of this Standard.

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 Standard.

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).

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.

NOTE : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the content between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

IEC 61131-2 : 2003 *Programmable controllers—Equipment requirements and tests* (MOD)

1.3 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect/publication is given to these referred standards, only the edition of indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of publication apply limiting only to the most recent editions (including amendments).

JIS B 3501 : 2004 *Programmable controllers—Part 1 : General information*

Remarks : IEC/FDIS 61131-1 : 2003 *Programmable Controllers—Part 1 : General information* is identical with the said standard.

JIS B 3503 : 1997 *Programmable controllers—Programming languages*

Remarks : IEC 61131-3 : 1993 *Programmable Controllers—Part 3 : Programming languages* is equivalent to the said standard.

JIS C 60068-2-1 : 1995 *Environmental testing procedures Part 2 : Tests, Tests A : Cold*

Remarks : IEC 60068-2-1 : 1990 *Environmental testing—Part 2 : Tests, Tests A : Cold* is identical with the said standard.

JIS C 60068-2-2 : 1995 *Basic environmental testing procedures Part 2 : Tests, Test B : Dry heat*

Remarks : **IEC 60068-2-2** : 1974 *Environmental testing—Part 2 : Tests. Tests B : Dry heat* is identical with the said standard.

JIS C 0025 : 1988 *Basic environmental testing procedures Part 2 : Tests Test N : Change of temperature*

Remarks : **IEC 60068-2-14** : 1984 *Environmental testing—Part 2 : Tests. Test N : Change of temperature* is equivalent to the said standard.

JIS C 60068-2-30 : 1988 *Basic environmental testing procedures Part 2 : Tests Test Db : Damp heat, cyclic (12+12-Hour cycle)*

Remarks : **IEC 60068-2-30** : 1980 *Environmental testing—Part 2 : Tests. Test Db and guidance : Damp heat, cyclic (12+12-hour cycle)* is identical with the said standard.

JIS C 60068-2-6 : 1999 *Environmental testing Part 2 : Tests—Test Fc : Vibration (sinusoidal)*

Remarks : **IEC 60068-2-6** : 1995 *Environmental testing—Part 2 : Tests—Test Fc : Vibration (sinusoidal)* is identical with the said standard.

JIS C 60068-2-27 : 1995 *Basic environmental testing procedures Part 2 : Tests, Test Ea and guidance : Shock*

Remarks : **IEC 60068-2-27** : 1987 *Environmental testing. Part 2 : Tests. Tests Ea and guidance : Shock* is identical with the said standard.

JIS C 60068-2-31 : 1995 *Environmental testing Part 2 : Tests. Test Ec : Drop and topple, primarily for equipment-type specimens*

Remarks : **IEC 60068-2-31** : 1969 *Environmental testing. Part 2 : Tests. Tests Ec : Drop and topple, primarily for equipment-type specimens* is identical with the said standard.

JIS C 60068-2-32 : 1995 *Environmental testing Part 2 : Tests. Test Ed : Free fall*

Remarks : **IEC 60068-2-32** : 1975 *Environmental testing. Part 2 : Tests. Test Ed : Free fall. (Procedure 1)* is identical with the said standard.

JIS C 0066 : 2001 *Flammability of solid non-metallic materials when exposed to flame sources—List of test methods*

Remarks : **IEC 60707** : 1999 *Flammability of solid non-metallic materials when exposed to flame sources—List of test methods* is identical with the said standard.

JIS C 60050-161 : 1997 *International Electrotechnical Vocabulary : Electromagnetic compatibility*

Remarks : **IEC 60050-161** : 1990 *International Electrotechnical Vocabulary—Chapter 161 : Electromagnetic compatibility* is identical with the said standard.

JIS C 0364-1 : 1999 *Electrical installations of buildings Part 1 : Scope, object and fundamental principle*

Remarks : **IEC 60364-1** *Electrical installations of buildings—Part 1 : Scope, object and fundamental principles* is identical with the said standard.

JIS C 0704 : 1995 *Insulation test for control gear*

JIS C 0920 : 1993 *Degrees of protection provided by enclosures (IP Code)*

Remarks : **IEC 60529** : 1989 *Degrees of protection provided by enclosures (IP Code)* is equivalent to the said standard.

JIS C 61000-4-2 : 1999 *Electromagnetic compatibility (EMC)—Part 4 : Testing and measurement techniques—Section 2 : Electrostatic discharge immunity test*

Remarks : **IEC 61000-4-2** : 1998 *Electromagnetic compatibility (EMC), Part 4-2 : Testing and measurement techniques—Electrostatic discharge immunity test* is identical with the said standard.

JIS C 61000-4-3 : 2004 *Electromagnetic compatibility (EMC)—Part 4-3 : Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test*

Remarks : **IEC 61000-4-3** : 1998 *Electromagnetic compatibility (EMC), Part 4-3 : Testing and measurement techniques—Radiated radio frequency electromagnetic field immunity test* is identical with the said standard.

JIS C 61000-4-4 : 1999 *Electromagnetic compatibility (EMC)—Part 4 : Testing and measurement techniques—Section 4 : Electrical fast transient/burst immunity test*

Remarks : **IEC 61000-4-4** : 1995 *Electromagnetic compatibility (EMC), Part 4 : Testing and measurement techniques—Section 4 : Electrical fast transient/burst immunity test* is equivalent to the said standard.

JIS C 61000-4-5 : 1999 *Electromagnetic compatibility (EMC), Part 4 : Testing and measurement techniques—Section 5 : Surge immunity test*

Remarks : **IEC 61000-4-5** : 1995 *Electromagnetic compatibility (EMC), Part 4-5 : Testing and measurement techniques—Surge immunity test* is equivalent to the said standard.

JIS C 61000-4-6 : 1999 *Electromagnetic compatibility (EMC)—Part 4 : Testing and measurement techniques—Section 6 : Immunity to conducted disturbances, induced by radio-frequency fields*

Remarks : **IEC 61000-4-6** : 1996 *Electromagnetic compatibility (EMC), Part 4-6 : Testing and measurement techniques—Immunity to conducted disturbances induced by radio frequency fields* is equivalent to the said standard.

JIS C 1010-1 : 1998 *Safety requirements for electrical equipment for measurement, control, and laboratory use—Part 1 : General requirements*

Remarks : **IEC 61010-1** : 1990 *Safety requirements for electrical equipment for measurement, control, and laboratory use—Part 1 : General requirements* is equivalent to the said standard.

JIS C 2134 : 1996 *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

Remarks : **IEC 60112** : 1979 *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions* is identical with the said standard.

JIS C 6950 : 2001 *Safety of information technology equipment*

Remarks : **IEC 60950-1** : 2001 *Information technology equipment—Safety—Part 1 : General requirements* is equivalent to the said standard.

JIS C 8201-5-1 : 1999 *Low-voltage switchgear and controlgear—Part 5-1 : Control circuit devices and switching elements—Electromechanical control circuit devices*

Remarks : **IEC 60947-5-1** : 1997 *Low-voltage switchgear and controlgear—Part 5-1 : Control circuit devices and switching elements—Electromechanical control circuit devices* is equivalent to the said standard.

JIS C 8201-5-2 : 1999 *Low-voltage switchgear and controlgear—Part 5 : Control circuit devices and switching elements—Section 2 : Proximity switches*

Remarks : **IEC 60947-5-2** : 1997 *Low-voltage switchgear and controlgear—Part 5-2 : Control circuit devices and switching elements—Proximity switches* is equivalent to the said standard.

IEC 60038 : 1983 *IEC standard voltages*

IEC 60050-151 : 2001 *International Electrotechnical Vocabulary—Part 151 : Electrical and magnetic devices*

IEC 60050-195 *International Electrotechnical Vocabulary—Part 195 : Earthing and protection against electric shock*

IEC 60060-1 : 1989 *High-voltage test techniques—Part 1 : General definitions and test requirements*

IEC 60417 *Graphical symbols for use on equipment*

IEC 60445 : 1999 *Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals and of terminations of certain designated conductors, including general rules for and alphanumeric system*

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 *Fire hazard testing—Part 2 : Test methods—Section 1 : Glow-wire test and methods*

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

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 61140 : 2001 *Protection against electric shock—Common aspects for installation and equipment*
- IEC 61131-2 : 1992 *Programmable controllers—Part 2 : Equipment requirements and tests*
- IEC/TR3 61131-4 : 1995 *Programmable controllers—Part 4 : User guidelines*
- IEC 61131-5 *Programmable controllers—Part 5 : Communications*
- IEC 61506 : 1997 *Industrial-process measurement and control—Documentation of application software*
- IEC 62079 : 2001 *Preparation of instructions—Structuring, content and presentation*
- 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*

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 Standard. This compliance verification includes

- a) verification by type tests given in 5.12, 8.4 and 11.16,
- b) 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.

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 : The application of statistical criteria based on samples for a large number of I/Os (for example, > 100) may be considered.

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

Interfaces/ports shown are meant to represent major/example links, not all links. Most EUTs will have multiple interface/ports active during testing

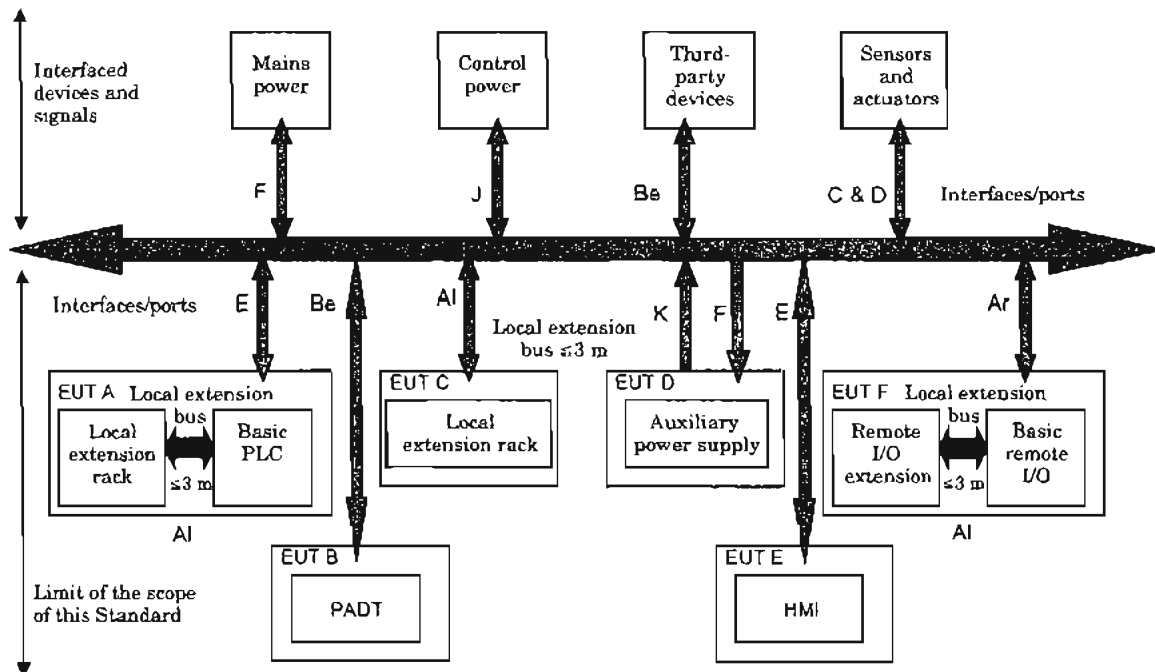


Figure 1 EUT configuration

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 one 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

- a) specify how this configuration shall be installed and externally connected;
- b) provide the suitable test programmes which shall be run during the test;
- c) 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

- a) destruction of hardware, unless required by the test;
- b) modification of the operating system and test programmes and/or alteration of their execution;
- c) unintended modification of system and application data stored or exchanged;
- d) erratic or unintended behaviour of the EUT;
- e) deviation of the analogue I/Os out of the limits specified in 4) of 7.10.2 and 3) of 7.11.2.

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

Item	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 mmHg to 800 mmHg)
Output loads	Outputs loaded to rated load
Pollution	Pollution degree 2

3 Terms and definitions For the purposes of this Standard, the following terms and definitions, in addition to those given in **JIS B 3501 : 2003**, 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 (**JIS C 0704**)

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 (**JIS C 2134**)

3.9 creepage distance shortest distance along the surface of the insulating material between two conductive parts (**IEV 60151-03-37**)

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 : Two-wire proximity switches described here are designed to **JIS C 8201-5-2**. 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 : This class could also be used for Type 1 applications.

Type 3 digital inputs offer lower power characteristics than 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 **JIS C 8201-5-2** 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 (**JIS C 60050-161**)

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 $\geq$ 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 (JIS C 60050-161)

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

— (To) insulate To prevent conduction between separate conductive bodies (IEV 60151-03-28).

— (To) isolate To disconnect completely a device or circuit from other devices or circuits.

NOTE : 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 supplementary insulation independent insulation applied in addition to basic insulation, for fault protection (**IEV 60195-06-07**)

3.29.3 double insulation insulation comprising both basic insulation and supplementary insulation (**IEV 60195-06-08**)

3.29.4 reinforced insulation insulation of hazardous live parts which provides a degree of protection against electric shock equivalent to double insulation (**IEV 60195-06-09**)

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

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 (**IEV 60195-02-19**)

NOTE : This concept does not necessarily imply a risk of electric shock (**IEV 60195-02-19**).

PEN conductor conductor combining the functions of both a protective earthing conductor and a neutral conductor (**IEV 60195-02-12**).

PEM conductor conductor combining the functions of a protective earthing conductor and a mid-point conductor (**IEV 60195-02-13**).

PEL conductor conductor combining the functions of both a protective earthing conductor and a line conductor (**IEV 60195-02-14**).

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. (JIS C 0704).

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 (JIS C 0704)

NOTE : 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.

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

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

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

NOTE : 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

Unit: °C

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

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.

4.1.2 Relative humidity The equipment shall be suitable for a relative humidity level from 10 % to 95 %, non-condensing.

Requirements of this subclause are verified in accordance with 6.1.3.

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 hand-held 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.

4.2.1 Vibrations Immunity requirements are:

Table 3 Sinusoidal vibrations service conditions for PLC-systems

Frequency range Hz	Continuous	Occasional
$5 \leq f < 9$	Amplitude 1.75 mm	Amplitude 3.5 mm
$9 \leq f < 150$	Constant acceleration 4.9 m/s ²	Constant acceleration 9.8 m/s ²

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 147 m/s², 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 147 m/s² 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	(²), (³), (⁵)
Flat drops	100 mm; 2 trials	—	(²), (⁵)
Supported drops	30° or 100 mm; 2 trials	—	(²), (⁴), (⁵)

Notes (²) 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.

- (3) From prescribed altitude (normal position of use) table 17.
- (4) See table 17.
- (5) 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.

4.3.1 Temperature The allowable temperature range is -40°C to $+70^{\circ}\text{C}$. The temperature range -25°C to $+70^{\circ}\text{C}$ is acceptable, but is not recommended for future designs.

Requirements of this subclause are verified in accordance with 6.1.1.

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 drop height mm		Number of falls
	With shipping package	With product package	
< 10	1 000	300	5
10 to 40	500	200	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.

4.4 Electrical service conditions and requirements

4.4.1 AC and d.c. mains power supply Refer to 5.1.1.

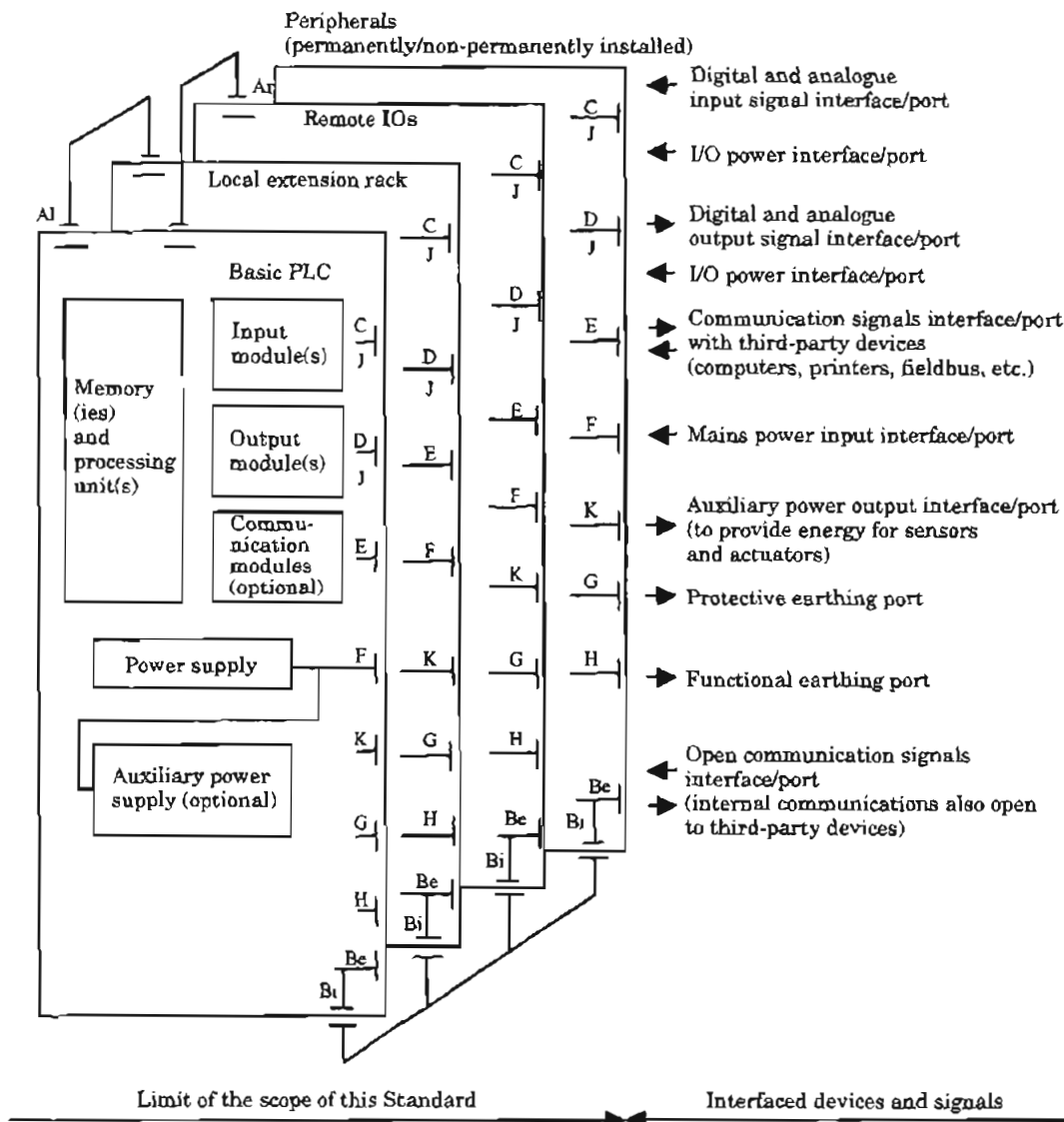
4.4.2 Overvoltage category, control of transient overvoltages The nature of the installation shall be such that overvoltage category II conditions shall not be exceeded.

Transient overvoltages at the point of connection to the mains 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.

4.4.3 Non-periodic overvoltages In the industrial environment, non-periodic overvoltage peaks may appear on mains power supply lines as a result of power interruptions to high-energy equipment (for example, blown fuse on 1 branch in a 3-phase system). This will cause high current pulses at relatively low voltage levels (approximately $2 \times U_{peak}$). The user shall take the necessary steps to prevent damage to the PLC-system (for example, by interposing a transformer).

4.5 Special conditions and requirements When the service conditions are more severe than those given in 4.1, 4.2, 4.3 and 4.4 or other adverse environmental conditions exist (for example, air pollution by dust, smoke, corrosive or radioactive particles, vapours or salts, attack by fungi, insects or small animals), the manufacturer should be consulted to determine suitability of the equipment or the steps to be taken.

5 Functional requirements A typical PLC-system and its interfaces/ports are shown in figure 2.



Key

- Al : Communication interface/port for local I/O
- Ar : Communication interface/port for remote I/O station
- Be : Open communication interface/port also open to third-party devices (for example, personal computer used for programming instead of a PADT)
- Bi : Internal communication interface/port for peripherals
- C : Interface/port for digital and analogue input signals
- D : Interface/port for digital and analogue output signals
- E : Serial or parallel communication interfaces/ports for data communication with third-party devices
- F : Mains-power interface/port
Devices with F ports have requirements on keeping downstream devices intelligent during power up, power down and power interruptions.
- G : Port for protective earthing
- H : Port for functional earthing
- J : I/O power interface/port used to power sensors and actuators
- K : Auxiliary power output interface/port

Figure 2 Typical interface/port diagram of a PLC-system

5.1 Functional power supply and memory back-up requirements

5.1.1 AC and d.c. power supply Requirements of this subclause are verified in accordance with 6.3.1, 6.3.2 and 6.3.3.

5.1.1.1 Rated values and operating ranges Incoming power supplies to the PLC-system and to the externally powered I/O modules shall be as shown in table 6.

Table 6 Rated values and operating ranges of incoming power supply

Voltage		Frequency		Recommended use (R)		Normative items ⁽⁸⁾
Rated (U_n)	Tolerance (min./max.)	Rated (F_n)	Tolerance (min./max.)	Power supply	I/O signals ⁽¹⁰⁾	
DC 24 V	−15 %			○	○	(6)
DC 48 V	+20 %			○	○	(6), (7)
DC 125 V				—	—	—
AC 24 V	−15 %	50 Hz or 60 Hz	−6 % +4 %	—	—	(11)
AC 48 V	+10 %			—	—	(11)
AC 100 V				○	○	—
AC 110 V				○	○	—
AC 120 V				○	○	(11)
AC 200 V				○	○	—
AC 230 V				○	○	(11)
AC 240 V				○	○	—
AC 400 V				○	—	(9), (11)

Notes (6) 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.

(7) See note (16) of table 7 if Type 2 digital inputs are likely to be used.

(8) For the rated voltage tolerances other than those given in table 7, this table and note (6) apply. These voltage tolerances shall be used to calculate the input limits of table 7, using the design equations given in annex B.

(9) Three-phase supply.

(10) For power supplies for analogue I/Os, see 5) of 7.10.3 and 3) of 7.11.3.

(11) The rated voltages are derived from IEC 60038.

Requirements of this subclause are verified in accordance with 6.3.1.

5.1.1.2 Voltage harmonics AC voltage is in terms of the total r.m.s. voltage values measured at the point of entry to the equipment.

Total r.m.s. content of true harmonics (integral multiple of nominal frequency) less than 10 times nominal frequency may reach 10 % of the measured voltage.

Harmonic and other frequency content for higher frequencies may reach 2 % of the measured voltage. However, to provide constant comparative results, the equipment shall be tested at the third harmonic only (10 % at 0° and at 180° phase angle).

The total content of harmonics of the power supply to the PLC-system may be affected when the energy source output impedance is relatively high with regard to the input impedance of the PLC-system power supply; sizing a dedicated power source such as an inverter for a PLC-system may require an agreement between the user and the manufacturer. The use of line conditioner should be considered (see IEC/TRS 61131-4).

Requirements of this subclause are verified in accordance with 6.3.1.2.

5.1.2 Memory back-up 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 a 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.)

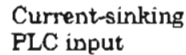
The manufacturer should specify storage time information relative to volatile memory if different from stated durations.

It shall be possible to change or refresh power back-up without loss of data in the backed-up portions of memory (see also 4.3, 7.6 and 7.13).

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

Requirements of this subclause are verified in accordance with 6.3.4.

5.2 Digital I/Os For the type of digital inputs, there are current-sinking inputs and current-sourcing inputs, and for the type of digital outputs, there are current-sinking outputs and current-sourcing outputs. Figure 3 and figure 3A give illustrations of combination of digital inputs and outputs.



PLC output

Mechanical or static contact (for example dry relay contact, triac, transistor or equivalent).

The earths shown are selectable.

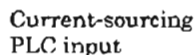
ments for electric facilities" and/or application needs.

Input impedance

External power supplies

E: Some applications may use only 1 PS common to inputs, outputs and PLC-system.

Figure 3 Current-sinking inputs and current-sourcing outputs



Current-sinking PLC output

Digital I/Os shall comply with the following requirements.

- a) The PLC-system shall be provided with at least 1 type of input interface and 1 type of output interface among those defined respectively in 5.2.1, 5.2.5 and 5.2.6.
- b) Digital inputs shall comply with the requirements of the standard voltage ratings given in 5.2.1. Non-standard voltage digital inputs should be in accordance with the design equations given in annex B.
- c) Digital outputs shall comply with the requirements of the standard ratings given in 5.2.5.1 for a.c. or 5.2.6.1 for d.c.
- d) It shall be possible to interconnect inputs and outputs by means of a correct selection of the above digital I/Os, resulting in proper PLC-system operation. Additional external load shall be specified by the manufacturer if necessary.
- e) It shall be possible to feed isolated multi-channel a.c. input modules from different phases and the modules shall then comply with the maximum voltage difference likely to occur between phases, or the user manual shall include a note indicating that all channels must be fed from the same phase.
- f) If a multi-channel a.c. circuit is intended for multi-phase use, the circuit shall comply with the clearance and creepage distance requirements and the dielectric test corresponding to the voltage between phases.

NOTES 1 For current-sinking inputs and current-sourcing outputs shown in figure 3B, when the input signal is disconnected or short-circuited to common [earth-faulted when external power supplies (PS) are earthed], the input signal is interpreted as the “off state”. Furthermore, when the output signal is disconnected or is short-circuited (earth-faulted) to the earth side of external power supplies (PS), the load is interpreted as the “off state”. On the other hand, for current-sourcing inputs and current-sinking outputs shown in figure 3C, when external power supplies (PS) are earthed, earth faults of the input signal line becomes “on state” of the input signal, and the earth fault of the output signal line are interpreted as the “on state” of the load. When applying, care should be taken so that external power supplies (PS) are made not to be earthed, etc.

- 2 A PLC-system may be offered with interfaces that are not covered in this Standard, i.e., interfaces for TTL and CMOS circuits, etc. In such a case, the manufacturer’s data shall give all relevant information to the user.

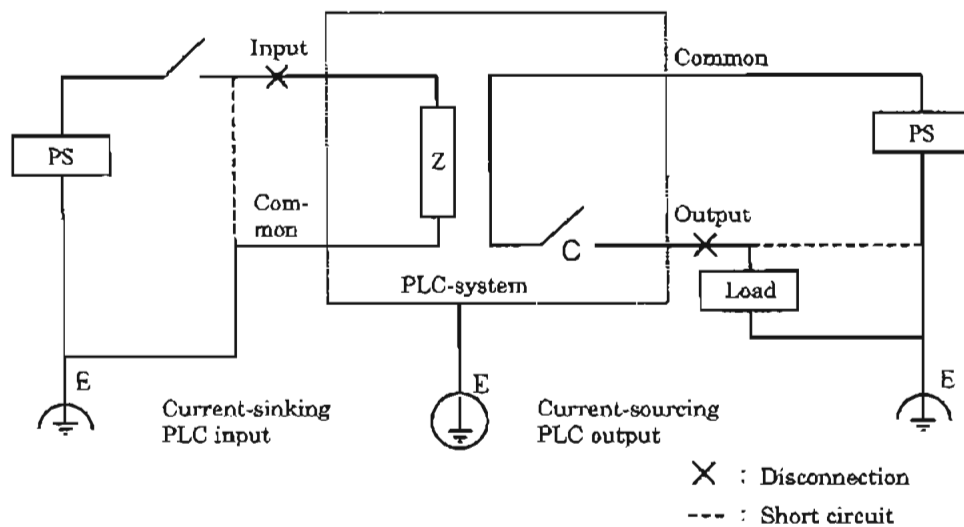


Figure 3B Short circuit—disconnection state for current-sinking inputs and current-sourcing outputs

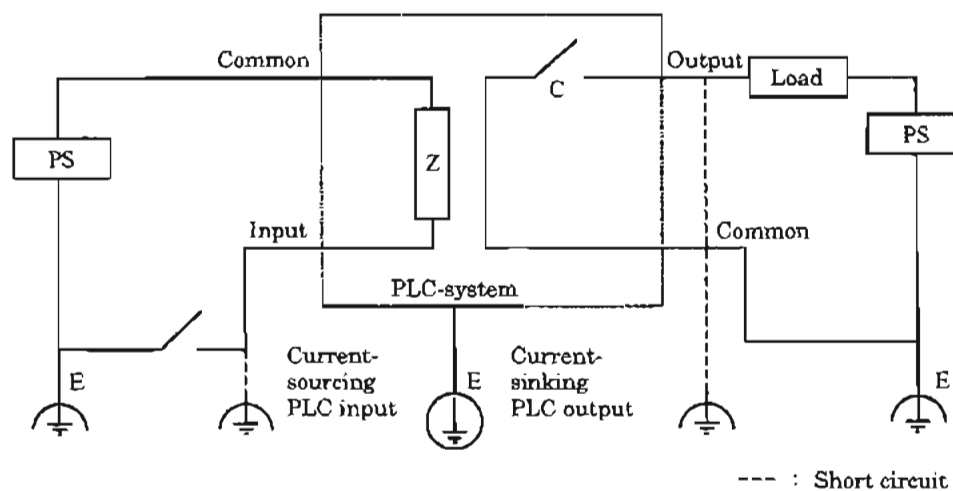
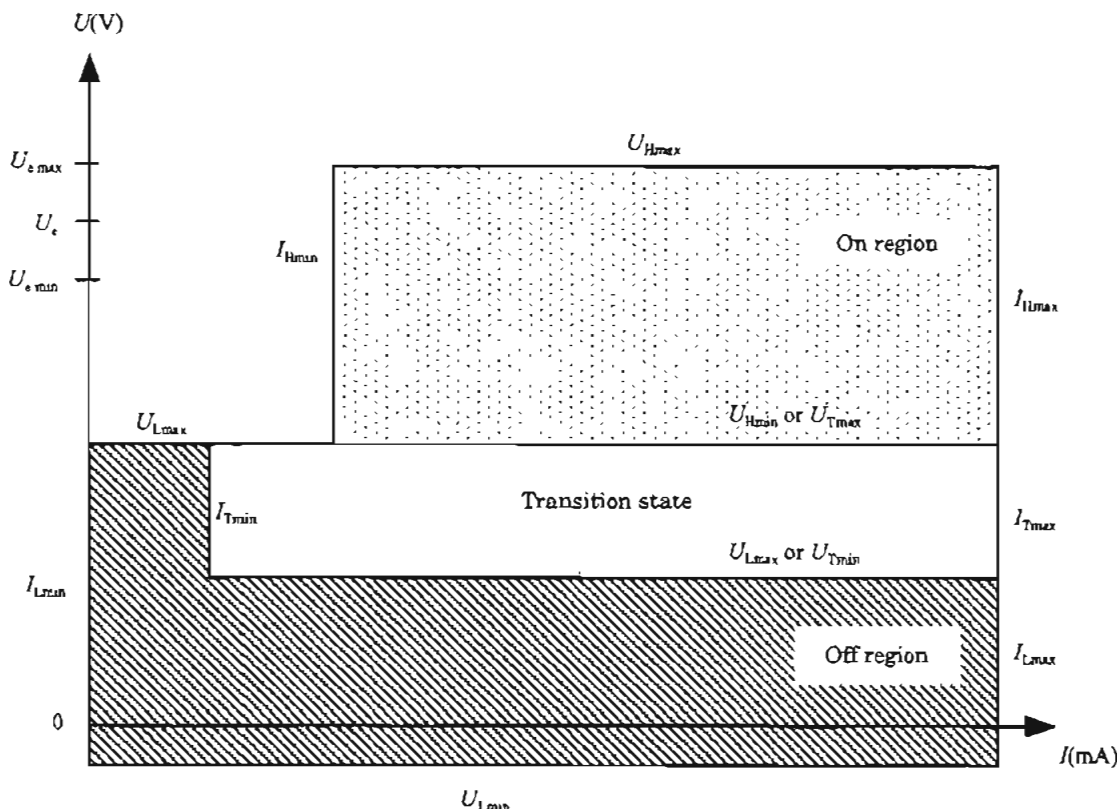


Figure 3C Earth fault state for current-sourcing inputs and current-sinking outputs

5.2.1 Digital inputs Requirements of this subclause are verified in accordance with 6.4.2.

5.2.2 U/I operation regions Figure 4 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_{Tmin} and I_{Tmin} to leave the “off region”, and to exceed I_{Hmin} before U_{Hmin} to enter the “on region”: all input U-I curves shall remain within these boundary conditions. The region below zero volts is a valid part of the “off region” for d.c. inputs only.



NOTES 1 State 1 shows on region, and state 0 shows off region.

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.

2 Figure 4 shows voltage and current of sinking inputs to common, and in the case of sourcing inputs, figure 4 is used by inverting the polarity of voltage and current.

Figure 4 U-I operation regions of current-sinking inputs

5.2.3 Standard operating ranges for digital inputs Current-sinking digital inputs shall operate within the limits presented in table 7.

Table 7 Standard operating ranges for digital inputs⁽¹⁹⁾

Rated voltage U_i (²⁰)	Rated frequency F_n Hz	Type of limit	Type 1 limits (¹⁸)						Type 2 limits (¹⁸)						Type 3 limits (¹⁸)						Normative items
			State 0		Transition		State 1		State 0		Transition		State 1		State 0		Transition		State 1		
			U_L (V)	I_L (mA)	U_T (V)	I_T (mA)	U_H (V)	I_H (mA)	U_L (V)	I_L (mA)	U_T (V)	I_T (mA)	U_H (V)	I_H (mA)	U_L (V)	I_L (mA)	U_T (V)	I_T (mA)	U_H (V)	I_H (mA)	
DC 24 V	—	Max	15/5	15	15	15	30	15	11/5	30	11	30	30	30	11/5	15	11	15	30	15	(12), (13), (15), (16)
		Min	—3	ND	5	0.5	15	2	—3	ND	5	2	11	6	—3	ND	5	1.5	11	2	
DC 48 V	—	Max	34/10	15	34	15	60	15	30/10	30	30	30	60	30	30/10	15	30	15	60	15	(12), (13), (15)
		Min	—6	ND	10	0.5	34	2	—6	ND	10	2	30	6	—6	ND	10	1.5	30	2	
AC 24 V	50/60	Max	14/5	15	14	15	27	15	10/5	30	10	30	27	30	10/5	15	10	15	27	15	(12), (14)
		Min	0	0	5	1	14	2	0	0	5	4	10	6	0	0	5	2	10	5	
AC 48 V	50/60	Max	34/10	15	34	15	53	15	29/10	30	29	30	53	30	30/10	15	30	15	53	15	(12), (14)
		Min	0	0	10	1	34	2	0	0	10	4	29	6	0	0	10	2	30	5	
AC 100 V AC 110 V AC 120 V	50/60	Max	74/20	15	79	15	1.1 U_i	15	74/20	30	74	30	1.1 U_i	30	74/20	15	74	15	1.1 U_i	15	(12), (14), (15), (17)
		Min	0	0	20	1	79	2	0	0	20	4	74	6	0	0	20	2.5	74	5	
AC 200 V AC 230 V AC 240 V	50/60	Max	164/40	15	164	15	1.1 U_i	15	159/40	30	159	30	1.1 U_i	30	159/40	15	159	15	1.1 U_i	15	(12), (14), (15), (17)
		Min	0	0	40	2	164	3	0	0	40	5	159	7	0	0	40	2.5	159	5	

ND : Not defined

Notes (¹²) 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.

(¹³) The given voltage limits include all alternating voltages components.

(¹⁴) 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 5.1.1.1 for requirements.

(¹⁵) Recommended for common usage and future designs.

(¹⁶) The minimum external power supply voltage for Type 2, d.c. 24 V inputs connected to 2-wire proximity switches should be higher than d.c. 20 V or U_{Hmin} lower than 11 V to allow sufficient safety margin.

(¹⁷) As allowed by current technology, and to encourage the design of single input modules compatible with all commonly used rated voltages, limits are absolute. For the calculation of limits, see annex B.

(¹⁸) For definitions, see 3.12, 3.13 and 3.14.

(¹⁹) Table 7 shows voltage and current of sinking inputs to common, and in the case of sourcing inputs, table 7 is used by inverting the polarity of voltage and current.

(²⁰) DC 12 V, DC 110 V, AC 220 V, etc. are calculated in annex B.

5.2.4 Additional requirements Each input channel shall be provided with a lamp or equivalent means to indicate the state 1 condition when the indicator is energized.

5.2.5 Digital outputs for alternating currents (current sourcing) Requirements of this subclause are verified in accordance with 6.4.3.

5.2.5.1 Rated values and operating ranges (a.c.) Digital a.c. outputs shall comply with the ratings given in table 8, at the output voltage(s) stated by the manufacturer according to 5.1.1.1.

Table 8 Rated values and operating ranges for current sourcing digital a.c. outputs

Rated current (state 1)	I_e A	0.25	0.5	1	2	Normative items
Current range for state 1 (continuous at max. voltage)	Min. (mA)	10 [5]	20	100	100	(²¹), (²²)
	Max. (A)	0.28	0.55	1.1	2.2	(²¹)
Voltage drop, U_d for state 1	U_d	—	—	—	—	—
— Non protected output	Max. (V)	3	3	3	3	(²¹)
— Protected and short-circuit proof	Max. (V)	5	5	5	5	(²¹)
Leakage current for state 0		—	—	—	—	—
— Solid-state outputs	Max. (mA)	5 [3]	10	10	10	(²¹), (²²), (²³)
— Electromechanical outputs	Max. (mA)	2.5	2.5	2.5	2.5	(²¹), (²³)
Repetition rate for temporary overload (see figure 5)	Operating cycle time (s)	—	—	—	—	
— Solid-state outputs	Max.	1	2	2	2	
— Relay-based outputs	Max.	10	10	10	10	

Notes (²¹) RMS currents and voltages.

(²²) 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.

(²³) Leakage current for solid-state outputs greater than 3 mA imply the use of additional external loads to drive Type 2 digital inputs.

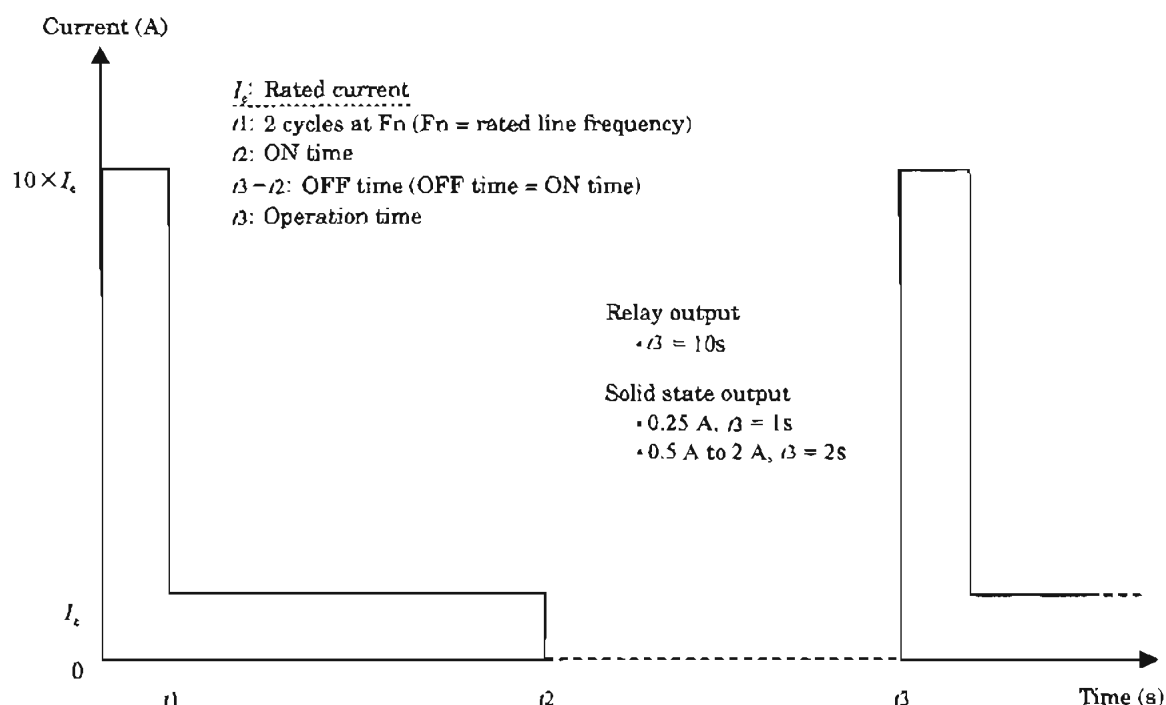


Figure 5 Temporary overload waveform for digital a.c. outputs

5.2.5.2 Additional requirements

5.2.5.2.1 Output indicators Each output channel shall be provided with a lamp or equivalent means to indicate the output state 1 condition when the indicator is energized.

5.2.5.2.2 Protected outputs 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 current value (I_e);
- b) after resetting or replacement of the protective device alone, as applicable, the PLC-system shall return to normal operation;
- c) optional restart capabilities may 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.).

Requirements of this subclause are verified in accordance with 6.4.3.2.

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

2 The protected outputs will not necessarily protect the external wiring. It is the user's responsibility to provide that protection when it is needed.

5.2.5.2.3 Short-circuit-proof outputs 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 PLC-system 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 [a)], the module may require repair or replacement.

Requirements of this subclause are verified in accordance with 6.4.3.2.

5.2.5.2.4 Non-protected outputs For outputs stated by the manufacturer to be non-protected, if the manufacturer recommends an external protection device, then the outputs shall meet all the requirements stated in 5.2.5.2.3.

5.2.5.2.5 Electromechanical relay outputs Electromechanical relay outputs shall be capable of performing at least 0.3 million operations with the load specified for AC-15 utilization category (durability class 0.3) (see **JIS C 8201-5-1**).

NOTE : The type test is not required if the relay components have been shown to comply with the requirements of **IEC 60947-5-1**.

5.2.6 Digital outputs for direct current Requirements of this subclause are verified in accordance with **6.4.3**.

5.2.6.1 Rated values and operating ranges (d.c.) Digital outputs shall comply with the ratings given in the following table 9, at the output voltage(s) stated by the manufacturer according to **5.1.1.1**.

Table 9 Rated values and operating ranges (d.c.) for current-sourcing digital d.c. outputs

Rated current for state 1	I_e A	0.1	0.25	0.5	1	2	Normative 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 for state 1	U_d	—	—	—	—	—	—
— Non-protected output	Max. (V)	3	3	3	3	3	—
— Protected and short-circuit proof	Max. (V)	3	3	3	3	3	(²⁴)
Leakage current for state 0	Max. (mA)	0.1	0.5	0.5	1	1	(²⁵), (²⁶)
Temporary overload	Max. (A)	See figure 6 or as specified by manufacturer.					

Notes (²⁴) 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.

(²⁶) The resulting compatibility between d.c. outputs and d.c. inputs, without additional external load, is as follows:

Rated output current I_e (A)	0.1	0.25	0.5	1	2
Type 1	Yes	Yes	Yes	No	No
Type 2	Yes	Yes	Yes	Yes	Yes
Type 3	Yes	Yes	Yes	Yes	Yes

(²⁶) With adequate external load, all d.c. outputs may become compatible with all Type 1, Type 2 and Type 3 d.c. inputs.