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STANDARD

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**Safety requirements for electrical
equipment for measurement, control,
and laboratory use — Part 1: General
requirements**

ICS 19.080 ; 29.020

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electromechanical devices, electrical safety

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS C 1004:1996** is withdrawn and replaced with **JIS C 1010-1:1998**. This Standard adopts the requirements for electrical equipment for control specified in **IEC 61010-1** additionally although **JIS C 1004** established in 1996 excepts the application of it, and Amendment 2 of **IEC 61010-1** was compiled into the body of this text as well as Amendment 1. Further, the former number of the standard was cancelled and changed into **JIS C 1010-1**.

Annex N of **JIS C 1004** was established as the standard individually.

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Safety requirements for electrical equipment for measurement, control, and laboratory use

Part 1: General requirements

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **IEC 61010-1**, *Safety requirements for electrical equipment for measurement, control, and laboratory use — Part 1: General requirements* published in 1990, Amendment 1: 1992 and Amendment 2: 1995 without modifying its technical content and structure. Amendments are, however, compiled in the text.

The Standard number of **IEC** is based on the new **IEC** Standard number system, which became effective from January 1, 1997. The number of Standards published before this date is changed to the number made by 60 000 being added to the Standard number described in the Standards before this date. Only the number of the Standard is changed and its content is not modified.

The portions with sidelines and dotted underlines in this Standard show the matters not given in the original International Standard.

1 Scope and object

1.1 Scope

This Japanese Industrial Standard specifies general safety requirements for electrical equipment intended for professional, industrial process, and educational use, including equipment and computing devices for:

- measurement and test;
- control;
- laboratory use;
- accessories intended for use with the above (e.g. sample handling equipment).

This Part 1 of the standard applies to the equipment defined in a) to c) below, when used under the environmental conditions of 1.4.

a) Electrical measurement and test equipment

This is equipment which by electrical means measures, indicates or records one or more electrical or non-electrical quantities, also non-measuring equipment such as signal generators, measurement standards, power supplies, transducers, transmitters, etc.

Remarks: All indicating and recording electrical measuring instruments (except those excluded in 1.1.2) fall within the scope of this Standard unless they are panel meters designed only for building-in to other equipment. Built-in panel meters are considered as components and only need to meet the relevant requirements of **JIS 1010**, or other standards, as part of the equipment into which they are built.

b) Electrical control equipment

This is equipment which controls one or more output quantities to specific values, with each value determined by manual setting, by local or remote programming, or by one or more input variables.

c) Electrical laboratory equipment

This is equipment which measures, indicates, monitors or analyses substances, or is used to prepare materials. This equipment may also be used in areas other than laboratories.

1.1.1 Aspects excluded from scope

This Part 1 of the standard does not cover:

- reliable function, performance or other properties of the equipment;
- effectiveness of transport packaging;
- servicing (repair);
- protection of servicing (repair) personnel.

Remarks: Servicing personnel are expected to be reasonably careful in dealing with obvious hazards, but the design should protect against mishap by the use of warning labels, shields for hazardous voltage terminals, segregation of low-voltage circuits from hazardous voltages, etc. More important, servicing personnel should be trained against unexpected hazards.

1.1.2 Equipment excluded from scope

This Part 1 does not apply to:

- electric power equipment, for example power electronics;
- machine tools and their controls (see **IEC 60204**);
- Class 0.5, 1 and 2 alternating current watt-hour meters (see **IEC 60521**);
- medical electrical equipment within the scope of **IEC 60601**;
- biological amplifiers which link humans to equipment in research or teaching contexts;
- type-tested and partially type-tested assemblies of low-voltage switchgear and controlgear (see **IEC 60439-1**);
- circuits and equipment which are part of the building electrical installation (see **IEC 60364**);
- computers, processors and similar equipment, except as specified in **1.1.3** (see **IEC 60950**);
- transformers separate from the equipment (see **IEC 60742**);
- equipment intended for household use (see **IEC 60335**);
- equipment intended for use in explosive gas atmospheres (see **IEC 60079**).

Informative reference: The corresponding Japanese Industrial Standards are as follows.

IEC 60204: The standard for machine tools corresponds to **JIS B 6015:1996** *Machine tools — Electrical equipment — General requirements*.

IEC 60601: The content of this IEC standard is equivalent to **JIS T 1001:1992** *General requirements for safety of medical electrical equipment*.

- IEC 60439-1: A part of this IEC standard corresponds to **JIS C 8480:1998** *Box-type switchgear assemblies for low-voltage distribution purpose*.
- IEC 60335: A part of the standard for individual equipment and devices corresponds to the **JIS C 9000** range.
- IEC 60079: A part of this IEC standard corresponds to **JIS C 0930:1993** *Electrical apparatus for explosive gas atmospheres — General requirements*.

1.1.3 Computing equipment

This Part 1 applies only to computers, processors, etc., which form part of equipment within the scope of this Standard or are designed for use exclusively with the equipment.

Remarks: Computing devices and similar equipment within the scope of **IEC 60950** and complying with its requirements are considered to be suitable for use with equipment within the scope of this Part 1.

However, some of the requirements of **IEC 60950** for resistance to moisture and liquids are less stringent than those in this Standard. Where hazards from moisture or liquids could affect equipment which complies with **IEC 60950** and is used with equipment which complies with this Standard, the instructions for use should specify any additional precautions required.

1.2 Object

The purpose of the requirements of this Part 1 is to ensure that the design and methods of construction used provide adequate protection for the **operator** and the surrounding area against:

- electric shock or burn, (see **6**, **10** and **11**);
- mechanical hazards (see **7**, **8** and **11**);
- excessive temperature (see **9**);
- spread of fire from the equipment (see **9**);
- effects of radiation, including lasers sources, sonic and ultrasonic pressure (see **12**);
- liberated gases, explosion and implosion (see **13**).

Remarks: Attention is drawn to the existence of additional requirements which may be specified by national authorities responsible for health and safety of labour forces.

1.3 Verification

This Part 1 also specifies methods of verifying, through inspection and type testing, that the equipment meets the requirements of this Standard.

Remarks: Requirements for **routine tests** are given in Annex K.

1.4 Environmental conditions

This Part 1 applies to equipment designed to be safe at least under the following conditions:

- indoor use;
- altitude up to 2 000 m, or above 2 000 m if specified by the manufacturer (see D.9 for further information);
- temperature 5 °C to 40 °C;
- maximum relative humidity 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;
- mains supply voltage fluctuations not to exceed ± 10 % of the nominal voltage;
- other supply voltage fluctuations as stated by the manufacturer;
- transient overvoltages according to **installation categories (overvoltage categories)** I, II, and III (see Annex J).

For mains supply the minimum and normal category is II;

- **pollution degree 1 or 2** in accordance with **IEC 60664** (see 3.7.3).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

2.1 Japanese Industrial Standards (JIS)

C 0043:1995 *Environmental testing Part 2: Tests. Test Ec: Drop and topple, primarily for equipment-type specimens* (**JIS C 0043** is identical with **IEC 60068-2-31**.)

C 0046:1993 *Environmental testing Part 2: Test methods Test Eg: Impact, spring hammer* (**JIS C 0046** is identical with **IEC 60068-2-63**.)

C 0066:1993 *Method of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source* (**JIS C 0066** is identical with **IEC 60707**.)

C 0301:1990 *Graphical symbols for electrical apparatus*

C 0920:1993 *Tests to prove protection against ingress of water and degrees of protection against ingress of solid objects for electrical equipment* (The Annex of **JIS C 0920** is identical with **IEC 60529**.)

C 1505:1988 *Precision sound level meters*

C 4003:1977 *Thermal evaluation and classification of electrical insulation*

C 6802:1997 *Safety of laser products*

K 7206:1991 *Testing method for Vicat softening temperature of thermoplastics*

T 1006:1992 *Graphical symbols for medical electrical equipment*

Z 8202:1985 *Quantity symbols, unit symbols and chemical symbols*

2.2 IEC standards

- 60027 *Letter symbols to be used in electrical technology.*
- 60050 (151):1978 *International Electrotechnical Vocabulary — Chapter 151: Electrical and magnetic devices.*
- 60050 (351):1975 *International Electrotechnical Vocabulary — Chapter 351: Automatic control.*
- 60051 *Direct acting indicating analogue electrical measuring instruments and their accessories.*
- 60060 *High-voltage test techniques.*
- 60060-1:1989 *High-voltage test techniques — Part 1: General definitions and test requirements.*
- 60065:1985 *Safety requirements for mains operated electronic and related apparatus for household and similar general use.*
- 60068-2-31:1969 *Environmental testing — Part 2: Tests — Test Ec: Drop and topple, primarily for equipment-type specimens.*
- 60068-2-75:1997 *Environmental testing — Part 2-75: Tests — Test Eh: Hammer tests.*
- 60071 *Insulation co-ordination.*
- 60085:1984 *Thermal evaluation and classification of electrical insulation.*
- 60227 *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V.*
- 60245 *Rubber insulated cables — Rated voltages up to and including 450/750 V.*
- 60309 *Plugs, socket-outlets and couplers for industrial purposes.*
- 60335 *Safety of household and similar electrical appliances.*
- 60359:1987 *Expression of the performance of electrical and electronic measuring equipment.*
- 60417:1973 *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets.*
- 60529:1989 *Degrees of protection provided by enclosures (IP Code).*
- 60617-2:1983 *Graphical symbols — Part 2: Symbol elements, qualifying symbols and other symbols having general applications.*
- 60651:1979 *Sound level meters.*
- 60664 *Insulation coordination for equipment within low-voltage systems.*
- 60664-3:1992 *Insulation coordination for equipment within low-voltage systems — Part 3: Use of coatings to achieve insulation coordination of printed board assemblies.*
- 60707:1981 *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source.*
- 60799:1984 *Cord sets.*
- 60804:1985 *Integrating-averaging sound level meters.*
- 60825:1984 *Radiation Safety of laser products, equipment classification, requirements and user's guide.*
- 60947-1:1988 *Low-voltage switchgear and controlgear — Part 1: General rules.*

60947-3:1990 *Low-voltage switchgear and controlgear — Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units.*

60990:1990 *Methods of measurement of touch-current and protective conductor current.*

Informative reference 1 IEC 60060-2 was replaced by IEC 60060-1.

2 IEC 60068-2-3 was deleted as it was not quoted.

3 IEC 6008-2-63 was deleted as it was replaced by IEC 60068-2-75.

2.3 ISO standards

306:1987 *Plastics — Thermoplastic materials. — Determination of Vicat softening temperature.*

3746:1979 *Acoustics — Determination of sound power levels of noise sources — Survey method.*

3864:1984 *Safety colours and safety signs.*

4126-1:1991 *Safety valves — Part 1: General requirements.*

9614-1:1993 *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points.*

3 Definitions

For the purpose of this Standard the following definitions apply.

For definitions of further terms used in this Standard see **IEC 60050 (351)**, **IEC 60051** and **IEC 60359**. Unless otherwise specified, the terms “voltage” and “current” mean the r.m.s. values of an alternating, direct or composite voltage or current.

3.1 Equipment and states of equipment

3.1.1 fixed equipment

Equipment fastened to a support or otherwise secured in a specific location.

3.1.2 permanently connected equipment

Equipment that is electrically connected to a supply by means of a permanent connection which can be detached only by the use of a **tool**.

3.1.3 portable equipment

Equipment intended to be carried by hand.

3.1.4 hand-held equipment

Portable equipment intended to be supported by one hand during **normal use**.

3.1.5 tool

An external device, including keys and coins, used to aid a person to perform a mechanical function.

3.2 Parts and accessories

3.2.1 terminal

A component provided for the connection of a device (equipment) to external conductors [IEV 151-01-03].

Remarks: It may contain one or several **terminal** contacts.

3.2.2 functional earth terminal

A **terminal** by which electrical connection is made directly to a point of a measuring or control circuit or to a screening part and which is intended to be earthed for any functional purpose other than safety.

Remarks: For measuring equipment, this **terminal** is often termed "measuring earth **terminal**".

3.2.3 protective conductor terminal

A **terminal** which is bonded to conductive parts of an equipment for safety purposes and is intended to be connected to an external protective earthing system.

3.2.4 enclosure

A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact.

3.2.5 barrier

A part providing protection against direct contact from any usual direction of access.

Remarks: **Enclosures** and **barriers** may provide protection against the spread of fire (see 9.1 and Annex F).

3.3 Electrical quantities

3.3.1 rated (value)

A quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment (IEV 151-04-03).

3.3.2 rating

The set of **rated** values and operating conditions (IEV 151-04-04).

3.4 Tests

3.4.1 type test

A test of one or more samples of equipment (or parts of equipment) made to a particular design, to show that the design and construction meet one or more requirements of this Standard.

Remarks: This is an amplification of the IEV 151-04-15 definition to cover both design and construction requirements.

3.4.2 routine test

A test to which each individual device (equipment) is subjected during or after manufacture to ascertain whether it complies with certain criteria (see Annex K) (IEV 151-04-16).

3.5 Safety terms

3.5.1 accessible (of a part)

Able to be touched with a standard test finger or test pin, when used as specified in 6.2.

3.5.2 hazardous live

Capable of rendering an electric shock or electric burn in **normal condition** or **single fault condition** (see 6.3.1 for values applicable to **normal condition** and 6.3.2 for the higher values deemed to be appropriate in **single fault condition**).

3.5.3 high integrity

Not liable to become defective in such a manner as to cause a risk of hazard within the sense of this Standard; a **high integrity** part is considered as not subject to failure when tests under fault conditions are made.

3.5.4 protective impedance

A component, assembly of components or the 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 condition** and **single fault condition**.

3.5.5 protective bonding

Electrical connection of **accessible** conductive parts and/or of protective screening to provide electrical continuity to the means for connection of an external protective conductor.

3.5.6 normal use

Operation, including stand-by, according to the instructions for use or for the obvious intended purpose.

Remarks: In most cases, **normal use** also implies **normal condition**, because the instructions for use will warn against using the equipment when it is not in **normal condition**.

3.5.7 normal condition

Condition in which all means for protection against hazards are intact.

3.5.8 single fault condition

Condition in which one means for protection against hazard is defective or one fault is present which could cause a hazard (see 1.2).

Remarks: If a **single fault condition** results unavoidably in another **single fault condition**, the two failures are considered as one **single fault condition**.

3.5.9 operator

Person operating equipment for its intended purpose.

Remarks: The **operator** should have received training appropriate for this purpose.

3.5.10 responsible body

Individual or group responsible for the use and maintenance of equipment, and for ensuring that **operators** are adequately trained.

3.6 Insulation

3.6.1 basic insulation

Insulation, the failure of which could cause a risk of electric shock.

Remarks: **Basic insulation** may serve also for functional purposes.

3.6.2 supplementary insulation

Independent insulation applied in addition to **basic insulation** in order to provide protection against electric shock in the event of a failure of **basic insulation**.

3.6.3 double insulation

Insulation comprising both **basic insulation** and **supplementary insulation**.

3.6.4 reinforced insulation

Insulation which provides protection against electric shock not less than that provided by **double insulation**. It may comprise several layers which cannot be tested singly as **supplementary insulation** or **basic insulation**.

3.7 Insulation co-ordination

3.7.1 installation category (overvoltage category)

Classification of parts of installation systems or circuits with standardized limits for transient overvoltages, dependent on the nominal line voltage to earth (see Annex J and IEC 60664).

3.7.2 pollution

Any addition of foreign matter, solid, liquid or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity.

3.7.3 pollution degree

For the purpose of evaluating **clearances** the following two degrees of **pollution** in the micro-environment are recognized for use with this Part 1.

3.7.3.1 pollution degree 1

No **pollution** or only dry, non-conductive **pollution** occurs. The **pollution** has no influence.

3.7.3.2 pollution degree 2

Normally only non-conductive **pollution** occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.

3.7.4 clearance

The shortest distance in air between two conductive parts.

3.7.5 creepage distance

The shortest distance along the surface of the insulating material between two conductive parts (**IEV 151-03-37**).

3.8 Mains

Where the term “mains” is used in this Part 1 it refers to the electricity supply (above the values of **6.3.2.1**) which is available to the consumer from the distribution system or systems for which the equipment concerned is designed.

Informative reference: The formal name of **IEV** is as follows. As for its technical content, see **IEC 60050 (151)** etc.

International Electrotechnical Vocabulary

4 Tests

4.1 General

Tests in this Part 1 are **type tests** to be carried out on samples of equipment or parts. Their only purpose is to check that the design and construction ensure compliance with this Part 1. In addition, manufacturers shall perform the **routine tests** of Annex K on 100 % of equipment produced which has both **hazardous live parts** and **accessible** conductive parts.

Tests on components or parts of the equipment meeting the requirements of the relevant standards specified in this Part 1 and used in accordance with them, need not be repeated during **type tests** of the whole equipment.

Compliance with the requirements of this Part 1 is checked by carrying out all applicable tests, except that a test may be omitted where examination of the equipment demonstrates conclusively that the equipment would pass the test. Tests are carried out under:

- reference test conditions (see **4.3**);
- fault conditions (see **4.4**).

Remarks 1 If the **rated** range of environmental conditions for equipment is wider than that stated in **1.4**, the manufacturer should make sure (e.g. by suitable alteration of test requirements or additional tests) that the safety requirements of this Part 1 are still fulfilled.

- 2 If, when carrying out a compliance test, there is any uncertainty about the exact value of the applied or measured quantity (e.g. voltage) due to the tolerance:
 - the manufacturer should ensure that at least the specified test value is applied;
 - the test house should ensure that no more than the specified test value is applied.

- 3 Equipment which has been **type tested** may no longer be suitable for its intended function because of the residual effect of stresses resulting from some of the tests. For this reason **type tests** should not be carried out (for example by the **responsible body**) after the equipment has left the manufacturer.

4.2 Sequence of tests

The sequence of tests is optional unless otherwise specified in this Part 1. The equipment under test shall be carefully inspected after each test. If the result of a test causes doubt whether any earlier tests would have been passed if the sequence had been reversed, these earlier tests shall be repeated. Where tests under fault conditions may be destructive, these tests may follow those under reference test conditions.

4.3 Reference test conditions

4.3.1 Environmental conditions

Unless otherwise specified in this Part 1, the following environmental conditions (but not conflicting with those of 1.4) shall exist in the test location:

- a temperature of 15 °C to 35 °C;
- a relative humidity of not more than 75 %;
- an air pressure of 75 kPa to 106 kPa;
- no hoar-frost, dew, percolating water, rain, solar irradiation etc.

4.3.2 State of equipment

Unless otherwise specified, tests shall be carried out on the equipment assembled for **normal use** and under the least favourable combination of the conditions given in 4.3.3 to 4.3.16.

When dimensions or mass make it unsuitable to carry out particular tests on a complete equipment, tests on sub-assemblies are allowed, provided it is verified that the assembled equipment will be in accordance with this Part 1.

Equipment intended to be built into a wall, recess, cabinet, etc., shall be installed in accordance with the manufacturer's instructions.

4.3.3 Position of equipment

The equipment shall be in any position of **normal use** and with any ventilation unimpeded.

4.3.4 Accessories

Accessories and **operator** interchangeable parts available from or recommended by the manufacturer for use with the equipment under test shall be either connected or not connected.

4.3.5 Covers and removable parts

Covers or parts which can be removed without using a **tool** shall be removed or not removed.

Covers which do not require the use of a **tool** for removal need not be removed if they have interlock systems meeting the requirements of 15.

4.3.6 Mains supply

The following requirements apply:

- The supply voltage shall be between 90 % and 110 % of any **rated** supply voltage for which the equipment can be set or, if the equipment is **rated** for a greater fluctuation, then any supply voltage within the fluctuation range;
- the frequency shall be any **rated** frequency;
- equipment for both a.c. and d.c. shall be connected to an a.c. or d.c. supply;
- equipment for d.c. or single-phase supply shall be connected both with normal and reverse polarity;
- unless the equipment is specified for use only on a non-earthed mains supply, one pole of the reference test supply shall be at or near earth potential;
- where the means of connection permits reversal, battery operated equipment shall be connected with both reverse and normal polarity.

4.3.7 Input and output voltages

Input and output voltages, including floating voltages but excluding the mains supply voltage, shall be set to any voltage within the **rated** voltage range.

4.3.8 Earth terminals

Protective conductor terminals, if any, shall be connected to earth. **Functional earth terminals** shall be connected or not connected to earth.

4.3.9 Controls

Controls which the **operator** can adjust by hand shall be set to any position except that:

- mains selection devices shall be set to the correct value;
- combinations of settings shall not be made if they are prohibited by the manufacturer by marking on the equipment.

4.3.10 Connections

The equipment shall be connected for its intended purpose, or not connected for any use whatsoever.

4.3.11 Load on motors

Load conditions of motor-driven parts of equipment shall be in accordance with the intended purpose.

4.3.12 Output

For equipment giving an electrical output:

- the equipment shall be operated in such a way as to provide the **rated** output power to the **rated** load;
- the rated load impedance of any output shall be connected or not connected.

4.3.13 Duty cycle

Equipment for short-term or intermittent operation shall be operated for the longest period and have the shortest recovery period consistent with the manufacturer's instructions.

4.3.14 Loading and filling

Equipment intended to be loaded with a specific material in **normal use** shall be loaded with the least favourable quantity of the materials specified in the instructions for use, including not loaded (empty), if the instructions for use permit this in **normal use**.

- Remarks 1 In case of doubt, tests should be performed in more than one loading condition.
- 2 If the specified material would cause a hazard during test, another material may be used provided that it can be shown that the result of the test is not affected.

4.3.15 Heating equipment

When measuring temperatures to evaluate the spread of fire, heating equipment shall be tested in a test corner as required by 9.2.1.

4.3.16 Built-in equipment

When measuring temperatures to evaluate the spread of fire, equipment intended for installation in a cabinet or a wall shall be built in as required by 9.2.2.

4.4 Testing in single fault condition

4.4.1 General

The following requirements apply:

- examination of the equipment and its circuit diagram will generally show the fault conditions which are liable to result in hazards within the meaning of this Part 1 and which, therefore, shall be applied;
- fault tests shall be made except where it can be demonstrated that no hazard could arise from a particular fault condition;
- the equipment shall be operated under the least favourable combination of reference test conditions (see 4.3). These combinations may be different for different faults and they should be recorded for each test;
- Annex F provides an alternative to testing for protection against spread of fire under fault condition (see 9.1).

4.4.2 Application of fault conditions

Fault conditions shall include those specified in 4.4.2.1 to 4.4.2.12. They shall be applied only one at a time and shall be applied in turn in the most convenient order. Multiple simultaneous faults shall not be applied unless they are a consequence of an applied fault.

After each application of a fault condition, the equipment or part shall pass the applicable tests of 4.4.4.

4.4.2.1 Protective impedance

The following requirements apply:

- if a **protective impedance** is formed by a combination of components, each component shall be short-circuited or disconnected, whichever is the less favourable;
- if a **protective impedance** is formed by the combination of **basic insulation** and a current or voltage limiting device, both the **basic insulation** and the current or voltage limiting device shall be subjected to single faults, applied one at a time. **Basic insulation** shall be short-circuited and the current or voltage limiting device shall be short-circuited or disconnected, whichever is less favourable.

Parts of **protective impedance** which are **high integrity** components need not be short-circuited or disconnected (see 6.5.3 and 14.6).

4.4.2.2 Protective conductor

The protective conductor shall be interrupted, except for **permanently connected equipment** or equipment utilizing a connector in accordance with IEC 60309.

4.4.2.3 Equipment or parts for short-term or intermittent operation

These shall be operated continuously if continuous operation could occur in a **single fault condition**. Individual parts may include motors, relays, other electromagnetic devices and heaters.

4.4.2.4 Motors

Motors shall be stopped while fully energized or prevented from starting, whichever is less favourable.

4.4.2.5 Capacitors

Capacitors (except for self-healing capacitors) in the auxiliary winding circuits of motors shall be short-circuited.

4.4.2.6 Mains transformers

The secondary windings of mains transformers tested as part of the equipment shall be short-circuited and also subjected to any overloads arising from any fault condition according to 4.4.

Windings, and sections of tapped windings, which are loaded in **normal use**, shall be tested in turn, one at a time, to simulate short circuits in the load. All other windings are loaded or not loaded, whichever load condition of **normal use** is the least favourable.

Short-circuits shall be made on the load side of any current-limiting impedance or overcurrent protective device which is connected directly to the winding.

Requirements and tests for mains transformers tested as separate components are specified in 14.7.

4.4.2.7 Outputs

Outputs shall be short-circuited one at a time.

4.4.2.8 Equipment for more than one supply

Equipment which is designed to be operated from more than one type of supply shall be simultaneously connected to these supplies, unless this is prevented by the construction.

4.4.2.9 Cooling

Equipment cooling shall be restricted as follows, one fault at a time:

- air-holes with filters shall be closed;
- forced cooling by motor-driven fans shall be stopped;
- cooling by circulation of water or other coolant shall be stopped.

4.4.2.10 Heating devices

In equipment incorporating heating devices, the following faults shall be applied one at a time:

- timers which limit the heating period shall be overridden to energize the heating circuit continuously;
- temperature controllers, except for overtemperature protection devices meeting the requirements of 14.3, shall be overridden to energize the heating circuit continuously;
- loss of cooling liquid shall be simulated.

4.4.2.11 Insulation between circuits and parts

The insulation between circuits and parts listed in Annex G shall be short-circuited unless it has been checked as specified in 9.1.

4.4.2.12 Interlocks

Each part of an interlock system for the protection of **operators** shall be short-circuited or open-circuited in turn if the system prevents access to hazards (see 1.2) when a cover, etc. is removed without the use of a **tool**.

High integrity components of interlock systems (see 14.6 and 15.3) need not be short-circuited or open-circuited.

4.4.3 Duration of tests

4.4.3.1 The equipment shall be operated until further change as a result of the applied fault is unlikely. Each test is normally limited to 1 h since any secondary fault arising from a **single fault condition** will usually manifest itself within that time. If at the end of 1 h there is an indication that a risk of electric shock, spread of fire or injury to persons may eventually occur, the test shall be continued until one of these hazards does occur or for a maximum period of 4 h.

4.4.3.2 Where a device which interrupts or limits the current during operation is included to limit the temperature of parts which can easily be touched, the maximum temperature attained by the equipment shall be measured, whether the device operates or not.

4.4.3.3 If a fault is terminated by the opening of a fuse and if the fuse does not operate within approximately 1 s, the current through the fuse under the relevant fault condition shall be measured. Evaluation with the pre-arcing time/current characteristics shall be made to find out whether the minimum operating current of the fuse is reached or exceeded and what is the maximum time before the fuse operates. The current through the fuse may vary as a function of time.

If the minimum operating current of the fuse is not reached in the test, the equipment shall be operated for a period corresponding to the maximum fusing time or continuously for the duration specified in **4.4.3.1**.

4.4.4 Compliance

4.4.4.1 Compliance with requirements for electric shock protection is checked:

- by making the measurements of **6.3.2**;
- by a voltage test as specified in **6.8.4** for **double insulation** or **reinforced insulation**, but with the test voltage for **basic insulation** only.

Remarks: The test of **basic insulation** simulates the **single fault condition** of failure of one level of **double insulation** or partial failure of **reinforced insulation**.

4.4.4.2 Compliance with requirements for temperature protection is checked by determining the temperature of the outer surface of the **enclosure** and of parts which can easily be touched.

Except for heated surfaces of heating equipment, the temperature of these parts shall not exceed 105 °C in an ambient temperature of 40 °C (see **1.4**).

This temperature is determined by measuring the temperature rise of the surface or part and adding it to 40 °C.

4.4.4.3 Compliance with requirements for protection against the spread of fire is checked by placing the equipment on white tissue-paper covering a softwood surface and covering the equipment with cheesecloth. No molten metal, burning insulation, flaming particles, etc. shall fall on the surface on which the equipment stands and there shall be no charring, glowing, or flaming of the tissue paper or cheesecloth. Melting of insulation material which is not of importance according to the requirements of this Part 1 shall be ignored.

Informative reference 1 See **4.1** of **JIS C 0068** *Fire hazard testing Part 2: Test methods — Section 4/sheet 0: Diffusion type and premixed type flame test methods*.

2 Tissue paper: tissue paper for packaging specified in **6.86** (wrapping tissue) of **ISO 4046:1978** *Paper, board, pulp, and related terms — Vocabulary*

Generally this tissue paper is a soft, strong and light paper for wrapping, 12 g/m² to 30 g/m², which is used mainly for protecting objects which require careful handling or for wrapping presents.

This tissue paper does not mean a facial tissue (**JIS S 3104** *Facial tissues*) used generally in Japan.

4.4.4.4 Compliance with the requirements for protection against the other hazards listed in 1.2 is checked as specified in 7 to 15.

5 Marking and documentation

5.1 Marking

5.1.1 General

Equipment shall bear markings in accordance with 5.1.2 to 5.2. Except for marking of internal parts, these markings shall be visible from the exterior, or be visible after removing a cover or opening a door without the aid of a **tool**, if the cover or door is intended to be removed or opened by an **operator**. Markings applying to the equipment as a whole shall not be put on parts which can be removed by an **operator** without the use of a **tool**.

For rack or panel mounted equipment, markings are permitted to be on any surface that becomes visible after removal of the equipment from the rack or panel.

Letter symbols for quantities and units shall be in accordance with **IEC 60027**. Graphic symbols shall be in accordance with Table 1.

Remarks: Except on **hand-held equipment** or where space is limited, markings should not be on the bottom of the equipment.

Compliance is checked by inspection.

Informative reference: IEC 60027 is equivalent to JIS Z 8202:1985 *Quantity symbols, unit symbols and chemical symbols* in technical content.

Table 1

Number	Symbol	Publication	Description
1		IEC 60417, No. 5031 JIS C 0301, JIS T 1006	Direct current
2		IEC 60417, No. 5032 JIS C 0301, JIS T 1006	Alternating current
3		IEC 60417, No. 5033 JIS T 1006	Both direct and alternating current
4		IEC 60617-2, No. 02-02-06 JIS T 1006	Three-phase alternating current
5		IEC 60417, No. 5017 JIS C 0301, JIS T 1006	Earth (ground) terminal
6		IEC 60417, No. 5019 JIS C 0301, JIS T 1006	Protective conductor terminal
7		IEC 60417, No. 5020 JIS C 0301, JIS T 1006	Frame or chassis terminal
8		IEC 60417, No. 5021 JIS C 0301, JIS T 1006	Equipotentiality
9		IEC 60417, No. 5007 JIS T 1006	On (Supply)
10		IEC 60417, No. 5008 JIS T 1006	Off (Supply)
11		IEC 60417, No. 5172 JIS T 1006	Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 60536 — see Annex H)
12	 Background colour—yellow; symbol and outline-black (see Remarks and Informative reference 1)	ISO 3864, No. B. 3.6	Caution, risk of electric shock
13	 Background colour—yellow; symbol and outline-black (see Remarks)	IEC 60417, No. 5041	Caution, hot surface
14	 Background colour—yellow; symbol and outline-black (see Remarks)	ISO 3864, No. B. 3.1 JIS T 1006	Caution (refer to accompanying documents)
15		IEC 60417, No. 5268-a JIS T 1006	In-position of a bistable push control
16		IEC 60417, No. 5269-a JIS T 1006	Out-position of a bistable push control
Remarks: Colour requirements for symbols 12, 13 and 14 do not apply to markings on equipment provided that the symbol is moulded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in colour with the background. Informative reference 1 If the marking area is limited, the triangle mark of symbol 12 may not be required. However the colour of the crimped arrow shall be red and the red colour contrast against background colour shall be high. 2 JIS C 0301:1990 Graphical symbols for electrical apparatus, JIS T 1006:1992 Graphical symbols for medical electrical equipment			

5.1.2 Identification

The equipment shall, as a minimum, be identified by:

- manufacturer's name or registered trade mark;
- model number, name or other means to identify the equipment.

Compliance is checked by inspection.

5.1.3 Mains supply

The equipment shall be marked with the following information:

a) Nature of supply:

- a.c. : **rated** mains frequency or range of frequencies;
- d.c. : with symbol 1 of Table 1.

Remarks: The documentation should give the **installation category** (**overvoltage category**) for which the equipment is intended (this is related to the ability to withstand transient overvoltages). For information purposes it may also be useful to mark:

- a.c. equipment with symbol 2 of Table 1;
- equipment suitable for both a.c. and d.c. with symbol 3 of Table 1;
- equipment for three-phase supply with symbol 4 of Table 1.

b) The **rated** value(s) of the supply voltage(s) or the **rated** range of the supply voltages.

Remarks: The permitted fluctuation from the **rated** value(s) may also be marked.

- c) The maximum **rated** power in watts (active power) or volt-amperes (apparent power), or the maximum **rated** input current, with all accessories or plug-in modules connected. If the equipment can be used on more than one voltage range, separate values shall be marked for each voltage range unless the maximum and minimum values do not differ by more than 20 % of the mean value.
- d) Equipment which the **operator** can set for different **rated** supply voltages shall be provided with means for the indication of the voltage for which the equipment is set. For **portable equipment** the indication shall be visible from the exterior. If the equipment is so constructed that the **operator** can alter the supply voltage setting without the use of a **tool**, the action of changing the setting shall also change the indication.
- e) Accessory mains socket-outlets accepting standard mains plugs shall be marked with the voltage if it is different from the mains supply voltage. If the outlet is for use only with specific equipment, it shall be marked to identify the equipment for which it is intended. If not, the maximum **rated** current or power, and maximum permitted leakage current shall be marked, or symbol 14 of Table 1 placed beside the outlet with the full details included in the documentation.

Compliance is checked by inspection and by measurement of power or input current to check the marking of 5.1.3 c). The measurement is made in such a manner as to exclude the measurement of any initial inrush current and after the current has reached a stationary stage (usually after 1 min). The equipment shall be in the condition of maximum power consumption. The measured value shall not exceed the marked value by more than 10 %.

5.1.4 Fuses

For any fuses which may be replaced by an **operator** there shall be a marking beside the fuseholder specifying the current **rating** and type, such as indication of rupturing speed, for example by the symbol or codes of **JIS C 6575** or **IEC 60127** (see Remarks below). For fuses not replaceable by the **operator** the same information shall be provided in the documentation (see 5.4.5).

Remarks: The letter and colour codes of **IEC 60127** are as follows:

- very quick acting: FF, or black;
- quick acting: F, or red;
- medium time-lag: M, or yellow;
- time-lag: T, or blue;
- long time-lag: TT, or grey.

Compliance is checked by inspection.

5.1.5 Measuring circuit terminals

Voltage and current measuring circuit **terminals** shall be marked with the **rated** maximum working voltage (see D.1.1 of Annex D) or current as applicable.

Unless a clear indication is provided on a measuring instrument that it is not intended to be connected to voltages to earth above 50 V a.c. or 120 V d.c., the measuring input circuit **terminals** for connection by an **operator** and used for voltage or current measurement shall be marked with the maximum **rated** voltage to earth. An exception is permitted for circuit **terminals** (connectors) which are dedicated only for connection to specific **terminals** of other equipment if a means for identifying these **terminals** is provided.

Examples of acceptable indications that the inputs in all cases are intended to be less than 50 V a.c. or 120 V d.c. to earth include:

- the full scale deflection marking of a single range indicating voltmeter or maximum marking of a multi-range voltmeter;
- the maximum range marking of a voltage selector switch;
- the marked intended function of the instrument (e.g. "millivoltmeter").

Marking shall be placed adjacent to the **terminals**. However, if there is insufficient space (as in multi-input equipment), it is permissible for the marking to be on the **rating** plate or scale plate, or for the **terminal** to be marked with symbol 14 of Table 1.

Measuring circuit **terminals** used for voltage or current measurement shall be marked with the **installation category (overvoltage category)**. This marking is done by adding CAT@ to the value of the maximum **rated** voltage to earth. A roman I, II or III shall replace @ to indicate the appropriate **installation category (overvoltage category)** (see Table J.1). (e.g. "CAT I")

Voltage and current measuring circuit **terminals** that are permanently connected and not **accessible** need not be marked. Information regarding the **installation category (overvoltage category)**, **rated** maximum working voltage (see D.1.1) or current for such **terminals** shall be in the equipment installation instructions (see 5.4.3).

Compliance is checked by inspection.

5.1.6 Terminals and operating devices

Where necessary for safety, an indication shall be given of the purpose of **terminals**, connectors, controls, and indicators, including any sequence of operations. Where there is insufficient space, symbol 14 of Table 1 may be used.

Remarks: For additional information see IEC 60445 and 60447.

Terminals for connection to the mains supply shall be identifiable.

If the power supply switch or circuit breaker is used as the disconnecting device, the on-position or the off-position shall be clearly marked. Symbols 9 and 10 of Table 1 can in some cases also be suitable as the device identification (see 6.12.3.1). A lamp alone is not considered to be a satisfactory marking. Symbols 9 and 10 shall not be used for switches other than the main switch.

If a push-button switch is used as the main switch, symbols 9 and 15 of Table 1 can be used to indicate the on-position, or symbols 10 and 16 to indicate the off-position, with the pair of symbols (9 and 15, or 10 and 16) close together.

The following **terminals** and operating devices shall be marked as follows:

- a) **Functional earth terminals** with symbol 5 of Table 1.
- b) **Protective conductor terminals** with symbol 6 of Table 1, except when the **protective conductor terminal** is part of an approved mains appliance inlet. The symbol shall be placed close to or on the **terminal**.
- c) **Terminals** of measuring and control circuits which are permitted by 6.6.3 to be connected to **accessible** conductive parts with symbol 7 of Table 1 if this connection is not self-evident.

Remarks: This symbol may also be considered as a warning symbol in that it indicates that a **hazardous live** voltage must not be connected to the **terminal**. The symbol should also be used where it is likely that the **operator** could make such a connection inadvertently.

- d) **Terminals** supplied from the interior of the equipment and which are **hazardous live**, with the voltage, current, charge or energy value or range, or with symbol 14 of Table 1. This requirement does not apply to mains supply outlets where a standard mains socket outlet is used.
- e) **Accessible functional earth terminals** connected to **accessible** conductive parts, with an indication that this is the case, unless it is self-evident. Symbol 8 of Table 1 is acceptable for this marking.

Compliance is checked by inspection.

5.1.7 Equipment protected by double insulation or reinforced insulation

Equipment protected throughout by **double insulation** or **reinforced insulation** (see Annex H) shall be marked with symbol 11 of Table 1 unless it is provided with a **protective conductor terminal**.

Equipment which is only partially protected by **double insulation** or **reinforced insulation** shall not bear symbol 11 of Table 1.

Compliance is checked by inspection.

5.1.8 Battery charging

Equipment which has means for charging rechargeable batteries, and where non-rechargeable cells could be fitted and connected in the battery compartment, shall be marked in or near the compartment,

- to warn against the charging of non-rechargeable batteries;
- to indicate the type of rechargeable battery that can be used with the recharging circuit.

Remarks: An acceptable marking is symbol 14 of Table 1.

Compliance is checked by inspection.

5.2 Warning markings

Warning markings shall be visible when the equipment is ready for **normal use**.

If it is necessary for the **operator** to refer to the instruction manual to preserve the protection afforded by the equipment, the equipment shall be marked with the symbol 14 of Table 1. If a warning applies to a particular part of the equipment, the marking shall be placed on or near to this part.

If the instructions for use state that an **operator** is permitted to gain access, using a **tool** to any part which in **normal use** may be **hazardous live**, there shall be a warning marking which states that the equipment must be isolated or disconnected from the **hazardous live** voltage before access.

A warning shall advise the **operator** of precautions to be taken to avoid contact with **hazardous live** parts which are **accessible** according to the exceptions of 6.1.1. See also 7.2, relating to access to hazardous moving parts.

An additional marking in certain cases is required by 6.6.2.

Terminals which are supplied from the interior of the equipment at a voltage exceeding 1 kV, or allow connection to a voltage exceeding 1 kV (see 6.6.2) shall be marked with symbol 12 of Table 1.

Unless their heated state is self-evident or is obvious from the function of the equipment, parts which are easily touched and are also permitted by 9.1 to exceed the temperature limits of Table 3 shall be marked with symbol 13 of Table 1.

Remarks 1 Warnings necessary for safety should contrast well with the background (see Table 1).

2 Warning markings relating to batteries are specified in 5.1.8 and 13.2.2.

Compliance is checked by inspection.

5.3 Durability of markings

Markings in accordance with 5.1.2 to 5.2 shall remain clear and legible under conditions of **normal use** and resist the effects of cleaning agents specified by the manufacturer.

Compliance is checked by inspection and by performing the following test for durability of markings on the outside of the equipment. The markings are rubbed by hand, without undue pressure, first for 15 s with a cloth soaked with the specified cleaning agent (or, if not specified, with water) and then for 15 s with a cloth soaked with isopropyl alcohol.

The markings shall be clearly legible after the above treatment, and adhesive labels shall not have worked loose or become curled at the edges.

5.4 Documentation

5.4.1 General

Equipment shall be accompanied by documentation for safety purposes as follows:

- technical specification;
- instructions for use;
- name and address of manufacturer or supplier from whom technical assistance may be obtained;
- the information specified in 5.4.2 to 5.4.5.
- definition of the relevant **installation category (overvoltage category)** when marking of **terminals** is required on the equipment (see 5.1.5).

Where applicable, warning statements and a clear explanation of warning symbols marked on the equipment shall be provided in the documentation. Alternatively, such information shall be durably and legibly marked on the equipment.

Remarks: If **normal use** involves the handling of hazardous substances, instructions should be given on correct use and safety provisions. If any hazardous substance is specified or supplied by the equipment manufacturer, the necessary information on its constituents and the correct disposal procedure should also be given.

Compliance is checked by inspection.

5.4.2 Equipment ratings

Documentation shall include the following:

- the supply voltage or voltage range, frequency or frequency range, and power or current **rating**;
- a description of all input and output connections;
- the **rating** of the insulation of external circuits, appropriate for **single fault conditions**, when such circuits are nowhere **accessible** (see 6.6).
- a statement of the range of environmental conditions for which the equipment is designed (see 1.4 and Remarks 1 of 4.1).

Compliance is checked by inspection.

5.4.3 Equipment installation

Documentation shall include the following installation and specific commissioning instructions as appropriate:

- assembly, location and mounting requirements;
- instructions for protective earthing;
- connections to the supply;
- ventilation requirements;
- requirements for special services, for example air, cooling liquid;
- the maximum sound power level produced by equipment which emits sound, if measurement is required by 12.5.1;
- instructions relating to sound pressure level (see 12.5.1).

For **permanently connected equipment**, additional information shall include:

- supply wiring requirements;
- requirements for any external switch or circuit-breaker (see **6.12.2.1**) and external overcurrent protection devices (see **9.6**) and a recommendation that the switch or circuit-breaker be near the equipment.

Compliance is checked by inspection.

5.4.4 Equipment operation

Instructions for use shall include:

- identification of operating controls and their use in all operating modes;
- where applicable, an instruction not to position the equipment so that it is difficult to operate the disconnecting device (see **6.12**).
- instructions for interconnection to accessories and other equipment, including indication of suitable accessories, detachable parts and any special materials;
- specification of limits for intermittent operation, where applicable;
- an explanation of symbols required by this Part 1 and used on the equipment;
- instructions for replacement of consumable materials;
- instructions for cleaning (see **11.2**).

The **responsible body** shall be made aware that, if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Compliance is checked by inspection.

5.4.5 Equipment maintenance

Instructions for the **responsible body** concerning preventive maintenance and inspection necessary for safety shall be given in sufficient detail. These shall include the inspection and replacement, where necessary, of any hoses or other parts containing liquids, if their failure could cause a hazard (see **1.2**). See also **7.2**.

For equipment using batteries, the specific battery type shall be stated (see also **5.1.8**).

The manufacturer shall specify any parts which are required to be examined or supplied only by the manufacturer or his agent.

The **rating** and characteristics of fuses used shall be stated (see **5.1.4**).

Compliance is checked by inspection.

6 Protection against electric shock

6.1 General

Protection against electric shock shall be maintained in **normal condition** (see **6.4**) and **single fault condition** (see **6.5**). **Accessible** parts of equipment shall not be **hazardous live** (see **6.3**).

Remarks: Annex H relates the safety requirements of this Part 1 to equipment safety classification used in other standards.

Compliance is checked by the determination of **6.2** and the measurements of **6.3**, followed by the tests of **6.4** to **6.12**.

6.1.1 Exceptions

If it is not feasible for operating reasons to prevent the following parts being both **accessible** and **hazardous live**, they are permitted to be **accessible** to the **operator** during **normal use** while they are **hazardous live**:

- parts of lamps and lamp sockets after lamp removal;
- parts intended to be replaced by the **operator** (e.g. batteries) and which may be **hazardous live** during the replacement or other **operator** action, but only if they are **accessible** only by means of a **tool** and have a warning marking in accordance with **5.2**;
- **terminals** and sockets of operating and measuring circuits. (This exception does not apply to the **terminals** listed in **6.6.2**.)

If any of these parts receive a charge from an internal capacitor, they shall not be **hazardous live** 10 s after interruption of the supply.

Remarks 1 Excepted **terminals** should be protected as far as possible against unintentional contact, by covering or recessing, or by position or arrangement.

2 See **5.2** for warning markings for **accessible** parts which are **hazardous live** and **5.4.1** for warning statements in the documentation.

Where a charge is received from an internal capacitor, **compliance** is checked by the measurements of **6.3** to establish that the levels of **6.3.1.3** are not exceeded.

6.2 Determination of accessible parts

Unless obvious, determination of whether a part is **accessible** shall be made as specified in **6.2.1** to **6.2.3**. Test fingers (Annex B) and pins shall be applied without force unless a force is specified. Parts are considered to be **accessible** if they can be touched with a test finger or pin, or if they could be touched in the absence of any covering which is not considered to provide suitable insulation (see Remarks to **6.4**, paragraph 1). For **hazardous live** parts at a voltage to earth exceeding 1 kV r.m.s. or 1.5 kV d.c., a part is considered to be **accessible** if the test finger or pin reaches a point nearer to the **hazardous live** part than the applicable **clearance** of Annex D for **basic insulation** for the working voltage (see **D.1.1** of Annex D).

However, on equipment accepting plug-in modules, parts are not considered to be **accessible** if they cannot be touched with the jointed test finger (see **6.2.1**) up to a depth of 180 mm from the opening in the equipment, nor if they are at a depth of more than 180 mm from the opening.

If the **operator** is intended to perform any actions in **normal use** (with or without a **tool**) which will increase the accessibility of parts, such actions shall be taken before performing the examinations of **6.2.1** to **6.2.3**. Examples include:

- removing covers;
- opening doors;
- adjusting controls;
- replacing consumable material;
- removing parts.

For rack and panel mounted equipment the equipment shall be installed according to the manufacturer's instructions before making the examinations of 6.2.1 to 6.2.3. For such equipment, the **operator** is assumed to be in front of the panel.

6.2.1 General examination

The jointed test finger (see Annex B, Fig. B.2) shall be applied in every possible position. Where a part could become **accessible** by applying a force, the rigid test finger (see Annex B, Fig. B.1) shall be applied with a force of 10 N. The force shall be exerted by the tip of the test finger so as to avoid wedge and lever action. The test shall be applied to all outer surfaces, including the bottom.

6.2.2 Openings above parts which are hazardous live

A metal test pin 100 mm long and 4 mm in diameter shall be inserted in any openings above parts which are **hazardous live**. The test pin shall be suspended freely and allowed to penetrate up to 100 mm. The additional safety measures of 6.5 for protection in **single fault condition** are not required solely because a part is **accessible** by this test only.

6.2.3 Openings for pre-set controls

A metal test pin 3 mm in diameter shall be inserted through holes intended to give access to pre-set controls which require the use of a screwdriver or other **tool**. The test pin shall be applied in every possible direction through the hole. Penetration shall not exceed three times the distance from the **enclosure** surface to the control shaft or 100 mm, whichever is smaller.

6.3 Permissible limits for accessible parts

To ensure that **accessible** parts are not **hazardous live**, the voltage, current, charge or energy between an **accessible** part and reference test earth, or between any two **accessible** parts on the same piece of equipment within a distance of 1.8 m (over a surface or through air), shall not exceed the values of 6.3.1 in **normal condition** nor of 6.3.2 in **single fault condition**.

The **accessible** voltage shall be measured. If the voltage is below the limit of 6.3.1 or 6.3.2 as applicable, **accessible** current and capacitance need not be measured. If the voltage exceeds that value, the current and capacitance shall be measured.

6.3.1 Values in normal condition

Values above the levels of 6.3.1.1 to 6.3.1.3 in **normal condition** are deemed to be **hazardous live**.

6.3.1.1 Voltage

The voltage levels are 30 V r.m.s. and 42.4 V peak or 60 V d.c.

6.3.1.2 Current

If the voltage exceeds one of the values of 6.3.1.1, the current levels are:

- 0.5 mA r.m.s. for sinusoidal waveforms, 0.7 mA peak for non-sinusoidal waveform or mixed frequencies, or 2 mA d.c., when measured with measuring circuit A.1 of Annex A. Alternatively measuring circuit A.2 can be used if the frequency does not exceed 100 Hz;

- 70 mA r.m.s. when measured with measuring circuit A.3. This relates to possible burns at higher frequencies.

6.3.1.3 Capacitance

If the voltage exceeds one of the values of **6.3.1.1**, the capacitance levels are:

- 45 μ C charge for voltages up to 15 kV peak or d.c.;
- 350 mJ stored energy for voltages above 15 kV peak or d.c.

6.3.2 Values in single fault condition

Values above the following levels in **single fault condition** are deemed to be **hazardous live**.

6.3.2.1 Voltage

The voltage levels are 50 V r.m.s. and 70 V peak or 120 V d.c.

For short-term temporary voltages, the levels are those of Fig. 1, measured across a 50 k Ω resistor.

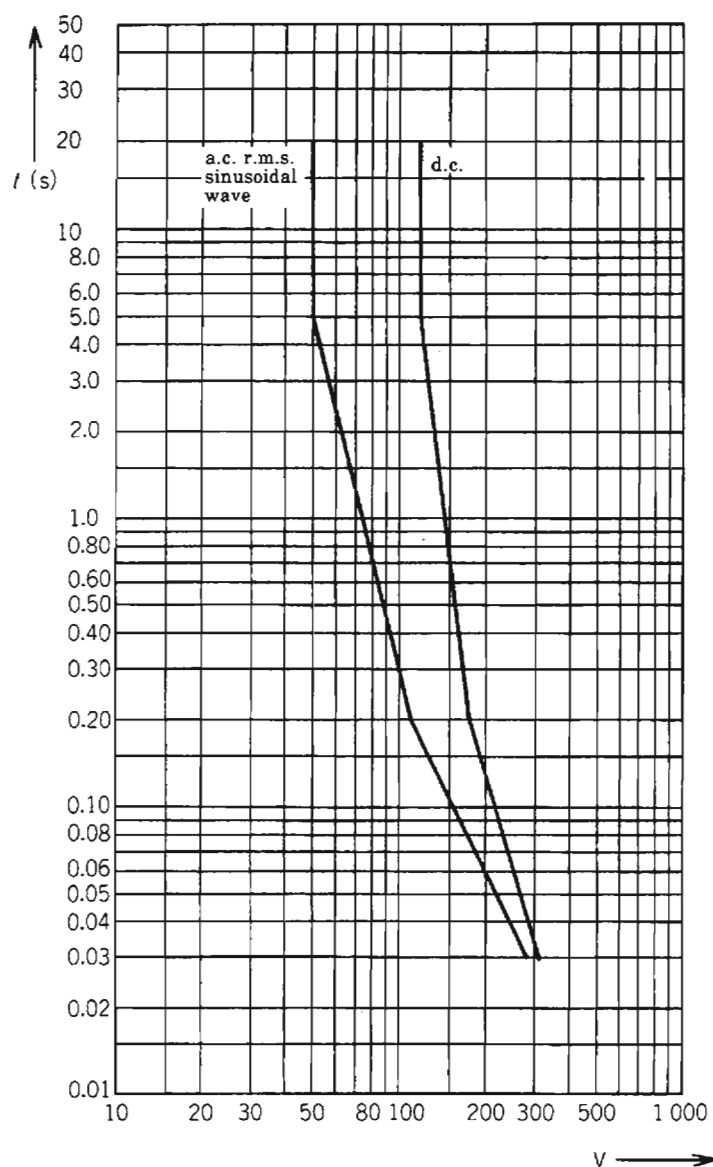


Fig. 1 Maximum duration of short-term temporary accessible voltages in single fault condition (see 6.3.2.1)

6.3.2.2 Current

If the voltage exceeds one of the values of 6.3.2.1, the current levels are:

- 3.5 mA r.m.s. for sinusoidal waveforms, 5 mA peak for non-sinusoidal waveforms or mixed frequencies, or 15 mA d.c., when measured with measuring circuit A.1. Alternatively measuring circuit A.2 can be used if the frequency does not exceed 100Hz;
- 500 mA r.m.s. when measured with measuring circuit A.3. This relates to possible burns at higher frequencies.

6.3.2.3 Capacitance

If the voltage exceeds one of the values of 6.3.2.1, the capacitance level is that of Fig. 2.

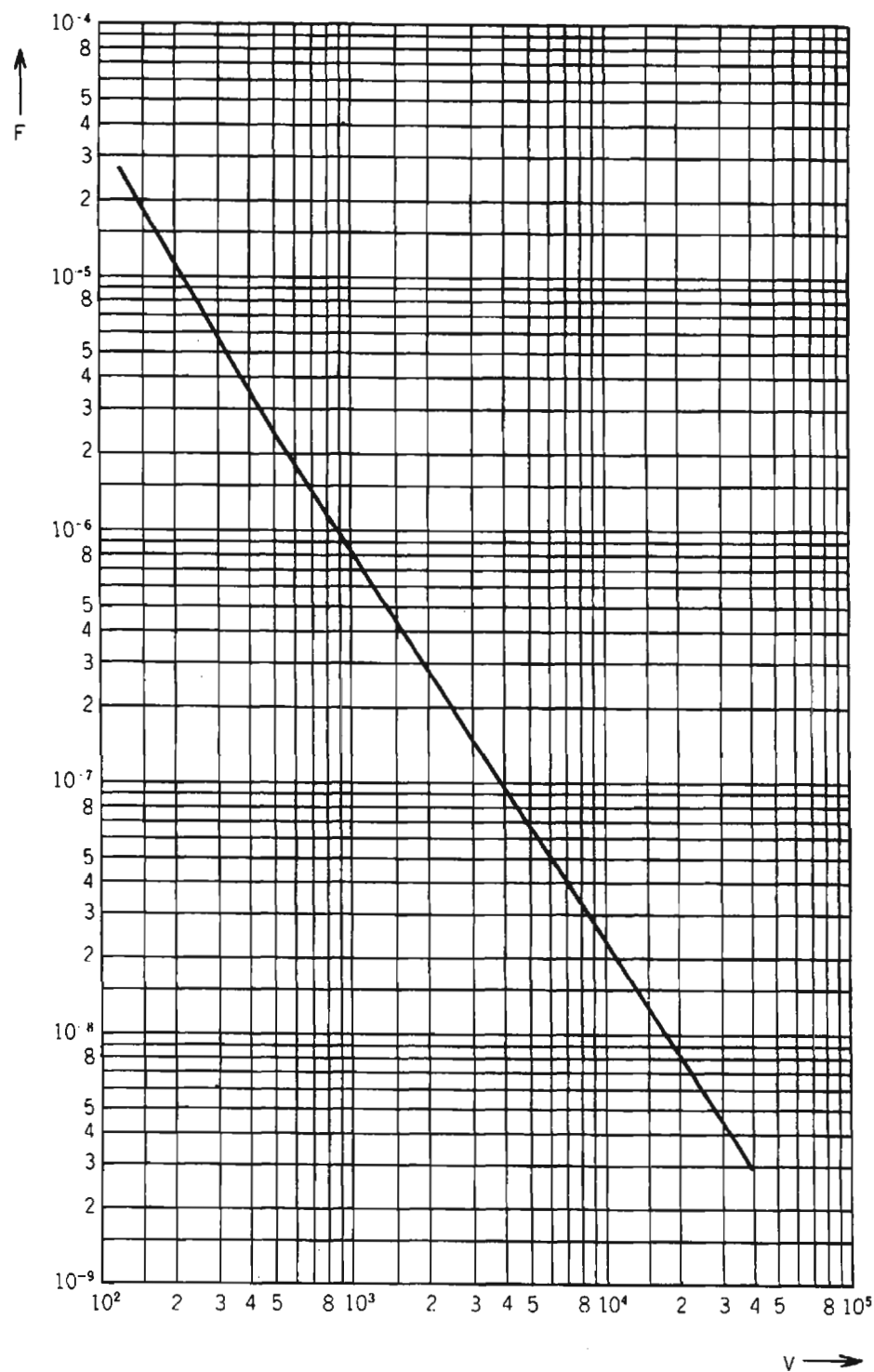


Fig. 2 Charged capacitance level in single fault condition
(see 6.3.2.3)

6.4 Protection in normal condition

Accessible parts shall be prevented from becoming **hazardous live** by one or more of the following means:

- **basic insulation** (see Annex E);
- **enclosures or barriers**;
- **protective impedance** (see 6.5.3).

Remarks: Materials which can easily be damaged are not considered to provide suitable insulation, for example lacquer, enamel, oxides and anodic films. Non-impregnated hygroscopic materials such as paper, fibres and fibrous materials are also not considered to provide suitable insulation.

Enclosures and barriers shall meet the rigidity requirements of 8.1. If **enclosures or barriers** provide protection by insulation, it shall meet the requirements for **basic insulation**.

Clearances, creepage distances and insulation between **accessible** parts and **hazardous live** parts shall meet the requirements of 6.7 and the applicable requirements for **basic insulation** of Annex D.

- Remarks 1 **Clearances and creepage distances** necessary for safety can be checked by measurement, except as specified in D.7 of Annex D.
- 2 Solid insulation necessary for safety can be checked by applying the test voltage of Annex D appropriate to the working voltage. The thickness required for solid insulation can be determined from the test voltage it must withstand. Partial discharge testing may also be appropriate (see IEC 60664).
- 3 Under mechanical or thermal stress conditions, insulation may have to be increased to meet the requirements of 7, 8 and 9.

Compliance is checked:

- by the determination of 6.2;
- by the tests of 6.8 for dielectric strength of **basic insulation**;
- by the tests of 8.1 for rigidity of **enclosures and barriers**.

6.5 Protection in single fault condition

Additional protection shall be provided to ensure that **accessible** parts are prevented from becoming **hazardous live** in **single fault condition**. The protection shall consist of one or more of the protective means specified in 6.5.1 to 6.5.3, except as specified in 6.5.4, or by automatic disconnection of the supply in case of a fault.

- Remarks 1 Protective devices which automatically disconnect equipment from its supply source are normally part of the building installation but can form part of the equipment.
- 2 Protective earthing (see 6.5.1) requires co-ordination of the type of system earthing, the characteristics of protective devices and the impedance of the earth path. For means of system earthing and for automatic disconnection of the supply, see IEC 60364-4-41, 413.1. However, if **double insulation** or **reinforced insulation** (see 6.5.2) is used throughout, co-ordination with the system or the installation is not required.

Compliance is checked as specified in 6.5.1 to 6.5.3.

6.5.1 Protective earthing

Accessible conductive parts shall be bonded to the **protective conductor terminal** if they could become **hazardous live** in case of a single fault of the primary protective means specified in 6.4. Alternatively, such **accessible** parts shall be separated from parts which are **hazardous live** by a conductive protective screen or

barrier bonded to the **protective conductor terminal**. For measuring and test equipment, indirect bonding is permitted as an alternative to direct bonding (see 6.5.1.4).

Accessible conductive parts need not be bonded to the **protective conductor terminal** if they are separated from all **hazardous live** parts by **double insulation** or **reinforced insulation**.

Compliance is checked by inspection.

6.5.1.1 Protective bonding

Protective bonding shall consist of directly connected structural parts or discrete conductors, or both. It shall withstand all thermal and dynamic stresses to which it could be subjected before one of the overcurrent protection means (see 9.6) disconnects the equipment from the supply [see also 6.11.2 h) 2)].

Compliance is checked by inspection and, when necessary, by measurement of the cross-sectional area of bonding conductors.

6.5.1.2 Bonding impedance of plug-connected equipment

The impedance between the **protective conductor terminal** and each **accessible** part for which **protective bonding** is specified shall not exceed 0.1 Ω . Mains cord impedance does not form part of the specified bonding impedance.

Compliance is checked by applying a test current for 1 min and then calculating the impedance. The test current is the greater of:

- 25A d.c. or a.c. r.m.s. at **rated** mains frequency;
- a current equal to twice the **rated** current of the equipment.

If the equipment contains overcurrent protection devices for all poles of the mains supply, and if the wiring between the supply and the overcurrent protection devices cannot become connected to **accessible** conductive parts in the case of a single fault, the current for the bonding impedance measurement shall not exceed twice the **rated** current of the internal overcurrent protection devices.

6.5.1.3 Bonding impedance of permanently connected equipment

Bonding of **permanently connected equipment** shall be of low impedance.

Compliance is checked by applying a test current for 1 min between the **protective conductor terminal** and each **accessible** conductive part for which **protective bonding** is specified. The voltage between them shall not exceed 10 V d.c. or a.c. r.m.s. The test current is twice the value of the overcurrent protection means specified in the installation instructions for the building supply mains circuit.

If the equipment contains overcurrent protection devices for all poles of the mains supply, and if the wiring between the supply and the overcurrent protection devices cannot become connected to **accessible** conductive parts in the case of a single fault, the current for the bonding impedance measurement shall not exceed twice the **rated** current of the internal overcurrent protection devices.

6.5.1.4 Indirect bonding for measuring and test equipment

Indirect bonding establishes a connection between the **protective conductor terminal** and **accessible** conductive parts when these become **hazardous live** as a result of a fault. Devices to establish indirect bonding are: