UL 60950

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Safety of Information Technology Equipment

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FOR USE IN THE U.S.

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IN ACCORDANCE WITH
IEC PUBLICATION 60950
FOR USE IN INTERNATIONAL
APPLICATIONS

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Information Technology Equipment, UL 60950

Third Edition, Dated December 1, 2000

Announcement Bulletin(s): This Standard contains the announcement bulletin(s) dated July 23, 1999. The announcement bulletin is located at the end of the Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the back side of the title page (page 2) of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the back side of the title page (page 2), this UL Standard for Safety has been adopted by the Department of Defense.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-430	December 1, 2000

CSA International
CAN/CSA-C22.2 No. 60950-00
Third Edition

Underwriters Laboratories Inc.
UL 60950
Third Edition

Safety of Information Technology Equipment

December 1, 2000

This national standard is based on publication IEC 60950, Third Edition (1999).

Approved
by
Standards Council
of Canada

American National Standard
ANSI/UL 60950-2000

Commitment for Amendments

This Standard is issued jointly by CSA International and Underwriters Laboratories Incorporated. Amendments to this Standard will be made only after processing according to the Standards writing procedures by both CSA International and Underwriters Laboratories Incorporated.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

Approval of UL 60950 as an American National Standard is maintained using the continuous maintenance process. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to the UL-SC Standards Department, 1655 Scott Blvd., Santa Clara, CA 95050.

The most recent approval of UL 60950 as an American National Standard (ANSI) occurred on October 11, 2000 and covers the Third Edition.

The U.S. Department of Defense (DoD) has adopted UL 1950 on December 21, 1994. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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Annex A (normative) Tests for resistance to heat and fire

Annex B (normative) Motor tests under abnormal conditions (see 4.7.2.2 and 5.3.2)

Annex C (normative) Transformers (see 1.5.4 and 5.3.3)

PREFACE DE

This is the common UL and CSA Standard for Safety of Information Technology Equipment. It DE
is the third edition of CSA Standard CAN/CSA-C22.2 No. 60950 and the third edition of UL DE
60950. This standard is based on IEC 60950, third edition. DE

Previous editions of this Standard were designated CAN/CSA-C22.2 No. 950/UL 1950. This DE
standard CAN/CSA-C22.2 No. 60950/UL 60950, third edition, replaces the previous standard DE
CAN/CSA-C22.2 No. 950/UL 1950, third edition. The standard number and edition number have DE
been aligned to correspond with the equivalent IEC 60950 standard. No first or second edition DE
of CAN/CSA-C22.2 No. 60950/UL 60950 will be published. DE

This common standard was prepared by CSA International and Underwriters Laboratories Inc. DE
and the information technology and telecommunication industries. The efforts and support of the DE
Electro Federation Canada (EFC, formerly EEMAC), the Information Technology Association of DE
Canada (ITAC), the Information Technology Industry Council (ITI, formerly CBEMA), and the DE
Telecommunication Industry Association (TIA) are gratefully acknowledged. DE

This Standard was reviewed by the CSA Subcommittee on Safety of Information Technology DE
Equipment Including Electrical Business Equipment under the jurisdiction of the Technical DE
Committee on Consumer and Commercial Products and the CSA Strategic Resource Group and DE
was approved by the Technical Committee. DE

This Standard has been approved as a National Standard of Canada by the Standards Council DE
of Canada and has been approved by the American National Standards Institute (ANSI) as an DE
American National Standard. DE

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

Level of Harmonization DE

This standard adopts the IEC text with deviations. This standard is published as an equivalent DE
standard. DE

An equivalent standard is a standard that is substantially the same in technical content, except DE
as follows. Technical deviations are allowed for Codes and Governmental Regulations and DE
those recognized as being in accordance with NAFTA Article 905, for example because of DE
fundamental, climatic, geographical, technological or infrastructural factors, scientific justification DE
or the level of protection that the country considers appropriate. Presentation shall be word for DE
word except for editorial changes. DE

UL Effective Date DE

New product submittals through April 1, 2003 will be evaluated using all the requirements in this DE
standard, or if requested in writing, evaluated using the requirements in UL 1950, Third Edition. DE
After April 1, 2003 all new product submittals are required to use this standard. DE

Products that were previously certified by Underwriters Laboratories Inc. to requirements in DE
other existing applicable standards, such as UL 114, UL 478, UL 1459 or UL 1950, First or DE
Second Editions, up to April 1, 2000, and UL 1950, Third Edition, up to April 1, 2003, may DE

continue to be certified without further reinvestigation until April 1, 2005, provided no significant DE
changes or revisions are made to such products. Non-significant changes will be evaluated to DE
the original standard. DE

As of April 1, 2005, all products, including those previously certified by UL, must comply with this DE
standard in order to continue to have the UL Mark applied after this date. DE

CSA Effective Date DE

The effective date for CSA International will be announced through CSA Informs or CSA DE
Certification Notice. DE

General DE

Deviations from the text of the International Electrotechnical Commission Publication 60950, DE
Safety of Information Technology Equipment, Copyright 1999, are indicated by the following DE
applicable margin notations: DE

D1 – deviations based on national regulatory requirements which result in equivalent DE
or more stringent requirements than in IEC 60950. DE

D2 – deviations based on other than national regulatory requirements which result in DE
equivalent or more stringent requirements than in IEC 60950. DE

DI – deviations based on IEC final draft international standards (FDIS). DI deviations DE
may be less stringent than, equivalent to, or more stringent than requirements in IEC DE
60950. DE

DC – deviations based on UL and CSA component requirements. DC deviations may DE
be less stringent than, equivalent to, or more stringent than component requirements DE
in IEC 60950. DE

D3 – deviations based on bi-national requirements which result in less stringent DE
requirements than in IEC 60950. DE

DE – editorial deviations that correct typographical errors in IEC 60950 or revise the DE
terminology, but do not alter the technical intent of the requirements. This is also used DE
for informative statements such as the Preface and Foreword. DE

D1, D2, D3, DI, DC, and DE deviations have been incorporated into the body of the standard. DE
If deviations necessitate the deletion of IEC 60950 text, the IEC 60950 text has been retained DE
but has been ~~lined out~~. Except for tables and figures and annexes, text added as a result of DE
deviations has been underlined. Text added as the Preface and UL and CSA Forewords is not DE
underlined. DE

Several annexes are included at the back of the standard. Pointers to these annexes are DE
provided in the right-hand margin of the body of the standard to direct the user to these DE
informative/normative annexes. The pointer text is provided in ***BOLD ITALICS***. Examples of DE ***NAAP***
such pointers are shown here in the right-hand margin. DE

The text, figures, and tables of International Electrotechnical Commission Publication 60950, DE
Safety of Information Technology Equipment, Copyright 1999, are used in this standard with the DE
consent of the International Electrotechnical Commission. DE

The International Electrotechnical Commission Foreword and Introduction are not a part of the DE
requirements of this standard but are included for information purposes only. DE

FOREWORD (CSA) DE

The Canadian Standards Association, which operates under the name CSA International (CSA), DE
provides certification services for manufacturers who, under license from CSA, wish to use the DE
appropriate registered CSA Marks on certain products of their manufacture to indicate DE
conformity with CSA Standards. DE

CSA Certification for a number of products is provided in the interest of maintaining agreed-upon DE
standards of quality, performance, interchangeability and/or safety, as appropriate. Where DE
applicable, certification may form the basis for acceptance by inspection authorities responsible DE
for enforcement of regulations. Where feasible, programs will be developed for additional DE
products for which certification is desired by producers, consumers or other interests. DE

In performing its functions in accordance with its objectives, CSA does not assume or undertake DE
to discharge any responsibility of the manufacturer or any other party. The opinions and findings DE
of the Association represent its professional judgement given with due consideration to the DE
necessary limitations of practical operation and state of the art at the time the Standard is DE
processed. DE

Products in substantial accord with this Standard but which exhibit a minor difference or a new DE
feature may be deemed to meet the Standard providing the feature or difference is found DE
acceptable utilizing appropriate CSA Certification and Testing Division Operating Procedures. DE
Products which comply with this Standard shall not be certified if they are found to have DE
additional features which are inconsistent with the intent of this Standard. Products shall not be DE
certifiable if they are discovered to contravene applicable laws or regulations. DE

Testing techniques, test procedures and instrumentation frequently must be prescribed by the DE
CSA Certification and Testing Division in addition to the technical requirements contained in DE
Standards of CSA. In addition to markings specified in the Standard, the CSA Certification and DE
Testing Division may require special cautions, markings and instructions that are not specified DE
by the Standard. DE

Some tests required by CSA Standards may be inherently hazardous. The Association neither DE
assumes nor accepts any responsibility for any injury or damage that may occur during or as DE
the result of tests, wherever performed, whether performed in whole or in part by the DE
manufacturer or the Association, and whether or not any equipment, facility or personnel for or DE
in connection with the test is furnished by the manufacturer or the Association. DE

Manufacturers should note that, in the event of the failure of the CSA Certification and Testing DE
Division to resolve an issue arising from the interpretation of requirements, there is an appeal DE
procedure: the complainant should submit the matter, in writing, to the Secretary of the DE
Canadian Standards Association. DE

If this Standard is to be used in obtaining CSA Certification please remember, when making DE
application for certification, to request all current Amendments, Bulletins, Notices and Technical DE
Information Letters that may be applicable and for which there may be a nominal charge. For DE
such information or for further information concerning CSA Certification please address your DE
inquiry to Applications and Customer Service, CSA International, 178 Rexdale Boulevard, DE
Toronto, Ontario M9W 1R3. DE

FOREWORD (UL)

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY OF INFORMATION TECHNOLOGY EQUIPMENT

FOREWORD

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

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

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

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

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

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

International Standard IEC 60950 has been prepared by IEC Technical Committee 74: Safety and energy efficiency of IT equipment.

This third edition cancels and replaces the second edition, issued in 1991, and its amendments 1 (1992), 2 (1993), 3 (1995) and 4 (1996) and constitutes a technical revision.

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

FDIS	Report on voting
74/498/FDIS	74/504/RVD

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

Annexes A, B, C, D, E, F, G, H, J, K, L, M, N, P, U and V form an integral part of this standard.

Annexes Q, R, S, T, W and X are for information only.

In this standard, the following print types are used:

– Requirements proper and normative annexes: in roman type.

– Compliance statements and test specifications: in italic type.

– Notes and other informative matter: in smaller roman type.

– Normative conditions within tables: in smaller roman type.

– Terms that are defined in 1.2: SMALL CAPITALS.

The numbering system in this standard uses a space instead of a comma to indicate thousands DE
and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means DE
1,000 and 1,01 means 1.01. DE

INTRODUCTION

0 Principles of safety

The following principles have been adopted by technical committee 74 in the development of this standard.

These principles do not cover performance or functional characteristics of equipment.

Words printed in SMALL CAPITALS are terms that are defined in 1.2 of this standard.

0.1 General principles of safety

It is essential that designers understand the underlying principles of safety requirements in order that they can engineer safe equipment.

These principles are not an alternative to the detailed requirements of this standard, but are intended to provide designers with an appreciation of the basis of these requirements. Where the equipment involves technologies and materials or methods of construction not specifically covered, the design of the equipment should provide a level of safety not less than those described in these principles of safety.

Designers shall take into account not only normal operating conditions of the equipment but also likely fault conditions, consequential faults, foreseeable misuse and external influences such as temperature, altitude, pollution, moisture, overvoltages on the mains and overvoltages on the telecommunication lines.

The following priorities should be observed in determining what design measures to adopt:

- where possible, specify design criteria that will eliminate, reduce or guard against hazards;
- where the above is not practicable because the functioning of the equipment would be impaired, specify the use of protective means independent of the equipment, such as personal protective equipment (which is not specified in this standard);
- where neither of the above measures is practicable, or in addition to those measures, specify the provision of markings and instructions regarding the residual risks.

There are two types of persons whose safety needs to be considered, USERS (or OPERATORS) and SERVICE PERSONNEL.

USER is the term applied to all persons other than SERVICE PERSONNEL. Requirements for protection should assume that USERS are not trained to identify hazards, but will not intentionally create a hazardous situation. Consequently, the requirements will provide protection for cleaners and casual visitors as well as the assigned USERS. In general, USERS should not have access to hazardous parts, and to this end, such parts should only be in SERVICE ACCESS AREAS or in equipment located in RESTRICTED ACCESS LOCATIONS.

When USERS are admitted to RESTRICTED ACCESS LOCATIONS they shall be suitably instructed.

SERVICE PERSONNEL are expected to use their training and skill to avoid possible injury to themselves and others due to obvious hazards which exist in SERVICE ACCESS AREAS of the equipment or on equipment located in RESTRICTED ACCESS LOCATIONS. However, SERVICE PERSONNEL should be protected against unexpected hazards. This can be done by, for example, locating parts that need to be accessible for servicing away from electrical and mechanical hazards, providing shields to avoid accidental contact with hazardous parts, and providing labels or instructions to warn personnel about any residual risk.

Information about potential hazards can be marked on the equipment or provided with the equipment, depending on the likelihood and severity of injury, or made available for SERVICE PERSONNEL. In general, USERS shall not be exposed to hazards likely to cause injury, and information provided for USERS should primarily aim at avoiding misuse and situations likely to create hazards, such as connection to the wrong power source and replacement of fuses by incorrect types.

MOVABLE EQUIPMENT is considered to present a slightly increased risk of shock, due to possible extra strain on the supply cord leading to rupture of the earthing conductor. With HAND-HELD EQUIPMENT, this risk is increased; wear on the cord is more likely, and further hazards could arise if the units were dropped. TRANSPORTABLE EQUIPMENT introduces a further factor because it can be used and carried in any orientation; if a small metallic object enters an opening in the ENCLOSURE it can move around inside the equipment, possibly creating a hazard.

0.2 Hazards

Application of a safety standard is intended to reduce the likelihood of injury or damage due to the following:

- electric shock;
- energy related hazards;
- fire;
- heat related hazards;
- mechanical hazards;
- radiation;
- chemical hazards.

0.2.1 Electric shock

Electric shock is due to current passing through the human body. The resulting physiological effects depend on the value and duration of the current and the path it takes through the body. The value of the current depends on the applied voltage, the impedance of the source and the impedance of the body. The body impedance depends in turn on the area of contact, moisture in the area of contact and the applied voltage and frequency. Currents of approximately half a milliampere can cause a reaction in persons in good health and may cause injury indirectly due to involuntary reaction. Higher currents can have more direct effects, such as burn or ventricular fibrillation.

Steady state voltages up to 42,4 V peak, or 60 V d.c., are not generally regarded as hazardous under dry conditions for an area of contact equivalent to a human hand. Bare parts which have to be touched or handled should be at earth potential or properly insulated.

Some equipment will be connected to telephone and other external networks. Some TELECOMMUNICATION NETWORKS operate with signals such as voice and ringing superimposed on a steady DC VOLTAGE; the total may exceed the values given above for steady-state voltages. It is common practice for the SERVICE PERSONNEL of telephone companies to handle parts of such circuits bare-handed. This has not caused serious injury, because of the use of cadenced ringing and because there are limited areas of contact with bare conductors normally handled by SERVICE PERSONNEL. However, the area of contact of a part accessible to the USER, and the likelihood of the part being touched, should be further limited (e.g. by the shape and location of the part).

It is normal to provide two levels of protection for USERS to prevent electric shock. Therefore, the operation of equipment under normal conditions and after a single fault, including any consequential faults, should not create a shock hazard. However, provision of additional protective measures, such as protective earthing or SUPPLEMENTARY INSULATION, is not considered a substitute for, or a relief from, properly designed BASIC INSULATION.

Hazards may result from:	**Examples of measures to reduce hazards:**
Contact with bare parts normally at HAZARDOUS VOLTAGES.	Prevent USER access to parts at HAZARDOUS VOLTAGES by fixed or locked covers, SAFETY INTERLOCKS, etc. Discharge accessible capacitors that are at HAZARDOUS VOLTAGES.
Breakdown of insulation between parts normally at HAZARDOUS VOLTAGES and accessible conductive parts.	Provide BASIC INSULATION and connect the accessible conductive parts and circuits to earth so that exposure to the voltage which can develop is limited because overcurrent protection will disconnect the parts having low impedance faults within a specified time; or provide a metal screen connected to protective earth between the parts, or provide DOUBLE or REINFORCED INSULATION between the parts, so that breakdown to the accessible part is not likely to occur.
Contact with circuits connected to TELECOMMUNICATION NETWORKS which exceed 42,4 V peak or 60 V d.c.	Limit the accessibility and area of contact of such circuits, and separate them from unearthed parts to which access is not limited.
Breakdown of USER-accessible insulation.	Insulation which is accessible to the USER should have adequate mechanical and electrical strength to reduce the likelihood of contact with HAZARDOUS VOLTAGES.

Table Continued on Next Page

Table Continued

Hazards may result from:	Examples of measures to reduce hazards:
TOUCH CURRENT (leakage current) flowing from parts at HAZARDOUS VOLTAGES to accessible parts, or failure of a protective earthing connection. TOUCH CURRENT may include current due to EMC filter components connected between PRIMARY CIRCUITS and accessible parts.	Limit TOUCH CURRENT to a specified value, or provide a high integrity protective earthing connection.

0.2.2 Energy related hazards

Hazards may result from a short circuit between adjacent poles of high current supplies or high capacitance circuits, causing:

- burns;
- arcing;
- ejection of molten metal.

Even circuits whose voltages are safe to touch may be hazardous in this respect.

Examples of measures to reduce such hazards include:

- separation;
- shielding;
- provision of safety interlocks.

0.2.3 Fire

Hazards may result from excessive temperatures either under normal operating conditions or due to overload, component failure, insulation breakdown or loose connections. Fires originating within the equipment should not spread beyond the immediate vicinity of the source of the fire, nor cause damage to the surroundings of the equipment.

Examples of measures to reduce such hazards include:

- providing overcurrent protection;
- using constructional materials having appropriate flammability properties for their purpose;
- selection of parts, components and consumable materials to avoid high temperature which might cause ignition;
- limiting the quantity of combustible materials used;
- shielding or separating combustible materials from likely ignition sources;
- using ENCLOSURES or barriers to limit the spread of fire within the equipment;

– using suitable materials for ENCLOSURES so as to reduce the likelihood of fire spreading from the equipment.

0.2.4 Heat related hazards

Hazards may result from high temperatures under normal operating conditions, causing:

- burns due to contact with hot accessible parts;
- degradation of insulation and of safety-critical components;
- ignition of flammable liquids.

Examples of measures to reduce such hazards include:

- taking steps to avoid high temperature of accessible parts;
- avoiding temperatures above the ignition point of liquids;
- provision of markings to warn USERS where access to hot parts is unavoidable.

0.2.5 Mechanical hazards

Hazards may result from:

- sharp edges and corners;
- moving parts which have the potential to cause injury;
- equipment instability;
- flying particles from imploding cathode ray tubes and exploding high pressure lamps.

Examples of measures to reduce such hazards include:

- rounding of sharp edges and corners;
- guarding;
- provision of SAFETY INTERLOCKS;
- providing sufficient stability to free-standing equipment;
- selecting cathode ray tubes and high pressure lamps that are resistant to implosion and explosion respectively;
- provision of markings to warn USERS where access is unavoidable.

0.2.6 Radiation

Hazards to USERS and to SERVICE PERSONNEL may result from some forms of radiation emitted by equipment. Examples are sonic (acoustic), radio frequency, infra-red, ultraviolet and ionizing radiation, and high intensity visible and coherent light (lasers).

Examples of measures to reduce such hazards include:

- limiting the energy level of potential radiation sources;
- screening radiation sources;
- provision of SAFETY INTERLOCKS;
- provision of markings to warn USERS where exposure to the radiation hazard is unavoidable.

0.2.7 Chemical hazards

Hazards may result from contact with some chemicals or from inhalation of their vapours and fumes.

Examples of measures to reduce such hazards include:

- avoiding the use of constructional and consumable materials likely to cause injury by contact or inhalation during intended and normal conditions of use;
- avoiding conditions likely to cause leakage or vaporization;
- provision of markings to warn USERS about the hazards.

0.3 Materials and components

Materials and components used in the construction of equipment should be so selected and arranged that they can be expected to perform in a reliable manner for the anticipated life of the equipment without creating a hazard, and would not contribute significantly to the development of a serious fire hazard. Components should be selected so that they remain within their manufacturers' ratings under normal operating conditions, and do not create a hazard under fault conditions.

SAFETY OF INFORMATION TECHNOLOGY EQUIPMENT –

1 General

1.1 Scope

1.1.1 Equipment covered by this standard

NAA
NAE

This standard is applicable to mains-powered or battery-powered information technology equipment, including electrical business equipment and associated equipment, with a RATED
VOLTAGE not exceeding 600 V and designed to be installed in accordance with the Canadian D1
Electrical Code, Part I, CSA C22.1; CSA C22.2 No. 0; and the National Electrical Code, NFPA D1
70. D1

The standard is also applicable to equipment, unless otherwise identified by a marking or D1
instructions, designed to be installed in accordance with Article 645 of the National Electrical D1
Code, NFPA 70, and the Standard for the Protection of Electronic Computer Data-Processing D1
Equipment, NFPA 75. D1

See annex NAE for examples of and references to regulatory requirements that may apply to D1
this equipment. D1

This standard is also applicable to such information technology equipment designed and intended to be connected directly to a TELECOMMUNICATION NETWORK, regardless of the source of power.

It is also applicable to such information technology equipment designed to use the AC MAINS SUPPLY as a telecommunication transmission medium (see note 4 of clause 6).

This standard specifies requirements intended to reduce risks of fire, electric shock or injury for the OPERATOR and layman who may come into contact with the equipment and, where specifically stated, for SERVICE PERSONNEL.

This standard is intended to reduce such risks with respect to installed equipment, whether it consists of a system of interconnected units or independent units, subject to installing, operating and maintaining the equipment in the manner prescribed by the manufacturer.

Examples of equipment which is in the scope of this standard are:

accounting machines
bookkeeping machines
calculators
cash registers
copying machines
data circuit terminating equipment
data preparation equipment
data processing equipment
data terminal equipment
dictation equipment
document shredding machines
duplicators
electrically operated drawing machines
erasers
facsimile equipment
key telephone systems
magnetic tape handlers
mail processing machines
micrographic office equipment
modems
monetary processing machines including automated teller (cash dispensing) machines
motor operated files
PABX's
paper jogging machines
paper trimmers (punchers cutting machines, separators)
pencil sharpeners
personal computers
photoprinting equipment
plotters
point of sale terminals including associated electronic scales
postage machines
public information terminals
staplers
telephone answering machines
telephone sets
text processing equipment
typewriters
visual display units

This list is not intended to be comprehensive, and equipment that is not listed is not necessarily excluded from the scope.

Equipment complying with the relevant requirements in this standard is considered suitable for use with process control equipment, automatic test equipment and similar systems requiring information processing facilities. However, this standard does not include requirements for performance or functional characteristics of equipment.

1.1.2 Additional requirements

P T NAE

Requirements additional to those specified in this standard may be necessary for:

- equipment intended for operation in special environments, for example, extremes of temperature; excessive dust, moisture or vibration; flammable gases; and corrosive or explosive atmospheres;
- electromedical applications with physical connections to the patient;
- equipment intended to be used in vehicles, on board ships or aircraft, in tropical countries, or at altitudes greater than 2 000 m;
- equipment intended for use where ingress of water is possible; for guidance on such requirements and on relevant testing, see annex T.

NOTE – Attention is drawn to the fact that authorities of some countries impose additional requirements.

1.1.3 Exclusions

P NAE

This standard does not apply to:

- support equipment, such as air conditioning, fire detection or fire extinguishing systems;
- power supply systems, such as motor-generator sets, battery backup systems and transformers, which are not an integral part of the equipment;
- building installation wiring;
- devices requiring no electrical power.

1.2 Definitions

For the purpose of this International Standard the following definitions apply. Where the terms ″voltage″ and ″current″ are used they imply the r.m.s. values, unless otherwise specified.

Definitions in alphabetical order of nouns

AREA, OPERATOR ACCESS	1.2.7.1
AREA, SERVICE ACCESS	1.2.7.2
BODY	1.2.7.5
CABLE, INTERCONNECTING	1.2.11.6
CIRCUIT, ELV	1.2.8.5
CIRCUIT, LIMITED CURRENT	1.2.8.7
CIRCUIT, PRIMARY	1.2.8.2
CIRCUIT, SECONDARY	1.2.8.3
CIRCUIT, SELV	1.2.8.6
CIRCUIT, TNV	1.2.8.9
CIRCUIT, TNV-1	1.2.8.10
CIRCUIT, TNV-2	1.2.8.11
CIRCUIT, TNV-3	1.2.8.12
CLEARANCE	1.2.10.1
CONDUCTOR, PROTECTIVE BONDING	1.2.13.11

1.2.1 Equipment electrical ratings

1.2.1.1 RATED VOLTAGE: The supply voltage (for a three-phase AC MAINS SUPPLY, the line-to-line voltage) as declared by the manufacturer.

1.2.1.2 RATED VOLTAGE RANGE: The supply voltage range as declared by the manufacturer, expressed by its lower and upper RATED VOLTAGES.

1.2.1.3 RATED CURRENT: The input current of the equipment as declared by the manufacturer.

1.2.1.4 RATED FREQUENCY: The supply frequency as declared by the manufacturer.

1.2.1.5 RATED FREQUENCY RANGE: The supply frequency range as declared by the manufacturer, expressed by its lower and upper RATED FREQUENCIES.

1.2.2 Operating conditions

1.2.2.1 NORMAL LOAD: The mode of operation which approximates as closely as possible the most severe conditions of normal use in accordance with the operating instructions. However, when the conditions of actual use can obviously be more severe than the maximum recommended load conditions, a load is used that is representative of the maximum that can be applied. ***L***

NOTE – NORMAL LOAD conditions for some types of electrical business equipment are given in annex L.

1.2.2.2 RATED OPERATING TIME: The operating time assigned to the equipment by the manufacturer.

1.2.2.3 CONTINUOUS OPERATION: Operation under NORMAL LOAD for an unlimited period.

1.2.2.4 SHORT-TIME OPERATION: Operation under NORMAL LOAD for a specified period, starting from cold, the intervals after each period of operation being sufficient to allow the equipment to cool down to room temperature.

1.2.2.5 INTERMITTENT OPERATION: Operation in a series of specified identical cycles, each composed of a period of operation under NORMAL LOAD followed by a rest period with the equipment switched off or running idle.

1.2.3 Equipment mobility

1.2.3.1 MOVABLE EQUIPMENT: Equipment which is either:

- 18 kg or less in mass and not fixed, or
- equipment with wheels, castors or other means to facilitate movement by the OPERATOR as required to perform its intended use.

NOTE – MOVABLE EQUIPMENT includes wall-mounted equipment whose mounting means permits removal by an OPERATOR. DE

1.2.3.2 HAND-HELD EQUIPMENT: MOVABLE EQUIPMENT, or a part of any kind of equipment, that is intended to be held in the hand during normal use.

1.2.3.3 TRANSPORTABLE EQUIPMENT: MOVABLE EQUIPMENTthat is intended to be routinely carried by a USER.

NOTE – Examples include laptop personal computers, pen-based tablet computers, and their portable accessories such as printers and CD-ROM drives.

1.2.3.4 STATIONARY EQUIPMENT: Equipment that is not MOVABLE EQUIPMENT.

1.2.3.5 EQUIPMENT FOR BUILDING-IN: Equipment intended to be installed in a prepared recess, such as in a wall, or similar situation.

NOTE – In general, EQUIPMENT FOR BUILDING-IN does not have an ENCLOSURE on all sides, as some of the sides will be protected after installation.

1.2.3.6 DIRECT PLUG-IN EQUIPMENT: Equipment that is intended to be used without a power supply cord; the mains plug forms an integral part of the equipment ENCLOSURE so that the weight of the equipment is taken by the socket-outlet.

1.2.4 Classes of equipment – Protection against electric shock

NOTE – Some information technology equipment cannot be identified as conforming to one of the following classes.

1.2.4.1 CLASS I EQUIPMENT: Equipment where protection against electric shock is achieved by:

- using BASIC INSULATION, and also
- providing a means of connecting to the PROTECTIVE EARTHING CONDUCTOR in the building wiring those conductive parts that are otherwise capable of assuming HAZARDOUS VOLTAGES if the BASIC INSULATION fails.

NOTE – CLASS I EQUIPMENT may have parts with DOUBLE INSULATION or REINFORCED INSULATION.

1.2.4.2 CLASS II EQUIPMENT: Equipment in which protection against electric shock does not rely on BASIC INSULATION only, but in which additional safety precautions, such as DOUBLE INSULATION or REINFORCED INSULATION are provided, there being no reliance on either protective earthing or installation conditions.

1.2.4.3 CLASS III EQUIPMENT: Equipment in which protection against electric shock relies upon supply from SELV CIRCUITS and in which HAZARDOUS VOLTAGES are not generated.

NOTE – For CLASS III EQUIPMENT, although there is no requirement for protection against electric shock, all other requirements of the standard apply.

1.2.5 Connection to the supply *P*

1.2.5.1 PLUGGABLE EQUIPMENT TYPE A: Equipment which is intended for connection to the building installation wiring via a non-industrial plug and socket-outlet or a non-industrial appliance coupler, or both.

NOTE – 1-15, 2-15, 2-20, 5-15 and 5-20 plugs and outlets as specified in IEC 60083 are considered to be non-industrial within the DE
meaning of this standard. DE

1.2.5.2 PLUGGABLE EQUIPMENT TYPE B: Equipment which is intended for connection to the building installation wiring via an industrial plug and socket-outlet or an appliance coupler, or both, complying with IEC 60309, or with a comparable national standard.

1.2.5.3 PERMANENTLY CONNECTED EQUIPMENT: Equipment which is intended for connection to the building installation wiring using screw terminals or other reliable means.

1.2.5.4 DETACHABLE POWER SUPPLY CORD: A flexible cord, for supply purposes, intended to be connected to the equipment by means of a suitable appliance coupler.

1.2.5.5 NON-DETACHABLE POWER SUPPLY CORD: A flexible cord, for supply purposes, fixed to or assembled with the equipment.

Such a cord may be:

> Ordinary: A flexible cord which can be easily replaced without special preparation of the cord or special TOOLS, or

Special: A flexible cord which is specially prepared or requires the use of specially designed tools for replacement, or is such that it cannot be replaced without damage to the equipment.

The term ″specially prepared″ includes provision of an integral cord guard, the use of cable lugs, formation of eyelets, etc., but not the re-shaping of the conductor before introduction into a terminal or the twisting of a stranded conductor to consolidate the end.

1.2.6 Enclosures

1.2.6.1 enclosure: A part of the equipment providing one or more of the functions described in 1.2.6.2, 1.2.6.3, or 1.2.6.4.

NOTE – One type of enclosure can be inside another type (e.g. an electrical enclosure inside a fire enclosure or a fire enclosure inside an electrical enclosure). Also, a single enclosure can provide the functions of more than one type (e.g. those of both an electrical enclosure and a fire enclosure).

1.2.6.2 fire enclosure: A part of the equipment intended to minimize the spread of fire or flames from within.

1.2.6.3 mechanical enclosure: A part of the equipment intended to reduce the risk of injury due to mechanical and other physical hazards. ***NAD***

1.2.6.4 electrical enclosure: A part of the equipment intended to limit access to parts that may be at hazardous voltage or hazardous energy levels or are in tnv circuits.

1.2.6.5 decorative part: A part of the equipment, outside the enclosure, which has no safety function.

1.2.7 Accessibility

1.2.7.1 operator access area: An area to which, under normal operating conditions, one of the following applies:

- access can be gained without the use of a tool, or
- the means of access is deliberately provided to the operator, or
- the operator is instructed to enter regardless of whether or not a tool is needed to gain access.

The terms ″access″ and ″accessible″, unless qualified, relate to operator access area as defined above.

1.2.7.2 service access area: An area, other than an operator access area, where it is necessary for service personnel to have access even with the equipment switched on.

1.2.7.3 restricted access location: A location for equipment where both of the following paragraphs apply:

- access can only be gained by service personnel or by users who have been instructed about the reasons for the restrictions applied to the location and about any precautions that shall be taken; and

– access is through the use of a TOOL or lock and key, or other means of security, and is controlled by the authority responsible for the location.

NOTE – The requirements for equipment intended for installation in RESTRICTED ACCESS LOCATIONS are the same as for OPERATOR ACCESS AREAS, except as given in 1.7.17, 2.1.3 and ~~4.5.1~~ 4.4.3. DE

1.2.7.4 TOOL: A screwdriver or any other object which may be used to operate a screw, latch or similar fixing means.

1.2.7.5 BODY: All accessible conductive parts, shafts of handles, knobs, grips and the like, and metal foil in contact with all accessible surfaces of insulating material.

1.2.7.6 SAFETY INTERLOCK: A means either of preventing access to a hazardous area until the hazard is removed, or of automatically removing the hazardous condition when access is gained.

1.2.8 Circuits and circuit characteristics *P*

1.2.8.1 AC MAINS SUPPLY: The external a.c. power distribution system supplying power to the equipment. These power sources include public or private utilities and, unless otherwise specified in the standard (e.g. 1.4.5), equivalent sources such as motor-driven generators and uninterruptible power supplies.

NOTE – See annex V for typical examples of a.c. power distribution systems.

1.2.8.2 PRIMARY CIRCUIT: A circuit which is directly connected to the AC MAINS SUPPLY. It includes, for example, the means for connection to the AC MAINS SUPPLY, the primary windings of transformers, motors and other loading devices.

NOTE – Conductive parts of an INTERCONNECTING CABLE may be part of a PRIMARY CIRCUIT as stated in 1.2.11.6.

1.2.8.3 SECONDARY CIRCUIT: A circuit which has no direct connection to a PRIMARY CIRCUIT and derives its power from a transformer, converter or equivalent isolation device, or from a battery.

NOTE – Conductive parts of an INTERCONNECTING CABLE may be part of a SECONDARY CIRCUIT as stated in 1.2.11.6.

1.2.8.4 HAZARDOUS VOLTAGE: A voltage exceeding 42,4 V peak, or 60 V d.c., existing in a circuit which does not meet the requirements for either a LIMITED CURRENT CIRCUIT or a TNV CIRCUIT.

1.2.8.5 ELV CIRCUIT: A SECONDARY CIRCUIT with voltages between any two conductors of the circuit, and between any one such conductor and earth (see 1.4.9), not exceeding 42,4 V peak, or 60 V d.c., under normal operating conditions, which is separated from HAZARDOUS VOLTAGE by BASIC INSULATION, and which neither meets all of the requirements for an SELV CIRCUIT nor meets all of the requirements for a LIMITED CURRENT CIRCUIT.

1.2.8.6 SELV CIRCUIT: A SECONDARY CIRCUIT which is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value.

NOTE 1 – The limit values of voltages under normal operating conditions and single fault conditions (see 1.4.14) are specified in 2.2. See also table 1A.

NOTE 2 – This definition of an SELV CIRCUIT differs from the term ″SELV system″ as used in IEC 61140[1].

1.2.8.7 LIMITED CURRENT CIRCUIT: A circuit which is so designed and protected that, under both normal operating conditions and single fault conditions, the current which can be drawn is not hazardous.

NOTE – The limit values of currents under normal operating conditions and single fault conditions (see 1.4.14) are specified in 2.4.

1.2.8.8 HAZARDOUS ENERGY LEVEL: A stored energy level of 20 J or more, or an available continuous power level of 240 VA or more, at a potential of 2 V or more.

1.2.8.9 TNV CIRCUIT: A circuit which is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions (see 1.4.14), the voltages do not exceed specified limit values.

A TNV CIRCUIT is considered to be a SECONDARY CIRCUIT in the meaning of this standard.

NOTE 1 – The specified limit values of voltages under normal operating conditions and single fault conditions (see 1.4.14) are given in 2.3.1. Requirements regarding accessibility of TNV CIRCUITS are given in 2.1.1.1.

TNV CIRCUITS are classified as TNV-1, TNV-2 and TNV-3 CIRCUITS as defined in 1.2.8.10, 1.2.8.11, and 1.2.8.12.

NOTE 2 – The voltage relationships between SELV and TNV CIRCUITS are shown in table 1A.

NOTE 3 – Conductive parts of an INTERCONNECTING CABLE may be part of a TNV CIRCUIT as stated in 1.2.11.6.

Table 1A – Voltage ranges of SELV and TNV circuits

	Normal operating voltages	
Overvoltages from TELECOMMUNICATION NETWORKS possible?	**Within SELV CIRCUIT limits**	**Exceeding SELV CIRCUIT limits but within TNV CIRCUIT limits**
Yes	TNV-1 CIRCUIT	TNV-3 CIRCUIT
No	SELV CIRCUIT	TNV-2 CIRCUIT

1.2.8.10 TNV-1 CIRCUIT: A TNV CIRCUIT:

– whose normal operating voltages do not exceed the limits for an SELV CIRCUIT under normal operating conditions, and

– on which overvoltages from TELECOMMUNICATION NETWORKS are possible.

1.2.8.11 TNV-2 CIRCUIT: A TNV CIRCUIT:

– whose normal operating voltages exceed the limits for an SELV CIRCUIT under normal operating conditions, and

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[1] A list of informative references is given in annex Q: ″Bibliography″.

– which is not subject to overvoltages from telecommunication networks.

1.2.8.12 tnv-3 circuit: A tnv circuit:

– whose normal operating voltages exceed the limits for an selv circuit under normal operating conditions; and

– on which overvoltages from telecommunication networks are possible.

1.2.9 Insulation

1.2.9.1 functional insulation: Insulation that is necessary only for the correct operation of the equipment.

NOTE – functional insulation by definition does not protect against electric shock. It may, however, reduce the likelihood of ignition and fire.

1.2.9.2 basic insulation: Insulation to provide basic protection against electric shock.

1.2.9.3 supplementary insulation: Independent insulation applied in addition to basic insulation in order to reduce the risk of electric shock in the event of a failure of the basic insulation.

1.2.9.4 double insulation: Insulation comprising both basic insulation and supplementary insulation.

1.2.9.5 reinforced insulation: A single insulation system which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard.

NOTE – The term ″insulation system″ does not imply that the insulation has to be in one homogeneous piece. It may comprise several layers which cannot be tested as supplementary or basic insulation.

1.2.9.6 working voltage: The highest voltage to which the insulation or the component under consideration is, or can be, subjected when the equipment is operating under conditions of normal use.

1.2.9.7 peak working voltage: The highest peak or d.c. value of a working voltage, including repetitive peak impulses generated in the equipment, but not including external transients.

1.2.9.8 required withstand voltage: The peak voltage that the insulation under consideration is required to withstand.

1.2.9.9 mains transient voltage: The highest peak voltage expected at the power input to the equipment, arising from external transients on the ac mains supply.

1.2.9.10 telecommunication network transient voltage: The highest peak voltage expected at the telecommunication network connection point of the equipment, arising from external transients on the network.

1.2.10 Clearances and creepage distances

1.2.10.1 clearance: The shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air.

1.2.10.2 creepage distance: The shortest path between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured along the surface of the insulation.

1.2.10.3 bounding surface: The outer surface of the electrical enclosure, considered as though metal foil were pressed into contact with accessible surfaces of insulating material.

1.2.11 Components

1.2.11.1 thermostat: A cycling temperature-sensing control, which is intended to keep a temperature between two particular values under normal operating conditions and which may have provision for setting by the operator.

1.2.11.2 temperature limiter: A temperature-sensing control which is intended to keep a temperature below or above one particular value during normal operating conditions and which may have provision for setting by the operator.

NOTE – A temperature limiter may be of the automatic reset or of the manual reset type.

1.2.11.3 thermal cut-out: A temperature-sensing control intended to operate under abnormal operating conditions and which has no provision for the operator to change the temperature setting.

NOTE – A thermal cut-out may be of the automatic reset or of the manual reset type.

1.2.11.4 thermal cut-out, automatic reset: A thermal cut-out which automatically restores the current after the relevant part of the equipment has cooled down sufficiently.

1.2.11.5 thermal cut-out, manual reset: A thermal cut-out which requires resetting by hand, or replacement of a part, in order to restore the current.

1.2.11.6 interconnecting cable: A cable that is external to the equipment and that is used to electrically connect an accessory to a unit of information technology equipment, to interconnect units in a system or to connect a unit to a telecommunication network; such a cable may carry any type of circuit from one unit to another.

1.2.12 Flammability

A P

1.2.12.1 FLAMMABILITY CLASSIFICATION OF MATERIALS: The recognition of the burning behaviour of materials and their ability to extinguish if ignited. Materials are classified as in 1.2.12.2 to 1.2.12.9 when tested in accordance with annex A.

NOTE 1 – When applying the requirements in this standard, HF-1 CLASS FOAMED MATERIALS are regarded as better than those of CLASS HF-2, and CLASS HF-2 better than HBF.

NOTE 2 – Similarly, other MATERIALS, including rigid (engineering structural) foam of CLASSES 5V or V-0 are regarded as better than those of CLASS V-1, V-1 better than V-2, and V-2 better than HB.

1.2.12.2 V-0 CLASS MATERIAL: A material that, when tested in accordance with A.6, may flame or glow but will meet certain criteria for times to extinguish; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.12.3 V-1 CLASS MATERIAL: A material that, when tested in accordance with A.6, may flame or glow but will meet certain criteria for times to extinguish; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.12.4 V-2 CLASS MATERIAL: A material that, when tested in accordance with A.6, may flame or glow but will meet certain criteria for times to extinguish; glowing particles or flaming drops released may ignite surgical cotton.

1.2.12.5 5V CLASS MATERIAL: A material that, when tested in accordance with A.9, may flame or glow but will extinguish within a prescribed period of time; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.12.6 HF-1 CLASS FOAMED MATERIAL: A foamed material that, when tested in accordance with A.7, may flame or glow but will extinguish within a prescribed period of time; flaming or glowing particles, or flaming drops released do not ignite surgical cotton.

1.2.12.7 HF-2 CLASS FOAMED MATERIAL: A foamed material that, when tested in accordance with A.7, may flame or glow but will extinguish within a prescribed period of time; flaming or glowing particles, or flaming drops released may ignite surgical cotton.

1.2.12.8 HB CLASS MATERIAL: Material that, when tested in accordance with A.8, does not exceed a specified maximum burning rate.

1.2.12.9 HBF CLASS FOAMED MATERIAL: A foamed material that, when tested in accordance with A.7, does not exceed a specified maximum burning rate.

1.2.12.10 EXPLOSION LIMIT: The lowest concentration of a combustible material in a mixture containing any of the following: gases, vapours, mists or dusts, in which a flame is able to propagate after removal of the ignition source.

1.2.13 Miscellaneous *P*

1.2.13.1 TYPE TEST: A test on a representative sample of the equipment with the objective of determining if the equipment, as designed and manufactured, can meet the requirements of this standard.

1.2.13.2 SAMPLING TEST: A test on a number of samples taken at random from a batch. [IEV 151-04-17, modified][1])

1.2.13.3 ROUTINE TEST: A test to which each individual sample is subjected during or after manufacture to check if the sample complies with certain criteria [IEV 151-04-16, modified].

1.2.13.4 DC VOLTAGE: The average value of a voltage (as measured by a moving coil meter) having a peak-to-peak ripple not exceeding 10 % of the average value.

NOTE – Where peak-to-peak ripple exceeds 10 % of the average value, the requirements related to peak voltage are applicable.

1.2.13.5 SERVICE PERSONNEL: Persons having appropriate technical training and experience necessary to be aware of hazards to which they may be exposed in performing a task and of measures to minimize the risks for themselves or other persons.

1.2.13.6 USER: Any person, other than SERVICE PERSONNEL. The term USER in this standard is the same as the term OPERATOR and the two can be interchanged.

1.2.13.7 OPERATOR: See USER (1.2.13.6).

1.2.13.8 TELECOMMUNICATION NETWORK: A metallically terminated transmission medium intended for communication between equipment that may be located in separate buildings, excluding:

- the mains system for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium;

- television distribution systems using cable;

- SELV CIRCUITS connecting units of data processing equipment.

NOTE 1 – The term TELECOMMUNICATION NETWORK is defined in terms of its functionality, not its electrical characteristics. A TELECOMMUNICATION NETWORK is not itself defined as being either an SELV CIRCUIT or a TNV CIRCUIT. Only the circuits in the equipment are so classified.

NOTE 2 – A TELECOMMUNICATION NETWORK may be
- publicly or privately owned;
- subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems;
- subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines.

NOTE 3 – Examples of TELECOMMUNICATION NETWORKS are:
- a public switched telephone network;
- a public data network;
- an Integrated Services Digital Network (ISDN);
- a private network with electrical interface characteristics similar to the above.

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[1] A list of normative references is given in annex P.

1.2.13.9 FUNCTIONAL EARTHING: The earthing of a point in equipment or in a system, which is necessary for a purpose other than safety. [IEV 195-01-13, modified]

1.2.13.10 PROTECTIVE EARTHING CONDUCTOR: A conductor in the building installation wiring, or in the power supply cord, connecting a main protective earthing terminal in the equipment to an earth point in the building installation.

NOTE – In some countries, the term ″grounding conductor″ is used instead of ″PROTECTIVE EARTHING CONDUCTOR″.

1.2.13.11 PROTECTIVE BONDING CONDUCTOR: A conductor in the equipment, or a combination of conductive parts in the equipment, connecting a main protective earthing terminal to a part of the equipment that is required to be earthed for safety purposes.

1.2.13.12 TOUCH CURRENT: Electric current through a human body when it touches one or more accessible parts. [IEV 195-05-21, modified][1])

NOTE – TOUCH CURRENT was previously included in the term ″leakage current″.

1.2.13.13 PROTECTIVE CONDUCTOR CURRENT: Current flowing through the PROTECTIVE EARTHING CONDUCTOR under normal operating conditions.

NOTE – PROTECTIVE CONDUCTOR CURRENT was previously included in the term ″leakage current″.

1.3 General requirements

1.3.1 Application of requirements

The requirements detailed in this standard shall be applied only if safety is involved.

In order to establish whether or not safety is involved, the circuits and construction shall be carefully investigated to take into account the consequences of possible failures.

1.3.2 Equipment design and construction

Equipment shall be so designed and constructed that, under all conditions of normal use and under likely abnormal use or single fault conditions (see 1.4.14), protection is provided to reduce the risk of personal injury from electric shock and other hazards, and against spread of fire originating in the equipment.

Compliance is checked by inspection and by the relevant tests.

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[1] To be published.

1.3.3 Supply voltage

Equipment shall be designed to be safe at any supply voltage to which it is intended to be connected.

Compliance is checked by inspection and by carrying out the relevant tests of this standard under the conditions specified in 1.4.5.

1.3.4 Constructions not specifically covered

Where the equipment involves technologies and materials or methods of construction not specifically covered in this standard, the equipment shall provide a level of safety not less than that generally afforded by this standard and the Principles of Safety contained herein.

NOTE – The need for additional detailed requirements to cope with a new situation should be brought promptly to the attention of the appropriate committee.

1.3.5 Equivalent materials

Where the standard specifies a particular grade of insulation, the use of a better grade of insulation is permitted. Similarly, where the standard requires material of a particular FLAMMABILITY CLASS, the use of a better class is permitted.

1.3.6 Orientation during transport and use

Where it is clear that the orientation of use of equipment is likely to have a significant effect on the application of the requirements or the results of tests, all orientations of use permitted in the installation or USER instructions shall be taken into account. For TRANSPORTABLE EQUIPMENT, all orientations of transport and use shall be taken into account.

NOTE – The above may apply to4.1, 4.5, 4.6 and 5.3.

1.3.7 Choice of criteria

Where the standard permits a choice between different criteria for compliance, or between different methods or conditions of test, the choice is specified by the manufacturer.

1.3.8 Examples mentioned in the standard

Where examples of equipment, parts, methods of construction, design techniques and faults are given in the standard, prefaced by ″e.g.″ or ″such as″, other examples are not excluded.

1.3.9 Conductive liquids

For the electrical requirements of this standard, conductive liquids shall be treated as conductive parts.

1.4 General conditions for tests

1.4.1 Application of tests

NAD

The tests detailed in this standard shall be carried out only if safety is involved.

If it is evident from the design and construction of the equipment that a particular test is not applicable, the test is not made.

Unless otherwise stated, upon conclusion of the tests, the equipment need not be operational.

1.4.2 Type tests

Except where otherwise stated, the tests specified in this standard are TYPE TESTS.

1.4.3 Test samples

Unless otherwise specified, the sample or samples under test shall be representative of the equipment the USER would receive, or shall be the actual equipment ready for shipment to the USER.

As an alternative to carrying out tests on the complete equipment, tests may be carried out separately on circuits, components or subassemblies outside the equipment, provided that inspection of the equipment and circuit arrangements indicates that the results of such testing will be representative of the results of testing the assembled equipment. If any such test indicates a likelihood of non-conformance in the complete equipment, the test shall be repeated in the equipment.

If a test specified in this standard could be destructive, it is permitted to use a model to represent the condition to be evaluated.

NOTE 1 – The tests should be carried out in the following order:
- component or material pre-selection;
- component or subassembly bench tests;
- tests where the equipment is not energized;
- live tests:
    - under normal operating conditions;
    - under abnormal operating conditions;
    - involving likely destruction.

NOTE 2 – In view of the amount of resource involved in testing and in order to minimize waste, it is recommended that all parties concerned jointly consider the test programme, the test samples and the test sequence.

1.4.4 Operating parameters for tests

Except where specific test conditions are stated elsewhere in the standard and where it is clear that there is a significant impact on the results of the test, the tests shall be carried out under the most unfavourable combination within the manufacturer’s operating specifications of the parameters:

- supply voltage (see 1.4.5);
- supply frequency (see 1.4.6);
- physical location of equipment and position of movable parts;
- operating mode;
- adjustment of THERMOSTATS, regulating devices or similar controls in OPERATOR ACCESS AREAS, which are:
  - adjustable without the use of a TOOL; or
  - adjustable using a means, such as a key or a TOOL, deliberately provided for the OPERATOR.

1.4.5 Supply voltage for tests

In determining the most unfavourable voltage for the power to energize the equipment under test (EUT), the following variables shall be taken into account:

- multiple RATED VOLTAGES;
- tolerances on RATED VOLTAGE as specified below;
- extremes of RATED VOLTAGE RANGES.

If the equipment is intended for direct connection to an AC MAINS SUPPLY, the tolerances on RATED VOLTAGE shall be taken as +6 % and -10 %, unless:

- the RATED VOLTAGE is 230 V single-phase or 400 V three-phase, in which case the tolerance shall be taken as +10 % and -10 %; or
- a wider tolerance is declared by the manufacturer, in which case the tolerance shall be taken as this wider value.

If the equipment is intended only for connection to an a.c. mains equivalent source, such as a motor-driven generator or an uninterruptible power supply (see 1.2.8.1), or a source other than an AC MAINS SUPPLY, the tolerances on RATED VOLTAGE shall be declared by the manufacturer.

When testing equipment designed for d.c. only, the possible influence of polarity shall be taken into account.

1.4.6 Supply frequency for tests

In determining the most unfavourable frequency for the power to energize the EUT, different RATED FREQUENCIES within the RATED FREQUENCY RANGE shall be taken into account (e.g. 50 Hz and 60 Hz) but consideration of the tolerance on a RATED FREQUENCY (e.g. 50 Hz ± 0,5 Hz) is not normally necessary.

1.4.7 Electrical measuring instruments

Electrical measuring instruments shall have adequate bandwidth to provide accurate readings, taking into account all components (d.c., AC MAINS SUPPLY frequency, high frequency and harmonic content) of the parameter being measured. If the r.m.s. value is being measured, care shall be taken that measuring instruments give true r.m.s. readings of non-sinusoidal waveforms as well as sinusoidal waveforms.

1.4.8 Normal operating voltages

For the assessment of voltages in ELV CIRCUITS, SELV CIRCUITS and TNV CIRCUITS:

– consideration shall be given both to normal operating voltages generated internally in the equipment and to those generated externally; and

– voltages other than normal operating voltages, such as earth potential rises and induced voltages from power lines and from electric traction lines, shall not be considered.

1.4.9 Measurement of voltage to earth

Where the standard specifies a voltage between a conductive part and earth, all of the following earthed parts are considered:

– the protective earthing terminal (if any); and

– any other conductive part required to be connected to protective earth (for example, see 2.6.1); and

– any conductive part that is earthed within the equipment for functional reasons.

Parts that will be earthed in the application by connection to other equipment, but are unearthed in the equipment as tested, shall be connected to earth at the point by which the highest voltage is obtained. When measuring a voltage between earth and a conductor in a circuit that will not be earthed in the intended application of the equipment, a non-inductive resistor of 5 000 Ω ± 10 % shall be connected across the voltage measuring instrument.

Voltage drop in the PROTECTIVE EARTHING CONDUCTOR of the power supply cord, or in an earthed conductor in other external wiring, is not included in the measurements.

1.4.10 Loading configuration of the EUT

In determining the input current, and where other test results could be affected, the following variables shall be considered and adjusted to give the most unfavourable results:

- loads due to optional features, offered or provided by the manufacturer for inclusion in or with the EUT;
- loads due to other units of equipment intended by the manufacturer to draw power from the EUT;
- loads which could be connected to any standard supply outlets in OPERATOR ACCESS AREAS on the equipment, up to the value indicated in the marking required by 1.7.5.

It is permitted to use artificial loads to simulate such loads during testing.

1.4.11 Power from a telecommunication network

For the purpose of this standard, the power available from a TELECOMMUNICATION NETWORK is considered to be limited to 15 VA.

1.4.12 Temperature measurement conditions *P*

Where a maximum temperature (T_{max}) or a maximum temperature rise (ΔT_{max}) is specified for compliance with tests, it is based on the assumption that the room ambient air temperature will be 25 °C when the equipment is operating. However, the manufacturer is permitted to specify a higher ambient air temperature.

It is not necessary to control the ambient temperature (T_{amb}) at a specific value during tests, but it shall be monitored and recorded.

Temperatures measured on the equipment shall conform with one of the following conditions, all temperatures being in °C.

If T_{max} is specified: $(T - T_{amb}) \leq (T_{max} - T_{mra})$

If ΔT_{max} is specified: $(T - T_{amb}) \leq (\Delta T_{max} + 25 - T_{mra})$

where:

T is the temperature of the given part measured under the prescribed test conditions;

T_{mra} is the maximum room ambient temperature permitted by the manufacturer’s specification or 25 °C, whichever is greater.

During the test, the room ambient temperature should not exceed T_{mra} unless agreed by all parties involved.

1.4.13 Temperature measurement methods *E*

Unless a particular method is specified, the temperatures of windings shall be determined either by the thermocouple method or by the resistance method (annex E). The temperatures of parts other than windings shall be determined by the thermocouple method. Any other suitable method of temperature measurement which does not noticeably influence the thermal balance and which achieves an accuracy sufficient to show compliance is also permitted. The choice of and position of temperature sensors shall be made so that they have minimum effect on the temperature of the part under test.

1.4.14 Simulated faults and abnormal conditions

Where it is required to apply simulated faults or abnormal operating conditions, these shall be applied in turn and one at a time. Faults which are the direct consequence of a simulated fault or abnormal operating condition are considered to be part of that simulated fault or abnormal operating condition.

When applying simulated faults or abnormal operating conditions, parts, supplies, consumable materials, media and recording materials shall be in place if they are likely to have an effect on the outcome of the test.

Where there is a specific reference to a single fault, the single fault consists of a single failure of any insulation (excluding DOUBLE INSULATION or REINFORCED INSULATION) or a single failure of any component (excluding components with DOUBLE INSULATION or REINFORCED INSULATION).

The equipment, circuit diagrams and component specifications are examined to determine those fault conditions that might reasonably be expected to occur. Examples include:

– short circuits and open circuits of semiconductor devices and capacitors;

– faults causing continuous dissipation in resistors designed for intermittent dissipation;

– internal faults in integrated circuits causing excessive dissipation;

– failure of BASIC INSULATION between current-carrying parts of the PRIMARY CIRCUIT and

  - accessible conductive parts;
  - earthed conductive screens;
  - parts of SELV CIRCUITS;
  - parts of LIMITED CURRENT CIRCUITS.

1.5 Components *P*

1.5.1 General

Where safety is involved, components shall comply either with the requirements of this standard or with the safety aspects of the relevant IEC component standards.

NOTE 1 – An IEC component standard is considered relevant only if the component in question clearly falls within its scope.

In this standard, certain IEC component standard requirements are replaced by the relevant requirements of component standards as listed in annex P.1. DC DC

In this standard, certain requirements (such as flammability tests) are alternatively satisfied by complying with relevant requirements of component standards as listed in annex P.2. DC DC

A component which is to be connected to an SELV CIRCUIT and also to an ELV CIRCUIT or to a part at HAZARDOUS VOLTAGE shall comply with the requirements of 2.2.

NOTE 2 – An example of such a component is a relay with different supplies connected to different elements (coils and contacts).

1.5.2 Evaluation and testing of components

Evaluation and testing of components shall be carried out as follows: ***K P***

- *a component that has been demonstrated to comply with a standard harmonized with the relevant IEC component standard shall be checked for correct application and use in accordance with its rating. It shall be subjected to the applicable tests of this standard as part of the equipment with the exception of those tests which are part of the relevant IEC component standard;*

- *a component that has not been demonstrated to comply with a relevant standard as above shall be checked for correct application and use in accordance with its specified rating. It shall be subjected to the applicable tests of this standard, as part of the equipment, and to the applicable tests of the component standard, under the conditions occurring in the equipment;*

NOTE – The applicable test for compliance with a component standard is, in general, carried out separately.

- *where no relevant IEC component standard exists, or where components are used in circuits not in accordance with their specified ratings, the components shall be tested under the conditions occurring in the equipment. The number of samples required for test is, in general, the same as required by an equivalent standard.*

1.5.3 Thermal controls

Thermal controls shall be tested in accordance with annex K.

1.5.4 Transformers *C P*

Transformers shall comply with the relevant requirements of this standard, including those of annex C.

1.5.5 Interconnecting cables *NAA NAE*

INTERCONNECTING CABLES provided as part of the equipment shall comply with the relevant requirements of this standard and shall not present a hazard in the meaning of this standard whether they are detachable or non-detachable.

INTERCONNECTING CABLES used for external interconnection between parts of equipment or between D1
components of a system shall be constructed of cable acceptable for external use and be rated D1
for the application with respect to voltage, current, anticipated temperature, flammability, D1
mechanical serviceability and the like. D1

Cable assemblies with lengths external to the unit not exceeding 3,05 m, coiled or uncoiled, may D1
be constructed of jacketed appliance wiring material, suitable for the maximum voltage, current D1
and temperature, rated VW-1 or FT-1 or better. Cable assemblies or wiring with lengths external D1
to the unit not exceeding 3,05 m, coiled or uncoiled, and supplied by a limited power source or D1
NEC Class 2 source of supply as defined in the National Electrical Code, ANSI/NFPA 70, may D1
be constructed of materials rated VW-1 or FT-1 or better with no additional requirements. D1

Compliance is checked by inspection. D1

1.5.6 Capacitors in primary circuits *P*

A capacitor connected between two line conductors of the PRIMARY CIRCUIT, or between one line conductor and the neutral conductor, shall comply with IEC 60384-14: 1993, subclass X1 or X2. The duration of the damp heat, steady state test as specified in 4.12 of IEC 60384-14: 1993, shall be 21 days.

A capacitor connected between the PRIMARY CIRCUIT and protective earth shall comply with ~~of~~ IEC 60384-14: 1993, subclass Y1, Y2 or Y4, as applicable. DE

NOTE – The above requirement does not apply to capacitors connected from a HAZARDOUS VOLTAGE SECONDARY CIRCUIT to earth. For such capacitors, the electric strength test of 5.2.2 is considered sufficient.

Compliance is checked by inspection.

1.5.7 Double or reinforced insulation bridged by components

Compliance with 1.5.7.1 to 1.5.7.3 is checked by inspection and relevant tests.

1.5.7.1 Bridging capacitors *P*

It is permitted to bridge DOUBLE or REINFORCED INSULATION by:

– a single capacitor complying with IEC 60384-14: 1993, subclass Y1; or

– two capacitors in series, each complying with IEC 60384-14: 1993, subclass Y2 or Y4.

A Y1 capacitor is considered to have REINFORCED INSULATION.

Where two capacitors are used in series, they shall each be rated for the total WORKING VOLTAGE across the pair and shall have the same nominal capacitance value.

1.5.7.2 Bridging resistors

It is permitted to bridge DOUBLE or REINFORCED INSULATION by two resistors in series. They shall each comply with the requirements of 2.10.3 and 2.10.4 between their terminations for the total WORKING VOLTAGE across the pair and shall have the same nominal resistance value.

1.5.7.3 Accessible parts

Where accessible conductive parts or circuits are separated from other parts by DOUBLE or REINFORCED INSULATION that is bridged by components in accordance with 1.5.7.1 or 1.5.7.2, the accessible parts shall comply with the requirements for LIMITED CURRENT CIRCUITS in 2.4. These requirements shall apply after electric strength testing of the insulation has been carried out.

1.5.8 Components in equipment for IT power systems *P*

For equipment to be connected to IT power systems, components connected between line and earth shall be capable of withstanding the stress due to the line-to-line voltage. However, capacitors rated for the applicable line-to-neutral voltage are permitted in such applications if they comply with IEC 60384-14: 1993, subclass Y1, Y2 or Y4.

NOTE 1 – The above capacitors are endurance tested at 1,7 times the voltage rating of the capacitor.

NOTE 2 – In Norway, due to the IT power distribution system used (see annex V, figure V.7), capacitors are required to be rated for the applicable line-to-line voltage.

Compliance is checked by inspection.

1.6 Power interface

1.6.1 AC power distribution systems

AC power distribution systems are classified as TN, TT or IT (see annex V).

NOTE – In Australia, TN-S and other systems apply.

1.6.2 Input current

The steady state input current of the equipment shall not exceed the rated current by more than 10 % under normal load.

Compliance is checked by measuring the input current of the equipment at normal load under the following conditions:

- *where an equipment has more than one rated voltage, the input current is measured at each rated voltage;*

- *where an equipment has one or more rated voltage ranges, the input current is measured at each end of each rated voltage range. Where a single value of rated current is marked (see 1.7.1), it is compared with the higher value of input current measured in the associated voltage range. Where two values of rated current are marked, separated by a hyphen, they are compared with the two values measured in the associated voltage range.*

In each case, the readings are taken when the input current has stabilized. If the current varies during the normal operating cycle, the steady-state current is taken as the mean indication of the value, measured on a recording r.m.s. ammeter, during a representative period.

1.6.3 Voltage limit of hand-held equipment

The rated voltage of hand-held equipment shall not exceed 250 V.

Compliance is checked by inspection.

1.6.4 Neutral connector

The neutral conductor, if any, shall be insulated from earth and from the BODY throughout the equipment as if it were a line conductor. Components connected between neutral and earth shall be rated for line-to-neutral voltage.

Compliance is checked by inspection.

1.7 Markings and instructions

NAA

NOTE – Additional requirements for markings and instructions are contained in the following subclauses:

- 2.1.1.2 USER access within battery compartments
- 2.6.1 Unearthed parts in SERVICE ACCESS AREAS
- 2.7.1 Protection provided by the building installation
- 2.7.6 Neutral fusing
- 3.4.11 Multiple power sources
- 4.1 Equipment stability
- 4.3.3 Adjustable controls
- 4.3.5 Connection of plugs and sockets
- 4.4.2 Hazardous moving parts
- 4.6.2 Stationary equipment on non-combustible floors
- 5.1.7 TOUCH CURRENT exceeding 3,5 mA
- 5.1.8.2 Summation of TOUCH CURRENTS
- 6.1.2.2 Earthing of equipment connected to the TELECOMMUNICATION NETWORK
- Annex NAA D2

1.7.1 Power rating

P
NAA
NAE

Equipment shall be provided with a power rating marking, the purpose of which is to specify a supply of correct voltage and frequency, and of adequate current-carrying capacity.

If a unit is not provided with a means for direct connection to the AC MAINS SUPPLY, it need not be marked with any electrical rating, such as its RATED VOLTAGE, RATED CURRENT or RATED FREQUENCY.

For equipment intended to be installed by an OPERATOR, the marking shall be readily visible in an OPERATOR ACCESS AREA, including any area that is directly visible only after an OPERATOR has opened a door or cover. If a manual voltage selector is not OPERATOR-accessible, the marking shall indicate the RATED VOLTAGE for which the equipment is set during manufacture; a temporary marker is permitted for this purpose. Marking is permitted on any outer surface of the equipment, except the bottom of equipment having a mass exceeding 18 kg. Additionally, on STATIONARY EQUIPMENT, the marking shall be visible after the equipment has been installed as in normal use.

For equipment intended to be installed by SERVICE PERSONNEL, and if the marking is in a SERVICE ACCESS AREA, the location of the permanent marking shall be indicated in the installation instructions or on a readily visible marker on the equipment. It is permitted to use a temporary marker for this purpose.

The marking shall include the following:

– RATED VOLTAGE(S) or RATED VOLTAGE RANGE(S), in volts;

- The voltage range shall have a hyphen (-) between the minimum and maximum RATED VOLTAGES. When multiple RATED VOLTAGES or RATED VOLTAGE RANGES are given, they shall be separated by a solidus (/).

NOTE 1 – Some examples of rated voltage markings are:

– RATED VOLTAGE RANGE: 220-240 V. This means that the equipment is designed to be connected to an AC MAINS SUPPLY having any voltage between 220 V and 240 V.
– Multiple RATED VOLTAGE: 120/230/240 V. This means that the equipment is designed to be connected to an AC MAINS SUPPLY having a voltage of 120 V or 230 V or 240 V, usually after internal adjustment.

- If equipment is to be connected to both of the line conductors and to the neutral conductor of a single-phase, 3-wire power system, the marking shall give the line-to-neutral voltage and the line-to-line voltage, separated by a solidus (/), with the added notation ″Three wires plus protective earth″, ″3W + PE″ or equivalent.

NOTE 2 – Some examples of the above system rating markings are:
120/240 V; 3 wire + PE
120/240 V; 3W + ⏚ (60417-1-IEC-5019)
100/200 V; 2W + N + PE

– symbol for nature of supply, for d.c. only;

– RATED FREQUENCY or RATED FREQUENCY RANGE, in hertz, unless the equipment is designed for d.c. only;

– RATED CURRENT, in milliamperes or amperes;

- for equipment with multiple RATED VOLTAGES, the corresponding RATED CURRENTS shall be marked such that the different current ratings are separated by a solidus (/) and the relation between RATED VOLTAGE and associated RATED CURRENT appears distinctly;

- equipment with a RATED VOLTAGE RANGE shall be marked with either the maximum RATED CURRENT or the current range;

- the marking for RATED CURRENT of a group of units having a single supply connection shall be placed on the unit which is directly connected to the AC MAINS SUPPLY. The RATED CURRENT marked on that unit shall be the total maximum current that can be on circuit at the same time and shall include the combined currents to all units in the group that can be supplied simultaneously through the unit and that can be operated simultaneously.

NOTE 3 – Some examples of RATED CURRENT markings are:
– for equipment with multiple RATED VOLTAGES;
120/240 V; 2,4/1,2 A
– for equipment with a RATED VOLTAGE RANGE:
100-240 V; 2,8 A
100-240 V; 2,8 – 1,1 A
100-120 V; 2,8 A
200-240 V; 1,4 A
It is recognized that in some regions it is customary to use a point (.) as a decimal marker instead of a comma.

– manufacturer’s name or trade-mark or identification mark;

– manufacturer’s model or type reference;

– symbol ⧈ 60417-1-IEC-5172, for CLASS II EQUIPMENT only.

Additional markings are permitted, provided that they do not give rise to misunderstanding.

Where symbols are used, they shall conform to ISO 7000 or IEC 60417-1 where appropriate symbols exist.

1.7.2 Safety instructions

NAD
NAE

Sufficient information shall be provided to the USER concerning any condition necessary to ensure that, when used as prescribed by the manufacturer, the equipment is unlikely to present a hazard within the meaning of this standard.

If it is necessary to take special precautions to avoid the introduction of hazards when operating, installing, servicing, transporting or storing equipment, the necessary instructions shall be made available.

NOTE 1 – Special precautions may be necessary, for example for connection of the equipment to the supply and for the interconnection of separate units, if any.

NOTE 2 – Where appropriate, installation instructions should include reference to national wiring rules.

NOTE 3 – Servicing instructions are normally made available only to SERVICE PERSONNEL.

NOTE 4 – In Norway and Sweden, PLUGGABLE CLASS I EQUIPMENT intended for connection to a telephone network or similar communications system may require a marking stating that the equipment must be connected to an earthed mains socket-outlet.

The operating instructions and, for PLUGGABLE EQUIPMENT intended for USER installation, also the installation instructions, shall be made available to the USER.

Where the disconnect device is not incorporated in the equipment (see 3.4.3) or where the plug on the power supply cord is intended to serve as the disconnect device, the installation instructions shall state that:

- for PERMANENTLY CONNECTED EQUIPMENT, a readily accessible disconnect device shall be incorporated in the building installation wiring;
- for PLUGGABLE EQUIPMENT, the socket-outlet shall be installed near the equipment and shall be easily accessible.

For equipment that may produce ozone, the installation and operating instructions shall refer to the need to take precautions to ensure that the concentration of ozone is limited to a safe value.

NOTE 5 – The present recommended long term exposure limit for ozone is 0,1 ppm (0,2 mg/m^3) calculated as an 8 h time-weighted average concentration. It should be noted that ozone is heavier than air.

1.7.3 Short duty cycles

Equipment intended for SHORT-TIME OPERATION or for INTERMITTENT OPERATION shall be marked with RATED OPERATING TIME, or RATED OPERATING TIME and rated resting time respectively, unless the operating time is limited by the construction or by the definition of its NORMAL LOAD.

The marking of SHORT-TIME OPERATION or INTERMITTENT OPERATION shall correspond to normal use.

The marking of INTERMITTENT OPERATION shall be such that the RATED OPERATING TIME precedes the rated resting time, the two markings being separated by a solidus (/).

1.7.4 Supply voltage adjustment *NAA*

For equipment intended for connection to multiple RATED VOLTAGES or FREQUENCIES, the method of adjustment shall be fully described in the servicing or installation instructions.

Unless the means of adjustment is a simple control near the power rating marking, and the setting of this control is obvious by inspection, the following instruction or a similar one shall appear in or near the power rating marking:

> SEE INSTALLATION INSTRUCTIONS BEFORE CONNECTING TO THE SUPPLY

1.7.5 Power outlets on the equipment *P*

If any standard power supply outlet in the equipment is accessible to the OPERATOR, a marking shall be placed in the vicinity of the outlet to show the maximum load that is permitted to be connected to it.

Socket-outlets conforming to IEC 60083 are examples of standard power supply outlets.

1.7.6 Fuse identification *NAA*

Marking shall be located adjacent to each fuse or fuseholder, or on the fuseholder, or in another location provided that it is obvious to which fuse the marking applies, giving the fuse current rating and, where fuses of different voltage rating value could be fitted, the fuse voltage rating.

Where fuses with special fusing characteristics such as time delay or breaking capacity are necessary, the type shall also be indicated.

For fuses not located in OPERATOR ACCESS AREAS and for soldered-in fuses located in OPERATOR ACCESS AREAS, it is permitted to provide an unambiguous cross-reference (e.g. F1, F2 etc.) to the servicing instructions which shall contain the relevant information.

NOTE – See 2.7.6 regarding other warnings to SERVICE PERSONNEL.

1.7.7 Wiring terminals

NAE

1.7.7.1 Protective earthing and bonding terminals

A wiring terminal intended for connection of a PROTECTIVE EARTHING CONDUCTOR shall be indicated by the symbol ⏚⃝ (60417-2-IEC-5019). This symbol shall not be used for other earthing terminals.

It is not a requirement to mark other terminals for PROTECTIVE BONDING CONDUCTORS, but where such terminals are marked, the symbol ⏚ (60417-2-IEC-5017) shall be used.

The following situations are exempt from the above requirements:

- where terminals for the connection of a supply are provided on a component (e.g. terminal block) or subassembly (e.g. power supply), the symbol ⏚ is permitted for the protective earthing terminal instead of ⏚⃝ ;

- on subassemblies or components, the symbol ⏚⃝ is permitted in place of the symbol ⏚ provided that it does not give rise to confusion.

These symbols shall not be located on screws, or other parts which might be removed when conductors are being connected.

These requirements are applicable to terminals for connection of a PROTECTIVE EARTHING CONDUCTOR whether run as an integral part of a power supply cord or with supply conductors.

1.7.7.2 Terminals for a.c. mains supply conductors

For PERMANENTLY CONNECTED EQUIPMENT and equipment with ordinary NON-DETACHABLE POWER SUPPLY CORDS:

- terminals intended exclusively for connection of the AC MAINS SUPPLY neutral conductor, if any, shall be indicated by the capital letter N; and

- on three-phase equipment, if incorrect phase rotation could cause overheating or other hazard, terminals intended for connection of the AC MAINS SUPPLY line conductors shall be marked in such a way that, in conjunction with any installation instructions, the sequence of phase rotation is unambiguous.

These indications shall not be located on screws, or other parts which might be removed when conductors are being connected.

1.7.8 Controls and indicators *P*

1.7.8.1 Identification, location and marking

Unless it is obviously unnecessary, indicators, switches and other controls affecting safety shall be identified or located so as to indicate clearly which function they control.

Markings and indications for switches and other controls shall be located either:

- on or adjacent to the switch or control, or
- elsewhere, provided that it is obvious to which switch or control the marking applies.

Indications used for this purpose shall, wherever practicable, be comprehensible without a knowledge of languages, national standards, etc.

1.7.8.2 Colours

Where safety is involved, colours of controls and indicators shall comply with IEC 60073. Where colours are used for functional controls or indicators, any colour, including red, is permitted provided that it is clear that safety is not involved.

1.7.8.3 Symbols

Where symbols are used on or near controls, for example switches, push buttons, etc., to indicate ″ON″ and ″OFF″ conditions, they shall be the line I for ″ON″ and circle O for ″OFF″ (60417-1-IEC-5007 and 60417-1-IEC-5008). For push-push type switches the symbol ⏼ shall be used (60417-1-IEC-5010).

It is permitted to use the symbols O and I to indicate the ″OFF″ and ″ON″ positions of any primary or secondary power switches, including isolating switches.

A ″STAND-BY″ condition shall be indicated by the symbol ⏻ (60417-1-IEC-5009).

1.7.8.4 Markings using figures

If figures are used for indicating different positions of any control, the ″OFF″ position shall be indicated by the figure 0 (zero) and higher figures shall be used to indicate greater output, input, etc.

1.7.9 Isolation of multiple power sources

Where there is more than one connection supplying HAZARDOUS VOLTAGES or ENERGY LEVELS to equipment, a prominent marking close to the access for SERVICE PERSONNEL to the hazardous parts shall indicate which disconnect device or devices isolate the equipment completely and which disconnect devices can be used to isolate each section of the equipment.

1.7.10 IT power systems

If the equipment has been designed or, when required, modified for connection to an IT power system, the equipment installation instructions shall so state.

1.7.11 Thermostats and other regulating devices

THERMOSTATS and similar regulating devices intended to be adjusted during installation or in normal use shall be provided with an indication for the direction of adjustment to increase or decrease the value of the characteristic being adjusted. Indication by the symbols + and − is permitted.

1.7.12 Language

Instructions and equipment marking related to safety shall be in a language which is acceptable in the country in which the equipment is to be installed.

NOTE 1 – Documentation intended for use only by SERVICE PERSONNEL is permitted to be in the English language only.

NOTE 2 – In Germany, safety related information also for SERVICE PERSONNEL has to be in the German language.

1.7.13 Durability **_P_**

Any marking required by this standard shall be durable and legible. In considering the durability of the marking, the effect of normal use shall be taken into account.

Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit. After this test, the marking shall be legible; it shall not be possible to remove marking plates easily and they shall show no curling.

The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0,1 % by volume, a kauri-butanol value of 29, an initial boiling point of approximately 65 °C, a dry point of approximately 69 °C and a mass per unit volume of approximately 0,7 kg/l.

1.7.14 Removable parts

Marking required by this standard shall not be placed on removable parts which can be replaced in such a way that the marking would become misleading.

1.7.15 Replaceable batteries ***NAA***

If an equipment is provided with a replaceable battery, and if replacement by an incorrect type could result in an explosion (e.g. with some lithium batteries), the following applies:

– if the battery is placed in an OPERATOR ACCESS AREA, there shall be a marking close to the battery or a statement in both the operating and the servicing instructions;

– if the battery is placed elsewhere in the equipment, there shall be a marking close to the battery or a statement in the servicing instructions.

This marking or statement shall include the following or similar text:

CAUTION

RISK OF EXPLOSION IF BATTERY IS REPLACED

BY AN INCORRECT TYPE.

DISPOSE OF USED BATTERIES ACCORDING

TO THE INSTRUCTIONS.

Compliance is checked by inspection.

1.7.16 Operator access with a tool ***P***

If a TOOL is necessary to gain access to an OPERATOR ACCESS AREA, either all other compartments within that area containing a hazard shall be inaccessible to the OPERATOR by the use of the same TOOL, or such compartments shall be marked to discourage OPERATOR access.

An acceptable marking for an electric shock hazard is ⚠ (ISO 3864, No. 5036).

1.7.17 Equipment for restricted access locations

For equipment intended only for installation in a RESTRICTED ACCESS LOCATION, the installation instructions shall contain a statement to this effect.

2 Protection from hazards

2.1 Protection from electric shock and energy hazards

NOTE – In Australia, additional requirements apply.

2.1.1 Protection in operator access areas *P*

This subclause specifies requirements for protection against electric shock from energized parts based on the principle that the OPERATOR is permitted to have access to:

- bare parts of SELV CIRCUITS; and
- bare parts of LIMITED CURRENT CIRCUITS; and
- TNV CIRCUITS under the conditions specified in 2.1.1.1.

Access to other energized parts, and to their insulation, is restricted as specified in 2.1.1.1.

Additional requirements are specified in 2.1.1.5 for protection against energy hazards.

2.1.1.1 Access to energized parts *NAE*

The equipment shall be so constructed that in OPERATOR ACCESS AREAS there is adequate protection against contact with:

- bare parts of ELV CIRCUITS; and
- bare parts at HAZARDOUS VOLTAGES; and
- FUNCTIONAL or BASIC INSULATION of parts or wiring in ELV CIRCUITS, except as permitted in 2.1.1.3; and
- FUNCTIONAL or BASIC INSULATION of parts or wiring at HAZARDOUS VOLTAGES; and

  NOTE 1 – FUNCTIONAL INSULATION includes, but is not limited to, insulation, such as lacquer, solvent-based enamel, ordinary paper, cotton and oxide film, or displaceable insulation such as beads and sealing compounds other than self-hardening resin.

- unearthed conductive parts separated from ELV CIRCUITS or from parts at HAZARDOUS VOLTAGES by FUNCTIONAL or BASIC INSULATION only; and
- bare parts of TNV CIRCUITS, except that access is permitted to:
  - bare conductive parts in the interior of equipment which are normally D3
    protected against contact by a cover intended for occasional removal by the D3
    OPERATOR, such as for the installation of accessories, provided that the D3
    installation instructions include directions for the disconnection of the TNV D3
    CIRCUIT connector before removing the cover; D3

- contacts of connectors which cannot be touched by the test probe, (figure 2C);

- bare conductive parts in the interior of a battery compartment that complies with 2.1.1.2;

- bare conductive parts of TNV-1 CIRCUITS that have any point connected in accordance with 2.6.1 e) to a protective earthing terminal;

- bare conductive parts of connectors in TNV-1 CIRCUITS that are separated from unearthed accessible conductive parts of the equipment in accordance with 6.2.1.

NOTE 2 – A typical application is the shell for a coaxial connector.

NOTE 3 – Access to TNV-1 CIRCUITS and TNV-3 CIRCUITS via other circuits is also restricted by 6.2.1 in some cases.

Unrestricted access is permitted to LIMITED CURRENT CIRCUITS.

These requirements apply for all positions of the equipment when it is wired and operated as in normal use.

Protection shall be achieved by insulation or by guarding or by the use of interlocks.

Compliance is checked by all of the following:

a) inspection; and

b) a test with the test finger, figure 2A, which shall not contact parts described above when applied to openings in the ENCLOSURES after removal of parts that can be detached by an OPERATOR, including fuseholders, and with OPERATOR access doors and covers open. It is permitted to leave lamps in place for this test. Connectors that can be separated by an OPERATOR, other than plugs and socket-outlets complying with IEC 60083, shall also be tested during disconnection; and

c) a test with the test pin, figure 2B, which shall not contact bare parts at HAZARDOUS VOLTAGES when applied to openings in an external ELECTRICAL ENCLOSURE. Parts that can be detached by an OPERATOR, including fuseholders and lamps, are left in place, and OPERATOR access doors and covers are closed during this test; and

d) a test with the test probe, figure 2C, where appropriate.

The test finger, the test pin and the test probe are applied as above, without appreciable force, in every possible position, except that floor-standing equipment having a mass exceeding 40 kg is not tilted.

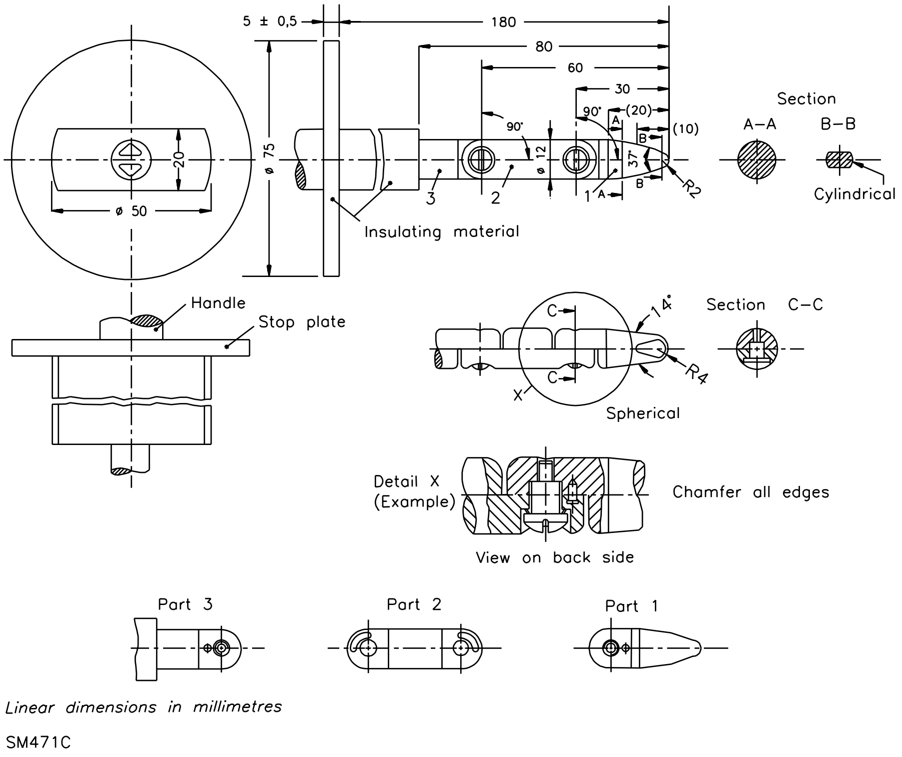
Equipment intended for building-in or rack-mounting, or for incorporation in larger equipment is tested with access to the equipment limited according to the method of mounting detailed in the installation instructions.

Openings preventing the entry of the test finger, test b) above, are further tested by means of a straight unjointed version of the test finger applied with a force of 30 N. If the unjointed finger enters, test b) is repeated except that the finger is pushed through the opening using any necessary force up to 30 N.

NOTE 4 – If an electrical contact indicator is used to show contact, care should be taken to ensure that the application of the test does not damage components of electronic circuits.

The above requirements regarding contact with parts at HAZARDOUS VOLTAGE apply only to HAZARDOUS VOLTAGES not exceeding 1 000 V a.c. or 1 500 V d.c. For higher voltages, contact is not permitted, and there shall be an air gap between the part at HAZARDOUS VOLTAGE and the test finger, figure 2A, or the test pin, figure 2B, placed in its most unfavourable position. The air gap shall have a minimum length equal to the minimum CLEARANCE specified in 2.10.3 for BASIC INSULATION or withstand the relevant electric strength test in 5.2.2 (See figure F.12, point A).

If components are movable, for instance, for the purpose of belt tensioning, the test with the test finger is made with each component in its most unfavourable position within the range of adjustment, the belt being removed, if necessary, for this purpose.



Linear dimensions in millimetres

Tolerances on dimensions without specific tolerances:

– for 14° and 37° angles	± 15’
– on radii:	± 0,1 mm
– on linear dimensions	
≤ 15 mm	0 − 0,1 mm
> 15 mm ≤ 25 mm	± 0,1 mm
> 25 mm	± 0,3 mm

Material of finger: e.g. heat-treated steel

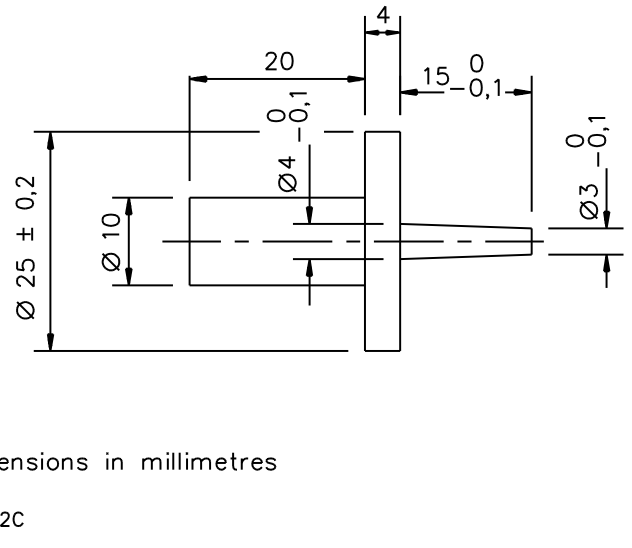
Both joints of this finger can be bent through an angle of 90° (+10°, − 0°) but in one and the same direction only.

NOTE 1 – Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design must insure a 90° bending angle with a 0° to +10° tolerance.

NOTE 2 – Dimensions in parentheses are for information only.

NOTE 3 – The test finger is taken from IEC 61032, figure 2, test probe B. In some cases, the tolerances are different.

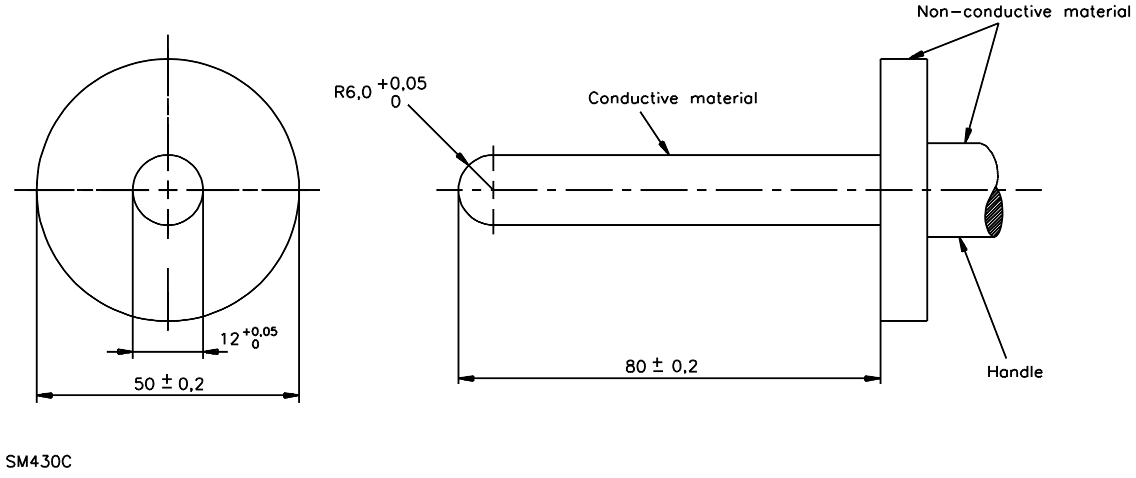
Figure 2A – Test finger



The handle dimensions (ø 10 and 20) are not critical.

NOTE – The test pin dimensions are those given in IEC 61032, figure 8, test probe 13. In some cases the tolerances are different.

Figure 2B – Test pin



Dimensions in millimetres

Figure 2C – Test probe

2.1.1.2 Battery compartments

Access to bare conductive parts of TNV CIRCUITS within a battery compartment in the equipment is permitted if all of the following conditions are met:

- the compartment has a door that requires a deliberate technique to open, such as use of a TOOL or latching device; and
- the TNV CIRCUIT is not accessible when the door is closed; and
- there is a marking next to the door, or on the door if the door is secured to the equipment, with instructions for protection of the USER once the door is opened.

NOTE – Information stating that the telephone cord is to be disconnected prior to opening the door is an example of an acceptable instruction.

Compliance is checked by inspection.

2.1.1.3 Access to ELV wiring

Insulation of internal wiring in an ELV CIRCUIT is permitted to be accessible to an OPERATOR, provided that :

a) the insulation meets the requirements for SUPPLEMENTARY INSULATION detailed in 3.1.4; or;

b) all of the following apply:

- the wiring does not need to be handled by the OPERATOR and is so placed that the OPERATOR is unlikely to pull on it, or is so fixed that the connecting points are relieved from strain; and
- the wiring is routed and fixed so as not to touch unearthed accessible conductive parts; and
- the insulation passes the electric strength test of 5.2.2 for SUPPLEMENTARY INSULATION; and
- the distance through insulation not less than that given in table 2A.

Table 2A – Distance through insulation of internal wiring

WORKING VOLTAGE (in case of failure of BASIC INSULATION)		Minimum distance through insulation
V peak or d.c.	V r.m.s. (sinusoidal)	mm
Over 71, up to 350	Over 50, up to 250	0,17
Over 350	Over 250	0,31

Compliance is checked by inspection and measurement, and by the test of 5.2.2.

2.1.1.4 Access to hazardous voltage circuit wiring

Where the insulation of internal wiring at HAZARDOUS VOLTAGE is accessible to an OPERATOR, or is not routed and fixed to prevent it from touching unearthed accessible conductive parts, it shall meet the requirements of 3.1.4 for DOUBLE or REINFORCED INSULATION.

Compliance is checked by inspection and measurement and, if necessary, by test.

2.1.1.5 Energy hazards

There shall be no energy hazard in OPERATOR ACCESS AREAS.

Compliance is checked by means of the test finger, figure 2A (see 2.1.1.1), in a straight position, applied without appreciable force. It shall not be possible to bridge with this test finger two or more bare parts, one of which may be an earthed conductive part, between which a HAZARDOUS ENERGY LEVEL exists.

2.1.1.6 Manual controls

Conductive shafts of operating knobs, handles, levers and the like shall not be connected to parts at HAZARDOUS VOLTAGES, to ELV CIRCUITS or to TNV CIRCUITS.

In addition, conductive operating knobs, handles, levers and the like which are manually moved in normal use and which are earthed only through a pivot or bearing, shall either:

- be separated from parts at HAZARDOUS VOLTAGES by DOUBLE or REINFORCED INSULATION; or
- have their accessible parts covered by SUPPLEMENTARY INSULATION.

Compliance is checked by inspection.

2.1.1.7 Discharge of capacitors in the primary circuit

Equipment shall be so designed that, at an external point of disconnection of the AC MAINS SUPPLY, the risk of electric shock from stored charge on capacitors connected in the PRIMARY CIRCUIT is reduced.

Compliance is checked by inspection of the equipment and relevant circuit diagrams, taking into account the possibility of disconnection of the supply with the "ON"/"OFF" switch in either position.

Equipment is considered to comply if any capacitor having a marked or nominal capacitance exceeding 0,1 µF and connected to the PRIMARY CIRCUIT has a means of discharge resulting in a time constant not exceeding:

- *1 s for PLUGGABLE EQUIPMENT TYPE A; and*
- *10 s for PERMANENTLY CONNECTED EQUIPMENT and for PLUGGABLE EQUIPMENT TYPE B.*

The relevant time constant is the product of the effective capacitance in microfarads and the effective discharge resistance in megohms. If it is difficult to determine the effective capacitance and resistance values, a measurement of voltage decay at the point of external disconnection can be used.

NOTE – During an interval equal to one time constant, the voltage will have decayed to 37 % of its original value.

2.1.2 Protection in service access areas

In a SERVICE ACCESS AREA, the following requirements apply.

Bare parts operating at HAZARDOUS VOLTAGES shall be located or guarded so that unintentional contact with such parts is unlikely during service operations involving other parts of the equipment.

Bare parts at HAZARDOUS VOLTAGE shall be located or guarded so that accidental shorting to SELV CIRCUITS or to TNV CIRCUITS, for example by TOOLS or test probes used by SERVICE PERSONNEL, is unlikely.

No requirement is specified regarding access to ELV CIRCUITS or to TNV CIRCUITS. However, bare parts that involve an energy hazard shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely during service operations involving other parts of the equipment.

Any guards required for compliance with 2.1.2 shall be easily removable and replaceable if removal is necessary for servicing.

Compliance is checked by inspection and measurement. In deciding whether or not unintentional contact is likely, account is taken of the way SERVICE PERSONNEL need to gain access past, or near to, the bare parts in order to service other parts.

2.1.3 Protection in restricted access locations

For equipment to be installed in a RESTRICTED ACCESS LOCATION, the requirements for OPERATOR ACCESS AREAS apply, except as permitted in the following three paragraphs:

If a SECONDARY CIRCUIT at HAZARDOUS VOLTAGE is used to supply a ringing signal generator that complies with 2.3.1 b), contact with bare parts of the circuit is permitted with the test finger, figure 2A (see 2.1.1.1). However, such parts shall be so located or guarded that unintentional contact is unlikely.

Bare parts that involve an energy hazard shall be located or guarded so that unintentional bridging by conductive materials that might be present is unlikely.

No requirement is specified regarding contact with bare parts of TNV-1, TNV-2, and TNV-3 CIRCUITS.

Compliance is checked by inspection and measurement. In deciding whether or not unintentional contact is likely, account is taken of the need to gain access past, or near to, the bare parts.

2.2 SELV circuits

2.2.1 General requirements

SELV CIRCUITS shall exhibit voltages that are safe to touch both under normal operating conditions and after a single fault (see 1.4.14).

Compliance with 2.2.1 to 2.2.4 is checked by inspection and relevant tests.

2.2.2 Voltages under normal conditions

In a single SELV CIRCUIT or in interconnected SELV CIRCUITS, the voltage between any two conductors of the SELV CIRCUIT or CIRCUITS and, between any one such conductor and earth (see 1.4.9), shall not exceed 42,4 V peak, or 60 V d.c., under normal operating conditions.

NOTE – A circuit that meets the above requirements, but that is subject to overvoltages from a TELECOMMUNICATION NETWORK, is a TNV-1 CIRCUIT.

2.2.3 Voltages under fault conditions

Except as permitted in 2.3.2, in the event of a single fault (see 1.4.14), the voltages between any two conductors of the SELV CIRCUIT or CIRCUITS and between any one such conductor and earth (see 1.4.9) shall not exceed 42,4 V peak, or 60 V d.c., for longer than 0,2 s. Moreover, a limit of 71 V peak, or 120 V d.c., shall not be exceeded.

NOTE – In Canada and the United States, the exception mentioned in 2.3.2 is not permitted.

Except as permitted in 2.2.4, one of the methods specified in 2.2.3.1, 2.2.3.2, or 2.2.3.3 shall be used.

It is permitted for some parts of a circuit (e.g. a transformer-rectifier circuit) to comply with all of the requirements for SELV CIRCUITS and to be OPERATOR-accessible, while other parts of the same circuit do not comply with all of the requirements for SELV CIRCUITS and are therefore not permitted to be OPERATOR-accessible.

2.2.3.1 Separation by double or reinforced insulation (Method 1)

Where an SELV CIRCUIT is separated from other circuits by DOUBLE or REINFORCED INSULATION only, one of the following constructions shall be used:

- provide permanent separation by barriers, routing or fixing; or
- provide insulation of all adjacent wiring involved that is rated for the highest WORKING VOLTAGE present; or
- provide insulation on either the wiring of the SELV CIRCUIT or that of the other circuits that meets the insulation requirements for SUPPLEMENTARY or REINFORCED INSULATION, as appropriate, for the highest WORKING VOLTAGE present; or
- provide an additional layer of insulation, where required, over either the wiring of the SELV CIRCUIT or that of the other circuits; or
- provide two separate transformers in tandem, where one transformer provides BASIC INSULATION and the other transformer provides SUPPLEMENTARY INSULATION; or
- use any other means providing equivalent insulation.

2.2.3.2 Separation by earthed screen (Method 2)

Where SELV CIRCUITS are separated from parts at HAZARDOUS VOLTAGE by an earthed screen or other earthed conductive parts, the parts at HAZARDOUS VOLTAGE shall be separated from the earthed parts by BASIC INSULATION. The earthed parts shall comply with 2.6.

2.2.3.3 Protection by earthing of the SELV circuit (Method 3)

Parts of SELV CIRCUITS protected by earthing shall be connected to a protective earthing terminal in such a way that the requirements of 2.2.3 are met by relative circuit impedances or by the operation of a protective device or both. Except as permitted in 2.3.2, parts of SELV CIRCUITS shall also be separated from parts of non-SELV CIRCUITS by BASIC INSULATION. The SELV CIRCUIT shall have adequate fault current-carrying capacity to ensure operation of the protective device, if any, and to ensure that the fault current path to earth will not open (see 2.6).

NOTE 1 – Different parts of the same SELV CIRCUIT may be protected by different methods, for example:
- Method 2 within a power transformer feeding a bridge rectifier; and
- Method 1 for the a.c. SECONDARY CIRCUIT; and
- Method 3 at the output of the bridge rectifier.

NOTE 2 – For normal conditions the SELV CIRCUIT voltage limit is the same for an ELV CIRCUIT; an SELV CIRCUIT may be regarded as an ELV CIRCUIT with additional protection under fault conditions.

2.2.4 Connection of SELV circuits to other circuits

An SELV CIRCUIT is permitted to be connected to other circuits provided that, when it is so connected, all of the following conditions are met:

- except as permitted by 1.5.7 and 2.4.3, the SELV CIRCUIT is separated by BASIC INSULATION from any PRIMARY CIRCUIT (including the neutral) within the equipment; and
- the SELV CIRCUIT meets the limits of 2.2.2 under normal operating conditions; and
- except as specified in 2.3.2, the SELV CIRCUIT meets the limits of 2.2.3 in the event of a single fault (see 1.4.14) in the SELV CIRCUIT or of in the SECONDARY CIRCUIT to which it is connected.

If a SELV CIRCUIT is connected to one or more other circuits, the SELV CIRCUIT is that part which complies with the requirements of 2.2.2 and 2.2.3.

If an SELV CIRCUIT obtains its supply conductively from a SECONDARY CIRCUIT which is separated from a HAZARDOUS VOLTAGE circuit by either:

- DOUBLE INSULATION or REINFORCED INSULATION, or
- an earthed conductive screen that is separated from the HAZARDOUS VOLTAGE circuit by BASIC INSULATION;

the SELV CIRCUIT shall be considered as being separated from the HAZARDOUS VOLTAGE circuit by the same method.

NOTE – For requirements in Norway, see 1.7.2, note 4 and 6.1.2.1, note ~~3~~ 2. DE

2.3 TNV circuits

2.3.1 Limits M

In a single TNV CIRCUIT or interconnected TNV CIRCUITS, the voltage between any two conductors of the TNV CIRCUIT or CIRCUITS and between any one such conductor and earth (see 1.4.9) shall comply with the following:

a) TNV-1 CIRCUITS

The voltages do not exceed the following:

– the limits in 2.2.2 for an SELV CIRCUIT under normal operating conditions;

– the limits of figure 2D measured across a 5 000 Ω ± 2 % resistor in the event of a single fault (see 1.4.14) within the equipment.

NOTE 1 – In the event of a single insulation or component failure, the limit after 200 ms is the limit in 2.3.1 b) for a TNV-2 or TNV-3CIRCUIT for normal operating conditions.

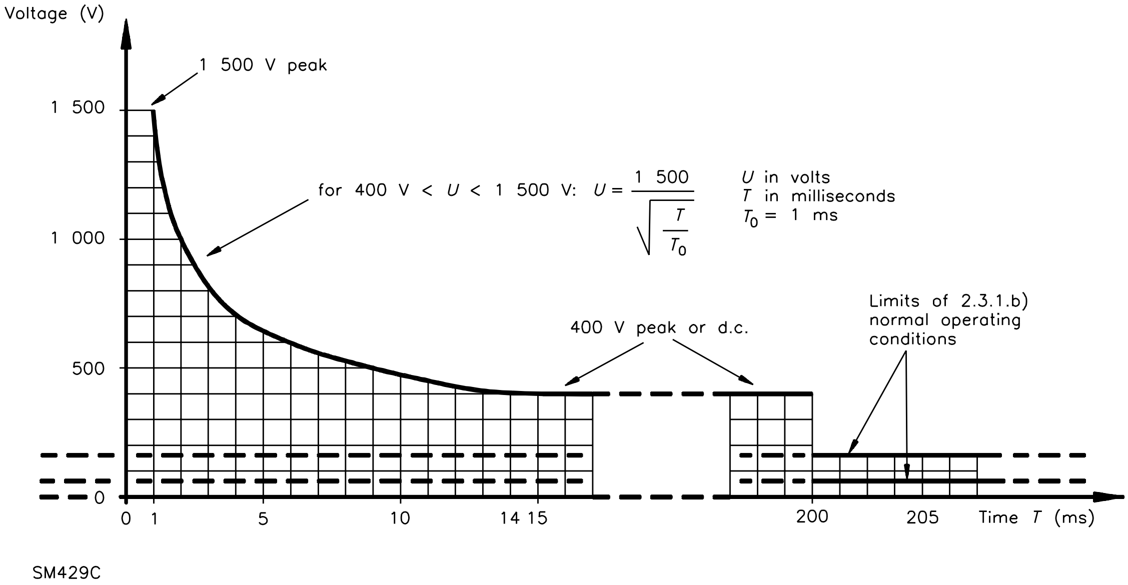


Figure 2D – Maximum voltages permitted after a single fault

b) TNV-2CIRCUITS and TNV-3CIRCUITS

Except as permitted in 3.6, the voltages exceed the limits in 2.2.2 for an SELV CIRCUIT but do not exceed the following: D2

– when telephone ringing signals are present, voltages such that the signal complies with the criteria of either M.2 or M.3;

– when other telephone signals are present, voltages such that the signal D2
complies with the criteria of M.4; D2

– when telephone ringing signals or other telephone signals are not present; D2

- a combination of a.c. voltage and DC VOLTAGE under normal operating conditions such that:

$$\frac{U_{ac}}{70{,}7} + \frac{U_{dc}}{120} \leq 1$$

and for voltages exceeding 42,4 V peak or 60 V d.c., the current flowing D2
through a 2 000 Ω ± 2 % resistor (or greater) connected across the voltage D2
source with other loads disconnected does not exceed 7,1 mA peak or 30 mA D2
d.c. D2

where

U_{ac} is the peak value of the a.c. voltage (V) at any frequency;

U_{dc} is the value of the DC VOLTAGE (V).

NOTE 2 – When U_{dc} is zero, U_{ac} can be up to 70,7 V peak.

NOTE 3 – When U_{ac} is zero, U_{dc} can be up to 120 V.

and

- the limits of figure 2D measured across a 5 000 Ω ± 2 % resistor in the
event of a single fault (see 1.4.14) within the equipment, except the current D2
limits after 200 ms specified in figure 2D are replaced by the limits of M.3.1.4. D2

Compliance is checked by inspection and measurement.

NOTE 4 – Telegraph and teletypewriter signals may be present on existing TELECOMMUNICATION NETWORKS. However, these signals are considered to be obsolescent and their characteristics are not considered in this standard.

2.3.2 Separation from other circuits and from accessible parts

NOTE 1 – See also 6.1.2 and 6.2.

Separation of SELV CIRCUITS, TNV-1CIRCUITS and accessible conductive parts from TNV-2CIRCUITS and TNV-3CIRCUITS shall be such that in the event of a single fault (see 1.4.14), the limits specified in 2.3.1 b) for TNV-2CIRCUITS and TNV-3CIRCUITS under normal operating conditions are not exceeded on the SELV CIRCUITS, TNV-1 CIRCUITS and accessible conductive parts.

NOTE 2 – In Canada and the United States, in the event of a single fault as described above, the limits of 2.2.3 apply.

NOTE 3 – Under normal operating conditions, the limits of 2.2.2 always apply to each SELV CIRCUIT and accessible conductive part.

NOTE 4 – The limits of 2.3.1 always apply to each TNV CIRCUIT.

The separation requirements will be met if BASIC INSULATION is provided as indicated in table 2G (see 2.9.5), other solutions are not excluded.

BASIC INSULATION is not required provided that all of the following are met:

- the SELV CIRCUIT, TNV-1 CIRCUIT or accessible conductive part shall be connected to a protective earthing terminal in accordance with 2.6; and

- for PLUGGABLE EQUIPMENT TYPE A, a separate protective earthing terminal shall be provided in addition to the main protective earthing terminal, if any (see 2.6.4.1). The installation instructions shall specify that this separate protective earthing terminal be permanently connected to earth; and

- for PLUGGABLE EQUIPMENT TYPE B, the equipment shall either comply with the above requirements for PLUGGABLE EQUIPMENT TYPE A or be provided with both a marking on the equipment and a statement in the installation instructions, specifying that the USER is to disconnect all TELECOMMUNICATION NETWORK connectors before disconnecting the power; and

NOTE 5 – PERMANENTLY CONNECTED EQUIPMENT is assumed to have the main protective earthing terminal permanently connected to earth.

- the test of 2.3.5 shall be carried out if the TNV-2 or TNV-3 CIRCUIT is intended to receive signals or power that are generated externally during normal operation (e.g. in a TELECOMMUNICATION NETWORK).

<u>Enamel coating on signal transformer winding wire may be used as an alternative to BASIC INSULATION only if:</u> D3 D3

<u>a) ringing signals do not exceed the limits for TNV-3,</u> D3

<u>b) the transformer is located on the disconnect side of the switchhook,</u> D3

<u>c) the wire complies with the component requirements for magnet wire, and</u> D3

<u>d) the transformer is subjected to a 1 000 V a.c. electric strength test as a ROUTINE TEST on 100 % of production without evidence of dielectric breakdown (see 6.2.1).</u> D3 D3

At the choice of the manufacturer, it is permitted to treat a TNV-1 CIRCUIT or a TNV-2 CIRCUIT as a TNV-3 CIRCUIT. In this case, the TNV-1 CIRCUIT or TNV-2 CIRCUIT shall meet all the separation requirements for a TNV-3 CIRCUIT.

Compliance is checked by inspection and measurement and, where necessary, by simulation of failures of components and insulation such as are likely to occur in the equipment. Prior to the tests, insulation that does not meet the requirements for BASIC INSULATION is short-circuited.

NOTE 6 – Where BASIC INSULATION is provided and 6.2.1 also applies to this insulation, the test voltage prescribed in 6.2.2 is in most cases higher than that for BASIC INSULATION.

NOTE 7 – For requirements in Norway, see 6.1.2.1, note ~~3~~ 2. DE

NOTE 8 – In Denmark, the insulation between TNV CIRCUITS and any part or circuit connected to earth shall withstand an electric strength test of 500 V a.c. r.m.s for 1 min.

2.3.3 Separation from hazardous voltages

Except as permitted in 2.3.4, TNV CIRCUITS shall be separated from circuits at HAZARDOUS VOLTAGES by one or both of the following methods:

a) DOUBLE or REINFORCED INSULATION;

b) BASIC INSULATION, together with protective screening connected to the protective earthing terminal.

Compliance is checked by inspection and measurement.

NOTE 1 – In Denmark and Finland, method b) is permitted only for PERMANENTLY CONNECTED EQUIPMENT or for PLUGGABLE EQUIPMENT TYPE B.

NOTE 2 – In Norway, method b) is not permitted.

2.3.4 Connection of TNV circuits to other circuits

Except as permitted in 1.5.7, a TNV CIRCUIT is permitted to be connected to other circuits, provided that it is separated by BASIC INSULATION from any PRIMARY CIRCUIT (including the neutral) within the equipment.

NOTE 1 – The limits of 2.3.1 always apply to TNV CIRCUITS.

If a TNV CIRCUIT is connected to one or more other circuits, the TNV CIRCUIT is that part which complies with 2.3.1.

If a TNV CIRCUIT obtains its supply conductively from a SECONDARY CIRCUIT which is separated from a HAZARDOUS VOLTAGE circuit by:

– DOUBLE or REINFORCED INSULATION; or

– the use of an earthed conductive screen that is separated from a HAZARDOUS VOLTAGE circuit by BASIC INSULATION;

the TNV CIRCUIT shall be considered as being separated from the HAZARDOUS VOLTAGE circuit by the same method.

Compliance is checked by inspection, and by simulation of single faults (see 1.4.14) such as are likely to occur in the equipment. No such simulated fault shall cause the voltage across a 5 000 Ω ± 2 % resistor, connected between any two conductors of the TNV CIRCUIT or between one such conductor and earth, to fall outside the shaded area of figure 2D (see 2.3.1). Observation is continued until stable conditions have existed for at least 5 s.

NOTE 2 – For requirements in Norway, see 6.1.2.1, note ~~3~~ 2. DE

NOTE 3 – For requirements in Finland, see 2.3.3, note 1.

2.3.5 Test for operating voltages generated externally

This test is only carried out if specified in 2.3.2.

A test generator specified by the manufacturer is used, representing the maximum normal operating voltage expected to be received from the external source. In the absence of such a specification, a test generator is used that provides 120 V ± 2 V a.c. at 50 Hz or 60 Hz and has an internal impedance of 1 200 Ω ± 2 %.

NOTE – The above test generator is not intended to represent the actual voltages on the TELECOMMUNICATION NETWORK but to stress the circuit of the EUT in a repeatable manner.

The test generator is connected between the TELECOMMUNICATION NETWORK terminals of the equipment. One pole of the test generator is also connected to the earthing terminal of the equipment, see figure 2E. The test voltage is applied for a maximum of 30 min. If it is clear that no further deterioration will take place, the test is terminated earlier.

During the test, the SELV CIRCUIT, TNV-1 CIRCUIT or accessible conductive part shall continue to comply with 2.2.2.

The test is repeated after reversing the connections to the TELECOMMUNICATION NETWORK terminals of the equipment.

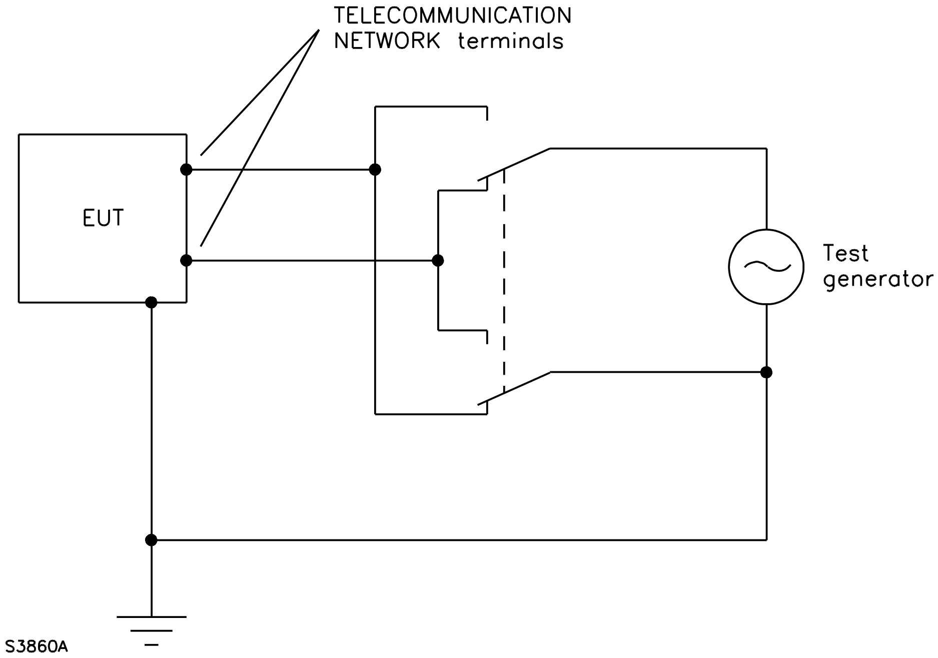


Figure 2E – Test generator

2.4 Limited current circuits

2.4.1 General requirements

LIMITED CURRENT CIRCUITS shall be so designed that the limits specified in 2.4.2 are not exceeded under normal operating conditions and in the event of a single failure within the equipment (see 1.4.14 and 1.5.7).

Except as permitted in 2.4.3, segregation of accessible parts of LIMITED CURRENT CIRCUITS from other circuits shall be as described in 2.2 for SELV CIRCUITS.

Compliance is checked by inspection and measurement.

2.4.2 Limit values

For frequencies not exceeding 1 kHz, the steady-state current drawn through a non-inductive resistor of 2 000 Ω ± 10 % connected between any two parts of a LIMITED CURRENT CIRCUIT, or between any such part and earth (see 1.4.9), shall not exceed 0,7 mA peak, or 2 mA d.c.

For frequencies above 1 kHz, the limit of 0,7 mA is multiplied by the value of the frequency in kilohertz but shall not exceed 70 mA peak.

For parts not exceeding 450 V peak or d.c., the circuit capacitance shall not exceed 0,1 µF.

For parts whose voltage, U, exceeds 0,45 kV peak or d.c., but does not exceed 15 kV peak or d.c., the circuit capacitance shall not exceed $45/U$ nF, where U is expressed in kilovolts.

NOTE 1 – The limit of $45/U$ corresponds to an available stored charge of 45 µC.

For parts whose voltage, U, exceeds 15 kV peak or d.c., the circuit capacitance shall not exceed $700/U^2$ nF, where U is expressed in kilovolts.

NOTE 2 – The limit of $700/U^2$ corresponds to an available energy of 350 mJ.

2.4.3 Connection of limited current circuits to other circuits

LIMITED CURRENT CIRCUITS are permitted to be supplied from or connected to other circuits, provided that the following conditions are met:

- the LIMITED CURRENT CIRCUIT meets the limits of 2.4.2 under normal operating conditions;

- the LIMITED CURRENT CIRCUIT continues to meet the limits of 2.4.2 in the event of a single failure of any component or insulation in the LIMITED CURRENT CIRCUIT, or of any component or insulation in the other circuit to which it is connected.

If a LIMITED CURRENT CIRCUIT is connected to one or more other circuits, the LIMITED CURRENT CIRCUIT is that part which complies with the requirements of 2.4.1.

2.5 Limited power sources

P
NAE

A limited power source operated from an AC MAINS SUPPLY, or a battery-operated limited power source that is recharged from an AC MAINS SUPPLY while supplying the load, shall incorporate an isolating transformer.

A limited power source shall comply with one of the following:

– the output is inherently limited in compliance with table 2B; or

– an impedance limits the output in compliance with table 2B. If a positive temperature coefficient device is used, it shall pass the tests specified in IEC 60730-1, clauses 15, 17, J15 and J17; or

– an overcurrent protective device is used and the output is limited in compliance with table 2C; or

– a regulating network limits the output in compliance with table 2B, both under normal operating conditions and after any single fault (see 1.4.14) in the regulating network (open circuit or short-circuit); or

– a regulating network limits the output in compliance with table 2B under normal operating conditions, and an overcurrent protective device limits the output in compliance with table 2C after any single fault (see 1.4.14) in the regulating network (open-circuit or short-circuit).

Where an overcurrent protective device is used, it shall be a fuse or a non-adjustable non-autoreset electromechanical device.

Compliance is checked by inspection and measurement and, where appropriate, by examination of the manufacturer's data for batteries. Batteries are to be fully charged when conducting the measurements for U_{oc} *and* I_{sc} *according to tables 2B and 2C.*

The load referenced in items 2) and 3) of tables 2B and 2C is adjusted to develop maximum current and power transfer respectively. Single faults in a regulating network are applied under these maximum current and power conditions.

Table 2B – Limits for inherently limited power sources

Output voltage[1) (U_{OC})		Output current[2) (I_{SC})	Apparent power[3) (S)
V a.c.	V d.c.	A	(VA)
≤ 20	≤ 20	$\leq 8{,}0$	$\leq 5 \times U_{OC}$
$20 < U_{OC} \leq 30$	$20 < U_{OC} \leq 30$	$\leq 8{,}0$	≤ 100
–	$30 < U_{OC} \leq 60$	$\leq 150 / U_{OC}$	≤ 100

1) U_{OC}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple-free d.c. For non-sinusoidal a.c. and d.c. with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

2) I_{SC}: Maximum output current with any non-capacitive load, including a short circuit, measured 60 s after application of the load.

3) S (VA): Maximum output VA after 60 s of operation with any non-capacitive load including short circuit. ~~Initial transients lasting less than 100 ms are permitted to exceed the limit.~~ D3 D3

Table 2C – Limits for power sources not inherently limited (overcurrent protective device required)

Output voltage[1) (U_{OC})		Output current[2) (I_{SC})	Apparent power[3) (S)	Current rating of overcurrent protective device[4)
V a.c.	V d.c.	A	VA	A
≤ 20	≤ 20	$\leq 1\,000 / U_{OC}$	≤ 250	$\leq 5{,}0$
$20 < U_{OC} \leq 30$	$20 < U_{OC} \leq 30$			$\leq 100 / U_{OC}$
–	$30 < U_{OC} \leq 60$			$\leq 100 / U_{OC}$

1) U_{OC}: Output voltage measured in accordance with 1.4.5 with all load circuits disconnected. Voltages are for substantially sinusoidal a.c. and ripple-free d.c. For non-sinusoidal a.c. and d.c. with ripple greater than 10 % of the peak, the peak voltage shall not exceed 42,4 V.

2) I_{SC}: Maximum output current with any non-capacitive load, including a short circuit, measured 60 s after application of the load. Current limiting impedances in the equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed.

3) S (VA): Maximum output VA after 60 s of operation with any non-capacitive load including short circuit. Current limiting impedances in equipment remain in the circuit during measurement, but overcurrent protective devices are bypassed. ~~Initial transients lasting less than 100 ms are permitted to exceed the limit.~~ D3 D3

NOTE – The reason for making measurements with overcurrent protective devices bypassed is to determine the amount of energy that is available to cause possible overheating during the operating time of the overcurrent protective devices.

4) The current ratings of overcurrent protective devices are based on fuses and circuit breakers that break the circuit within 120 s with a current equal to 210 % of the current rating specified in the table.

2.6 Provisions for earthing and bonding *NAE*

NOTE – For additional requirements with regard to earthing of equipment to be connected to TELECOMMUNICATION NETWORKS, see 2.3.2, 2.3.3, 6.1.1 and 6.1.2.

2.6.1 Protective earthing *NAE*

The following parts of equipment shall be reliably connected to the main protective earthing terminal of the equipment.

Parts likely to carry fault currents intended to operate overcurrent protective devices:

a) accessible conductive parts that might assume a HAZARDOUS VOLTAGE in the event of a single fault (see 1.4.14);

b) parts required to be earthed to maintain the integrity of SELV CIRCUITS, if required by 2.2.3.2 and 2.2.3.3;

c) parts required to be earthed to maintain the integrity of TNV CIRCUITS, if required by 2.3.3 b);

d) SELV CIRCUITS, TNV CIRCUITS and accessible conductive parts required to be earthed by 2.3.2, if the power source is not a TELECOMMUNICATION NETWORK.

Parts that carry other currents:

e) SELV CIRCUITS, TNV CIRCUITS and accessible conductive parts required to be earthed by 2.3.2, if the power source is a TELECOMMUNICATION NETWORK;

f) transformer screens and components (such as surge suppressors) that could not assume a HAZARDOUS VOLTAGE in the event of a single fault (see 1.4.14) but are required to be earthed in order to reduce transients that might affect insulation (e.g. see 6.2.1);

g) SELV CIRCUITS and TNV CIRCUITS that are required to be earthed in order to reduce or eliminate TOUCH CURRENT to a TELECOMMUNICATION NETWORK (see 5.1.8.1).

In SERVICE ACCESS AREAS, where conductive parts such as motor frames, electronic chassis, etc., might assume a HAZARDOUS VOLTAGE in the event of a single fault (see 1.4.14), either these conductive parts shall be connected to the main protective earthing terminal or, if this is impossible or impracticable, a suitable marking shall indicate to SERVICE PERSONNEL that such parts are not earthed and should be checked for HAZARDOUS VOLTAGE before being touched.

NOTE – The requirements of 2.6.1 do not apply to accessible conductive parts that are separated from parts at HAZARDOUS VOLTAGE by either:

- earthed metal parts; or
- solid insulation or an air gap, or a combination of the two, meeting the requirements for DOUBLE or REINFORCED INSULATION, provided that the parts involved are so fixed and so rigid that minimum distances are maintained during the application of force as required by the relevant tests of 4.2.2, 4.2.3 and 4.2.4.

Compliance is checked by inspection and, where appropriate, by the test specified in 2.6.3.

2.6.2 Functional earthing

If FUNCTIONAL EARTHING of accessible or other conductive parts is necessary, all of the following apply to the FUNCTIONAL EARTHING circuit:

– the FUNCTIONAL EARTHING circuit shall be separated from parts at HAZARDOUS VOLTAGES in the equipment by either:

- DOUBLE or REINFORCED INSULATION; or
- a protectively earthed screen or another protectively earthed conductive part, separated from parts at HAZARDOUS VOLTAGES by at least BASIC INSULATION; and

– it is permitted to connect the FUNCTIONAL EARTHING circuit to a protective earth terminal or to a PROTECTIVE BONDING CONDUCTOR; and

– wiring terminals to be used only for FUNCTIONAL EARTHING shall not be marked by the symbol ⏚ (60417-1-IEC-5017) or by the symbol ⊜ (60417-1-IEC-5019), except that, where a wiring terminal is provided on a component (e.g. a terminal block) or subassembly, the symbol ⏚ is permitted; and

NOTE – Other markings such as one of the symbols, ⏚ (60417-1-IEC-5018) or ⊥ (60417-1-IEC-5020), if appropriate, are permitted.

– for internal FUNCTIONAL EARTHING conductors, the colour combination green-and-yellow shall not be used except in multipurpose preassembled components (e.g. multi-conductor cables or EMC filters); and

– in a power supply cord where a conductor having green-and-yellow insulation is used only to provide a FUNCTIONAL EARTHING connection;

- the equipment shall not be marked with the symbol ⧈ (60417-1-IEC-5172); and
- there are no requirements other than those in 3.1.9 regarding the termination of this conductor at the equipment end.

Compliance is checked by inspection.

2.6.3 Protective earthing and protective bonding conductors **_NAE_**

The requirements of 2.6.3.1, 2.6.3.2 and 2.6.3.3 apply to PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS provided to comply with 2.6.1 a), b), c) and d).

For PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS provided to comply with 2.6.1 e), the requirements of 2.6.3.3 apply. The test current is 1,5 times the maximum current available from the TELECOMMUNICATION NETWORK (if known) or 2 A, whichever is the larger.

For PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS provided to comply with 2.6.1 f), 2.6.1 g) and for FUNCTIONAL EARTHING conductors, the current carrying capacity shall be adequate for the actual current under normal operating conditions, in accordance with 3.1.1, i.e. they are not required to carry fault currents to earth.

2.6.3.1 Size of protective earthing conductors

PROTECTIVE EARTHING CONDUCTORS in power supply cords supplied with the equipment, shall comply with the minimum conductor sizes in table 3B (see 3.2.5).

Compliance is checked by inspection and measurement.

2.6.3.2 Size of protective bonding conductors **_NAE_**

PROTECTIVE BONDING CONDUCTORS shall comply with one of the following:

- the minimum conductor sizes in table 3B (see 3.2.5); or
- the requirements of 2.6.3.3 and also, if the current rating of the circuit is more than 16 A, with the minimum conductor sizes in table 2D; or
- for components only, be not smaller than the conductors supplying power to the component.

The current rating of the circuit used in table 2D and in the test of 2.6.3.3 depends on the provision and location of overcurrent protective devices and shall be taken as the smallest of the following:

- the RATED CURRENT of the equipment; or
- the rating of an overcurrent protective device specified in the equipment installation instructions to be installed in the building installation wiring to protect the equipment; or
- the rating of an overcurrent protective device in the equipment that protects the circuit or part required to be earthed.

Compliance is checked by inspection and measurement.

Table 2D – Minimum size of protective bonding conductors

Current rating of the circuit under consideration **A**	**Minimum conductor sizes**	
	Cross-sectional area **mm^2**	**AWG or kcmil** **(cross-sectional area in mm^2)**
Up to and including 16	Size not specified	Size not specified
Over 16 up to and including 25	1,5	14 (2)
Over 25 up to and including 32	2,5	12 (3)
Over 32 up to and including 40	4,0	10 (5)
Over 40 up to and including 63	6,0	8 (8)
Over 63 up to and including 80	10	6 (13)
Over 80 up to and including 100	16	4 (21)
Over 100 up to and including 125	25	2 (33)
Over 125 up to and including 160	35	1 (42)
Over 160 up to and including 190	50	0 (53)
Over 190 up to and including 230	70	000 (85)
Over 230 up to and including 260	95	0000 (107)
Over 260 up to and including 300	120	250 kcmil (126)
Over 300 up to and including 340	150	300 kcmil (152)
Over 340 up to and including 400	185	400 kcmil (202)
Over 400 up to and including 460	240	500 kcmil (253)

NOTE – AWG and kcmil sizes are provided for information only. The associated cross-sectional areas have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term ″cmil″ refers to circular mils where one circular mil is equal to the area of a circle having a diameter of one mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America.

2.6.3.3 Resistance of earthing conductors and their terminations

Earthing conductors and their terminations shall not have excessive resistance.

PROTECTIVE EARTHING CONDUCTORS are considered to comply without test.

PROTECTIVE BONDING CONDUCTORS that meet the minimum conductor sizes in table 3B (see 3.2.5) and are terminated in accordance with table 3E (see 3.3.5) are considered to comply without test.

PROTECTIVE BONDING CONDUCTORS and their terminals of non-standard constructions, such as printed D1
wiring protective traces, shall also be evaluated in accordance with the Limited Short-Circuit D1
Test in CSA C22.2 No. 0.4, Bonding and Grounding of Electrical Equipment. PROTECTIVE BONDING D1
CONDUCTORS that can be determined to meet the equivalent of the minimum conductor sizes in D1
table 3B (see 3.2.5) and are terminated in accordance with table 3E (see 3.3.5) are considered D1
to comply without test. D1

NOTE – Short circuit values for d.c. equipment and systems are under consideration. D1

Compliance is checked by inspection, measurement and, for PROTECTIVE BONDING CONDUCTORS *that do not comply with the minimum sizes in table 3B (see 3.2.5) and for protective bonding terminals that do not comply with table 3E (see 3.3.5), by the following test.*

The voltage drop in a PROTECTIVE BONDING CONDUCTOR *is measured after it has conducted the test current for a time period specified below. The test current can be either a.c. or d.c. The measurement is made between the main protective earthing terminal and the point in the equipment that is required by 2.6.1 to be earthed. The resistance of the* PROTECTIVE EARTHING

CONDUCTOR is not included in the measurement. However, if the PROTECTIVE EARTHING CONDUCTOR is supplied with the equipment, it is permitted to include it in the test circuit but the measurement of the voltage drop is made only from the main protective earthing terminal to the part required to be earthed.

On equipment where the protective earth connection to a subassembly or to a separate unit is by means of one core of a multicore cable which also supplies mains power to that subassembly or unit, the resistance of the PROTECTIVE BONDING CONDUCTOR in that cable is not included in the measurement. However, this option is only permitted if the cable is protected by a suitably rated protective device which takes into account the size of the conductor.

If the protection of an SELV CIRCUIT is achieved by earthing in accordance with 2.2.3.3, the resistance limit applies between the earthed side of the SELV CIRCUIT and the main protective earthing terminal and not from the unearthed side of the SELV CIRCUIT.

Care is taken that the contact resistance between the tip of the measuring probe and the conductive part under test does not influence the test results.

If the current rating of the circuit under test is 16 A or less, the test current, test voltage and the duration of the test are determined as follows:

– the test current is ~~1,5~~ two times the current rating of the circuit under test; and D1

– the test voltage is not to exceed 12 V; and

– the duration of the test is ~~60~~ 120 s; D1

and the resistance of the PROTECTIVE BONDING CONDUCTOR, calculated from the voltage drop, shall not exceed 0,1 Ω.

If the current rating of the circuit under test exceeds 16 A, the test current and the duration of the test are ~~as follows:~~ two times the current rating of the circuit for ~~2 min; or~~ the time durations D2
noted below: D2

Current rating of circuit, A	**Time, minutes**	**D1**
≤ 30	2	D1
> 30, ≤ 60	4	D1
> 60, ≤ 100	6	D1
> 100, ≤ 200	8	D1
> 200	10	D1

– *or as specified by the manufacturer for d.c. powered equipment* DE

and the voltage drop across the PROTECTIVE BONDING CONDUCTOR shall not exceed 2,5 V.

2.6.3.4 Colour of insulation

The insulation of the PROTECTIVE EARTHING CONDUCTOR in a power supply cord supplied with the equipment shall be green-and-yellow.

If a PROTECTIVE BONDING CONDUCTOR is insulated, the insulation shall be green-and-yellow except in the following two cases:

- for an earthing braid, the insulation shall be either green-and-yellow or transparent;
- for a PROTECTIVE BONDING CONDUCTOR in assemblies such as ribbon cables, busbars, printed wiring, etc., any colour is permitted provided that no misinterpretation of the use of the conductor is likely to arise.

Except as permitted in 2.6.2, the colour combination green-and-yellow shall be used only to identify PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS.

Compliance is checked by inspection.

2.6.4 Terminals ***NAE***

The requirements of 2.6.4.1 and 2.6.4.2 apply only to protective earthing terminals provided to comply with 2.6.1 a), b), c) and d).

NOTE – For additional requirements concerning terminals, see 3.3.

For protective earthing provided to comply with 2.6.1 e), f) and g), it is sufficient for the terminals to comply with 3.3.

2.6.4.1 Protective earthing and bonding terminals ***NAE***

Equipment required to have protective earthing shall have a main protective earthing terminal. For equipment with a DETACHABLE POWER SUPPLY CORD, the earthing terminal in the appliance inlet is regarded as the main protective earthing terminal.

If equipment is provided with more than one supply connection (e.g. with different voltages or frequencies or as backup power), it is permitted to have a main protective earthing terminal associated with each supply connection. In such a case, the terminals shall be sized according to the rating of the associated supply input.

Terminals shall be designed to resist accidental loosening of the conductor. In general, the designs commonly used for current-carrying terminals, other than some terminals of the pillar type, provide sufficient resilience to comply with this requirement; for other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, shall be used.

Except as noted below, all pillar, stud or screw type protective earthing and protective bonding terminals shall comply with the minimum size requirements of table 3E (see 3.3.5).

Protective bonding terminals which do not comply with table 3E (see 3.3.5) are considered acceptable if they meet the test requirements of 2.6.3.3.

The main protective earthing terminal for PERMANENTLY CONNECTED EQUIPMENT shall be:

– located so that it is readily accessible while making the supply connections; and

– provided with factory installed pillar terminals, studs, screws, bolts or similar terminals, together with the necessary fixing hardware, if a protective earthing conductor larger than 7 mm^2 (3 mm diameter) is required.

Compliance is checked by inspection and measurement.

2.6.4.2 Separation of the protective earthing conductor from protective bonding conductors

Separate wiring terminals, which may be on the same busbar, shall be provided, one for the protective earthing conductor, or one for each protective earthing conductor if more than one is provided, and one or more for protective bonding conductors.

However, it is permitted to provide a single wiring terminal of the screw or stud type in permanently connected equipment having a non-detachable power supply cord, and in pluggable equipment type a or b having a special non-detachable power supply cord, provided that the wiring termination of the protective earthing conductor is separated by a nut from that of the protective bonding conductors. The order of stacking of the terminations of the protective earthing conductor and the protective bonding conductors is not specified.

It is also permitted to provide a single wiring terminal in equipment with an appliance inlet.

Compliance is checked by inspection.

2.6.5 Integrity of protective earthing

2.6.5.1 Interconnection of equipment ***NAD***

In a system of interconnected equipment, the protective earthing connection shall be assured for all equipment requiring a protective earthing connection, regardless of the arrangement of equipment in the system.

Equipment that contains a protective bonding conductor to maintain continuity of protective earthing circuits to other equipment in the system, shall not be marked with the symbol ⧈ (60417-2-IEC-5172).

Such equipment shall also provide power to the other equipment in the system (see 2.6.5.3).

Compliance is checked by inspection.

2.6.5.2 Components in protective earthing conductors and protective bonding conductors

PROTECTIVE EARTHING CONDUCTORS and PROTECTIVE BONDING CONDUCTORS shall not contain switches or overcurrent protective devices.

Compliance is checked by inspection.

2.6.5.3 Disconnection of protective earth

Protective earthing connections shall be such that disconnection of a protective earth at one point in a unit or a system does not break the protective earthing connection to other parts or units in a system, unless the relevant potential hazard is removed at the same time.

Compliance is checked by inspection.

2.6.5.4 Parts that can be removed by an operator

Protective earthing connections shall make earlier and break later than the supply connections in each of the following:

- the connector of a part that can be removed by an OPERATOR;
- a plug on a power supply cord;
- an appliance coupler.

Compliance is checked by inspection.

2.6.5.5 Parts removed during servicing

Protective earthing connections shall be so designed that they do not have to be disconnected for servicing other than for the removal of the part which they protect unless the relevant potential hazard is removed at the same time.

Compliance is checked by inspection.

2.6.5.6 Corrosion resistance

J

Conductive parts in contact at protective earthing terminals and connections shall not be subject to significant corrosion due to electrochemical action in any working, storage or transport environment conditions as specified in the instructions supplied with the equipment. Combinations above the line in annex J shall be avoided. Corrosion resistance can be achieved by a suitable plating or coating process.

Compliance is checked by inspection and by reference to the table of electrochemical potentials (annex J).

2.6.5.7 Screws for protective bonding

NOTE –The following requirements are additional to those in 3.1.6.

Self-tapping (thread-cutting and thread-forming) and spaced thread (sheet metal) screws are permitted to provide protective bonding but it shall not be necessary to disturb the connection during servicing.

In any case, the thickness of the metal part at the point where a screw is threaded into it shall be not less than twice the pitch of the screw thread. It is permitted to use local extrusion of a metal part to increase the effective thickness.

At least two screws shall be used for each connection. However, it is permitted to use a single self-tapping screw provided that the thickness of the metal part at the point where the screw is threaded into it is a minimum of 0,9 mm for a screw of the thread-forming type and 1,6 mm for a screw of the thread-cutting type.

Compliance is checked by inspection.

2.6.5.8 Reliance on telecommunication network

Protective earthing shall not rely on a TELECOMMUNICATION NETWORK.

Compliance is checked by inspection.

2.7 Overcurrent and earth fault protection in primary circuits *P*

2.7.1 Basic requirements *NAA NAE*

Protection in PRIMARY CIRCUITS against overcurrents, short-circuits and earth faults shall be provided, either as an integral part of the equipment or as part of the building installation.

If PLUGGABLE EQUIPMENT TYPE B or PERMANENTLY CONNECTED EQUIPMENT relies on protective devices in the building installation for protection, the equipment installation instructions shall so state and shall also specify the requirements for short-circuit protection or overcurrent protection or, where necessary, for both.

NOTE – In the member countries of CENELEC, the protective devices necessary to comply with the requirements of 5.3 must, with certain exceptions, be included as part of the equipment.

2.7.2 Faults not covered in 5.3

Protection against faults not covered in 5.3 (e.g. short-circuits to protective earth in primary wiring) need not be fitted as an integral part of the equipment.

Compliance is checked by inspection.

2.7.3 Short-circuit backup protection

Unless appropriate short-circuit backup protection is provided, protective devices shall have adequate breaking (rupturing) capacity to interrupt the maximum fault current (including short-circuit current) which can flow.

For PERMANENTLY CONNECTED EQUIPMENT or PLUGGABLE EQUIPMENT TYPE B, it is permitted for short-circuit backup protection to be in the building installation.

For PLUGGABLE EQUIPMENT TYPE A, the building installation is considered as providing short-circuit backup protection.

NOTE – If fuses complying with IEC 60127 are used in PRIMARY CIRCUITS, they should have high breaking capacity (1 500 A) if the prospective short-circuit current exceeds 35 A or 10 times the current rating of the fuse, whichever is greater.

Compliance is checked by inspection and by the tests of 5.3.

2.7.4 Number and location of protective devices

Protective systems or devices in PRIMARY CIRCUITS shall be in such a number and located so as to detect and to interrupt the overcurrent flowing in any possible fault current path (e.g. line-to-line, line-to-neutral, line to protective earth conductor or line to PROTECTIVE BONDING CONDUCTOR).

No protection is required against earth faults in equipment that either:

– has no connection to earth; or

– has DOUBLE or REINFORCED INSULATION between the PRIMARY CIRCUIT and all parts connected to earth.

NOTE 1 – Where DOUBLE or REINFORCED INSULATION is provided, a short circuit to earth would be considered to be two faults.

In a supply to a load using more than one line conductor, if a protective device interrupts the neutral conductor it shall also interrupt all other supply conductors. Single-pole protective devices, therefore, shall not be used in such cases.

Compliance is checked by inspection and, where necessary, by simulation of fault conditions.

NOTE 2 – For protective devices that are an integral part of the equipment, examples of the number and location of fuses or circuit-breaker poles necessary to provide fault current interruption in commonly encountered supply systems are given in informative table 2E for single-phase equipment or subassemblies and in informative table 2F for three-phase equipment. The examples are not necessarily valid for protective devices in the building installation.

Table 2E – Informative examples of protective devices in single-phase equipment or subassemblies

Equipment supply connections	Protection against	Minimum number of fuses or circuit-breaker poles	Location
Case A: Equipment to be connected to power systems with earthed neutral reliably identified, except for case C below.	Earth faults	1	Line conductor
	Overcurrent	1	Either of the two conductors
Case B: Equipment to be connected to any supply, including IT power systems and supplies with reversible plugs, except for case C below.	Earth faults	2	Both conductors
	Overcurrent	1	Either of the two conductors
Case C: Equipment to be connected to 3-wire power systems with earthed neutral reliably identified.	Earth faults	2	Each line conductor
	Overcurrent	2	Each line conductor

Table 2F – Informative examples of protective devices in three-phase equipment

Power system	**Number of supply conductors**	**Protection against**	**Minimum number of fuses or circuit-breaker poles**	**Location**
Three-phase without neutral	3	Earth faults	3	All three conductors
		Overcurrent	2	Any two conductors
With earthed neutral (TN or TT)	4	Earth faults	3	Each line conductor
		Overcurrent	3	Each line conductor
With unearthed neutral	4	Earth faults	4	All four conductors
		Overcurrent	3	Each line conductor

2.7.5 Protection by several devices

Where protective devices are used in more than one pole of a supply to a given load, those devices shall be located together. It is permitted to combine two or more protective devices in one component.

Compliance is checked by inspection.

2.7.6 Warning to service personnel

NAA

Suitable marking shall be provided on the equipment or a statement shall be provided in the servicing instructions to alert SERVICE PERSONNEL to a possible hazard, where both of the following conditions exist:

- where a fuse is used in the neutral of single-phase equipment either permanently connected or provided with a non-reversible plug; and

- where, after operation of the fuse, parts of the equipment that remain energized might represent a hazard during servicing.

The following or similar wording is regarded as suitable:

CAUTION

DOUBLE POLE/NEUTRAL FUSING

2.8 Safety interlocks

2.8.1 General principles

SAFETY INTERLOCKS shall be provided where OPERATOR access involves areas normally presenting hazards in the meaning of this standard.

2.8.2 Protection requirements

SAFETY INTERLOCKS shall be so designed that the hazard will be removed before the covers, doors, etc. are in any position that will permit contact with hazardous parts by the test finger, of figure 2A (see 2.1.1.1).

For protection against electric shock and energy hazards, removal, opening or withdrawal of the cover, door, etc., shall either:

– necessitate previous de-energization of such parts, or

– automatically initiate disconnection of the supply to such parts, and reduce within 2 s the voltage to 42,4 V peak, or 60 V d.c., or less, and the energy level to less than 20 J.

For a moving part which will continue to move through momentum and will continue to present a mechanical hazard (e.g. a spinning print drum), removal, opening or withdrawal of the cover, door, etc., shall either:

– necessitate previous reduction of movement to an acceptably safe level; or

– automatically initiate reduction of the movement to an acceptably safe level.

Compliance is checked by inspection, measurement and use of the test finger, of figure 2A (see 2.1.1.1).

2.8.3 Inadvertent reactivation

SAFETY INTERLOCKS shall be designed so that inadvertent reactivation of the hazard cannot occur when covers, guards, doors, etc., are not in the closed position.

Any accessible interlock which can be operated by means of the test finger, of figure 2A (see 2.1.1.1), is considered to be likely to cause inadvertent reactivation of the hazard.

SAFETY INTERLOCK switches shall be selected taking into account the mechanical shock and vibration experienced in normal operation, so that this does not cause inadvertent switching to an unsafe condition.

Compliance is checked by inspection and, where necessary, by a test with the test finger, of figure 2A (see 2.1.1.1).

2.8.4 Fail-safe operation **P**

A SAFETY INTERLOCK system shall be so designed and constructed that either:

- if a failure of the interlock system during the normal life of the equipment is not likely to occur and, even if a failure should occur, it shall not create an extreme hazard; or

- if a failure of the interlock system during the normal life of the equipment is possible, the probable failure mode(s) will not create a hazard for which protection is required.

Compliance is checked by inspection of the interlock system, circuit diagrams and available data and, if necessary, by simulation of single faults (see 1.4.14), for example, failure of a semi-conductor device or an electromechanical component. Moving mechanical parts in mechanical and electromechanical systems are not subjected to simulated single faults if they comply with 2.8.5 and 2.8.7.

It is permitted to use simulated interlock systems for tests.

2.8.5 Interlocks with moving parts

Moving mechanical parts in mechanical and electromechanical interlock systems shall have adequate endurance.

Compliance is checked by inspection of the interlock system, available data and, if necessary, by cycling the interlock system through 10 000 operations without failure other than in a safe mode.

NOTE – The above test is carried out to check the endurance of moving parts other than those in interlock switches and relays. Interlock switches and relays, if any, are subject to 2.8.7. If the test of 2.8.7.3 is required in addition to the above test, the tests should be combined.

2.8.6 Overriding an interlock

Where it may be necessary for SERVICE PERSONNEL to override a SAFETY INTERLOCK, the override system shall comply with all of the following:

- require an intentional effort to operate; and

- reset automatically to normal operation when servicing is complete, or prevent normal operation unless the SERVICE PERSONNEL have carried out restoration; and

- require a TOOL for operation when in OPERATOR ACCESS AREA and not be operable with the test finger, of figure 2A (see 2.1.1.1); and

- not bypass a SAFETY INTERLOCK for an extreme hazard unless another reliable means of safety protection becomes effective when the interlock is thus bypassed. The equipment shall be designed such that the interlock cannot be bypassed until the other means of protection is fully in place and operational.

Compliance is checked by inspection.

2.8.7 Switches and relays in interlock systems *P*

A switch in an interlock system shall:

- – for switches, conform with IEC 61058-1, with evaluation for 10 000 operating cycles in accordance with IEC 61058-1, 7.1.4.4; or
- – comply with 2.8.7.1 and pass the tests of 2.8.7.3 and 2.8.7.4; or
- – pass the tests of 2.8.7.2, 2.8.7.3 and 2.8.7.4.

A relay in an interlock system shall:

- – comply with 2.8.7.1and pass the tests of 2.8.7.3 and 2.8.7.4; or
- – pass the tests of 2.8.7.2, 2.8.7.3 and 2.8.7.4.

2.8.7.1 Contact gaps

If the contact gap is located in the PRIMARY CIRCUIT, the contact gap shall not be less than that for a disconnect device (see 3.4.2). If the contact gap is located in a circuit other than a PRIMARY CIRCUIT, the contact gap shall not be less than the relevant minimum CLEARANCE value in 2.10.3.3 for BASIC INSULATION in a SECONDARY CIRCUIT.

Compliance is checked by inspection of the available data and, if by necessary, measurement.

2.8.7.2 Overload test

The contact of the interlock switch or relay is subjected to an overload test consisting of 50 cycles of operation at the rate of 6 to 10 cycles per minute, making and breaking 150 % of the current imposed in the application, except that where a contact switches a motor load, the test is conducted with the rotor of the motor in a locked condition. After the test, the switch or relay shall still be functional.

2.8.7.3 Endurance test

The contact of the interlock switch or relay is subjected to an endurance test, making and breaking 100 % of the current imposed in the application at a rate of 6 to 10 cycles of operation per minute. A higher rate of cycling is permitted if requested by the manufacturer. For reed switches in ELV CIRCUITS, SELV CIRCUITS and TNV-1 CIRCUITS, the test is 100 000 cycling operations. For other switches and relays, the test is 10 000 cycling operations. After the test, the switch or relay shall still be functional.

2.8.7.4 Electric strength test

Except for reed switches in ELV CIRCUITS, SELV CIRCUITS and TNV-1 CIRCUITS, an electric strength test as specified in 5.2.2, is applied between the contacts after the tests of 2.8.7.2 and 2.8.7.3. If the contact is in a PRIMARY CIRCUIT, the test voltage is as specified for REINFORCED INSULATION. If the contact is in a circuit other than a PRIMARY CIRCUIT, the test voltage is as specified for BASIC INSULATION in a PRIMARY CIRCUIT.

2.8.8 Mechanical actuators

Where the actuating part in a mechanical interlock system is relied upon for safety, precautions shall be taken to ensure that it is not overstressed. If this requirement is not covered by the design of the component, the over-travel beyond the operating position of the actuator shall be limited to 50 % of the maximum, for example by its mounting or location, or by adjustment.

Compliance is checked by inspection and measurement.

2.9 Electrical insulation

2.9.1 Properties of insulating materials *P*

The choice and application of insulating materials shall take into account the needs for electrical, thermal and mechanical strength, frequency of the WORKING VOLTAGE and the working environment (temperature, pressure, humidity and pollution).

Natural rubber, hygroscopic materials and materials containing asbestos shall not be used as insulation.

Driving belts and couplings shall not be relied upon to ensure electrical insulation, unless the belt or coupling is of a special design which removes the risk of inappropriate replacement.

Compliance is checked by inspection and, where necessary, by evaluation of the data for the material.

Where necessary, if the data does not confirm that the material is non-hygroscopic, the hygroscopic nature of the material is determined by subjecting the component or subassembly employing the insulation in question to the humidity treatment of 2.9.2. The insulation is then subjected to the relevant electric strength test of 5.2.2 while still in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature.

2.9.2 Humidity conditioning

Where required by 2.9.1, 2.10.6.5 or 2.10.7, humidity conditioning is carried out for 48 h in a cabinet or room containing air with a relative humidity of 91 % to 95 %. The temperature of the air, at all places where samples can be located, is maintained within 1 °C of any convenient value t between 20 °C and 30 °C such that condensation does not occur. During this conditioning the component or subassembly is not energized.

With the concurrence of the manufacturer, it is permitted to increase the 48 h time duration.

Before the humidity conditioning the sample is brought to a temperature between t and t + 4 °C.

2.9.3 Requirements for insulation

Insulation in equipment shall comply with the heating requirements of 4.5.1 and, except where 2.1.1.3 or 2.1.1.4 applies, with both of the following

– the applicable electric strength requirements of 5.2; and

– the requirements for clearance, creepage distance and solid insulation of 2.10.

2.9.4 Insulation parameters

For the purpose of determining the test voltages, minimum clearances, minimum creepage distances, solid insulation criteria and other requirements for a given piece of insulation, two parameters shall be considered:

– application of insulation (see 2.9.5); and

– working voltage (see 2.10.2 and 5.2).

2.9.5 Categories of insulation **P**

Insulation shall be considered to be functional, basic, supplementary, reinforced or double insulation.

The application of insulation in many common situations is described in table 2G and illustrated in figure 2F, but other situations and solutions are possible. These examples are informative; in some cases the necessary grade of insulation may be higher or lower. Where a different grade may be necessary, or if a particular configuration of energized parts is not represented in the examples, the necessary grade of insulation should be determined by considering the effect of a single fault (see 1.4.14). This should leave the requirements for protection against electric shock intact.

In certain cases, insulation may be bridged by a conductive path (e.g., where 1.5.7, 2.2.4, 2.3.4 or 2.4.3 applies) provided that the level of safety is maintained.

For double insulation it is permitted to interchange the basic and supplementary insulation elements. Where double insulation is used, elv circuits or unearthed conductive parts are permitted between the basic insulation and the supplementary insulation provided that the overall level of insulation is maintained.

Table 2G – Examples of application of insulation

Grade of insulation	Location of Insulation		Key to figure 2F
	between	and	
1. FUNCTIONAL see 1)	unearthed SELV CIRCUIT or double-insulated conductive part	– earthed conductive part – double-insulated conductive part – unearthed SELV CIRCUIT – earthed SELV CIRCUIT – earthed TNV-1 CIRCUIT	F1 F2 F2 F1 F10 see 6)
	earthed SELV CIRCUIT	– earthed SELV CIRCUIT – earthed conductive part – unearthed TNV-1 CIRCUIT – earthed TNV-1 CIRCUIT	F11 F11 F12 see 6) F13 see 6)
	ELV CIRCUIT or basic- insulated conductive part	– earthed conductive part – earthed SELV CIRCUIT – basic-insulated conductive part – ELV CIRCUIT	F3 F3 F4 F4
	earthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	earthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	F5
	TNV-1 CIRCUIT	TNV-1 CIRCUIT	F7
	TNV-2 CIRCUIT	TNV-2 CIRCUIT	F8
	TNV-3 CIRCUIT	TNV-3 CIRCUIT	F9
	series-parallel sections of a transformer winding		F6

Table 2G – Examples of application of insulation Continued on Next Page

Table 2G – Examples of application of insulation Continued

Grade of insulation	Location of Insulation		Key to figure 2F
	between	and	
2. BASIC	PRIMARY CIRCUIT	– earthed or unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT – earthed conductive part – earthed SELV CIRCUIT – basic-insulated conductive part – ELV CIRCUIT	B1 B2 B2 B3 B3
	earthed or unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	– unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT – earthed conductive part – earthed SELV CIRCUIT – basic-insulated conductive part – ELV CIRCUIT	B4 B5 B5 B6 B6
	unearthed SELV CIRCUIT or double-insulated conductive part	– unearthed TNV-1 CIRCUIT – TNV-2 CIRCUIT – TNV-3 CIRCUIT	B7 see 6) B8 B9 see 5)
	earthed SELV CIRCUIT	– TNV-2 CIRCUIT – TNV-3 CIRCUIT	B10 see 4) B10 see 4) 5)
	TNV-2 CIRCUIT	– unearthed TNV-1 CIRCUIT – earthed TNV-1 CIRCUIT – TNV-3 CIRCUIT	B12 see 5) B13 see 4) 5) B14 see 6)
	TNV-3 CIRCUIT	– unearthed TNV-1 CIRCUIT – earthed TNV-1 CIRCUIT	B12 B13 see 4)
3. SUPPLEMENTARY	basic-insulated conductive part or ELV CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT	S1 see 2) S1 see 2)
	TNV CIRCUIT	– basic-insulated conductive part – ELV CIRCUIT	S2 see 4) S2
4. SUPPLEMENTARY or REINFORCED	unearthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT – TNV CIRCUIT	S/R1 see 3) S/R1 see 3) S/R2 see 3)
5. REINFORCED	PRIMARY CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT – TNV CIRCUIT	R1 R1 R2
	earthed HAZARDOUS VOLTAGE SECONDARY CIRCUIT	– double-insulated conductive part – unearthed SELV CIRCUIT – TNV CIRCUIT	R3 R3 R4

1)See 5.3.4 for requirements for FUNCTIONAL INSULATION.

2)The working voltage of the SUPPLEMENTARY INSULATION between an ELV CIRCUIT or a basic-insulated conductive part and an unearthed accessible conductive part is equal to the most onerous WORKING VOLTAGE for the BASIC INSULATION. The most onerous WORKING VOLTAGE may be due to a PRIMARY CIRCUIT or SECONDARY CIRCUIT and the insulation is specified accordingly.

Table 2G – Examples of application of insulation Continued on Next Page

Table 2G – Examples of application of insulation Continued

<table>
<tr><th rowspan="2">Grade of insulation</th><th colspan="2">Location of Insulation</th><th rowspan="2">Key to figure 2F</th></tr>
<tr><th>between</th><th>and</th></tr>
<tr><td colspan="4">3)Insulation between an unearthed SECONDARY CIRCUIT at HAZARDOUS VOLTAGE and an unearthed accessible conductive part or circuit (S/R in figure 2F) shall satisfy the more onerous of the following:
– REINFORCED INSULATION whose WORKING VOLTAGE is equal to the HAZARDOUS VOLTAGE; or
– SUPPLEMENTARY INSULATION whose WORKING VOLTAGE is equal to the voltage between:
• the SECONDARY CIRCUIT at HAZARDOUS VOLTAGE; and
• another SECONDARY CIRCUIT at HAZARDOUS VOLTAGE or a PRIMARY CIRCUIT.
These examples apply if:
– there is only BASIC INSULATION between the SECONDARY CIRCUIT and the PRIMARY CIRCUIT; and
– there is only BASIC INSULATION between the SECONDARY CIRCUIT and earth.
4)BASIC INSULATION is not always required (see 2.3.2.).
5)The requirements of 2.10 apply. See also 6.2.1.
6)The requirements of 2.10 do not apply, but see 6.2.1.</td></tr>
<tr><td colspan="4">NOTE – The term ″conductive part″ refers to an electrically conductive part that is:
– not normally energized, and
– not connected to any of the following:
• a circuit at HAZARDOUS VOLTAGE, or
• an ELV CIRCUIT, or
• a TNV CIRCUIT, or
• an SELV CIRCUIT, or
• a LIMITED CURRENT CIRCUIT.
Examples of such a conductive part are the BODY of equipment, a transformer core, and in some cases a conductive screen in a transformer.
If such a conductive part is protected from a part at HAZARDOUS VOLTAGE by:
– DOUBLE OR REINFORCED INSULATION, it is termed a ″double-insulated conductive part″;
– BASIC INSULATION plus protective earthing, it is termed an ″earthed conductive part″;
– BASIC INSULATION but is not earthed, i.e. it has no second level of protection, it is termed a ″basic-insulated conductive part″.
A circuit or conductive part is termed ″earthed″ if it is connected to a protective earthing terminal or contact in such a way as to meet the requirements in 2.6 (although it will not necessarily be at earth potential). Otherwise the circuit or conductive part is termed ″unearthed″.</td></tr>
</table>

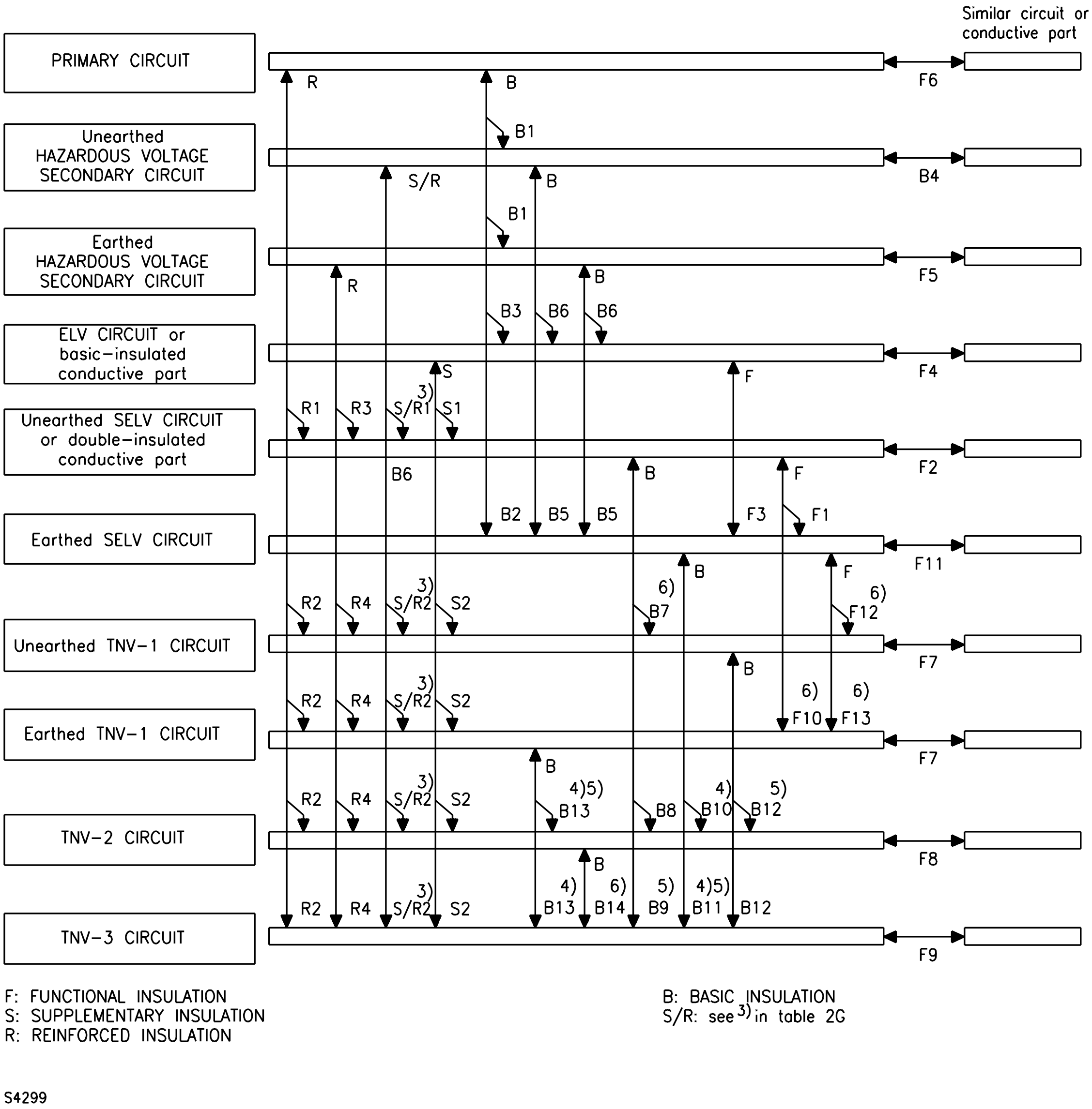


Figure 2F – Examples of application of insulation

2.10 Clearances, creepage distances and distances through insulation *F*

2.10.1 General

CLEARANCES shall be so dimensioned that overvoltage transients which may enter the equipment, and peak voltages which may be generated within the equipment, do not break down the CLEARANCE. Detailed requirements are given in 2.10.3.

CREEPAGE DISTANCES shall be so dimensioned that, for a given WORKING VOLTAGE and Pollution Degree, no flashover or breakdown (tracking) of insulation will occur. Detailed requirements are given in 2.10.4.

The methods of measuring CLEARANCES and CREEPAGE DISTANCES are given in annex F.

Solid insulation shall be:

- so dimensioned that overvoltage transients that enter the equipment and peak voltages that may be generated within the equipment, do not break down the solid insulation; and

- for thin layers of insulation, so arranged that the likelihood of having pinholes aligned is limited.

Detailed requirements are given in 2.10.5.

The insulation requirements given in 2.10 are for frequencies up to 30 kHz. It is permitted to use the same requirements for insulation operating at frequencies over 30 kHz until additional data is available.

NOTE – For information on insulation behaviour in relation to frequency see IEC 60664-1 and IEC 60664-4.

For FUNCTIONAL INSULATION, CLEARANCES and CREEPAGE DISTANCES smaller than those specified in 2.10 are permitted subject to the requirements of 5.3.4 b) or 5.3.4 c).

It is permitted for CLEARANCES and CREEPAGE DISTANCES to be divided by intervening, unconnected (floating) conductive parts, such as unused contacts of a connector, provided that the sum of the individual distances meets the specified minimum requirements (see figure F.13).

The minimum CLEARANCE and CREEPAGE DISTANCE values given for various Pollution Degrees apply as follows:

- Pollution Degree 1 for components and assemblies which are sealed so as to exclude dust and moisture (see 2.10.7).

- Pollution Degree 2 generally for equipment covered by the scope of this standard.

- Pollution Degree 3 where a local internal environment within the equipment is subject to conductive pollution or to dry non-conductive pollution which could become conductive due to expected condensation.

2.10.2 Determination of working voltage

In determining the WORKING VOLTAGES, all of the following requirements apply (see also 1.4.7):

– the value of the RATED VOLTAGE or the upper voltage of the RATED VOLTAGE RANGE shall be:

- used for WORKING VOLTAGE between a PRIMARY CIRCUIT and earth; and
- taken into account for determination of the WORKING VOLTAGE between a PRIMARY CIRCUIT and a SECONDARY CIRCUIT; and

– unearthed accessible conductive parts shall be assumed to be earthed; and

– where a transformer winding or other part is floating, i.e. not connected to a circuit which establishes its potential relative to earth, it shall be assumed to be earthed at the point by which the highest WORKING VOLTAGE is obtained; and

– where DOUBLE INSULATION is used, the WORKING VOLTAGE across the BASIC INSULATION shall be determined by imagining a short circuit across the SUPPLEMENTARY INSULATION, and vice versa. For DOUBLE INSULATION between transformer windings, the short circuit shall be assumed to take place at the point by which the highest WORKING VOLTAGE is produced in the other insulation; and

– except as permitted in 2.10.10, for insulation between two transformer windings, the highest voltage between any two points in the two windings shall be used, taking into account external voltages to which the windings will be connected; and

– except as permitted in 2.10.10, for insulation between a transformer winding and another part, the highest voltage between any point on the winding and the other part shall be used.

2.10.3 Clearances

P R

2.10.3.1 General

It is permitted to use either the following method or the alternative method in annex G for a particular component or subassembly or for the whole equipment.

NOTE 1 – The advantages of annex G are as follows:

– CLEARANCES are aligned with the basic safety publication IEC 60664-1 and are therefore harmonized with other safety publications (e.g. for transformers).

– Additional flexibility is provided for the designer due to an improved interpolation method compared to the method in 2.10.3 where steps are taken from one line to the next in tables 2H, 2J and 2K.

– Attenuation of transients within the equipment is considered, including attenuation of transients in PRIMARY CIRCUITS.

– Inconsistencies in table 2H are corrected (4 000 V_{peak} requires 2,0 mm or 2,5 mm for FUNCTIONAL INSULATION and 3,2 mm for BASIC INSULATION).

NOTE 2 – CLEARANCE and electric strength requirements are based on the expected overvoltage transients which may enter the equipment from the AC MAINS SUPPLY. According to IEC 60664-1, the magnitude of these transients is determined by the normal supply voltage and the supply arrangements. These transients are categorized according to IEC 60664-1 into four groups as Overvoltage Categories I to IV (also known as installation categories I to IV). Annex G covers all four Overvoltage Categories. Elsewhere in this standard Overvoltage Category II is assumed.

NOTE 3 – The design of solid insulation and CLEARANCES should be coordinated in such a way that if an incident overvoltage transient exceeds the limits of Overvoltage Category II, the solid insulation can withstand a higher voltage than the CLEARANCES.

For all a.c. power systems, the AC MAINS SUPPLY voltage in tables 2H, 2J and 2K is the line-to-neutral voltage.

NOTE 4 – In Norway, due to the IT power distribution system used (see annex V, figure V.7), the AC MAINS SUPPLY voltage is considered to be equal to the line-to-line voltage, and will remain 230 V in case of a single earth fault.

The specified CLEARANCES are subject to the following minimum values:

– 10 mm for an air gap serving as REINFORCED INSULATION between a part at HAZARDOUS VOLTAGE and an accessible conductive part of the ENCLOSURE of floor-standing equipment or of the non-vertical top surface of desk top equipment;

– 2 mm for an air gap serving as BASIC INSULATION between a part at HAZARDOUS VOLTAGE and an earthed accessible conductive part of the external ENCLOSURE of PLUGGABLE EQUIPMENT TYPE A.

The specified CLEARANCES are not applicable to the air gap between the contacts of THERMOSTATS, THERMAL CUT-OUTS, overload protection devices, switches of microgap construction, and similar components where the CLEARANCE varies with the contacts.

NOTE 5 – For air gaps between contacts of interlock switches, see 2.8.7.1. For air gaps between contacts of disconnect switches, see 3.4.2.

NOTE 6 – CLEARANCES should not be reduced by manufacturing tolerances or by deformation which can occur due to handling, shock and vibration likely to be encountered during manufacture, transport and normal use.

Compliance with 2.10.3 is checked by measurement, taking into account annex F. The following conditions are applicable. There is no electric strength test to verify CLEARANCES.

Movable parts shall be placed in the most unfavourable position.

When measuring CLEARANCES from an ENCLOSURE of insulating material through a slot or opening in the ENCLOSURE, the accessible surface shall be considered to be conductive as if it were covered by metal foil wherever it can be touched by the test finger, figure 2A (see 2.1.1.1), applied without appreciable force (see figure F.12, point B).

When measuring CLEARANCES, 4.2.2, 4.2.3 and 4.2.4 apply.

2.10.3.2 Clearances in primary circuits

CLEARANCES in PRIMARY CIRCUITS shall comply with the minimum dimensions in table 2H and, where appropriate, table 2J.

Table 2H is applicable to equipment that will not be subjected to transients exceeding Overvoltage Category II according to IEC 60664-1. The appropriate MAINS TRANSIENT VOLTAGES are given in parentheses in each nominal AC MAINS SUPPLY voltage column. If higher transients are expected, additional protection might be necessary in the supply to the equipment or in the installation.

NOTE 1 – Annex G provides an alternative design method for higher transients.

For PRIMARY CIRCUITS operating on nominal AC MAINS SUPPLY voltages up to 300 V, if the PEAK WORKING VOLTAGE in the circuit exceeds the peak value of the AC MAINS SUPPLY voltage, the minimum CLEARANCE for the insulation under consideration is the sum of the following two values:

– the minimum CLEARANCE value from table 2H for a WORKING VOLTAGE equal to the AC MAINS SUPPLYvoltage; and

– the appropriate additional CLEARANCE value from table 2J.

For a WORKING VOLTAGE to be used in determining CLEARANCES for PRIMARY CIRCUITS in accordance with table 2H:

– the peak value of any superimposed ripple on a DC VOLTAGE, shall be included;

– non-repetitive transients (due, for example, to atmospheric disturbances) shall not be taken into account;

NOTE 2 – It is assumed that any such non-repetitive transients in a SECONDARY CIRCUIT will not exceed the MAINS TRANSIENT VOLTAGE of the PRIMARY CIRCUIT.

– the voltage of any ELV CIRCUIT, SELV CIRCUIT or TNV CIRCUIT (including ringing voltage) shall be regarded as zero;

and in accordance with table 2J, where appropriate, for PEAK WORKING VOLTAGES exceeding the values of the AC MAINS SUPPLY voltage, the maximum PEAK WORKING VOLTAGE shall be used.

NOTE 3 – The total CLEARANCES obtained by the use of table 2J lie between the values required for homogeneous and inhomogeneous fields. As a result, they may not assure conformance with the appropriate electric strength test in case of fields which are substantially inhomogeneous.

NOTE 4 – Use of CLEARANCE – tables 2H and 2J:

Select the appropriate column in table 2H for the AC MAINS SUPPLY voltage and Pollution Degree. Select the row appropriate to a WORKING VOLTAGE equal to the AC MAINS SUPPLY voltage. Note the CLEARANCE requirement.

Go to table 2J. Select the appropriate column for the AC MAINS SUPPLY voltage and Pollution Degree and choose the row in that column which covers the actual PEAK WORKING VOLTAGE. Read the additional CLEARANCE required from one of the two right-hand columns and add this to the minimum CLEARANCE from table 2H to give the total minimum CLEARANCE.

Table 2H – Minimum clearances for insulation in primary circuits, and between primary and secondary circuits

CLEARANCES in millimetres																
WORKING VOLTAGE up to and including		**Nominal AC MAINS SUPPLY voltage ≤ 150 V (MAINS TRANSIENT VOLTAGE 1 500 V)**						**Nominal AC MAINS SUPPLY voltage > 150 V ≤ 300 V (MAINS TRANSIENT VOLTAGE 2 500 V)**						**Nominal AC MAINS SUPPLY voltage > 300 V ≤ 600 V (MAINS TRANSIENT VOLTAGE 4 000 V)**		
Voltage peak or d.c.	**Voltage r.m.s. (sinu-soidal)**	**Pollution Degrees 1 and 2**			**Pollution Degree 3**			**Pollution Degrees 1 and 2**			**Pollution Degree 3**			**Pollution Degrees 1, 2 and 3**		
V	**V**	**F**	**B/S**	**R**	**F**	**B/S**	**R**	**F**	**B/S**	**R**	**F**	**B/S**	**R**	**F**	**B/S**	**R**
71	50	0,4	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,0	2,0 (1,5)	4,0 (3,0)	1,3	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
210	150	0,5	1,0 (0,5)	2,0 (1,0)	0,8	1,3 (0,8)	2,6 (1,6)	1,4	2,0 (1,5)	4,0 (3,0)	1,5	2,0 (1,5)	4,0 (3,0)	2,0	3,2 (3,0)	6,4 (6,0)
420	300	F 1,5 B/S 2,0 (1,5) R 4,0 (3,0)												2,5	3,2 (3,0)	6,4 (6,0)
840	600	F 3,0 B/S 3,2 (3,0) R 6,4 (6,0)														
1 400	1 000	F/B/S 4,2 R 6,4														
2 800	2 000	F/B/S/R 8,4														
7 000	5 000	F/B/S/R 17.5														
9 800	7 000	F/B/S/R 25														
14 000	10 000	F/B/S/R 37														
28 000	20 000	F/B/S/R 80														
42 000	30 000	F/B/S/R 130														

1) The values in the table are applicable to FUNCTIONAL (F), BASIC (B), SUPPLEMENTARY (S) and REINFORCED (R) INSULATION.

2) The values in parentheses are applicable to BASIC, SUPPLEMENTARY or REINFORCED INSULATION only if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in annex R.2. In particular, DOUBLE and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

3) For WORKING VOLTAGES between 2 800 V peak or d.c. and 42 000 V peak or d.c., linear interpolation is permitted between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.

Table 2J – Additional clearances for insulation in primary circuits with peak working voltages exceeding the peak value of the nominal a.c. mains supply voltage

Nominal AC MAINS SUPPLY voltage ≤ 150 V		Nominal AC MAINS SUPPLY voltage > 150 V ≤ 300 V	Additional CLEARANCE mm	
Pollution Degrees 1 and 2	Pollution Degree 3	Pollution Degrees 1, 2 and 3		
Maximum PEAK WORKING VOLTAGE V	Maximum PEAK WORKING VOLTAGE V	Maximum PEAK WORKING VOLTAGE V	FUNCTIONAL, BASIC or SUPPLEMENTARY INSULATION	REINFORCED INSULATION
210 (210)	210 (210)	420 (420)	0	0
298 (288)	294 (293)	493 (497)	0,1	0,2
386 (366)	379 (376)	567 (575)	0,2	0,4
474 (444)	463 (459)	640 (652)	0,3	0,6
562 (522)	547 (541)	713 (729)	0,4	0,8
650 (600)	632 (624)	787 (807)	0,5	1,0
738 (678)	715 (707)	860 (884)	0,6	1,2
826 (756)	800 (790)	933 (961)	0,7	1,4
914 (839)		1 006 (1 039)	0,8	1,6
1 002 (912)		1 080 (1 116)	0,9	1,8
1 090 (990)		1 153 (1 193)	1,0	2,0
		1 226 (1 271)	1,1	2,2
		1 300 (1 348)	1,2	2,4
		– (1 425)	1,3	2,6

The values in parentheses shall be used:

– When the values in parentheses in table2H are used in accordance with item 2) of table 2H; and

– for FUNCTIONAL INSULATION.

2.10.3.3 Clearances in secondary circuits

CLEARANCES in SECONDARY CIRCUITS shall comply with the minimum dimensions of table 2K.

For a WORKING VOLTAGE to be used in determining CLEARANCES for SECONDARY CIRCUITS in accordance with table 2K:

- the peak value of any superimposed ripple on a DC VOLTAGE, shall be included;
- the peak value shall be used for non-sinusoidal voltages.

SECONDARY CIRCUITS will normally be Overvoltage Category I if the PRIMARY CIRCUIT is Overvoltage Category II; the maximum transients for various AC MAINS SUPPLY voltages in Overvoltage Category I are shown in the column headings of table 2K. However, a floating SECONDARY CIRCUIT shall be subjected to the requirements for PRIMARY CIRCUIT in tables 2H and 2J unless it is in equipment with a protective earthing terminal and either

- it is separated from the PRIMARY CIRCUIT by an earthed metal screen; or

– transients on the SECONDARY CIRCUIT are below the permitted maximum value for Overvoltage Category I (e.g. due to being attenuated by connecting a component, such as a capacitor, between the SECONDARY CIRCUIT and earth). See 2.10.3.4 for the method of measuring the transient level.

NOTE – For CLEARANCES which are provided for compliance with 2.3.2, table 2K applies.

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is not known, an assumed transient rating of 800 V peak should be used for TNV-2 CIRCUITS and 1,5 kV peak for TNV-1 CIRCUITS and TNV-3 CIRCUITS.

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is known, the known value should be used.

If it is known that the incoming transients will be attenuated within the equipment, the value should be determined in accordance with 2.10.3.4 b) and be used.

Table 2K – Minimum clearances in secondary circuits

		CLEARANCES in millimetres																	
WORKING VOLTAGE up to and including		Nominal AC MAINS SUPPLY voltage ≤ 150 V (transient rating for SECONDARY CIRCUIT 800 V) see 5)						Nominal AC MAINS SUPPLY voltage > 150 V ≤ 300 V (transient rating for SECONDARY CIRCUIT 1500 V) see 5)						Nominal AC MAINS SUPPLY voltage > 300 V ≤ 600 V (transient rating for SECONDARY CIRCUIT 2500 V) see 5)			Circuit not subject to transient overvoltages see 4)		
Voltage peak or d.c.	Voltage r.m.s. (sinu-soidal)	Pollution Degrees 1 and 2			Pollution Degree 3			Pollution Degrees 1 and 2			Pollution Degree 3			Pollution Degrees 1, 2 and 3			Pollution Degrees 1 and 2 only		
V	V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
71	50	0,4 (0,2)	0,7 (0,2)	1,4 (0,4)	1,0 (0,8)	1,3 (0,8)	2,6 (1,6)	0,7 (0,5)	1,0 (0,5)	2,0 (1,0)	1,0 (0,8)	1,3 (0,8)	2,6 (1,6)	1,7 (1,5)	2,0 (1,5)	4,0 (3,0)	0,4 (0,2)	0,4 (0,2)	0,8 (0,4)
140	100	0,6 (0,2)	0,7 (0,2)	1,4 (0,4)	1,0 (0,8)	1,3 (0,8)	2,6 (1,6)	0,7 (0,5)	1,0 (0,5)	2,0 (1,0)	1,0 (0,8)	1,3 (0,8)	2,6 (1,6)	1,7 (1,5)	2,0 (1,5)	4,0 (3,0)	0,6 (0,2)	0,7 (0,2)	1,4 (0,4)
210	150	0,6 (0,2)	0,9 (0,2)	1,8 (0,4)	1,0 (0,8)	1,3 (0,8)	2,6 (1,6)	0,7 (0,5)	1,0 (0,5)	2,0 (1,0)	1,0 (0,8)	1,3 (0,8)	2,6 (1,6)	1,7 (1,5)	2,0 (1,5)	4,0 (3,0)	0,6 (0,2)	0,7 (0,2)	1,4 (0,4)
280	200	F 1,1 (0,8) B/S 1,4 (0,8) R 2,8 (1,6)												1,7 (1,5)	2,0 (1,5)	4,0 (3,0)	1,1 (0,2)	1,1 (0,2)	2,2 (0,4)
420	300	F 1,6 (1,0) B/S 1,9 (1,0) R 3,8 (2,0)												1,7 (1,5)	2,0 (1,5)	4,0 (3,0)	1,4 (0,2)	1,4 (0,2)	2,8 (0,4)
700	500	F/B/S 2,5	R, 5,0																
840	600	F/B/S 3,2	R, 5,0																
1 400	1 000	F/B/S 4,2	R, 5,0																
2 800	2 000	F/B/S/R 8,4	See 6)																
7 000	5 000	F/B/S/R 17,5	See 6)																
9 800	7 000	F/B/S/R 25	See 6)																
14 000	10 000	F/B/S/R 37	See 6)																
26 000	20 000	F/B/S/R 80	See 6)																

Table 2K – Minimum clearances in secondary circuits Continued on Next Page

Table 2K – Minimum clearances in secondary circuits Continued

		CLEARANCES in millimetres																	
WORKING VOLTAGE up to and including		Nominal AC MAINS SUPPLY voltage ≤ 150 V (transient rating for SECONDARY CIRCUIT 800 V) see 5)						Nominal AC MAINS SUPPLY voltage > 150 V ≤ 300 V (transient rating for SECONDARY CIRCUIT 1500 V) see 5)						Nominal AC MAINS SUPPLY voltage > 300 V ≤ 600 V (transient rating for SECONDARY CIRCUIT 2500 V) see 5)			Circuit not subject to transient overvoltages see 4)		
Voltage peak or d.c.	Voltage r.m.s. (sinu-soidal)	Pollution Degrees 1 and 2			Pollution Degree 3			Pollution Degrees 1 and 2			Pollution Degree 3			Pollution Degrees 1, 2 and 3			Pollution Degrees 1 and 2 only		
V	V	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R	F	B/S	R
42 000	30 000	F/B/S/R 130 See 6)																	

1) The values in the table are applicable to FUNCTIONAL (F), BASIC (B), SUPPLEMENTARY (S) and REINFORCED (R) INSULATION.

2) The values in parentheses are applicable to BASIC, SUPPLEMENTARY or REINFORCED INSULATION only if manufacturing is subjected to a quality control programme that provides at least the same level of assurance as the example given in annex R.2. In particular, DOUBLE and REINFORCED INSULATION shall be subjected to ROUTINE TESTS for electric strength.

3) For WORKING VOLTAGES between 2 800 V peak or d.c. and 42 000 V peak or d.c., linear interpolation is permitted between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.

4) The values are applicable to d.c. SECONDARY CIRCUITS which are reliably connected to earth and have capacitive filtering which limits the peak-to-peak ripple to 10 % of the DC VOLTAGE.

5) Where transients in the equipment exceed this value, the appropriate higher CLEARANCE shall be used.

6) Compliance with a CLEARANCE value of 8,4 mm or greater is not required if the CLEARANCE path is:

– entirely through air, or

– wholly or partly along the surface of an insulating material of Material Group I;

– and the insulation involved passes an electric strength test according to5.2.2 using:

– an a.c. test voltage whose r.m.s. value is equal to 1,06 times the PEAK WORKING VOLTAGE, or

– a d.c. test voltage equal to the peak value of the a.c. test voltage prescribed above.

If the CLEARANCE path is partly along the surface of a material that is not Material Group I, the electric strength test is conducted across the air gap only.

2.10.3.4 Measurement of transient levels

The following tests are conducted only where it is required to determine whether or not transient voltages across the CLEARANCE in any circuit are lower than normal, due, for example, to the effect of a filter in the equipment. The transient voltage across the CLEARANCE is measured using the following test procedure, and the CLEARANCE shall be based on the measured value.

During the tests, the equipment is connected to its separate power supply unit, if any, but is not connected to the mains, nor to any TELECOMMUNICATION NETWORKS, and any surge suppressors in PRIMARY CIRCUITS are disconnected.

A voltage measuring device is connected across the CLEARANCE in question.

a) Transients due to mains overvoltages

To measure the reduced level of transients due to mains overvoltages, the impulse test generator of annex N is used to generate 1,2/50 µs impulses, with U_c *equal to the MAINS TRANSIENT VOLTAGE given in the column headings of table 2H.*

Three to six impulses of alternating polarity, with intervals of at least 1 s between impulses, are applied between each of the following points where relevant:

- *line-to-line;*
- *all line conductors joined together and neutral;*
- *all line conductors joined together and protective earth;*
- *neutral and protective earth.*

b) Transients due to TELECOMMUNICATION NETWORK overvoltages

To measure the reduced level of transients due to TELECOMMUNICATION NETWORKovervoltages, the impulse test generator of annex N is used to generate 10/700 µs impulses, with U_c *equal to the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE.*

If the TELECOMMUNICATION NETWORK TRANSIENT VOLTAGE is not known for the TELECOMMUNICATION NETWORK in question, it shall be taken as:

- *1 500* V_{peak} *if the circuit connected to the TELECOMMUNICATION NETWORK is a TNV-1 CIRCUIT or a TNV-3 CIRCUIT; and*
- *800* V_{peak} *if the circuit connected to the TELECOMMUNICATION NETWORK is an SELV CIRCUIT or a TNV-2 CIRCUIT.*

Three to six impulses of alternating polarity, with intervals of at least 1 s between impulses, are applied between each of the following TELECOMMUNICATION NETWORK connection points:

- *each pair of terminals (e.g. A and B or tip and ring) in an interface;*
- *all terminals of a single interface type joined together and earth.*

2.10.4 Creepage distances *P*

CREEPAGE DISTANCES shall be not less than the appropriate minimum values specified in table 2L, taking into account the value of the WORKING VOLTAGE, the Pollution Degree and the material group.

For REINFORCED INSULATION, the values for CREEPAGE DISTANCE are twice the values for BASIC INSULATION in table 2L.

If the CREEPAGE DISTANCE derived from table 2L is less than the applicable CLEARANCE from tables 2H and 2J, or from table 2K, as appropriate, then the value for that CLEARANCE shall be applied for the minimum CREEPAGE DISTANCE.

It is permitted to use minimum CREEPAGE DISTANCES equal to the applicable CLEARANCES for glass, mica, ceramic or similar materials.

For the WORKING VOLTAGE to be used in determining CREEPAGE DISTANCES:

– the actual r.m.s. or d.c. value shall be used;

– if the d.c. value is used, any superimposed ripple shall not be taken into account;

– short-term conditions (e.g. in cadenced ringing signals in TNV CIRCUITS) shall not be taken into account;

– short-term disturbances (e.g. transients) shall not be taken into account.

When determining the WORKING VOLTAGE for a TNV CIRCUIT connected to a TELECOMMUNICATION NETWORK whose characteristics are not known, the normal operating voltages shall be assumed to be the following values:

– 60 V d.c. for TNV-1 circuits;

– 120 V d.c. for TNV-2 circuits and TNV-3 circuits.

Material Groups are classified as follows:

Material group I	600 ≤ CTI (comparative tracking index)
Material group II	400 ≤ CTI < 600
Material group IIIa	175 ≤ CTI < 400
Material group IIIb	100 ≤ CTI < 175

The Material Group is verified by evaluation of the test data for the material according to IEC 60112 using 50 drops of solution A.

If the material group is not known, Material Group IIIb shall be assumed.

If a CTI of 175 or greater is needed, and the data is not available, the Material Group can be established with a test for proof tracking index (PTI) as detailed in IEC 60112. A material may be included in a group if its PTI established by these tests is equal to, or greater than, the lower value of the CTI specified for the group.

Table 2L – Minimum creepage distances

							CREEPAGE DISTANCES in millimetres
WORKING VOLTAGE V r.m.s. or d.c.	**FUNCTIONAL, BASIC and SUPPLEMENTARY INSULATION**						
	Pollution Degree 1	**Pollution Degree 2**			**Pollution Degree 3**		
	Material Group	**Material Group**			**Material Group**		
	I, II, IIIa or IIIb	**I**	**II**	**IIIa +or IIIb**	**I**	**II**	**IIIa or IIIb**
≤ 50	Use the CLEARANCE from the appropriate table	0,6	0,9	1,2	1,5	1,7	1,9
100		0,7	1,0	1,4	1,8	2,0	2,2
125		0,8	1,1	1,5	1,9	2,1	2,4
150		0,8	1,1	1,6	2,0	2,2	2,5
200		1,0	1,4	2,0	2,5	2,8	3,2
250		1,3	1,8	2,5	3,2	3,6	4,0
300		1,6	2,2	3,2	4,0	4,5	5,0
400		2,0	2,8	4,0	5,0	5,6	6,3
600		3,2	4,5	6,3	8,0	9,6	10,0
800		4,0	5,6	8,0	10,0	11,0	12,5
1 000		5,0	7,1	10,0	12,5	14,0	16,0
Linear interpolation is permitted between the nearest two points, the calculated spacing being rounded to the next higher 0,1 mm increment.							

Compliance is checked by measurement, taking into account annex F.

The following conditions are applicable.

Movable parts are placed in their most unfavourable positions.

For equipment incorporating ordinary NON-DETACHABLE POWER SUPPLY CORDS*,* CREEPAGE DISTANCE *measurements are made with supply conductors of the largest cross-sectional area specified in 3.3.4, and also without conductors.*

When measuring CREEPAGE DISTANCES *from an* ENCLOSURE *of insulating material through a slot or opening in the* ENCLOSURE, *the accessible surface is considered to be conductive as if it were covered by metal foil wherever it can be touched by the test finger, figure 2A (see 2.1.1.1), applied without appreciable force (see figure F.12, point ~~of~~ B).* DE

2.10.5 Solid insulation *U*

The adequacy of solid insulation is verified by electric strength tests according to 5.2.

NOTE 1 – The term ″solid insulation″ refers to material that provides electrical insulation between two opposite surfaces, not along an outer surface. Its required properties are specified either as the actual minimum distance through the insulation (see 2.10.5.1), or by other requirements and tests in this standard instead of a minimum distance.

NOTE 2 – See also 3.1.4.

2.10.5.1 Minimum distance through insulation

Except where 2.1.1.3 or another subclause of 2.10.5 applies, distances through insulation shall be dimensioned according to PEAK WORKING VOLTAGE and to the application of the insulation (see 2.9), and as follows:

- if the PEAK WORKING VOLTAGE does not exceed 71 V, there is no requirement for distance through insulation;
- if the PEAK WORKING VOLTAGE exceeds 71 V, the following rules apply:
  - for FUNCTIONAL INSULATION and BASIC INSULATION there is no requirement at any PEAK WORKING VOLTAGE for distance through insulation;
  - SUPPLEMENTARY INSULATION or REINFORCED INSULATION shall have a minimum distance through insulation of 0,4 mm.

The requirements of 2.10.5.1 also apply to gel dielectrics such as are used in some opto-couplers.

There is no distance through insulation requirement for SUPPLEMENTARY INSULATION or REINFORCED INSULATION consisting of an insulating compound completely filling the casing of a semiconductor component (e.g. an opto-coupler), so that CLEARANCES and CREEPAGE DISTANCES do not exist, if the component:

- passes the tests and inspection criteria of 2.10.8; and
- is subjected to ROUTINE TESTS for electric strength during manufacturing, using the appropriate value of the test voltage in 5.2.2.

Compliance is checked by inspection and measurement.

2.10.5.2 Thin sheet material

NOTE – The requirements for wound components are given in 2.10.5.4.

Insulation in thin sheet materials is permitted, irrespective of its thickness, provided that it is used within the equipment ENCLOSURE and is not subject to handling or abrasion during OPERATOR servicing, and one of the following applies:

- SUPPLEMENTARY INSULATION comprises at least two layers of material, each of which will pass the electric strength test for SUPPLEMENTARY INSULATION; or
- SUPPLEMENTARY INSULATION comprises three layers of material for which all combinations of two layers together will pass the electric strength test for SUPPLEMENTARY INSULATION; or
- REINFORCED INSULATION comprises at least two layers of material, each of which will pass the electric strength test for REINFORCED INSULATION; or
- REINFORCED INSULATION comprises three layers of material for which all combinations of two layers together will pass the electric strength test for REINFORCED INSULATION.

There is no requirement for all layers of insulation to be of the same material.

Solvent-based enamel coatings are not considered to be insulation in thin sheet material.

Compliance is checked by inspection and by electric strength test.

2.10.5.3 Printed boards

For the inner layers of multi-layer boards, the distance between two adjacent tracks on the same layer of a printed circuit board is treated as distance through insulation (see 2.10.5.1).

SUPPLEMENTARY or REINFORCED INSULATION between conductor layers in double-sided, single-layer printed boards, multi-layer printed boards, and metal core printed boards, shall have a minimum thickness of 0,4 mm or meet the requirements according to table 2M.

Table 2M – Insulation in printed boards

Insulation	Type tests[1]	ROUTINE TESTS for electric strength[3]
Two layers of sheet insulating material including pre-preg [2]	No	Yes
Three or more layers of sheet insulating material including pre-preg [2]	No	No
A ceramic coating that is cured at ≥ 500 °C	No	Yes
An insulation system, with two or more coatings, that is cured at < 500 °C	Yes	Yes

1) Thermal ageing and thermal cycling of 2.10.6 followed by the electric strength test of 5.2.2.

2) Layers of pre-preg are counted before curing.

3) Electric strength testing is carried out on the finished printed circuit board.

NOTE – Pre-preg is the term used for a layer of glass cloth impregnated with a partially cured resin.

Compliance is checked by inspection and measurement and by electric strength tests.

Where ROUTINE TESTS are required, the test voltage is the relevant test voltage of 5.2.2. The electric strength tests apply to the overall SUPPLEMENTARY or REINFORCED INSULATION.

2.10.5.4 Wound components

P U

Where BASIC, SUPPLEMENTARY, or REINFORCED INSULATION is required between windings, they shall be separated by interleaved insulation complying with 2.10.5.1 or 2.10.5.2, or both, unless one of the following wire constructions a), b) or c) is used.

a) Wire that has insulation, other than solvent-based enamel, complying with 2.10.5.1.

b) Wire that has multi-layer extruded or spirally wrapped insulation (where the layers can be individually tested for electric strength) complying with 2.10.5.2 and passes the tests of annex U.

c) Wire that has multi-layer extruded or spirally wrapped insulation (where only the finished wire can be tested) and passes the tests of annex U.

NOTE 1 – See also 6.2.1.

In 2.10.5.4 c), the minimum number of constructional layers applied to the conductor shall be as follows:

- BASIC INSULATION: two wrapped layers or one extruded layer;
- SUPPLEMENTARY INSULATION: two layers, wrapped or extruded;
- REINFORCED INSULATION: three layers, wrapped or extruded.

In 2.10.5.4 b) and 2.10.5.4 c), for spirally wrapped insulation where the CREEPAGE DISTANCES between layers, as wrapped, are less than those given in table 2L for pollution degree 1, the path between layers shall be sealed as for a cemented joint in 2.10.8 and the test voltages of the TYPE TESTS in clause U.2 are increased to 1,6 times their normal values.

NOTE 2 – One layer of material wound with more than 50 % overlap is considered to constitute two layers.

Where two insulated wires or one bare and one insulated wire are in contact inside the wound component, crossing each other at an angle between 45° and 90° and subject to winding tension, protection against mechanical stress shall be provided. This protection can be achieved, for example, by providing physical separation in the form of insulating sleeving or sheet material, or by using double the required number of insulation layers.

The finished component shall pass ROUTINE TESTS for electric strength using the appropriate values of test voltages in 5.2.2.

Compliance is checked by inspection and measurement, and if applicable, as specified in annex U. However, the tests of annex U are not repeated if the material data sheets confirm compliance.

2.10.6 Coated printed boards *R*

2.10.6.1 General

For printed boards whose surface conductors are coated with a suitable coating material, the minimum separation distances of table 2N are applicable to conductors before they are coated, subject to the following requirements.

Either one or both conductive parts and at least 80 % of the distances over the surface between the conductive parts shall be coated. Between any two uncoated conductive parts and over the outside of the coating, the minimum distances in tables 2H, 2J or 2K apply.

The values in table 2N shall be used only if manufacturing is subject to a quality control programme that provides at least the same level of assurance as the example given in annex R.1. In particular, DOUBLE and REINFORCED INSULATION shall be subject to ROUTINE TESTS for electric strength.

In default of the above conditions, the requirements of 2.10.1, 2.10.2, 2.10.3 and 2.10.4 shall apply.

The coating process, the coating material and the base material shall be such that uniform quality is assured and the separation distances under consideration are effectively protected.

Compliance is checked by measurement taking into account figure F.11, and by the following tests.

2.10.6.2 Sample preparation and preliminary inspection

Three sample boards (or, for 2.10.9, two components and one board) identified as samples 1, 2 and 3 are required. It is permitted to use either actual boards or specially produced samples with representative coating and minimum separations. Each sample board shall be representative of the minimum separations used, and coated. Each sample is subjected to the full sequence of manufacturing processes, including soldering and cleaning, to which it is normally subjected during equipment assembly.

When visually inspected, the boards shall show no evidence of pinholes or bubbles in the coating or breakthrough of conductive tracks at corners.

Table 2N – Minimum separation distances for coated printed boards

WORKING VOLTAGE V r.m.s. or d.c.				FUNCTIONAL, BASIC or SUPPLEMENTARY INSULATION mm	REINFORCED INSULATION mm
		up to and including	63	0,1	0,2
Over	63	up to and including	125	0,2	0,4
Over	125	up to and including	160	0,3	0,6
Over	160	up to and including	200	0,4	0,8
Over	200	up to and including	250	0,6	1,2
Over	250	up to and including	320	0,8	1,6
Over	320	up to and including	400	1,0	2,0
Over	400	up to and including	500	1,3	2,6
Over	500	up to and including	630	1,8	3,6
Over	630	up to and including	800	2,4	3,8
Over	800	up to and including	1 000	2,8	4,0
Over	1 000	up to and including	1 250	3,4	4,2
Over	1 250	up to and including	1 600	4,1	4,6
Over	1 600	up to and including	2 000	5,0	5,0
Over	2 000	up to and including	2 500	6,3	6,3
Over	2 500	up to and including	3 200	8,2	8,2
Over	3 200	up to and including	4 000	10	10
Over	4 000	up to and including	5 000	13	13
Over	5 000	up to and including	6 300	16	16
Over	6 300	up to and including	8 000	20	20
Over	8 000	up to and including	10 000	26	26
Over	10 000	up to and including	12 500	33	33
Over	12 500	up to and including	16 000	43	43
Over	16 000	up to and including	20 000	55	55
Over	20 000	up to and including	25 000	70	70
Over	25 000	up to and including	30 000	86	86

For voltages between 2 000 V and 30 000 V linear interpolation is permitted between the nearest two points, the calculated spacing being rounded up to the next higher 0,1 mm increment.

2.10.6.3 Thermal cycling

Sample 1 is subjected 10 times to the following sequence of temperature cycles:

68 h at T_1 *± 2 °C;*

1 h at 25 °C ± 2 °C;

2 h at 0 °C ± 2 °C;

not less than 1 h at 25 °C ± 2 °C.

$T_1 = T_2 + T_{mra} - T_{amb} + 10$ *K, measured in accordance with 1.4.5 and, where relevant, 1.4.13, or 100 °C, whichever is higher. However, the 10 K margin is not added if the temperature is measured by an embedded thermocouple.*

T_2 *is the temperature of the parts measured during the test of 4.5.1.*

The significances of T_{mra} *and* T_{amb} *are as given in 1.4.12.*

The period of time taken for the transition from one temperature to another is not specified, but the transition is permitted to be gradual.

2.10.6.4 Thermal ageing

Sample 2 shall be aged in a full draught oven at a temperature and for a time duration chosen from the graph of figure 2G using the temperature index line that corresponds to the maximum operating temperature of the coated board. The temperature of the oven shall be maintained at the specified temperature ± 2 °C. The temperature used to determine the temperature index line is the highest temperature on the board where safety is involved.

When using figure 2G, interpolation is permitted between the nearest two temperature index lines.

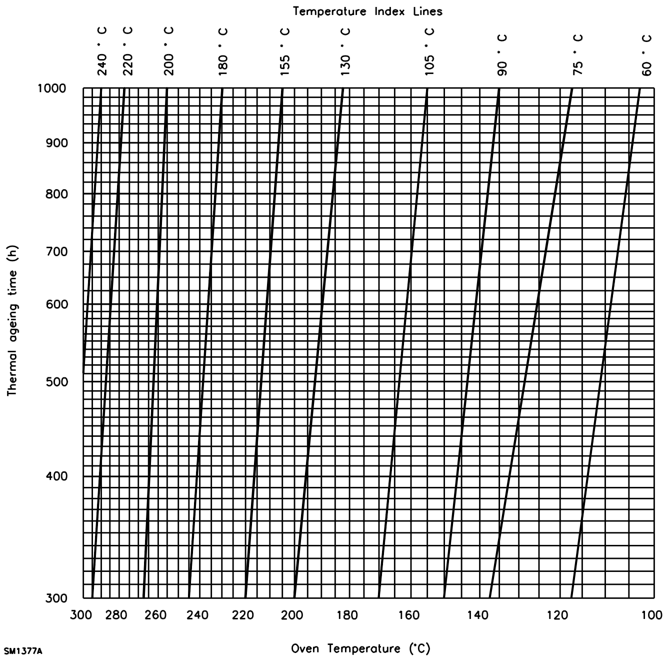


Figure 2G – Thermal ageing time

2.10.6.5 Electric strength test

Samples 1 and 2 are then subjected to the humidity conditioning of 2.9.2 (48 h) and shall withstand the relevant electric strength test of 5.2.2 between conductors.

2.10.6.6 Abrasion resistance test

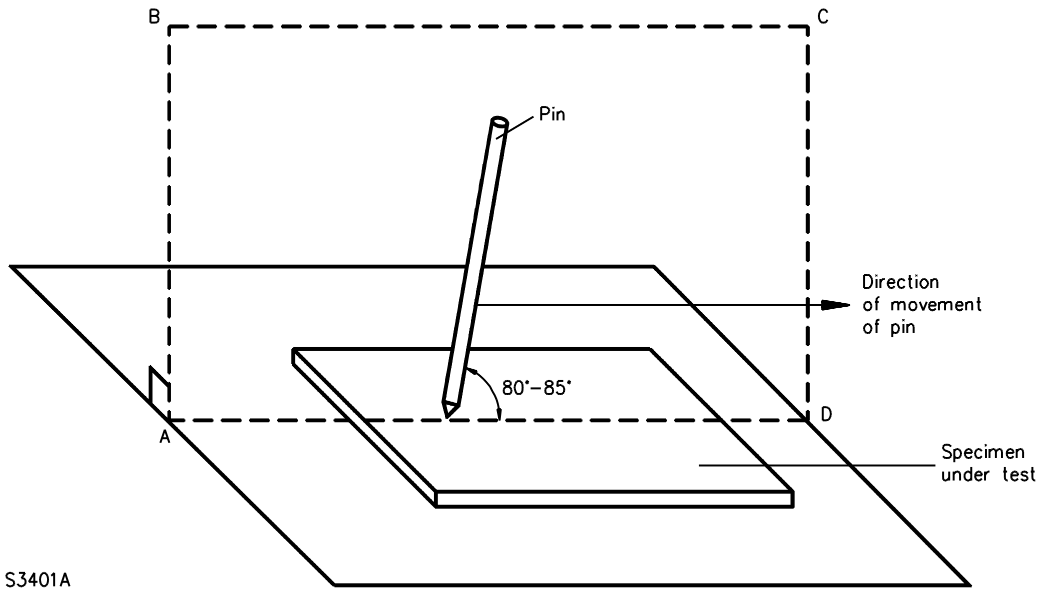
Sample board 3 is subjected to the following test.

Scratches are made across five pairs of conducting parts and the intervening separations at points where the separations will be subject to the maximum potential gradient during the tests.

The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a tip angle of 40°, its tip being rounded and polished, with a radius of 0,25 mm ± 0,02 mm.

Scratches are made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a speed of 20 mm/s ± 5 mm/s as shown in figure 2H. The pin is so loaded that the force exerted along its axis is 10 N ± 0,5 N. The scratches shall be at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the coating layer shall neither have loosened nor have been pierced and it shall withstand an electric strength test as specified in 5.2.2 between conductors. In the case of the metal core printed boards, the substrate is one of the conductors.



NOTE – The pin is in the plane ABCD which is perpendicular to the specimen under test.

Figure 2H – Abrasion resistance test for coating layers

2.10.7 Enclosed and sealed parts

For components or subassemblies which are adequately enclosed by enveloping or hermetic sealing to prevent ingress of dirt and moisture, the values for Pollution Degree 1 apply to internal CLEARANCES and CREEPAGE DISTANCES.

NOTE – Some examples of such construction include parts in boxes that are hermetically sealed by adhesive or otherwise, and parts enveloped in a dip coat.

Compliance is checked by inspection from the outside, measurement and, if necessary, by test. A component or subassembly is considered to be adequately enclosed if a sample passes the following sequence of tests.

The sample is subjected 10 times to the following sequence of temperature cycles:

68 h at T_1 ± 2 °C;

1 h at 25 °C ± 2 °C;

2 h at 0 °C ± 2 °C;

not less than 1 h at 25 °C ± 2 °C.

$T_1 = T_2 + T_{mra} - T_{amb}$ + 10 K, measured in accordance with 1.4.5 and, where relevant, 1.4.8, or 85 °C, whichever is higher. However, the 10 K margin is not added if the temperature is measured by an embedded thermocouple or by the resistance method.

T_2 is the temperature of the parts measured during the test of 4.5.1.

The significance of T_{mra} and T_{amb} is as given in 1.4.12.

The period of time taken for the transition from one temperature to another is not specified, but the transition is permitted to be gradual.

The sample is allowed to cool to room temperature and is subjected to the humidity conditioning of 2.9.2, followed immediately by the electric strength tests of 5.2.2.

For transformers, magnetic couplers and similar devices, where insulation is relied upon for safety, a voltage of 500 V r.m.s at 50 Hz to 60 Hz is applied between windings during the thermal cycling conditioning. No evidence of insulation breakdown shall occur during this test.

2.10.8 Spacings filled by insulating compound

Where distances between conductive parts are filled with insulating compound, including where insulation is reliably cemented together with insulating compound, so that CLEARANCES and CREEPAGE DISTANCES do not exist, only the requirements for distance through insulation of 2.10.5.1 apply.

NOTE 1 – Some examples of such treatment are variously known as potting, encapsulation and vacuum impregnation.

NOTE 2 – Acceptable forms of construction include:
- components or subassemblies which are treated with an insulating compound that fills voids; and
- internal insulation of multi-layer printed boards.

Compliance is checked by inspection, measurement and test. There is no measurement of CLEARANCES *and* CREEPAGE DISTANCES *if samples pass the thermal cycling, humidity conditioning and electric strength test specified in 2.10.7, applied as follows:*

- *for components where insulating compound forms solid insulation between conductive parts, a single finished component is tested. The tests are followed by inspection, including sectioning, and measurement. There shall be neither cracks nor voids in the insulating compound such as would affect compliance with 2.10.5.1.*

- *for components where insulating compound forms a cemented joint with other insulating parts, the reliability of the joint is checked by subjecting three samples to the electric strength tests applied directly to the cemented joint. If a winding of solvent-*

based enamelled wire is used in the component, it is replaced for the test by a metal foil or by a few turns of bare wire, placed closed to the cemented joint. The three samples are then tested as follows:

- *one of the samples is subjected to the relevant electric strength test of 5.2.2 immediately after the last period at highest temperature during thermal cycling, except that the test voltage is multiplied by 1,6;*

- *the other samples are subjected to the relevant electric strength test of 5.2.2 after the humidity conditioning, except that the test voltage is multiplied by 1,6.*

2.10.9 Component external terminations

The requirements of 2.10.1, 2.10.2, 2.10.3 and 2.10.4 are applicable to the spacings between external terminations of components unless they have a coating of material satisfying the requirements of 2.10.6 including the quality control requirements, an example of which is given in annex R.1. In such a case, the minimum separation distances of table 2N (see 2.10.6.1) apply to the component before coating. Between any two uncoated conductive parts and over the outside of the coating, the minimum distances of tables 2H, 2J, 2K and 2L shall be applied.

If coatings are used over terminations to increase effective CREEPAGE DISTANCES and CLEARANCES, the mechanical arrangement and rigidity of the terminations shall be adequate to ensure that, during normal handling, assembly into equipment and subsequent use, the terminations will not be subject to deformation which would crack the coating or reduce the separation distances between conductive parts below the values in table 2N (see 2.10.6.1).

Compliance is checked by inspection, taking into account figure F.10, and by applying the sequence covered by 2.10.6.2, 2.10.6.3, 2.10.6.4 and 2.10.6.5. This test is carried out on a completed assembly including the component(s).

The abrasion resistance test of 2.10.6.6 is carried out on a specially prepared sample printed board as described for sample 3 in 2.10.6.2, except that the separation between the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.

2.10.10 Insulation with varying dimensions

If the insulation of a transformer has different WORKING VOLTAGES along the length of the winding, it is permitted to vary CLEARANCES, CREEPAGE DISTANCES and distances through insulation accordingly.

NOTE – An example of such a construction is a 30 kV winding, consisting of multiple bobbins connected in series, and earthed at one end.

3 Wiring, connections and supply *P*

3.1 General

3.1.1 Current rating and overcurrent protection *NAE*

The cross-sectional area of internal wires and INTERCONNECTING CABLES shall be adequate for the current they are intended to carry when the equipment is operating under NORMAL LOAD such that the maximum permitted temperature of conductor insulation is not exceeded.

All internal wiring (including bus-bars) and INTERCONNECTING CABLES used in the distribution of
PRIMARY CIRCUIT power and all INTERCONNECTING CABLES shall be protected against overcurrent and D1
short circuit by suitably rated protective devices.

Wiring not directly involved in the distribution path does not require protection if it can be shown that hazards in the meaning of this standard are unlikely (e.g. indicating circuits).

Examples considered to comply with this requirement are: D1

- conductors provided with overcurrent protection in accordance with Article 240 of D1
  the National Electrical Code, ANSI/NFPA 70, and the Canadian Electrical Code, Part I, D1
  CSA C22.1, Section 14; D1

- internal conductors supplied by a power source that is limited to the output voltage D1
  and current values specified in table 2B or is limited to the output voltage values and D1
  provided with an overcurrent protective device with a RATED CURRENT value as specified D1
  in table 2C; D1

- INTERCONNECTING CABLES supplied by a limited power source (see 2.5); D1

- a 20-A protective device used with any size wire in the primary. D1

NOTE 1 – Devices for overload protection of components may also provide protection of associated wiring.

NOTE 2 – Internal circuits connected to the AC MAINS SUPPLY may require individual protection depending on reduced wire size and length of conductors.

Compliance is checked by inspection and, as appropriate, by the tests of 4.5.1 and/or 5.3. D1

3.1.2 Protection against mechanical damage

Wireways shall be smooth and free from sharp edges. Wires shall be protected so that they do not come into contact with burrs, cooling fins, moving parts, etc., which could cause damage to the insulation of conductors. Holes in metal, through which insulated wires pass, shall have smooth well-rounded surfaces or shall be provided with bushings.

It is permitted for wires to be in close contact with wire wrapping posts and the like if any breakdown of insulation will not create a hazard, or if adequate mechanical protection is provided by the insulation system.

Compliance is checked by inspection.

3.1.3 Securing of internal wiring

Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of:

- excessive strain on wire and on terminal connections; and
- loosening of terminal connections; and
- damage of conductor insulation.

Compliance is checked by inspection.

3.1.4 Insulation of conductors

Except as covered in 2.1.1.3 b), insulation of individual conductors of internal wiring shall fulfil the requirements of 2.10.5 and be capable of withstanding the applicable electric strength test specified in 5.2.2.

Where a power supply cord, whose insulating properties comply with those of the cord types of 3.2.5, is used inside the equipment, either as an extension of the external power supply cord or as an independent cable, the sheath of the power supply cord is considered to be adequate SUPPLEMENTARY INSULATION for the purpose of 3.1.4.

NOTE – Requirements regarding colours of insulation are in 2.6.3.4.

Compliance is checked by inspection and evaluation of test data showing that the insulation withstands the relevant test voltage.

If such applicable test data is not available, compliance is checked by applying the electric strength test using a sample of approximately 1 m in length and by applying the relevant test voltage as follows:

- *for insulation of a conductor: by the voltage test method given in clause 3 of IEC 60885-1, using the relevant test voltage in 5.2.2 in this standard for the grade of insulation under consideration; and*
- *for* SUPPLEMENTARY INSULATION *(e.g. sleeving around a group of conductors): between a conductor inserted into the sleeve and metal foil wrapped tightly round the sleeve for a length of at least 100 mm.*

3.1.5 Beads and ceramic insulators

Beads and similar ceramic insulators on conductors shall

- be so fixed or supported that they cannot change their position in such a way that a hazard would be created ; and
- not rest on sharp edges or sharp corners.

If beads are located inside flexible metal conduits, they shall be contained within an insulating sleeve, unless the conduit is mounted or secured in such a way that movement in normal use would not create a hazard.

Compliance is checked by inspection and, where necessary,by the following test.

A force of 10 N is applied to the insulators or to the conduit. The resulting movement, if any, shall not create a hazard in the meaning of this standard.

3.1.6 Screws for electrical contact pressure

Where electrical contact pressure is required, a screw shall engage at least two complete threads into a metal plate, a metal nut or a metal insert.

Screws of insulating material shall not be used where electrical connections, including protective earthing, are involved, or where their replacement by metal screws could impair SUPPLEMENTARY or REINFORCED INSULATION.

Where screws of insulating material contribute to other safety aspects, they shall be engaged by at least two complete threads.

NOTE – See also 2.6.5.7 for screws used for protective earthing continuity.

Compliance is checked by inspection.

3.1.7 Non-metallic materials in electrical connections

Electrical connections, including those for protective earthing functions (see 2.6), shall be so designed that contact pressure is not transmitted through insulating material unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

Compliance is checked by inspection.

3.1.8 Self-tapping and spaced thread screws

Spaced thread (sheet metal) screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other and are provided with a suitable means of locking.

Self-tapping (thread-cutting or thread-forming) screws shall not be used for the electrical connection of current- carrying parts, unless they generate a full form standard machine screw thread. Moreover, such screws shall not be used if they are operated by the USER or installer unless the thread is formed by a swaging action.

NOTE – See also 2.6.5.7 for screws used for protective earthing continuity.

Compliance is checked by inspection.

3.1.9 Termination of conductors

Conductors shall be provided with a means (e.g. barriers or fixing), or be so terminated, that they and their terminators (e.g. ring terminals, flat quick-connect terminals, etc.) cannot, in normal use, become so displaced that CLEARANCES or CREEPAGE DISTANCES are reduced to less than the values specified in 2.10.

It is permitted to use soldered, welded, crimped, screwless (push-in) and similar terminations for the connection of conductors. For soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position.

In multiway plugs and sockets, and wherever shorting could otherwise occur, means shall be provided to prevent contact between parts in SELV CIRCUITS or TNV CIRCUITS and parts at HAZARDOUS VOLTAGE due to loosening of a terminal or breaking of a wire at a termination.

Compliance is checked by inspection, by measurement and, where necessary, by the following test.

A force of 10 N is applied to the conductor near its termination point. The conductor shall not break away or pivot on its terminal to the extent that required CLEARANCE *or* CREEPAGE DISTANCES *are reduced below the values required in 2.10.*

For the purpose of assessing compliance it is assumed that:

- *two independent fixings will not become loose at the same time; and*
- *parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose.*

NOTE – Spring washers and the like can provide satisfactory locking.

Examples of constructions regarded as meeting the requirements include:

- *close-fitting tubing (e.g. a heat shrink or synthetic rubber sleeve), applied over the wire and its termination;*

- *conductors connected by soldering and held in place near to the termination, independently of the soldered connection;*

- *conductors connected by soldering and "hooked in" before soldering, provided that the hole through which the conductor is passed is not unduly large;*

- *conductors connected to screw terminals, with an additional fixing near to the terminal that clamps, in the case of stranded conductors, the insulation and not only the conductors;*

- *conductors connected to screw terminals and provided with terminators which are unlikely to become free (e.g. ring lugs crimped onto the conductors). The pivoting of such terminators is considered;*

- *short rigid conductors that remain in position when the terminal screw is loosened.*

3.1.10 Sleeving on wiring

Where sleeving is used as SUPPLEMENTARY INSULATION on internal wiring, it shall be retained in position by positive means.

Compliance is checked by inspection.

Examples of constructions that are considered to meet the intent of this requirement include:

- *sleeving that can be removed only by breaking or cutting of either the wiring or sleeving;*

- *sleeving that is clamped at both ends;*

- *heat shrinkable sleeving that tightens against the wire insulation;*

- *sleeving that is of such length that it will not slip.*

3.2 Connection to a.c. mains supplies ***NAE***

3.2.1 Means of connection ***P***

For safe and reliable connection to an AC MAINS SUPPLY, equipment shall be provided with one of the following: ***NAE***

- terminals for permanent connection to the supply;

- a NON-DETACHABLE POWER SUPPLY CORD ~~for permanent connection to the supply, or~~ for connection to the supply by means of a plug; D1

NOTE – In the United Kingdom, it is required to fit a plug conforming to BS 1363 to the power supply cord of certain equipment.

- an appliance inlet for connection of a DETACHABLE POWER SUPPLY CORD;

- a mains plug that is part of DIRECT PLUG-IN EQUIPMENT.

Where equipment is intended to be connected to a standard U.S. or Canadian source of supply D1
by a power supply cord, the attachment plug shall be rated not less than 125 % of the RATED D1
CURRENT of the equipment at the nominal system voltage range as defined by the configuration of D1
the plug. D1

Compliance is checked by inspection.

3.2.2 Multiple supply connections

If equipment is provided with more than one supply connection (e.g. with different voltages or frequencies or as backup power), the design shall be such that all of the following conditions are met:

- separate means of connection are provided for different circuits; and
- supply plug connections, if any, are not interchangeable if a hazard could be created by incorrect plugging; and
- bare parts of an ELV CIRCUIT or parts at HAZARDOUS VOLTAGES, such as plug contacts, are not accessible to an OPERATOR when one or more connectors are disconnected.

Compliance is checked by inspection and for accessibility, where necessary, by a test with the test finger, of figure 2A (see 2.1.1.1).

3.2.3 Permanently connected equipment ***NAA NAE***

PERMANENTLY CONNECTED EQUIPMENT shall be provided with ~~either~~: DE

- a set of terminals as specified in 3.3, ~~or~~ D1
- ~~– a NON-DETACHABLE POWER SUPPLY CORD~~. D1

PERMANENTLY CONNECTED EQUIPMENT ~~having a set of terminals~~ shall: D1

- permit the connection of the supply wires after the equipment has been fixed to its support; and
- be provided with cable entries, conduit entries, knock-outs or glands, which allow connection of the appropriate types of cables or conduits.

For equipment having a RATED CURRENT not exceeding 16 A, the cable entries shall be suitable for cables and conduits having an overall diameter as shown in table 3A.

NOTE 1 – In some countries the sizes of conduit in parentheses are required.

NOTE 2 – In Australia, additional requirements apply.

Conduit and cable entries and knock-outs for supply connections shall be so designed or located that the introduction of the conduit and cable does not affect the protection against electric shock, or reduce CLEARANCES and CREEPAGE DISTANCES below the values specified in 2.10.

Compliance is checked by inspection, by a practical installation test and by measurement.

Table 3A – Sizes of cables and conduits for equipment having a rated current not exceeding 16 A

Numbers of conductors, including the PROTECTIVE EARTHING CONDUCTOR where provided	Overall diameter (mm)		
	Cable	Conduit	
2	13,0	16,0	(23,0)
3	14,0	16,0	(23,0)
4	14,5	20,0	(29,0)
5	15,5	20,0	(29,0)

3.2.4 Appliance inlets

Appliance inlets shall meet all of the following:

- be so located or enclosed that parts at HAZARDOUS VOLTAGE are not accessible during insertion or removal of the connector (appliance inlets complying with IEC 60309 or with IEC 60320 are considered to comply with this requirement); and

- be so located that the connector can be inserted without difficulty; and

- be so located that, after insertion of the connector, the equipment is not supported by the connector for any position of normal use on a flat surface.

Compliance is checked by inspection and, for accessibility, by means of the test finger, figure 2A (see 2.1.1.1).

3.2.5 Power supply cords

P
NAE

A power supply cord for connection to the AC MAINS SUPPLY shall comply with all of the following, as appropriate:

- if rubber insulated, be of synthetic rubber and not lighter than ordinary tough rubber-sheathed flexible cord according to IEC 60245 (designation 60245 IEC 53); and

- if PVC insulated:

    - for equipment provided with a NON-DETACHABLE POWER SUPPLY CORD and having a mass not exceeding 3 kg, be not lighter than light PVC sheathed flexible cord according to IEC 60227 (designation 60227 IEC 52);

    - for equipment provided with a NON-DETACHABLE POWER SUPPLY CORD and having a mass exceeding 3 kg, be not lighter than ordinary PVC sheathed flexible cord IEC 60227 (designation 60227 IEC 53);

    - for equipment provided with a DETACHABLE POWER SUPPLY CORD, be not lighter than light PVC sheathed flexible cord IEC 60227 (designation 60227 IEC 52); and

    NOTE 1 – There is no limit on the mass of the equipment if the equipment is intended for use with a DETACHABLE POWER SUPPLY CORD.

- include, for equipment required to have protective earthing, a PROTECTIVE EARTHING CONDUCTOR having green-and-yellow insulation; and

- have conductors with cross-sectional areas not less than those specified in table 3B.

NOTE 2 – In Australia, additional requirements apply.

Compliance is checked by inspection and by measurement. In addition, for screened cords, compliance is checked by the tests of IEC 60227. However, flexing tests need be applied only to screened power supply cords for MOVABLE EQUIPMENT.

NOTE 3 – Although screened cords are not covered in the scope of IEC 60227, the relevant tests of IEC 60227 are used.

Damage to the screen is acceptable provided that:

- *during the flexing test the screen does not make contact with any conductor; and*

- *after the flexing test, the sample withstands the electric strength test between the screen and all other conductors.*

Table 3B – Sizes of conductors

RATED CURRENT of equipment A				**Minimum conductor sizes**	
				Nominal cross-sectional area mm^2	**AWG or kcmil [cross-sectional area in mm^2] see note 2**
		Up to and including	6	0,75 1)	18 [0,8]
Over	6	up to and including	10	(0,75) 2) 1,00	16 [1,3]
Over	10	up to and including	13	(1,0) 3) 1,25	16 [1,3]
Over	13	up to and including	16	(1,0) 3) 1,5	14 [2]
Over	16	up to and including	25	2,5	12 [3]
Over	25	up to and including	32	4	10 [5]
Over	32	up to and including	40	6	8 [8]
Over	40	up to and including	63	10	6 [13]
Over	63	up to and including	80	16	4 [21]
Over	80	up to and including	100	25	2 [33]
Over	100	up to and including	125	35	1 [42]
Over	125	up to and including	160	50	0 [53]
Over	160	up to and including	190	70	000 [85]
Over	190	up to and including	230	95	0000 [107]
Over	230	up to and including	260	120	250 kcmil [126]
Over	260	up to and including	300	150	300 kcmil [152]
Over	300	up to and including	340	185	400 kcmil [202]
Over	340	up to and including	400	240	500 kcmil [253]
Over	400	up to and including	460	300	600 kcmil [304]

1) For RATED CURRENT up to 3 A , a nominal cross-sectional area of 0,5 mm^2 is permitted in some countries provided the length of cord does not exceed 2 m.

Table 3B – Sizes of conductors Continued on Next Page

Table 3B – Sizes of conductors Continued

<table>
<tr><th rowspan="2">RATED CURRENT of equipment
A</th><th colspan="2">Minimum conductor sizes</th></tr>
<tr><th>Nominal cross-sectional area
mm^2</th><th>AWG or kcmil [cross-sectional area in mm^2]
see note 2</th></tr>
<tr><td colspan="3">2) The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 10 A in accordance with IEC 60320 (types C13, C15, C15A, and C17) provided that the length of the cord does not exceed 2 m.
3) The value in parentheses applies to DETACHABLE POWER SUPPLY CORDS fitted with the connectors rated 16 A in accordance with IEC 60320 (types C19, C21, and C23) provided that the length of the cord does not exceed 2 m.</td></tr>
<tr><td colspan="3">NOTE 1 – IEC 60320 specifies acceptable combinations of appliance couplers and flexible cords, including those covered by items 1), 2), and 3). However, a number of countries have indicated that they do not accept all of the values listed in table 3B, particularly those covered by conditions 1), 2), and 3).
NOTE 2 – AWG and kcmil sizes are provided for information only. The associated cross-sectional areas, in square brackets, have been rounded to show significant figures only. AWG refers to the American Wire Gage and the term ″cmil″ refers to circular mils where one circular mil is equal to the area of a circle having a diameter of one mil (one thousandth of an inch). These terms are commonly used to designate wire sizes in North America.</td></tr>
</table>

3.2.6 Cord anchorages and strain relief

For equipment with a NON-DETACHABLE POWER SUPPLY CORD, a cord anchorage shall be supplied such that:

- the connecting points of the cord conductors are relieved from strain; and
- the outer covering of the cord is protected from abrasion.

It shall not be possible to push the cord back into the equipment to such an extent that the cord or its conductors, or both, could be damaged or internal parts of the equipment could be displaced.

For NON-DETACHABLE POWER SUPPLY CORDS containing a PROTECTIVE EARTHING CONDUCTOR, the construction shall be such that if the cord should slip in its anchorage, placing a strain on conductors, the PROTECTIVE EARTHING CONDUCTOR will be the last to take the strain.

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for SUPPLEMENTARY INSULATION. However, where the cord anchorage is a bushing that includes the electrical connection to the screen of a screened power cord, this requirement shall not apply. The construction of the cord anchorage shall be such that:

- cord replacement does not impair the safety of the equipment; and
- for ordinary replacement cords, it is clear how relief from strain is to be obtained; and
- the cord is not clamped by a screw which bears directly on the cord, unless the cord anchorage, including the screw, is made of insulating material and the screw is of comparable size to the diameter of the cord being clamped; and
- methods such as tying the cord into a knot or tying the cord with a string are not used; and

– the cord cannot rotate in relation to the body of the equipment to such an extent that mechanical strain is imposed on the electrical connections.

INTERCONNECTING CABLES shall be provided with strain relief unless strain relief is provided as part of the equipment. Where disconnection or breaking of wiring at the connections will not result in a hazard, strain relief need not be provided, for example, in a limited power circuit where breaking of a connection will not result in a reduction of CREEPAGE DISTANCE or CLEARANCE. D1 D1 D1 D1

Compliance is checked by inspection and by applying the following tests which are made with the type of power supply cord supplied with the equipment.

The cord is subjected to a steady pull of the value shown in table 3C, applied in the most unfavourable direction. The test is conducted 25 times, each time for a duration of 1 s.

During the tests, the power supply cord shall not be damaged. This is checked by visual inspection, and by an electric strength test between the power cord conductors and accessible conductive parts, at the test voltage appropriate for REINFORCED INSULATION.

After the tests, the power supply cord shall not have been longitudinally displaced by more than 2 mm nor shall there be appreciable strain at the connections, and CLEARANCES and CREEPAGE DISTANCES shall not be reduced below the values specified in 2.10.

Table 3C – Physical tests on power supply cords

Mass (M) of the equipment kg	Pull N
$M \le 1$	30
$1 < M \le 4$	60
$M > 4$	100

3.2.7 Protection against mechanical damage

Power supply cords shall not be exposed to sharp points or cutting edges within or on the surface of the equipment, or at the inlet opening or inlet bushing.

The overall sheath of a NON-DETACHABLE POWER SUPPLY CORD shall continue into the equipment through any inlet bushing or cord guard and shall extend by at least half the cord diameter beyond the clamp of the cord anchorage.

Inlet bushings, where used, shall:

- be reliably fixed; and
- not be removable without the use of a TOOL.

An inlet bushing in a non-metallic ENCLOSURE shall be of insulating material.

An inlet bushing or cord guard secured to a conductive part that is not protectively earthed shall meet the requirements for SUPPLEMENTARY INSULATION.

Compliance is checked by inspection and measurement.

3.2.8 Cord guards

A cord guard shall be provided at the power supply cord inlet opening of equipment which has a NON-DETACHABLE POWER SUPPLY CORD, and which is hand-held or intended to be moved while in operation. Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 1,5 times the overall diameter of the cord with the largest cross-sectional area to be connected.

Cord guards shall:

– be so designed as to protect the cord against excessive bending where it enters the equipment; and

– be of insulating material; and

– be fixed in a reliable manner; and

– project outside the equipment beyond the inlet opening for a distance of at least five times the overall diameter or, for flat cords, at least five times the major overall cross-sectional dimension of the cord.

Compliance is checked by inspection, by measurement and, where necessary, by the following test with the cord as delivered with the equipment.

The equipment is so placed that the axis of the cord guard, where the cord leaves it, projects at an angle of 45° when the cord is free from stress. A mass equal to $10 \times D^2$*g is then attached to the free end of the cord, where D is the overall diameter of, or for flat cords, the minor overall dimension of the cord, in millimetres.*

If the cord guard is of temperature-sensitive material, the test is made at 23 °C ± 2 °C.

Flat cords are bent in the plane of least resistance.

Immediately after the mass has been attached, the radius of curvature of the cord shall nowhere be less than 1,5 D.

3.2.9 Supply wiring space

NAE

The supply wiring space provided inside, or as part of, the equipment for permanent connection or for connection of ordinary NON-DETACHABLE POWER SUPPLY CORDS shall be designed:

- to allow the conductors to be introduced and connected easily; and
- so that the uninsulated end of a conductor is unlikely to become free from its terminal, or, should it do so, cannot come into contact with:
  - an accessible conductive part that is not protectively earthed; or
  - an accessible conductive part of HAND-HELD EQUIPMENT; and
- to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned; and
- so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation; and
- so that covers, if any, giving access to the terminals can be removed with a commonly available TOOL.

Compliance is checked by inspection and by an installation test with cords of the largest cross-sectional area of the appropriate range specified in 3.3.4.

3.3 Wiring terminals for connection of external conductors

P
NAE

Subclause 3.3 specifies requirements for wiring terminals used for the connection of AC MAINS SUPPLY conductors and the PROTECTIVE EARTHING CONDUCTOR to the equipment.

3.3.1 Wiring terminals

NAE

PERMANENTLY CONNECTED EQUIPMENT and equipment with ordinary NON-DETACHABLE POWER SUPPLY CORDS shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices (see also 2.6.4).

Compliance is checked by inspection.

3.3.2 Connection of non-detachable power supply cords

For equipment with special NON-DETACHABLE POWER SUPPLY CORDS, the connection of the individual conductors to the internal wiring of the equipment shall be accomplished by any means that will provide a reliable electrical and mechanical connection without exceeding the permitted temperature limits while the equipment is operated under NORMAL LOAD. (See also 3.1.9).

Compliance is checked by inspection and by measuring the temperature rise of the connection which shall not exceed the values of 4.5.1.

3.3.3 Screw terminals *NAE*

Screws and nuts which clamp external power supply conductors shall have a thread conforming with ISO 261 or ISO 262, or a thread comparable in pitch and mechanical strength (e.g. unified threads). The screws and nuts shall not serve to fix any other component, except that they are permitted also to clamp internal conductors provided that the internal conductors are so arranged that they are unlikely to be displaced when fitting the supply conductors. For protective earthing terminals, see also 2.6.4.1.

The terminals of a component (e.g. a switch) built into the equipment are permitted for use as terminals for external power supply conductors, provided that they comply with the requirements of 3.3.

Compliance is checked by inspection.

3.3.4 Conductor sizes to be connected *NAE*

Terminals shall allow the connection of conductors having nominal cross-sectional areas ~~as~~ D1
~~shown in table 3D.~~ in accordance with annex NAE. D1

Where heavier gauge conductors are used, the terminals shall be sized accordingly.

Compliance is checked by inspection, by measurement and by fitting cords of the smallest and largest cross-sectional areas of the appropriate range. ~~shown in table 3D.~~ D1

~~Table 3D – Range of conductor sizes to be accepted by terminals~~ D1

~~RATED CURRENT of equipment~~ ~~A~~	~~Nominal cross-sectional area~~ ~~mm^2~~						
	~~Flexible cords~~			~~Other cables~~			D1
~~Up to and including 3~~	~~0,5~~	~~to~~	~~0,75~~	~~1~~	~~to~~	~~2,5~~	D1
~~Over 3 up to and including 6~~	~~0,75~~	~~to~~	~~1~~	~~1~~	~~to~~	~~2,5~~	D1
~~Over 6 up to and including 10~~	~~1~~	~~to~~	~~1,5~~	~~1~~	~~to~~	~~2,5~~	D1
~~Over 10 up to and including 13~~	~~1,25~~	~~to~~	~~1,5~~	~~1,5~~	~~to~~	~~4~~	D1
~~Over 13 up to and including 16~~	~~1,5~~	~~to~~	~~2,5~~	~~1,5~~	~~to~~	~~4~~	D1
~~Over 16 up to and including 25~~	~~2,5~~	~~to~~	~~4~~	~~2,5~~	~~to~~	~~6~~	D1
~~Over 25 up to and including 32~~	~~4~~	~~to~~	~~6~~	~~4~~	~~to~~	~~10~~	D1
~~Over 32 up to and including 40~~	~~6~~	~~to~~	~~10~~	~~6~~	~~to~~	~~16~~	D1
~~Over 40 up to and including 63~~	~~10~~	~~to~~	~~16~~	~~10~~	~~to~~	~~25~~	D1

3.3.5 Wiring terminal sizes

Wiring terminals shall comply with the minimum sizes in table 3E.

Compliance is checked by inspection and measurement.

Table 3E – Sizes of terminals for a.c. mains supply conductors and protective earthing conductors

RATED CURRENT of equipment A	Minimum nominal thread diameter mm	
	Pillar type or stud type	Screw type[1)]
Up to and including 10	3,0	3,5
Over 10 up to and including 16	3,5	4,0
Over 16 up to and including 25	4,0	5,0
Over 25 up to and including 32	4,0	5,0
Over 32 up to and including 40	5,0	5,0
Over 40 up to and including 63	6,0	6,0

[1)] ″Screw type″ refers to a terminal that clamps the conductor under the head of a screw, with or without a washer.

3.3.6 Wiring terminal design

NAA
NAE

Wiring terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without damage to the conductor.

Terminals shall be so designed or located that the conductor cannot slip out when the clamping screws or nuts are tightened.

Terminals shall be provided with appropriate fixing hardware for the conductors (e.g. nuts and washers).

Terminals shall be so fixed that, when the means of clamping the conductor is tightened or loosened:

– the terminal itself does not work loose; and

– internal wiring is not subjected to stress; and

– CLEARANCES and CREEPAGE DISTANCES are not reduced below the values specified in 2.10.

Compliance is checked by inspection and measurement.

3.3.7 Grouping of wiring terminals

For ordinary NON-DETACHABLE POWER SUPPLY CORDSand for PERMANENTLY CONNECTED EQUIPMENT, all associated AC MAINS SUPPLY terminals shall be located in proximity to each other and to the main protective earthing terminal, if any.

Compliance is checked by inspection.

3.3.8 Stranded wire

NAA

The end of a stranded conductor shall not be consolidated by soft soldering at places where the conductor is subject to contact pressure unless the method of clamping is designed so as to reduce the likelihood of a bad contact due to cold flow of the solder.

Spring terminals that compensate for the cold flow are deemed to satisfy this requirement.

Preventing the clamping screws from rotating is not considered to be adequate.

Terminals shall be located, guarded or insulated so that, should a strand of a flexible conductor escape when the conductor is fitted, there is no likelihood of accidental contact between such a strand and:

– accessible conductive parts; or

– unearthed conductive parts separated from accessible conductive parts by SUPPLEMENTARY INSULATION only.

Compliance is checked by inspection and, unless a special cord is prepared in such a way as to prevent the escape of strands, by the following test.

A piece of insulation approximately 8 mm long is removed from the end of a flexible conductor having the appropriate nominal cross-sectional area. One wire of the stranded conductor is left free and the other wires are fully inserted into, and clamped in, the terminal.

Without tearing the insulation back, the free wire is bent in every possible direction, but without making sharp bends around the guard.

If the conductor is at HAZARDOUS VOLTAGE, the free wire shall not touch any conductive part which is accessible or is connected to an accessible conductive part or, in the case of DOUBLE INSULATED equipment, any conductive part which is separated from accessible conductive parts by SUPPLEMENTARY INSULATION only.

If the conductor is connected to an earthing terminal, the free wire shall not touch any part at HAZARDOUS VOLTAGE.

3.4 Disconnection from the a.c. mains supply *P*

3.4.1 General requirement

A disconnect device or devices shall be provided to disconnect the equipment from the AC MAINS SUPPLY for servicing.

Compliance is checked by inspection.

3.4.2 Disconnect devices *NAE*

Disconnect devices shall have a contact separation of at least 3 mm and, when incorporated in the equipment, shall be connected as closely as practicable to the incoming supply.

Functional switches are permitted to serve as disconnect devices provided that they comply with all the requirements for disconnect devices. However, these requirements do not apply to functional switches where other means of isolation are provided.

The following types of disconnect devices are permitted:

- the plug on the power supply cord;
- a mains plug that is part of DIRECT PLUG-IN EQUIPMENT;
- an appliance coupler;
- isolating switches;
- circuit breakers;
- any equivalent device.

NOTE – Some disconnect devices complying with IEC 61058-1 are examples of those considered to comply with the requirements of this standard.

Compliance is checked by inspection.

3.4.3 Permanently connected equipment

For PERMANENTLY CONNECTED EQUIPMENT the disconnect device shall be incorporated in the equipment, unless the equipment is accompanied by installation instructions in accordance with 1.7.2, stating that an appropriate disconnect device shall be provided as part of the building installation.

NOTE – External disconnect devices will not necessarily be supplied with the equipment.

Compliance is checked by inspection.

3.4.4 Parts which remain energized

Parts on the supply side of a disconnect device in the equipment, which remain energized when the disconnect device is switched off, shall be guarded so as to reduce the likelihood of accidental contact by SERVICE PERSONNEL.

Compliance is checked by inspection.

3.4.5 Switches in flexible cords

Isolating switches shall not be fitted in flexible cords.

Compliance is checked by inspection.

3.4.6 Single-phase equipment

For single-phase equipment, the disconnect device shall disconnect both poles simultaneously, except that a single-pole disconnect device can be used to disconnect the line conductor where it is possible to rely on the identification of the neutral in the AC MAINS SUPPLY.

For equipment provided with a single-pole disconnect device, the installation instructions shall specify that an additional two-pole disconnect device is to be provided in the building installation if the equipment is used where identification of the neutral in the AC MAINS SUPPLY is not possible.

NOTE – Three examples of cases where a two-pole disconnect device is required are:

- on equipment supplied from an IT power system;
- on PLUGGABLE EQUIPMENT supplied through a reversible appliance coupler or a reversible plug (unless the appliance coupler or plug itself is used as the disconnect device);
- on equipment supplied from a socket-outlet with indeterminate polarity.

Compliance is checked by inspection.

3.4.7 Three-phase equipment

For three-phase equipment, the disconnect device shall disconnect simultaneously all line conductors of the AC MAINS SUPPLY.

For equipment requiring a neutral connection to an IT power system, the disconnect device shall be a four-pole device and shall disconnect all line conductors and the neutral conductor. If this four-pole device is not provided in the equipment, the installation instructions shall specify the need for the provision of the device as part of the building installation.

If a disconnect device interrupts the neutral conductor, it shall simultaneously interrupt all line conductors.

Compliance is checked by inspection.

3.4.8 Switches as disconnect devices ***NAE***

Where the disconnect device is a switch incorporated in the equipment, its ″ON″ and ″OFF″ positions shall be marked in accordance with 1.7.8.

Compliance is checked by inspection.

3.4.9 Plugs as disconnect devices

Where a plug on the power supply cord is used as the disconnect device, the installation instructions shall comply with 1.7.2.

Compliance is checked by inspection.

3.4.10 Interconnected equipment ***NAE***

Where a group of units having individual supply connections is interconnected in such a way that it is possible for HAZARDOUS VOLTAGE or HAZARDOUS ENERGY LEVELS to be transmitted between units, a disconnect device shall be provided to disconnect hazardous parts likely to be contacted while the unit under consideration is being serviced, unless these parts are guarded and marked with appropriate warning labels. In addition a prominent label shall be provided on each unit giving adequate instructions for the removal of all such power from the unit.

Compliance is checked by inspection.

3.4.11 Multiple power sources

Where a unit receives power from more than one source (e.g. different voltages or frequencies or as backup power), there shall be a prominent marking at each disconnect device giving adequate instructions for the removal of all power from the unit.

Compliance is checked by inspection.

3.5 Interconnection of equipment

3.5.1 General requirements

Where equipment is intended to be electrically connected to other equipment, interconnection circuits shall be selected to provide continued conformance to the requirements of 2.2 for SELV CIRCUITS, and with the requirements of clause 2.3 for TNV CIRCUITS, after making connections.

NOTE 1 – This is normally achieved by connecting SELV CIRCUITS to SELV CIRCUITS, and TNV CIRCUITS to TNV CIRCUITS.

NOTE 2 – It is permitted for an INTERCONNECTING CABLE to carry more than one type of CIRCUIT (e.g. SELV, LIMITED CURRENT, TNV, ELV or HAZARDOUS VOLTAGE) provided that they are separated as required by this standard.

3.5.2 Types of interconnection circuits

Each interconnection circuit shall be one of the following types:

- – an SELV CIRCUIT or a LIMITED CURRENT CIRCUIT; or
- – a TNV-1, TNV-2 or TNV-3; or
- – a HAZARDOUS VOLTAGE circuit.

Except as permitted in 3.5.3, interconnection circuits shall not be ELV CIRCUITS.

Compliance is checked by inspection.

3.5.3 ELV circuits as interconnection circuits **NAE**

Where additional equipment is specifically complementary to the host (first) equipment (e.g. a collator for a copying machine) ELV CIRCUITS are permitted as interconnection circuits between the equipments, provided that the equipments continue to meet the requirements of this standard when connected together.

Compliance is checked by inspection.

3.6 Special considerations for equipment connected to a centralized d.c. power system – DC mains voltages D2 D2 **NAA NAB NAE**

DC mains voltages are considered SECONDARY CIRCUITS and are characterized as either SELV D2
CIRCUITS or HAZARDOUS VOLTAGE circuits depending on the maximum operating voltage (including the D2
″float voltage″) of the source. D2

For the purpose of applying insulation requirements, d.c. mains voltages are treated as: D2

– SELV CIRCUIT	up to 60 V	D2
– TNV 2 CIRCUIT	> 60 V up to and including 80 V	D2
– HAZARDOUS VOLTAGE	> 80 V	D2

These circuits are not current limited to TNV CIRCUIT limits when providing power for centralized D2
d.c. equipment but shall be appropriately current limited when connected to a TELECOMMUNICATION D2
NETWORK. D2

See annex NAB for additional requirements that apply to centralized d.c. power systems. D2 **NAB**

4 Physical requirements

4.1 Stability

4.1.1 Under conditions of normal use, units and equipment shall not become physically unstable to the degree that they could become a hazard to OPERATORS and SERVICE PERSONNEL. ***NAA***

If units are designed to be fixed together on site and not used individually, the stability of each individual unit is exempt from the requirements of 4.1.

The requirements of 4.1 are not applicable when the installation instructions for a unit specify that the equipment is to be secured to the building structure before operation.

Under conditions of OPERATOR use, a stabilizing means, if needed, shall be automatic in operation when drawers, doors, etc., are opened.

During operations performed by SERVICE PERSONNEL, the stabilizing means, if needed, shall either be automatic in operation, or a marking shall be provided to instruct SERVICE PERSONNEL to deploy the stabilizing means.

Compliance is checked by the following tests, where relevant. Each test is carried out separately. During the tests, containers are to contain the amount of substance within their rated capacity producing the most disadvantageous condition. All castors and jacks, if used in normal operation, are placed in their most unfavourable position, with wheels and the like locked or blocked. However, if the castors are intended only to transport the unit, and if the installation instructions require jacks to be lowered after installation, then the jacks (and not the castors) are used in this test; the jacks are placed in their most unfavourable position, consistent with reasonable levelling of the unit.

- *A unit shall not overbalance when tilted to an angle of 10 ° from its normal upright position. Doors, drawers, etc. are closed during this test.*

- *A floor-standing unit having a mass of 25 kg or more shall not tip over when a force equal to 20 % of the weight of the unit, but not more than 250 N, is applied in any direction except upwards, at a height not exceeding 2 m from the floor. Doors drawers, etc. which may be moved for servicing by the OPERATOR or by SERVICE PERSONNEL, are placed in their most unfavourable position, consistent with the installation instructions.*

- *A floor-standing unit shall not overbalance when a constant downward force of 800 N is applied at the point of maximum moment to any horizontal surface of at least 12,5 cm by at least 20 cm, at a height up to 1 m from the floor. Doors, drawers, etc. are closed during this test. The 800 N force is applied by means of a suitable test tool having a flat surface of approximately 12,5 cm by 20 cm. The downward force is applied with the complete flat surface of the test tool in contact with the EUT; the test tool need not be in full contact with uneven surfaces, e.g. corrugated or curved surfaces.*

4.2 Mechanical strength **P**

4.2.1 General

Equipment shall have adequate mechanical strength and shall be so constructed as to remain safe in the meaning of this standard when subjected to handling as may be expected.

Mechanical strength tests are not required on an internal barrier, screen or the like, provided to meet the requirements of 4.6.2, if the ENCLOSURE provides mechanical protection.

A MECHANICAL ENCLOSURE shall be sufficiently complete to contain or deflect parts which, because of failure or for other reasons, might become loose, separated or thrown from a moving part.

Compliance is checked by inspection of the construction and available data and, where necessary, by the relevant tests of 4.2.2 to 4.2.7 as specified

The tests are not applied to handles, levers, knobs, the face of cathode ray tubes (see 4.2.8), or to transparent or translucent covers of indicating or measuring devices unless parts at HAZARDOUS VOLTAGE are accessible by means of the test finger, of figure 2A (see 2.1.1.1), if the handle, lever, knob or cover is removed.

During the tests of 4.2.2, 4.2.3 and 4.2.4, earthed or unearthed conductive ENCLOSURES shall not bridge parts between which a HAZARDOUS ENERGY LEVEL exists and shall not contact a bare part at HAZARDOUS VOLTAGE. For voltages exceeding 1 000 V a.c. or 1 500 V d.c., contact is not permitted and there shall be an air gap between the part at HAZARDOUS VOLTAGE and the ENCLOSURE. This air gap shall either have a minimum length equal to the minimum CLEARANCE specified in 2.10.3 for BASIC INSULATION or withstand the relevant electric strength test in 5.2.2.

After the tests of 4.2.2 to 4.2.7, the sample shall continue to comply with the requirements of 2.1.1, 2.6.1, 2.10, 3.2.6 and 4.4.1. It shall show no signs of interference with the operation of safety features such as THERMAL CUT-OUTS, overcurrent protection devices or interlocks. In case of doubt, SUPPLEMENTARY or REINFORCED INSULATION is subjected to an electric strength test as specified in 5.2.2.

Damage to finish, cracks, dents and chips are disregarded if they do not adversely affect safety.

NOTE – If a separate ENCLOSURE or part of an ENCLOSURE is used for a test, it may be necessary to reassemble such parts on the equipment in order to check compliance.

4.2.2 Steady force test, 10 N

Components and parts, other than parts serving as an ENCLOSURE *(see 4.2.3 and 4.2.4), are subjected to a steady force of 10 N ± 1 N.*

Compliance criteria are in 4.2.1.

4.2.3 Steady force test, 30 N

Parts of an ENCLOSURE *located in an* OPERATOR ACCESS AREA*, which are protected by a cover or door meeting the requirements of 4.2.4, are subjected to a steady force of 30 N ±3 N for a period of 5 s, applied by means of a straight unjointed version of the test finger, of figure 2A (see 2.1.1.1), to the part on or within the equipment.*

Compliance criteria are in 4.2.1.

4.2.4 Steady force test, 250 N

External ENCLOSURES *are subjected to a steady force of 250 N ± 10 N for a period of 5 s, applied in turn to the top, bottom and sides of the* ENCLOSURE *fitted to the equipment, by means of a suitable test tool providing contact over a circular plane surface 30 mm in diameter. However, this test is not applied to the bottom of an* ENCLOSURE *of equipment having a mass of more than 18 kg.*

Compliance criteria are in 4.2.1.

4.2.5 Impact test

Except for equipment identified in 4.2.6, external surfaces of ENCLOSURES*, the failure of which would give access to hazardous parts, are tested as follows:*

A sample consisting of the complete ENCLOSURE *or a portion thereof representing the largest unreinforced area is supported in its normal position. A solid smooth steel ball, approximately 50 mm in diameter and with a mass of 500 g ±25 g, is permitted to fall freely from rest through a vertical distance (H) of 1,3 m (see figure 4A) onto the sample. (Vertical surfaces are exempt from this test.)*

In addition, the steel ball is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distance (H) of 1,3 m (see figure 4A). (Horizontal surfaces are exempt from this test). Alternatively, the sample is rotated 90° about each of its horizontal axes and the ball dropped as in the vertical impact test.

The test is not applied to flat panel displays or to the platen glass of equipment (e.g. copying machines).

Compliance criteria are in 4.2.1.

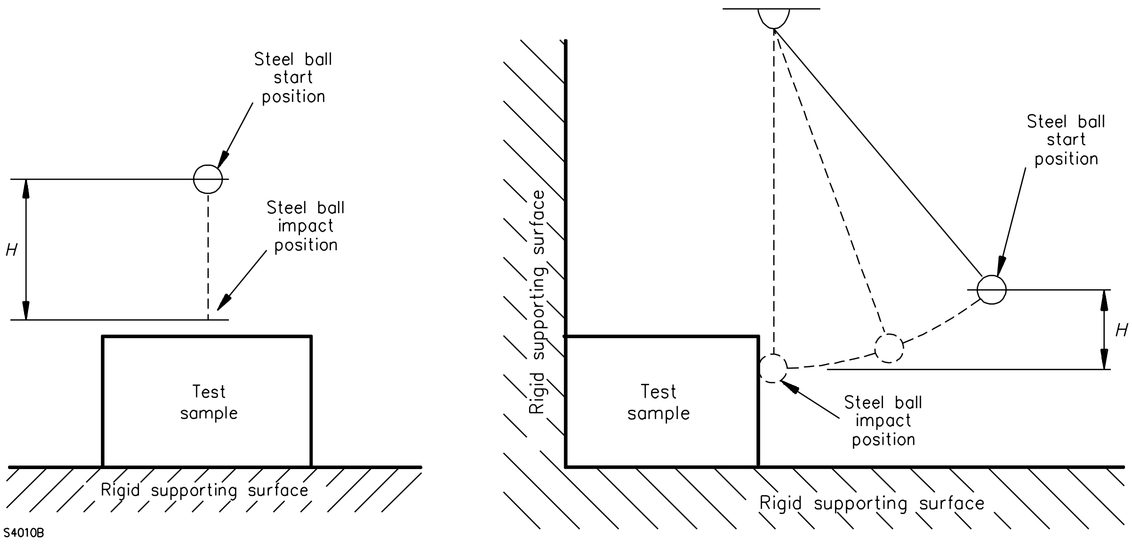


Figure 4A – Impact test using a steel ball

4.2.6 Drop test

The following equipment is subjected to a drop test:

- – HAND-HELD EQUIPMENT;
- – DIRECT PLUG-IN EQUIPMENT;
- – TRANSPORTABLE EQUIPMENT;
- – desk-top equipment having a mass of 5 kg or less that is intended for use with any one of the following:
  - a cord-connected telephone handset, or
  - another cord-connected hand-held accessory with an acoustic function, or
  - a headset.

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The height of the drop shall be

- *– 750 mm ± 10 mm for desk-top equipment as described above;*

- *1 000 mm ± 10 mm for hand-held equipment, direct plug-in equipment and transportable equipment.*

The horizontal surface consists of hardwood at least 13 mm thick, mounted on two layers of plywood each 19 mm to 20 mm thick, all supported on a concrete or equivalent non-resilient floor.

Compliance criteria are in 4.2.1.

4.2.7 Stress relief

enclosures of moulded or formed thermoplastic materials shall be so constructed that any shrinkage or distortion of the material due to release of internal stresses caused by the moulding or forming operation does not result in the exposure of hazardous parts or in the reduction of creepage distances or clearances below the minimum required.

Compliance is checked by the stress relief conditioning of clause A.10 or by the inspection of the construction and the available data where appropriate.

If stress relief conditioning is conducted, the compliance criteria of 4.2.1 apply.

4.2.8 Cathode ray tubes

P
NAD

If cathode ray tubes having a maximum face dimension exceeding 160 mm is included in the equipment, the cathode ray tube or the equipment, or both, shall comply with the requirements of IEC 60065 for mechanical strength and protection against the effects of implosion.

Compliance is checked by inspection, by measurement and by the relevant tests of IEC 60065.

4.2.8.1 Cathode ray tube enclosure D2

To reduce the risk of injury that may result from implosion of a cathode ray tube having a D2
minimum diameter of 160 mm or equivalent face area, the projected area of any opening in the D2
top, back, sides or front of the enclosure onto a plane perpendicular to a line passing through D2
the centre of the opening and any point on the central axis of the bulb section of the picture tube D2
shall not exceed 129 mm^2 unless the minor dimension of the projected area is not more than D2
9,5 mm. The cathode ray tube enclosure opening is illustrated in figure 4A1. D2

Compliance is checked by inspection and measurement. D2

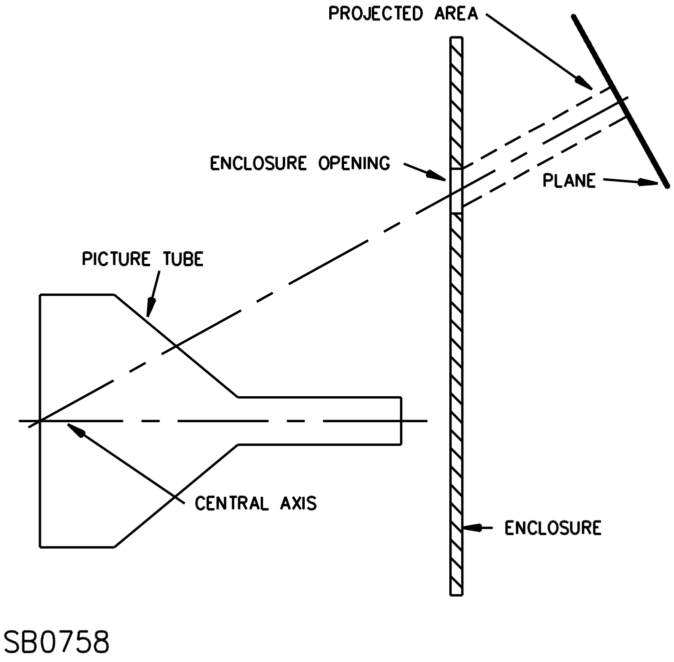


Figure 4A1 – Cathode ray tube enclosure opening

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4.2.9 High pressure lamps *NAA*

The MECHANICAL ENCLOSURE of a high pressure lamp shall have adequate strength to contain an explosion of the lamp so as to reduce the likelihood of a hazard to an OPERATOR or person near the equipment during normal use or OPERATOR servicing.

For the purpose of this standard, a ″high pressure lamp″ means one in which the pressure exceeds 0,2 MPa when cold or 0,4 MPa when operating.

Compliance is checked by inspection.

4.2.10 Wall or ceiling mounted equipment

The mounting means of equipment intended for wall or ceiling mounting shall be adequate.

Compliance is checked by inspection of the construction and of available data, or where necessary, by the following test.

The equipment is mounted in accordance with the manufacturer's instructions. A force in addition to the weight of the equipment is applied downwards through the geometric centre of the equipment, for 1 min. The additional force shall be equal to three times the weight of the equipment but not less than 50 N. The equipment and its associated mounting means shall remain secure during the test.

4.3 Design and construction

4.3.1 Edges and corners

Where edges or corners could be hazardous to OPERATORS because of location or application in the equipment, they shall be rounded or smoothed.

This requirement does not apply to edges or corners that are required for proper functioning of the equipment.

Compliance is checked by inspection.

4.3.2 Handles and manual controls

Handles, knobs, grips, levers and the like shall be reliably fixed so that they will not work loose in normal use, if this might result in a hazard. Sealing compounds and the like, other than self-hardening resins, shall not be used to prevent loosening.

If handles, knobs and the like are used to indicate the position of switches or similar components, it shall not be possible to fix them in a wrong position if this might result in a hazard.

Compliance is checked by inspection, by manual test and by trying to remove the handle, knob, grip or lever by applying for 1 min an axial force as follows.

If the shape of these parts is such that an axial pull is unlikely to be applied in normal use, the force is:

- *15 N for the operating means of electrical components; and*
- *20 N in other cases.*

If the shape is such that an axial pull is likely to be applied, the force is:

- *30 N for the operating means of electrical components; and*
- *50 N in other cases.*

A handle or handles intended to support more than 9,0 kg shall be capable of supporting four D2
times the weight of the product without breakage of the handle, its securing means or that part D2
of the product to which the handle is attached. D2

Compliance is determined by applying a force in the intended carrying direction uniformly over D2
a 75 mm length at the centre of the handle. Starting at zero, the applied force is to be gradually D2
increased so that the required test value is attained in 5 – 10 s and then maintained at the test D2
value for 1 min. If more than one handle is provided, the test force is to be determined by the D2
percentage of the product weight sustained by each handle with the product in the intended D2
carrying position. If a product weighing less than 25,0 kg is provided with more than one handle D2
but can be carried by only one handle, each handle is to be capable of withstanding a force D2
based on the total weight of the product. D2

4.3.3 Adjustable controls

Equipment shall be so constructed that manual adjustment of a control device, such as a device for selection of different AC MAINS SUPPLY voltages, requires the use of a TOOL if incorrect setting or inadvertent adjustment might create a hazard.

NOTE – Marking requirements for supply voltage adjustment are in 1.7.4.

Compliance is checked by manual test.

4.3.4 Securing of parts *P*

Screws, nuts, washers, springs or similar parts shall be secured so as to withstand mechanical stresses occurring in normal use if loosening would create a hazard, or if CLEARANCES or CREEPAGE DISTANCES over SUPPLEMENTARY INSULATION or REINFORCED INSULATION would be reduced to less than the values specified in 2.10.

NOTE 1 – Requirements regarding fixing of conductors are in 3.1.9.

Compliance is checked by inspection, by measurement and by manual test.

For the purpose of assessing compliance:

- *it is assumed that two independent fixings will not become loose at the same time; and*

- *it is assumed that parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose.*

NOTE 2 – Spring washers and the like can provide satisfactory locking.

4.3.5 Connection of plugs and sockets

Within a manufacturer's unit ~~of~~ or system, plugs and sockets likely to be used by the OPERATOR or by SERVICE PERSONNEL shall not be employed in a manner likely to create a hazard due to misconnection. In particular, connectors complying with IEC 60083 or IEC 60320 shall not be used for SELV CIRCUITS or TNV CIRCUITS. Keying, location or, in the case of connectors accessible only to SERVICE PERSONNEL, clear markings are permitted to meet the requirement. DE

Compliance is checked by inspection.

4.3.6 Direct plug-in equipment *P*

DIRECT PLUG-IN EQUIPMENT shall not impose undue strain on the socket-outlet. The mains plug part shall comply with the standard for the relevant mains plug.

Compliance is checked by inspection and, if necessary, by the following test:

The equipment is inserted, as in normal use, into a fixed socket-outlet of a configuration as intended by the manufacturer, which can be pivoted about a horizontal axis intersecting the centre lines of the contacts at a distance of 8 mm behind the engagement face of the socket-outlet. The additional torque which has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 N·m.

NOTE 1 – In Australia, compliance is checked in accordance with AS/NZS 3112.

NOTE 2 – In the United Kingdom:

- the torque test is performed using a socket-outlet complying with BS 1363, with an earthing contact;
- the plug part of DIRECT PLUG-IN EQUIPMENT is assessed to BS 1363: Part 1, 12.1, 12.2, 12.3, 12.9, 12.11, 12.12, 12.16 and 12.17, except that the test in 12.17 is carried out at not less than 125 °C.

4.3.7 Heating elements in earthed equipment

Heating elements in equipment that is earthed for safety purposes shall be protected so that, under earth fault conditions, a fire hazard due to overheating is prevented. In such equipment, temperature sensing devices, if provided, shall be located in all line conductors supplying the heating elements.

The temperature sensing devices shall also disconnect the neutral conductor for each of the following cases:

a) in equipment supplied from an IT power system;

b) in PLUGGABLE EQUIPMENT supplied through a reversible appliance coupler or a reversible plug;

c) in equipment supplied from a socket-outlet with indeterminate polarity.

In cases b) and c), it is permitted to meet this requirement by connecting a THERMOSTAT in one conductor and a THERMAL CUT-OUT in the other conductor.

It is not required to disconnect the conductors simultaneously.

Compliance is checked by inspection.

4.3.8 Batteries

NOTE 1 – Requirements for markings or instructions are given in 1.7.15.

Equipment containing batteries shall be designed to reduce the risk of fire, explosion and chemical leaks under normal conditions and after a single fault in the equipment (see 1.4.14), including a fault in circuitry within the equipment battery pack. For USER-replaceable batteries, the design shall reduce the likelihood of reverse polarity installation if this would create a hazard.

Battery circuits shall be designed so that:

- the output characteristics of a battery charging circuit are compatible with its rechargeable battery; and
- for non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer’s recommendations, and unintentional charging, are prevented; and
- for rechargeable batteries, charging and discharging at a rate exceeding the battery manufacturer’s recommendations, and reversed charging, are prevented.

NOTE 2 – Reversed charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

Compliance is checked by inspection and by evaluation of the data provided by the equipment manufacturer and battery manufacturer for charging and discharging rates.

When appropriate data is not available, compliance is checked by test. However, batteries that are inherently safe for the conditions given are not tested under those conditions. Consumer grade, non-rechargeable carbon-zinc or alkaline batteries are considered safe under short-circuiting conditions and therefore are not tested for discharge; nor are such batteries tested for leakage under storage conditions.

A new non-rechargeable battery or fully charged rechargeable battery provided with, or recommended by the manufacturer for use with, the equipment shall be used for each of the following tests:

- *for evaluating the overcharging of a rechargeable battery, a battery is charged for a period of 7 h under each of the following conditions in turn:*
  - *with the battery charging circuit adjusted for its maximum charging rate (if such an adjustment exists); followed by*
  - *any single component failure that is likely to occur in the charging circuit and which would result in overcharging of the battery; and*
- *for evaluating the unintentional charging of a non-rechargeable battery, a battery is charged for 7 h with any single component failure that is likely to occur and which would result in unintentional charging of the battery; and*