

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

SAFETY REQUIREMENTS
FOR
DATA PROCESSING EQUIPMENT

(ECMA/TR 9)

January 1978

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European Computer Manufacturers Association
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BRIEF HISTORY

At the meeting of IEC 74 in Ljubljana, June 1975, the German Committee and the European Computer Manufacturers Association announced that they would undertake the revision of Publication 435, Safety of Data Processing Equipment. This revision was distributed in June 1976 to Working Groups 1 and 2 as document IEC/TC74 (Germany) 2.

At the meeting of IEC TC74 in London, November 1976, the document was discussed informally. At the same meeting it was agreed that ECMA would prepare a new document, taking into account the comments made in London and the comments made to documents IEC TC74 (Central Office) 6 and 7, the results of the work at the Ljubljana meeting.

This document takes into consideration the physical size, technical complexity and value of data processing equipment and, whilst incorporating the relevant requirements of IEC 435, is aimed primarily at enabling designers to realize safety requirements at an early design state and build them into the equipment. For this reason a new format seemed desirable, and the opportunity was also taken to eliminate all requirements which do not fully relate to data processing equipment.

This document has been prepared by ECMA TC12 "Product Safety". The different national needs were taken into account, and a strict co-operation maintained with the corresponding American committee.

It represents the state of development as of May 1977. The attention of all who refer to and apply this document is drawn to the fact that further development is proceeding and that IEC TC74 has already made significant advances, particularly in sub-clause 5.2.

It should also be noted that the requirements for creepage distances and clearances (sub-clause 2.9) are not entirely consistent with the needs of modern technology. They will require to be reviewed when the Recommendations of the appropriate IEC Committee are available.

This document replaces the following ECMA Standards:

ECMA-22 - Electrical Safety Requirements for Data Processing Machines (June 1969),

ECMA-31 - Mechanical Safety Requirements for Data Processing Machines (September 1971),

and the Wite Cover Document:

Safety Requirements for Data Processing Machines
(Fire Protection - Physical Safety - Mechanical
Safety) (March 1972).

This document has been adopted by the General Assembly of ECMA on December 13, 1977.

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Principles of Safety as applied to Data Processing Equipment

Introduction

Designers must understand the underlying principles of safety requirements in order that they can engineer safe equipment.

The following notes are not an alternative to the detailed requirements of this document, but are intended to provide designers with an appreciation of the principles on which these requirements are based.

Hazards

This document is intended to prevent injury or damage due to the following hazards:

- Electric shock
- Fire
- Energy hazards
- Mechanical and heat hazards
- Radiation hazards
- Chemical hazards

Electric shock is due to current passing through the body. Currents of the order of a milliampere can cause a reaction in persons in good health and may cause indirect danger due to involuntary reaction. Higher currents can have more damaging effects. Voltages up to about 40 V (peak or d.c.) are not generally regarded as dangerous under dry conditions, but parts which have to be touched or handled should be at earth potential or properly insulated.

There are two types of persons who are normally concerned with data processing equipment, the operator and the service engineer.

"Operator" is the term applied to all non-engineering staff and requirements for his/her protection assume that he/she is oblivious to electrical hazards, but does not have suicidal tendencies. Consequently, the requirements provide protection for cleaners and casual visitors as well as the true operators.

It is assumed that the service engineer will be reasonably careful in dealing with obvious hazards, but the design should protect him against mishap by use of warning labels, shields for hazardous voltage terminal, segregation of safety extra low and hazardous voltage, etc. More important, the service engineer must be protected against unexpected hazards.

It is normal to provide two levels of protection for the operator to prevent electric shock hazards arising due to faults. Thus a single fault and its resulting faults will not produce a shock hazard.

Movable equipment is considered to present a slightly increased risk of shock due to possible extra strain on the supply cord, lead-

ing to rupture of the earth conductor and a consequent leakage current hazard. With hand-held equipment, this risk is increased, wear on the cord is more likely, and further hazards could arise if the unit were dropped.

Electric Shock: Causes and Prevention

Cause

Prevention

Contact with normally live parts.

Prevent operator access to parts at hazardous voltage (or energy levels) by fixed or locked covers, interlocks, etc. Discharge capacitors at hazardous voltages.

Breakdown of insulation between normally hazardous live parts and exposed metal.

Either connect the exposed metal to earth so that the voltage which can develop is limited to a safe value and the circuit overcurrent protection will disconnect low impedance faults; or use double or reinforced insulation between normally hazardous live parts and exposed metal-work, so that breakdown is not likely to occur.

Breakdown of insulation between normally live parts at hazardous voltages and SELV circuits.

Segregate hazardous and safety extra low voltage circuits. Separate by earthed metal screens or double or reinforced insulation. Earth safety extra low voltage circuits if capable of carrying possible fault currents.

Breakdown of insulation guarding hazardous voltage parts.

Insulation for hazardous voltage parts which is accessible to the operator should have adequate mechanical and electrical strength to eliminate this danger.

Leakage current from live parts to body of Class II equipment. Failure of protective earth connection carrying leakage current.

Limit leakage current to body to a safe value, or provide high-integrity protective earth connection.

(Leakage current includes current due to RFI filter components connected between live and frame).

Energy Hazards

Shorting between adjacent poles of high current supplies or high capacitance circuits may cause burns or splashing. Even low voltage circuits may be dangerous in this respect. Protect by separation, by shielding or by using safety interlocks.

Fire

Temperatures which could cause a fire exposure may result from overloads, component failure, insulation breakdown, high resistance or loose connections. However, fires originating within a unit should not spread beyond the immediate vicinity of the source of the fire, nor cause damage to the surroundings of the unit.

Mechanical and Heat Hazards

Requirements are included to prevent injury due to high temperatures of parts accessible to the operator; to ensure that the equipment is mechanically stable and structurally sound; to avoid the presence of sharp edges and points; and to provide adequate guarding of dangerous moving parts.

Radiation Hazards

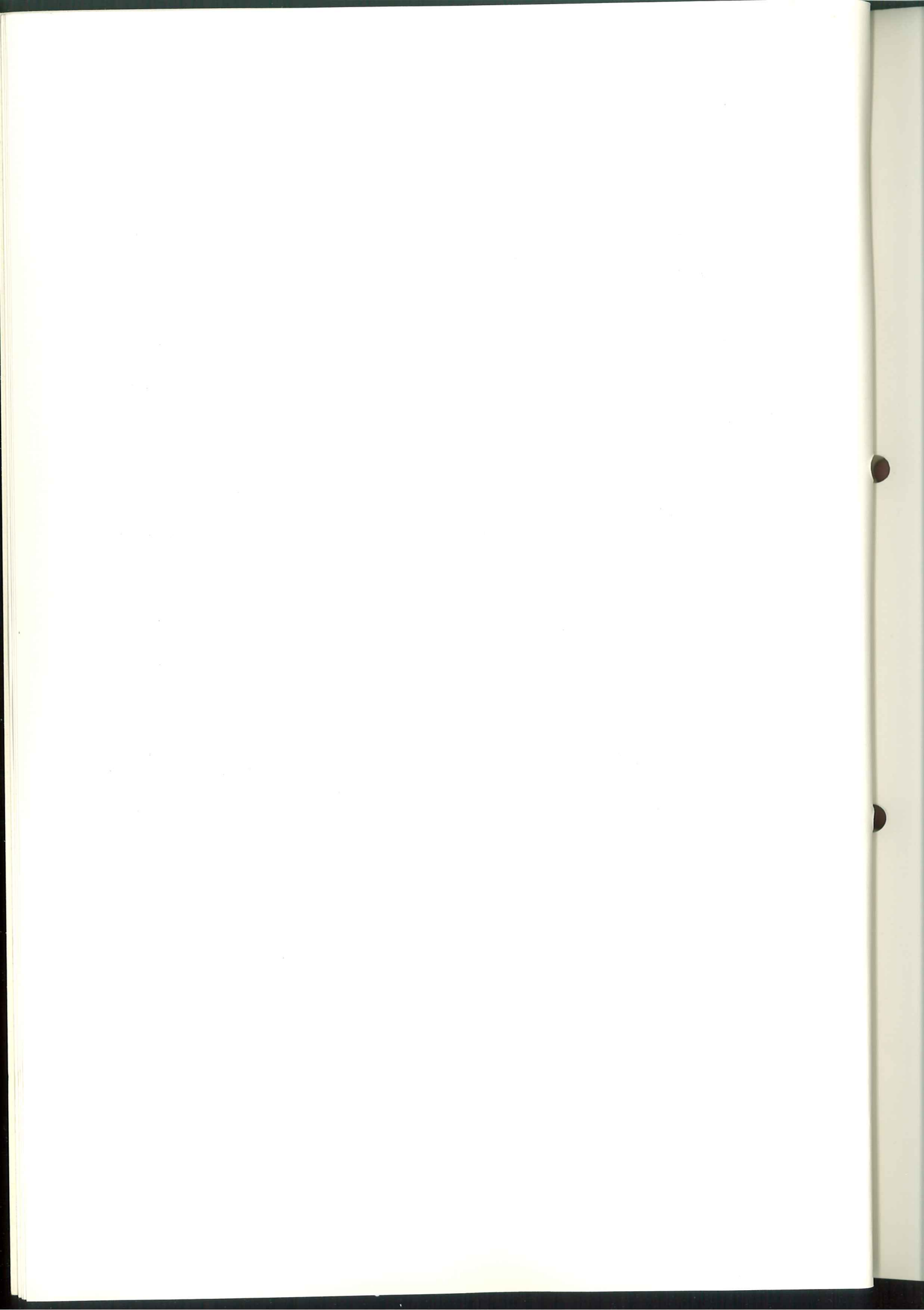
Radiation from some equipment can include radio frequency, sonic, ionizing radiation, infrared or ultraviolet, and high intensity visible and coherent lights, etc. Requirements must keep operator and service engineer exposures to acceptable levels.

Chemical Hazards

Hazardous chemicals potentially cause injuries and damage through contact with the material, its vapors and fumes. Controls including appropriate warning labels are required to limit such contact, as far as is practicable, under normal and abnormal conditions.

Materials

Materials used in the construction of data processing equipment should be selected and arranged such that they can be expected to perform in a reliable manner without shock or energy hazards developing, and so that they would not contribute significantly to the development of a serious fire hazard.



N O T E

In this document the following fonts have been used :

- Delegate, for the Requirements
- *Italics*, for the *Test Specifications*
- Polygo Pica, for Explanatory Matters.

The corresponding fonts in the IEC Publications are :

- Roman Type
- Italics Type
- Small Roman Type.

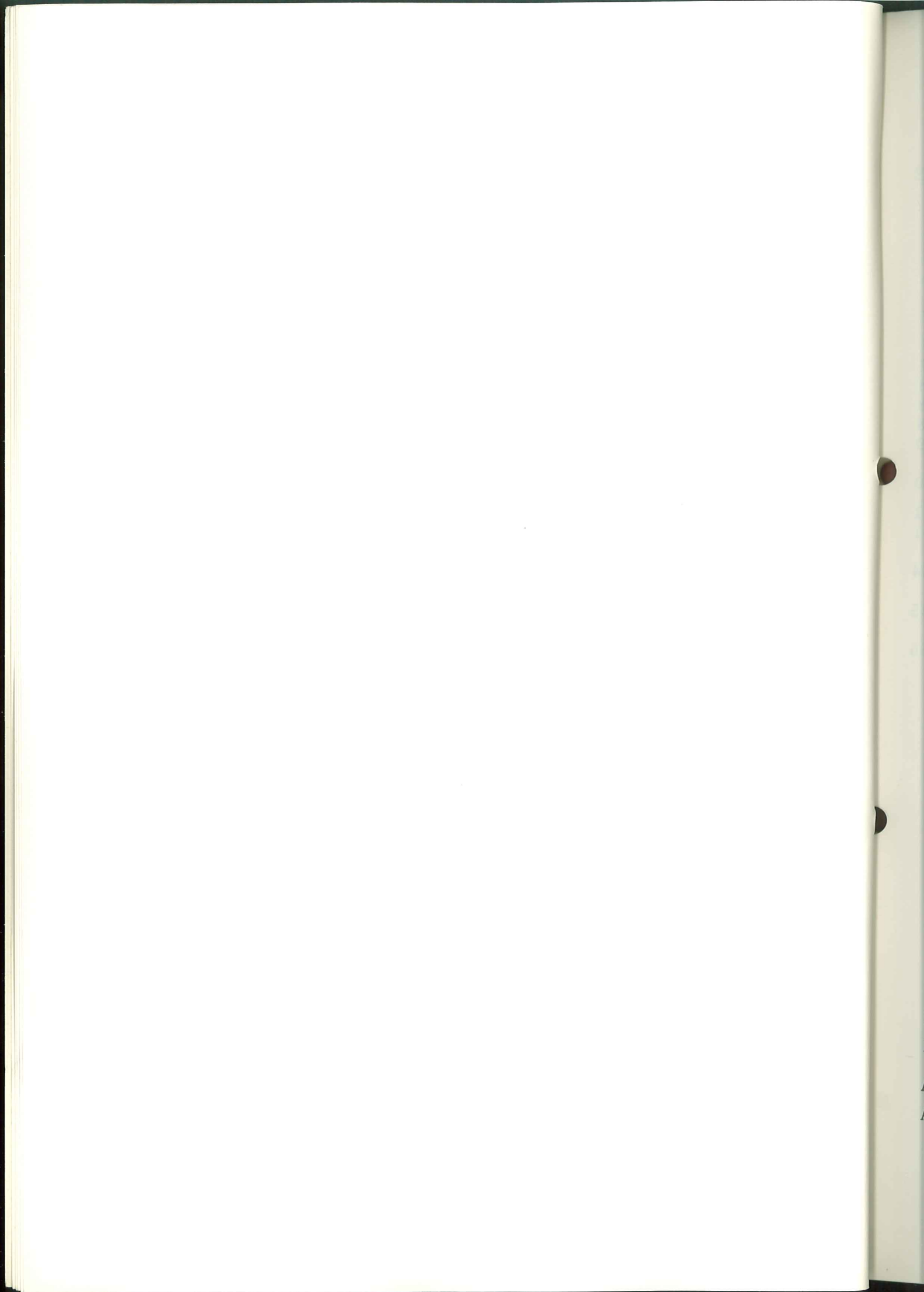


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1 General

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1.1 Scope

1.1.1 This document applies to data processing equipment and the associated electronic units, data preparation equipment and data communication terminal equipment with a maximum rated supply voltage of 600 V and designed to be operated continuously under conditions of normal use. Equipment designed for intermittent use may require different tests.

This document covers safety for the operator and layman who may come into contact with the equipment and, where specifically stated, the service engineer.

This document is intended to ensure the safety of installed equipment, whether such installed equipment consists of a system of interconnected units or independent units, subject to installing the equipment in the manner prescribed by the equipment manufacturer.

This document applies to equipment intended for operation in normal office environments or special data processing rooms.

Where there is doubt about the end use of the equipment, the manufacturer shall clearly state in the instruction sheets or in a separate manufacturer declaration that the equipment is intended for data processing use.

This document does not cover:

- equipment intended for operation whilst exposed to extremes of temperature, excessive dust, damp, vibration, flammable gases, etc.
- Support equipment such as air-conditioning, fire detection or fire extinguishing systems, power supply systems such as motor generator sets, transformers external to the computer, or building branch circuit wiring.
- Interface equipment for connection to data transmission lines, e.g. modems (modulator-demodulator), nor the data transmission line equipment.

Attention is drawn to the fact that the telecommunications authorities of some countries impose additional requirements relating to the safety of equipment. These concern the protection of transmission lines and equipment against the hazards to be expected from the lines.

1.1.2 Where the equipment involves safety situations not specifically covered, the design shall provide a level of safety not less than that generally afforded by this document.

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

1.2 Definitions

Where the terms voltage and current are used, they imply the r.m.s. values, unless otherwise specified.

- 1.2.1 Rated voltage denotes the primary power voltage (for three-phase supply, the phase-to-phase voltage) as declared by the manufacturer.
- 1.2.2 Rated voltage range denotes the primary power voltage range as declared by the manufacturer, expressed by its lower and upper limits, excluding tolerances.
- 1.2.3 Working voltage denotes the voltage to which the part under consideration is subjected when the equipment is operating at its rated voltage under conditions of normal use.
- 1.2.4 Rated current denotes the input current of the equipment as declared by the manufacturer.
- 1.2.5 Rated frequency denotes the primary power frequency as declared by the manufacturer.
- 1.2.6 Rated frequency range denotes the primary power frequency range as declared by the manufacturer, expressed by its lower and upper limits, excluding tolerances.
- 1.2.7 Detachable cord denotes a flexible cord, for supply purposes, intended to be connected to the equipment by means of a suitable appliance coupler.
- 1.2.8 Power supply cord denotes a flexible cord, for supply purposes, fixed to or assembled with the equipment.
- 1.2.9 Functional insulation denotes the insulation necessary for the proper functioning of the equipment and for basic protection against electric shock.
- 1.2.10 Supplementary insulation (protective insulation) denotes an independent insulation provided in addition to the functional insulation, in order to ensure protection against electric shock in the event of a failure of the functional insulation.
- 1.2.11 Double insulation denotes insulation comprising both functional insulation and supplementary insulation.
- 1.2.12 Reinforced insulation denotes an improved functional insulation with such mechanical and electrical qualities that it provides the same degree of protection against electric shock as double insulation.
- 1.2.13 Class I equipment denotes equipment having at least functional insulation throughout and provided with a protective earthing terminal or contact and, for equipment designed for connection by means of a flexible cord, provided with either an appliance inlet with protective earthing contact, or a non-detachable flexible cable or cord with protective earthing conductor and a plug with protective earthing contact.

Class I equipment may have parts with double insulation or reinforced insulation, or parts operating at safety extra-low voltage.
- 1.2.14 Class II equipment denotes equipment with double insulation and or reinforced insulation throughout and without provision for protective earthing.

Class II equipment may have an earth connection for functional purposes.

Such equipment may be of one of the following types:

- equipment having a durable and substantially continuous enclosure of insulating material which envelopes all metal parts, with the exception of small parts, such as name-plates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation; such equipment is called insulation-encased Class II equipment;
- equipment having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable; such equipment is called metal-encased Class II equipment;
- equipment which is a combination of the two above types.

The enclosure of insulation-encased Class II equipment may form a part or the whole of the supplementary insulation or of the reinforced insulation.

If equipment with double insulation and or reinforced insulation throughout has a protective earthing terminal or contact, it is deemed to be of Class I construction. Class II equipment may have parts operating at safety extra-low voltage.

1.2.15 Safety extra-low voltage (SELV) circuit denotes a circuit which is so designed and protected that under normal and fault conditions the voltage between any two accessible circuit parts, one of which may be the body or earth, does not create a shock hazard.

Under normal conditions the limit is 42,4 V peak or d.c. Under fault conditions higher limits are specified in the Standard for transient deviations.

1.2.16 Safety Isolating Transformer for use in data processing equipment denotes a transformer in which windings supplying SELV circuits are isolated from other windings such that an insulation breakdown either is unlikely or does not cause a hazardous condition on SELV windings.

1.2.17 Movable equipment denotes equipment which is either

- under 18 kg in mass, or
- equipment with wheels, castors or other means to facilitate movement by the operator as required to perform its intended use.

1.2.18 Hand-held equipment denotes movable equipment intended to be held in the hand during normal use, the motor, when provided, forming an integral part of the equipment.

Hand-held equipment does not include movable parts of non-hand-held equipment, such as keypads and light pens, which cannot be operated independently.

- 1.2.19 Stationary equipment denotes either fixed equipment or equipment which is intended to be moved from one place to another only by authorized technical personnel.
- 1.2.20 Fixed equipment denotes equipment which is fastened or otherwise secured at a specific location.
- 1.2.21 Thermostat denotes a temperature sensing device, the operating temperature of which may be either fixed or adjustable and which in normal use keeps the temperature of the equipment, or parts of it, between certain limits by automatically opening and closing a circuit.
- 1.2.22 Tool denotes a screwdriver or any other object which may be used to operate a screw, latch or similar fixing means.
- 1.2.23 Body: this includes all accessible metal parts, shafts of handles, knobs, grips and the like and metal foil in contact with all accessible surfaces of insulating material; it does not include non-accessible metal parts.
- 1.2.24 Clearance denotes the shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air.

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

- 1.2.25 Creepage distance denotes 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.
- 1.2.26 Secondary circuit denotes a circuit which has no direct connection to primary power and derives its power from a transformer, converter or equivalent isolation device situated within the equipment.

Some solid state devices may provide equivalent isolation.

- 1.2.27 Operator access area denotes any area to which access may be gained without the use of a tool, or any area for which the means of access is deliberately provided to the operator.
- 1.2.28 Hazardous voltage denotes a voltage existing at a live part connected to a circuit which does not meet the requirement for SELV circuits or limited current circuits.

Parts in non-SELV circuits, which are normally below the SELV limit, may assume hazardous potentials under faulty conditions.

- 1.2.29 Energy hazard denotes a hazard that exists at any exposed live part of a piece of equipment if, between the exposed live part and an adjacent exposed metal part of different

polarity, there exists 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. Above the SELV limit the protection required against electric shock will also protect against energy hazards.

- 1.2.30 Data processing equipment denotes electrically operated units that, separately or assembled in systems, accumulate, process and store data. Acceptance and divulgence of data may or may not be by electronic means.
- 1.2.31 Flammability classification of materials denotes the recognition of the ignition and burning resistance characteristics of materials other than metallic or ceramic. For the purposes of this document, materials are classified as in sub-clauses 1.2.32 to 1.2.37, when tested in accordance with Appendix A.
- 1.2.32 Material classed V-1 denotes a material that, when tested in accordance with Appendix A.6, may flame or glow but will extinguish within a prescribed period of time. Glowing particles and or flaming drops released shall not ignite surgical cotton.
- 1.2.33 Material classed V-2 denotes a material that, when tested in accordance with Appendix A.6, may flame or glow but will extinguish within a prescribed period of time. Glowing particles and or flaming drops released may ignite surgical cotton.
- 1.2.34 Foamed plastic classed HF-1 denotes a foamed plastic material that, when tested in accordance with Appendix A.7, may flame or glow but will extinguish within a prescribed period of time. Flaming or glowing particles or flaming drops shall not ignite surgical cotton.
- 1.2.35 Foamed plastic classed HF-2 denotes a foamed plastic material that, when tested in accordance with Appendix 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.
- 1.2.36 Material classed HB denotes a material that, when tested as indicated in Appendix A.8, burns with specified maximum burning rates.
- 1.2.37 Foamed plastic classed HBF denotes a foamed plastic material that, when tested as indicated in Appendix A.7, burns with specified maximum burning rate.
- 1.2.38 Enclosure denotes a construction which protects against contact with hazardous parts. The construction may be an integral part of a component, a separate part of a component, the outer cabinet or a part of the outer cabinet.

- 1.2.39 Safety interlock denotes a means of preventing access to a hazardous area until the hazard is removed, or automatically removing the hazardous condition when access is gained.
- 1.2.40 Limited current circuit denotes a circuit which is so designed and protected that under both normal conditions and fault conditions the current which can be drawn is not hazardous.
- 1.2.41 Thermal cut-out denotes a device which, during abnormal operation, limits the temperature of the equipment, or of parts of it, by automatically opening the circuit or by reducing the current, and which is so constructed that its setting cannot be altered by the user.

1.3 General Requirements

- 1.3.1 Equipment shall be so designed and constructed that, in normal operation and under a likely fault condition, it causes no hazards within the meaning of this document to persons or surroundings.
- 1.3.2 Equipment containing hazardous voltages shall be Class I or Class II.
- 1.3.3 Sufficient information shall be provided to the user concerning any condition necessary to ensure that, when in use, the equipment will not present a safety or health hazard within the meaning of this document.

In general, compliance is checked by inspection or by carrying out all the relevant tests specified.

1.4 General Notes on Requirements and Tests

- 1.4.1 The requirements and tests detailed in this document are to be considered only if safety is involved.
- 1.4.2 Tests according to this document are type tests.
- 1.4.3 Unless otherwise specified, the tests shall be made on a single sample which shall withstand all the relevant tests.

As an alternative to carrying out tests on the complete equipment, tests may be carried out separately on components and sub-assemblies, provided that inspection of the equipment and circuit arrangements indicates that such tests will ensure that the assembled equipment complies with the Standard.

When a destructive test must be employed to evaluate the safety of the product, a model representing the condition to be evaluated may be used.

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

- supply voltage
- supply frequency
- physical location of equipment and position of movable parts
- operating mode.

1.4.5 In determining the most unfavourable supply voltage for a test, the following variables shall be considered:

- multiple rated voltages
- extreme of rated voltage range
- tolerance on rated voltage as specified by the manufacturer for continuous operation. When no tolerance is specified it shall be assumed to be $\pm 6\%$.

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

1.4.6 In determining the most unfavourable supply frequency for a test, different nominal frequencies within the rated frequency range shall be considered (e.g. 50 Hz and 60 Hz) but consideration of the tolerance on a rated frequency (e.g. 50 Hz $\pm 0,5$ Hz) is not normally deemed to be necessary.

1.4.7 In this document, maximum temperature rises are specified for compliance with certain tests, and the ambient air temperature during the tests need not be controlled. These maximum temperature rises are based on the assumption that the ambient air temperature of the equipment or components is 25 °C (when in operation). If the equipment or individual components are to be operated in a higher ambient temperature, the specified temperature rise shall be reduced accordingly.

Where temperature rises are measured under local ambient conditions of atmospheric pressure and relative humidity they should be adjusted to allow for adverse limits of pressure and humidity and the effect of partially blocked air filters within the manufacturer's specification.

1.4.8 Temperature rises of windings are determined by the resistance method where practicable (Appendix E). In all other cases measurement is made by the thermocouple or a similar method, using temperature sensors so chosen and positioned that they have the minimum effect on the temperature of the part under test.

1.4.9 Equipment for which optional features are offered by the manufacturer shall be tested with those features which give the most unfavourable results, or suitable simulation of these features.

1.4.10 Equipment containing safety extra-low voltage circuits only shall be tested with the supply device.

1.4.11 For the purpose of the tests of sub-clauses 2.1.6, 2.5.1, 3.2.5, 3.2.7 and of Clause 5.3, parts separated from live parts by double insulation or reinforced insulation are not regarded as likely to become live in the event of an insula-

tion fault; connection of accessible metal parts to a protective earthing terminal or contact does not remove the necessity for carrying out these tests.

- 1.4.12 If Class I equipment has accessible conductive parts which are not connected to a protective earthing terminal and are not separated from live parts by an intermediate metal part which is connected to a protective earthing terminal, such parts shall be checked for compliance with the appropriate requirements specified for Class II equipment, except as provided in sub-clause 2.5.1.

1.5 Components

- 1.5.1 Where safety is involved, components shall comply with the requirements of this document and with the safety aspects of the relevant IEC component Standards.

- 1.5.2 *Evaluation and testing of components shall be carried out as follows:*

- *A component certified by a recognized testing authority for compliance 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 which is not certified for compliance 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 document as part of the equipment, and to the applicable tests of the relevant component Standard, under the conditions occurring in the equipment.*

The test for compliance with a relevant component Standard is, in general, carried out separately. The number of test samples is, in general, the same as required in the component Standard.

- *Where no 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 A Safety Isolating Transformer shall be so constructed that a single insulation fault and its consequence will not cause a hazardous voltage to appear on SELV windings. This may be achieved as follows:

The SELV windings of a safety transformer shall be protected from all other windings as described below. The construction

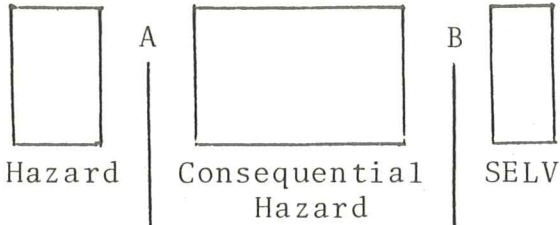
shall be such as to prevent accidental connection between SELV and hazardous voltages, either:

- directly, or
- indirectly through other windings, or
- indirectly through unearthed metal parts. It is not expected that two independent fixings will loosen at the same time.

Two methods of providing separation are recognized:

- Separation of the windings and connections by insulation having creepage distances, clearances and thickness through insulation complying with the requirements for Double Insulation or Reinforced Insulation appropriate to the working voltages involved, or
- Separation of the windings and connections by an earthed metal screen or other earthed metal parts. Insulation between each winding and the metal parts shall comply with the requirements for Functional Insulation appropriate to working voltage of that winding.

Rules for the application of such separation are as follows:

Between SELV and	Separation
Hazards	Either Double or Reinforced Insulation or Earthed Screen
<p>Consequential Hazards</p>  <p style="text-align: center;"> A B </p> <p style="text-align: center;"> Hazard Consequential Hazard SELV </p>	Supplementary Insulation at "B" and Functional Insulation at "A", so that A+B is Double Insulation.
Another SELV winding (V_2) where $V_1 + V_2 > 42,4$ V peak and where V_1 or V_2 but not both are referred to earth	Double or Reinforced Insulation
Any other part	Functional Insulation

Notes to the Table:

- Hazards are items which are normally at hazardous potential as part of their function; such as primary windings, secondary windings over 42,4 V peak, guard screens, etc.
- Consequential Hazards are any unearthed metal part or winding which is not separated from a hazard by double/reinforced insulation or an earthed metal screen.

- Working Voltage: the working voltage for insulation between windings is determined by the maximum peak voltage which occurs between any two points in the two windings taking into account external voltages to which the windings may be connected.

The working voltage for insulation between windings and other metal is determined by maximum peak voltage occurring at any point on the winding relative to earth.

These considerations need not include the working voltage of the SELV winding.

Where a winding is floating, i.e. not connected to an external circuit which establishes its potential relative to earth, the winding is considered to be earthed at its most adverse end.

Where a number of floating windings are connected together via external circuitry they must each be considered as operating at the maximum voltage developed between any two points in the floating circuit.

Appendix C shows examples of the standard of constructional detail that is expected of a transformer designed to meet the above requirements, together with suitable dielectric strength tests.

1.6 Power Interface

- 1.6.1 For equipment to be connected to IT power systems (unearthed or impedant neutral), components connected between phase and earth shall be rated at least at the phase-to-phase voltage and components connected between neutral and earth shall be rated at least at the phase-to-neutral voltage.
- 1.6.2 The steady state input current of the equipment shall not exceed the rated current by more than 10% under the most adverse normal operating conditions and at rated voltage.
- 1.6.3 The rated voltage of hand-held equipment shall not exceed 250 V.
- 1.6.4 Neutral shall be insulated from earth and the body throughout the equipment, as if it were a live phase.

1.7 Marking and Instructions

- 1.7.1 Equipment shall be provided with a power rating plate, the purpose of which is to specify a supply of correct voltage and frequency and of adequate capacity. The power rating plate shall be on a main part of the equipment and shall include the following markings:

- rated voltage(s) or rated voltage range(s), in volts.

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

Examples of voltage ratings:

Rated voltage range: 220 V - 240 V. This means that the equipment is designed to be connected to any supply having a nominal voltage between 220 V and 240 V.

Multiple rated voltage: 120 V/220 V/240 V. This means that equipment is designed to be connected to a supply having a nominal voltage of 120 V or 220 V or 240 V, usually after internal voltage adjustment.

- 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 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.

If an equipment is not provided with a means for connection directly to the supply, that equipment need not be marked with the rated current.

The rated current to be marked on the equipment is the total maximum current that can be on circuit at the same time and shall include the combined currents to all equipment in the system that may be supplied through that equipment and can be operated simultaneously.

- manufacturer's name, trade mark or identification mark,
- manufacturer's model or type reference,
- symbol for Class II construction, for Class II equipment only.

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

When symbols and abbreviations are used, they shall conform with the relevant ISO and IEC Standards.

- 1.7.2 For equipment intended for connection to multiple rated voltages or frequencies the method of adjustment and the power requirements, including possible variations, shall be fully covered in the engineering service manual or installation instructions. Unless the means of adjustment

is a simple control near the power rating plate, 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 plate:

"SEE INSTALLATION INSTRUCTIONS BEFORE CONNECTING THE SUPPLY."

- 1.7.3 Standard supply outlets in data processing equipment accessible to the operator shall be marked with the maximum permissible load which may be connected to the outlet. This marking shall be placed in the vicinity of the standard supply outlet.
- 1.7.4 Fuseholders shall be marked with the current rating of the fuse. This marking shall be placed on or adjacent to the fuseholder.
- 1.7.5 Protective earthing terminals intended for connection of the supply earthing conductor shall be indicated by the symbol No 5017 defined in IEC Publ. 417 ($\frac{1}{2}$).

Terminals intended exclusively for connection of the primary power neutral conductor shall be indicated by the capital letter N.

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

- 1.7.6 Unless it is obviously unnecessary, switches and other control devices shall be marked so as to indicate clearly which function they control.

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

The ON/OFF condition of the power control switch shall be reliably indicated at the operating point.

The OFF position shall not be indicated by words only. If figures are used for indicating the different positions, the OFF position shall be indicated by the figure 0 (ZERO) and the position for a greater output, input, speed, cooling effect, etc. shall be indicated by a higher figure.

Marking on, and indications for switches and other control devices, shall be placed in the vicinity of these components; they shall not be placed on removable parts if these parts can be replaced in such a way that the marking is misleading.

- 1.7.7 Where there is more than one connection supplying hazardous voltage or energy levels to a unit, there shall be a prominent permanent marking close to the service access to the hazardous parts to indicate which disconnect devices isolate each section of the unit and which disconnect device may be used to isolate the unit completely.

1.7.8 The equipment installation instructions shall state whether the equipment has been designed for connection to an IT power system (unearthed or impedant neutral) or not.

1.7.9 If it is necessary to take special precautions when installing the equipment, details of these shall be given in installation instructions.

If equipment is not provided with a disconnect device in accordance with sub-clause 2.6 the installation instructions shall state that:

- for equipment permanently connected to the primary power supply, a disconnect device must be incorporated in the fixed wiring,
- for equipment connected to the primary power supply by means of a non-detachable flexible cord and a plug, the socket outlet shall be installed near the equipment and shall be easily accessible.

Special precautions may be necessary, e.g. for connection of the equipment to the supply and the inter-connection of separate components, if any.

1.7.10 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.

1.7.11 Marking shall be durable and easily legible from outside the equipment, if necessary after removal of a cover; for hand-held equipment the removal of this cover shall not require the use of a tool.

In considering the durability of the marking, the effect of normal use shall be taken into account. Thus, for example, marking by means of paint or enamel on containers that are likely to be cleaned frequently is not deemed to be durable.

2 Safe Electrical Design

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2.1 Protection against Electric Shock and Energy Hazards

2.1.1 Live parts are divided into two groups with respect to protection against electric shock:

- parts which operate in SELV circuits or in limited current circuits,
- parts which operate at hazardous voltages.

It is the intention of this document to prevent operator contact with live parts at hazardous voltages.

Operator access to live parts in SELV circuits or in limited current circuits is not prohibited, however such parts are subject to the requirements relating to energy hazards.

2.1.2 Equipment shall be so constructed that there is adequate protection against accidental contact with parts at hazardous voltages and, for Class II equipment, with metal parts separated from parts at hazardous voltages by functional insulation only. This requirement applies for all positions of the equipment when it is wired and operated as in normal use, even after removal of operator detachable parts, except lamps, and with operator access covers open.

This requirement precludes the use of screw-type fuses and screw-type miniature circuit breakers in operator access areas.

Compliance is checked by inspection and by a test with the standard test finger (Fig. 1). In addition, apertures in Class II equipment and apertures in Class I equipment other than those in metal parts connected to an earthing terminal or earthing contact, shall be tested with the test pin (Fig. 2). The test finger and the test pin shall be applied, without appreciable force, in every possible position, except that equipment normally used on the floor and having a mass exceeding 40 kg is not tilted.

Testing shall be carried out with access to the equipment limited according to the method of mounting the equipment as detailed by the manufacturer (e.g. wall-mounting, etc.). Apertures preventing the entry of the finger (Fig. 1) shall be further tested by means of a straight unjointed version of the test finger which is applied with a force of 30 N; if this finger enters, the test with the finger (Fig. 1) is repeated, the finger being pushed through the aperture, if necessary. An electrical contact indicator shall be used to show contact.

Care must be taken to ensure that the application of the test does not damage components of electronic circuits.

It shall not be possible to touch with the test finger (Fig. 1) bare parts at hazardous voltages nor functional insulation of parts or wiring, at hazardous voltage. In addition, for Class II equipment, it shall not be possible to touch, with the

test finger (Fig. 1), metal parts separated from hazardous parts by functional insulation only, nor to touch with the test pin (Fig. 2) bare parts at hazardous voltages.

Parts at hazardous voltages, protected only by lacquer, enamel, ordinary paper, cotton, oxide film, beads or sealing compounds other than self-hardening resin, shall be considered to be bare metal parts.

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

- 2.1.3 There shall be no energy hazard in an operator access area.

Compliance is checked by means of the test finger (Fig. 1) in a straight position applied without appreciable force. It shall not be possible to bridge with this test finger two parts, one of which may be an earthed metal part, between which an energy hazard exists.

- 2.1.4 Accessible conducting liquids shall not be in direct contact with hazardous live parts.

Compliance is checked by inspection.

- 2.1.5 Shafts of operating knobs, handles, levers and the like shall not be at hazardous voltages.

Compliance is checked by inspection.

- 2.1.6 Handles, levers and knobs, which are held or actuated in normal use, shall be either of insulating material or adequately covered by insulating material, if their shafts or fixings are likely to acquire hazardous voltages in the event of an insulation fault. For stationary equipment, this requirement does not apply to handles, levers and knobs, other than those of electrical components, provided they are either reliably connected to an earthing terminal or earthing contact or separated from parts at hazardous voltages by earthed metal.

Compliance is checked by inspection.

- 2.1.7 For Class II equipment, capacitors operating in non-SELV circuits shall not be connected to accessible metal parts, and their casings, if of metal, shall be separated from accessible metal parts by supplementary insulation.

Compliance is checked by inspection and by the tests specified for supplementary insulation.

- 2.1.8 Equipment intended to be connected to the supply by means of a plug shall be so designed that in normal use there is no risk of electric shock from charged capacitors when touching the pins of the plug.

Compliance is checked by the following test, which is performed only if the rated capacitance exceeds 0,1 μF . The equipment shall be operated at rated voltage or at the upper limit of the

rated voltage range. The equipment ON/OFF switch, if any, is then moved to the OFF position and the equipment disconnected from the supply by means of the plug. One second after disconnection the voltage between the pins of the plug is measured with an instrument which does not appreciably affect the value to be measured. This voltage shall not exceed 34 V peak. The test shall be performed ten times.

2.2 Insulation

- 2.2.1 Electrical insulation shall be designed either by using solid or laminated insulating materials having adequate thickness and adequate creepage distances over their surfaces or by using adequate clearances through air or by a combination of the two.

Insulation in layers is considered acceptable when, for supplementary insulation, at least two layers are used of which one layer of the material will pass the electric strength test for supplementary insulation, and when, for reinforced insulation, at least three layers are used, of which two layers of the material will pass the electric strength test for reinforced insulation.

- 2.2.2 Electrical, thermal and mechanical strength of insulating materials shall be adequate.
- 2.2.3 For sufficient electric strength, equipment shall comply with the requirements for creepage distances and clearances and with those for electrical strength test voltages according to sub-clauses 2.9 and 5.3 of this document.
- 2.2.4 For the purpose of determining these spacings and test voltages for a given piece of insulation, two parameters shall be considered:
- Application (see sub-clause 2.2.5)
 - Working Voltage (see sub-clause 2.2.6)
- 2.2.5 Application of insulation is considered to be:
- Functional, or
 - Supplementary, or
 - Reinforced.

See definitions 1.2.9, 1.2.10 and 1.2.12.

Reinforced insulation shall only be provided where it is manifestly impracticable to provide separate Functional and Supplementary insulation.

Examples of situations where these types of insulation are required are as follows:

Functional:

- Between live parts of different potential.
- Between live parts and other metal parts.

- Between live parts at hazardous voltage and SELV circuits which rely on being earthed for their integrity.
- Between primary power conductors and the earthed screen or core of a primary power transformer.

Supplementary:

- Generally, between an accessible part and a part which could become hazardous in the event of failure of functional insulation, e.g.
 - . between the outer surface of handles, knobs, grips and the like, and their shafts unless earthed,
 - . between the equipment body and the outer cover of a flexible supply cord on Class II equipment,
 - . between a floating non-SELV secondary circuit and unearthed metal parts of body.

Reinforced:

- Generally, between a non-earthed accessible part and a part at hazardous voltage, e.g. thickness through insulation or creepage distance or clearance
 - . between an earthed secondary circuit operating at more than 42,4 V peak or d.c. and a floating SELV circuit,
 - . between a floating SELV circuit and a primary power part.

- 2.2.6 Working voltage is the voltage which exists across the insulation under normal working conditions. Where the r.m.s. value is used, a sinusoidal a.c. waveform shall be assumed. Where the d.c. value is used, the peak value of any superimposed ripple shall be allowed for.

Where double insulation is used, the working voltage for each of the constituent layers of functional and supplementary insulation shall be taken as the working voltage across the double insulation.

Where a circuit is floating, i.e. not connected in such a way as to establish a potential relative to earth, the working voltage shall be determined by assuming the floating circuit to be earthed at the more adverse end.

2.3 Safety Extra-Low Voltage (SELV) Circuits

- 2.3.1 In a single SELV circuit or in interconnected SELV circuits the voltage between any circuit parts or between any circuit part and earth or body shall not exceed 42,4 V peak or d.c. under normal conditions.
- 2.3.2 Equipment shall be so constructed that a SELV circuit cannot acquire a hazardous voltage due to failure of functional insulation or loosening or displacement of a single part.

- Where both SELV circuits and hazardous voltage circuits are present in a component or assembly they shall be separated by double or reinforced insulation or by earthed metal parts. Creepage and clearance distances between the circuits shall meet the requirements specified in sub-clause 2.9 for reinforced insulation. Alternatively, where a SELV circuit is earthed as described in sub-clause 2.3.4 it may be separated from hazardous voltage circuits by functional insulation and creepage and clearance distances complying with the requirements for functional insulation.
- Means shall be provided, other than terminal pressure, to prevent ring-tongue and similar termination pivoting so as to reduce creepage and clearance distances between SELV circuits and hazardous voltage circuits below the specified minimum values.
- In multiway plugs and sockets and elsewhere where shorting could otherwise occur, means shall be provided to prevent contact between hazardous voltage circuits and SELV circuits due to loosening of a terminal or breaking of a wire at a termination.
- Parts at hazardous voltages shall be covered or shielded or so located as to avoid accidental shorting to SELV circuits.

Accidental shorting creating a shock hazard may be caused by tools, test pins, etc. whilst power is switched on.

- It shall not be possible to mate plugs and sockets used in SELV circuits with connectors carrying hazardous voltages such that a SELV circuit is connected to a hazardous voltage. This may be achieved by the design or the location of the connector.

Except where the SELV circuit is earthed as described in 2.3.4, wires for SELV circuits shall be separated from wiring at hazardous voltages by one of the following methods:

- separation between the functional insulation on the SELV circuit and the functional insulation on the hazardous voltage wiring meeting the clearance requirements appropriate to reinforced insulation;
- separation by an earthed metallic screen;
- separation by an additional layer of insulation complying with the requirements for supplementary insulation. This may be in the form of an insulating sheet over either the SELV wires or over the hazardous voltage wires;
- insulation of all wires to be rated for highest working voltage present in accordance with IEC 227 or IEC 245;
- thicker insulation on either SELV or hazardous voltage wires meeting the requirements for reinforced insulation for the highest voltage present.

- 2.3.3 SELV circuits shall not be conductively connected to the primary power supply circuit (including the neutral) within the equipment.
- 2.3.4 Where a SELV circuit is connected to a winding on a double-wound transformer, means shall be provided to ensure that functional insulation breakdown of the transformer does not result in a shock hazard.

Either a safety isolating transformer for use in data processing equipment shall be used, or where separation between windings is functional insulation only, accessible parts of SELV circuits shall be so connected to earth that in the event of a fault they are prevented from exceeding 42,4 V peak or d.c. for more than 0,2 s with a limit of 65 V peak or d.c.

- 2.3.5 SELV circuits shall not be interconnected with other circuits unless the design is such that protective devices and or relative impedance and relative current-carrying capacity prevent the SELV circuit exceeding 42,4 V peak or d.c. for more than 0,2 s in the event of any possible insulation or component failure, with a limit of 65 V peak or d.c.

Control circuits between SELV circuits and transformer output windings, having working voltages in excess of 42,4 V peak or d.c. are other circuits in the meaning of this sub-clause.

2.4 Limited Current Circuits

- 2.4.1 The steady-state current drawn through a non-inductive resistor of 2000 ohm connected between an accessible part of a limited current circuit and either pole of the circuit supply or earth shall not exceed 0,7 mA peak a.c. or 2 mA d.c.
- 2.4.2 For accessible parts not exceeding 450 V peak or d.c., the circuit capacity shall not exceed 0,1 uF.
- 2.4.3 For accessible parts not exceeding 15 000 V peak or d.c., the available stored charge shall not exceed 45 uC.
- 2.4.4 For accessible parts exceeding 15 000 V peak or d.c., the available energy shall not exceed 350 mJ.
- 2.4.5 Limited current circuits shall be so designed that the limits specified above are not exceeded in the event of breakdown of any insulation or a single component failure.

Segregation of limited current circuits from circuits at hazardous voltage shall be as described in sub-clause 2.3.2 for SELV circuits.

Compliance is checked by inspection and measurements.

2.5 Provisions for Protective Earthing

- 2.5.1 Accessible metal parts of Class I equipment, which may become hazardous in the event of an insulation fault, shall be permanently and reliably connected to an earthing terminal in the equipment.

Metal parts behind a cover which does not withstand the test of sub-clause 4.2 are deemed to be accessible metal parts.

Accessible parts such as removable covers, detachable metal parts and insulated metal parts need not be earthed provided that they are separated from parts at hazardous voltages by earthed metal or double or reinforced insulation, or provided such parts are fixed with a clearance of not less than 25 mm from the accessible metal parts in such a way that they cannot come into physical contact due to a failure of fixing or termination or accidental displacement of the removable covers.

Contact with functional insulation is regarded as physical contact with a live part.

Class II equipment shall have no provision for protective earthing.

Compliance is checked by inspection.

- 2.5.2 Protective earthing conductors shall not contain switches or fuses.

If a data processing system is made up of a group of Class I and Class II units, the interconnection of the units shall be such that earthing connection shall be assured for all Class I units irrespective of the arrangement of the units in the system.

Protective earthing conductors may be bare or insulated. If insulated, the insulation shall be green/yellow except in case of earthing braids which may use transparent insulation. Earthed metal parts shall not be electrically connected to the neutral terminal, if any.

Protective earth connections shall not be such that disconnection of the earth at one assembly may break the earth connection to other assemblies, if this may cause a hazard.

If operator detachable parts have a protective earth connection, this connection shall be made before the current-carrying connections are established when placing the part in position, and the current-carrying connections shall be separated before the earth connection is broken when removing the part.

Protective earth 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 serve or where removal of hazardous voltages from that part is accomplished at the same time.

Screws or other fastenings, which are used to secure removable components, may be used for earth continuity purposes provided that the following conditions are satisfied:

- the equipment and or the removable component cannot be operated with all such screws or fastenings removed,
- there are at least two such screws or fastenings used,
- no wire is terminated at such screws or fastenings,
- such joints as are involved meet other requirements for protective earth.

- 2.5.3 Earthing terminals for fixed supply conductors or for power supply cords shall comply with the requirements of Clause 3.3, but screwless terminals shall not be used.

External earthing terminals shall not be used to provide earthing continuity between different parts of the equipment. The clamping means of earthing terminals shall be adequately locked against accidental loosening and it shall not be possible to loosen them without the aid of a tool.

Compliance is checked by inspection and by manual test.

In general, the designs commonly used for current-carrying terminals, other than some terminals of the pillar type, provide sufficient resiliency to comply with the latter requirement: for other designs special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

- 2.5.4 The metals in contact at safety earth connections shall not be subjected to corrosion due to electro-chemical action in any working, storage and transport environment conditions as specified in the instruction sheets.

The earthing terminal shall be resistant to significant corrosion. Corrosion resistance may be achieved by a suitable plating or coating process. If the body of the earthing terminal is a part of a frame or enclosure of aluminium alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between the frame and copper or its alloys.

Compliance is checked by inspection and by manual test.

- 2.5.5 The connection between the earthing terminal or earthing contact, and parts required to be connected thereto, shall be of low resistance.

Compliance is checked by the following test:

The test current shall be 1,5 times the current capacity of any hazardous voltage circuit at the point where a functional insulation failure would make the accessible metal part live. The test voltage shall not exceed 12 V and the test current may either be a.c. or d.c. When it is obvious that the earthing contact and associated parts are adequate, a 25 A 12 V a.c. tester can then be used.

The voltage drop between the earthing terminal or earthing contact and the accessible part shall be measured and the resistance calculated from the current and this voltage drop. The resistance of the flexible cord is not included in the resistance measurement.

On large equipment where the safety earth connection to a sub-assembly is by means of one core of a multicore cable supplying mains power to that sub-assembly, the resistance of the cable is not included in the resistance measurement, provided that the cable is protected by a suitably rated overcurrent device.

In no case shall the resistance exceed 0,1 Ohm.

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

2.6 Primary Power Isolation

2.6.1 A disconnect device shall be provided to disconnect the equipment from the supply for servicing.

Parts remaining live when the device is switched off shall be shielded to prevent accidental contact by a service engineer.

This disconnect device 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.

When the disconnect device is not incorporated in the equipment it will not necessarily be supplied with the equipment (see sub-clause 1.7.9).

When an isolating switch is used it shall not be fitted in a flexible cord.

The requirements for disconnect devices do not apply to functional switches where other means of isolation are provided.

Examples of disconnect devices within the meaning of this sub-clause are:

- the attachment cord plug of pluggable equipment
- isolating switches
- circuit breakers
- any equivalent device offering an equal degree of safety to the above.

Requirements for disconnect devices are still under consideration. Devices complying with publication CEE 24, "Specifications for switches for appliances", are deemed to be sufficient.

2.6.2 For single-phase units the disconnect device shall disconnect simultaneously both poles, except that where an earthed neutral can be reliably identified, it need not be disconnected.

Two examples of cases where a two-pole disconnect device is required are:

- an impedant neutral
- a supply obtained through a reversible plug.

For three-phase units the disconnect device shall disconnect simultaneously all live poles of the supply. The neutral is considered to be a live pole if it is an unearthed or impedant neutral.

- 2.6.3 For pluggable equipment the attachment cord plug may be used as the disconnect device. In this case the installation instructions shall comply with sub-clause 1.7.9.

For Class I pluggable equipment, when connecting and disconnecting the supply plug (and the appliance coupler, if any), the protective earthing connection shall be made earlier than the phase connection and shall disconnect later than the phase disconnection.

- 2.6.4 Where a unit or group of units is to be permanently connected to the supply, the disconnect device shall be incorporated in the equipment, unless the equipment is accompanied by installation instructions stating that the disconnect device shall be provided as part of the building installation in accordance with sub-clause 1.7.9.

- 2.6.5 Where a group of units having individual pluggable or permanent supply connections is interconnected in such a way that hazardous voltage or energy levels may be transmitted between units, a disconnect device shall be provided to disconnect simultaneously the supply from all units which may transmit or receive hazardous voltage or energy levels via interconnections.

- 2.6.6 Where a unit receives primary power from two separate sources (e.g. different voltages/frequencies or as redundant power), there shall be a single disconnect device which disconnects both supplies. This shall be in addition to any disconnect device which may be provided to disconnect one supply at a time.

2.7 Protection of Internal Wiring

- 2.7.1 All internal wiring (including busbars and interconnecting cables) used in the distribution of primary power shall be protected against short circuits by suitably rated short circuit (s/c) protection devices. These may be integral parts of the equipment or parts of the building installation.

Short runs of wiring not directly involved in the distribution path are exempt from this requirement where it can be shown that no safety hazard is involved (e.g. indicating circuits).

Devices for overload protection of components may also provide s/c protection of associated wiring.

Internal branch circuits may require individual s/c protection depending on reduced wire size and length of conductors.

2.7.2 For Class I equipment s/c protection devices shall be connected in all phase conductors of the supply, and unless the neutral is earthed and can be reliably identified the s/c protection devices shall be connected in all supply conductors including the neutral. Except for single phase pluggable equipment, any such device which switches a neutral conductor shall be connected so that operation of any s/c protection device breaks all supply conductors simultaneously.

Examples for the commonest supply systems are as follows:

Supply System	Number of Supply Conductors	Minimum Number of Fuses or Circuit Breaker Poles	Location
Single phase with earthed neutral reliably identified	2	1	Phase conductor
Other single phase	2	2	Both conductors
3-phase	3	3	All conductors
3-phase with earthed neutral	4	3	All phase conductors
3-phase with un-earthed or impedance neutral	4	4	All conductors

2.7.3 In situations where earth faults are unlikely (e.g. Class II equipment) the following minimum number of s/c protection devices shall be provided in primary power circuits in the locations stated.

Supply System	Number of Supply Conductors	Minimum Number of Fuses or Circuit Breaker Poles	Location
Phase-neutral or phase-phase	2	1	Either conductor
3-phase	3	2	Any two conductors
3-phase and neutral	4	3	Each phase conductor

2.7.4 All s/c protection devices which are not capable of interrupting the prospective fault current shall be provided in turn with back-up protection.

2.7.5 If the required protection is obtained from s/c protection devices which are part of the building installation they shall be specified in the installation instruction.

For single phase equipment to be connected to standard supply outlets it is assumed that the building installation provides s/c protection in accordance with the rating of the wall outlet and appropriate back-up protection.

2.7.6 Short circuit protection devices shall:

- operate automatically at current values which are suitably related to the safe current ratings of the circuits;
- be capable of reliably breaking the maximum fault current which may flow, having regard to the back-up protection which is provided or specified;
- be so constructed and positioned that their operation does not cause hazard;
- be so constructed and positioned that their characteristics are not adversely affected by normal operating conditions;
- be mounted as specified if requiring special mounting positions.

Two or more s/c protection devices may be combined in one component.

2.7.7 All wires and cables carrying primary power shall be designed to carry the maximum fault energy which may occur due to abnormal conditions specified in sub-clause 5.4.

2.8 Safety Interlocks

2.8.1 Safety interlocks shall be provided where access is required without the use of a tool to areas normally presenting hazards in the meaning of this document. Access may be gained

by removal of covers, opening of enclosures, or withdrawal of parts of enclosures (doors, casings, lids, covers and the like).

2.8.2 Safety interlocks shall be so designed that the hazard will be reduced to an acceptable level before the cover, door, etc. is in any position that will permit entry of the test finger onto the hazardous area.

- For live parts at hazardous voltages the design shall be such that removal, opening or withdrawal
 - . necessitates previous switching off of live parts, or
 - . initiates automatic disconnection of the supply to live parts.
- For moving parts the design shall be such that removal, opening or withdrawal
 - . necessitates previous reduction of movement to a non-hazardous level, or
 - . initiates automatic reduction of movement to a non-hazardous level.
- Where circuit capacitance might otherwise cause a hazardous voltage or energy hazard to persist between accessible live parts, after operation of a guard interlock switch, a means of discharge shall be provided to ensure that the voltage does not exceed 42,4 V peak or d.c. and the energy level does not exceed 20 J, 5 s after operation of the interlock switch.

2.8.3 Safety interlocks shall be designed so that inadvertent re-activation of the hazard is unlikely to occur when covers, guards, doors, etc. are not in the closed position. Any interlock which can be operated by means of the standard test finger (Fig. 1) is considered as likely to cause inadvertent reactivation of the hazard.

2.8.4. Where it may be necessary for a service engineer to override a safety interlock, the override system shall:

- require an intentional effort to operate,
- be self-restoring or require restoration by service personnel to restore the equipment to normal operation,
- require a tool for operation when in operator access areas. For the purpose of this requirement, slotted-type override devices operable with commonly available objects such as coins shall not be used,
- not be used to by-pass a safety interlock for an extreme hazard (such as light source that would cause permanent eye damage).

2.8.5 With interlocked guards, doors, etc. open no unexpected hazard shall occur to operator or service personnel.

Unexpected hazards may be caused by automatic reset thermal devices or by remote and programmed starts.

- 2.8.6 Design of the interlock shall be such that the probable failure mode(s) of the device used shall not create a hazard within the meaning of this document.

When the design does not assume a fail-safe mode, an assessment of the interlock, equipment, circuit diagrams and available data shall result in the conclusion that the failure mode is not likely to occur during the normal life of the product.

Compliance is checked by examination or by cycling the interlock device through 10'000 operations without failure. Simulated interlock devices may be used where testing is necessary.

2.9 Creepage Distances, Clearances and Distances through Insulation

- 2.9.1 The requirements of this sub-clause apply only to circuits where breakdown of insulation may result in a hazard.
- 2.9.2 Insulation distances shall be dimensioned according to the application as specified in sub-clause 2.2.5 and working voltage as specified in sub-clause 2.2.6, in accordance with the following table.

The requirements of this table do not apply to printed wiring other than in primary circuits. The requirements for secondary circuits are under consideration. Furthermore the entire subject of creepage distances and clearances will require to be reviewed when the Recommendations of the appropriate IEC Committee are available.

Creepage distances and clearances smaller than those required in the table are allowed for live parts of different potential separated by functional insulation, provided the equipment does not show any defect within the meaning of this Standard if they are consecutively short-circuited, and the creepage distances are on insulating material having a comparative tracking index of 175 or more when tested according to IEC Publication 112.

In cases where no spacing is specified and above 4000 V d.c. or peak, compliance with the electric strength test in sub-clause 5.3 is required.

For transformers, the distances through insulation are under consideration.

Working Voltage (V)		Minimum Values for Insulation Distance (mm)								
		Functional			Supplementary			Reinforced		
a.c. (r.m.s.)	peak or d.c.	Cl.	Cr.	Th. ⁶	Cl.	Cr.	Th.	Cl.	Cr.	Th.
50	71	no requirement								
130	185	1,5 ¹	2 ²		4	4	1 ⁶	8 ²	8 ²	2 ⁶
250	350	3 ³ 4	4 ³ 5		4	4	1 ⁶	8 ²	8 ²	2 ⁶
440	620	3	4					8	10	
570	800	4	5					8	10	
710	1000	4	6					8	12	
890	1250	4,5	8					9	16	
1000	1400	5,5	9					11	18	
1140	1600	7	10					14	20	
1280	1800	8	11					16	22	
1420	2000	9	11,5					18	23	
1560	2200	10	12					20	24	
1780	2500	11	13					22	26	
1990	2800	12	14					24	28	
2260	3200	13	14,5					26	29	
2560	3600	14	15,5					28	31	
2840	4000	14,5	16,5					29	33	
over 2840	4000	15,5	17,5					31	35	

Cl. = Clearance

Cr. = Creepage distance

Th. = Distance through insulation

NOTES TO THE TABLE

- ¹ - 1 mm if protected against deposition of dirt.
- ² - For live parts being lacquered or enamelled windings, the distances may be reduced to 3/4.
- ³ - 2 mm for live parts being lacquered or enamelled windings, or between live parts of different potentials, if protected against deposition of dirt.
- ⁴ - 2,5 mm between live parts of different potentials, if not protected against deposition of dirt, or between live parts and other metal parts if protected against deposition of dirt.
- ⁵ - 3 mm between live parts of different potentials if not protected against deposition of dirt, or between live parts and other metal parts if protected against deposition of dirt.
- ⁶ - See note to sub-clause 2.2.1.

Compliance is checked by measurement, taking into account figures F1 to F11.

Any air gap less than 1 mm wide (0,25 mm in dirt-free situations) is ignored in computing the total clearance.

The measurements are made:

- with belts, if any, in position with the belt tension devices in the most unfavourable location, and
- with the belt removed.

Movable parts are placed in the most unfavourable position; nuts and screws with non-circular heads, are assumed to have been tightened in the most unfavourable position.

The effect of insulation linings of metal enclosures or covers is taken into consideration.

For equipment incorporating non-detachable power supply cords, measurements are made with supply conductors of the largest cross-sectional area specified in sub-clause 3.3.2 and also without conductors.

The clearances between terminals and accessible metal parts are also measured with the screws or nuts unscrewed as far as possible, but the clearances shall not be less than 50% of the values shown in the table.

Distances through slots or openings in external parts of insulating material are measured to metal foil in contact with the accessible surface. For the purpose of this sub-clause, accessible surfaces of insulating material are treated as though they were covered with a layer of metal foil, the foil being stretched across any openings, but pressed into corners with the test finger (Fig. 1).

If necessary, a force is applied to any point on bare conductors and to the outside of metal enclosures, in an endeavour to reduce the creepage distances and clearances while taking measurements.

The force is applied by means of a test finger having a tip as shown in Fig. 1 and has a value of:

- 2 N for bare conductors
- 30 N for enclosures.

The requirement concerning distances through insulation does not imply that the prescribed distance must be through solid insulation only; it may consist of a thickness of solid insulation plus one or more air layers.

2.9.3 Creepage distances and clearances as defined above apply to terminal devices for external conductors except that larger clearances are required where the supply connections are made.

These shall be so located or shielded that, should a wire of a stranded conductor escape when the conductors are fitted, there is no risk of accidental connection between live parts and accessible metal parts, and, in the case of Class II equipment, between live parts and metal parts separated from accessible metal parts by supplementary insulation only.

Creepage distances and clearances between terminals for fixed wiring and between these terminals and adjacent metal parts shall have at least the following values:

Terminals for fixed wiring	
Rated voltage (V)	Distance and clearance (mm)
250	6,0
380	8,0
440	9,5

The clearance to the case from the terminals, for cables involving current values above 25 A, shall not be less than 9,5 mm.



3 Wiring and Connections

3.1 Internal Wiring

3.1.1 The cross-sectional area of internal wires shall be adequate for the currents they are intended to carry, such that the maximum permitted temperature of conductor insulation shall not be exceeded.

3.1.2 Wire ways shall be smooth and free from sharp edges. Wires shall be protected so that they do not come into contact with burrs, cooling fins, etc., which may cause damage to the insulation of conductors. Holes in metal through which insulated wires pass shall have smooth well-rounded surfaces or be provided with bushings.

Wiring shall be effectively prevented from coming into contact with moving parts.

In electronic assemblies, wires are allowed to be in close contact with wire wrapping posts and the like if the breakdown of insulation will not result in a hazard, or if mechanical protection is provided by additional insulation.

3.1.3 Internal wiring shall be routed, supported, clamped or secured in a manner that prevents:

- excessive strain on wiring and on terminal connections
- loosening of terminal connections
- damage of conductor insulation.

3.1.4 Uninsulated conductors shall be either so rigid and so fixed or so arranged that, in normal use, creepage distances and clearances cannot be reduced below the relevant values specified in sub-clause 2.9.

3.1.5 If the insulation on a primary power conductor is not at least electrically equivalent to the insulation of individual conductors of the cables and cords complying with IEC Publication 227 and 245, that conductor is considered to be a bare conductor.

Requirements for insulation of single conductors are under consideration.

3.1.6 Wires identified by the colour combination green/yellow shall be used only for protective earth connections.

Compliance is checked by inspection.

3.2 Supply Connection

3.2.1 For safe and reliable connection to a primary power supply, equipment shall be provided with one of the following means:

- terminals for permanent connection to fixed wiring, or
- a non-detachable power supply cord for permanent connection to a fixed wiring or with a plug, or
- an appliance inlet.

Where equipment is supplied with more than one supply connec-

tion (e.g. with different voltages/frequencies or as redundant power) the design shall be such that:

- separate terminals be provided for the different circuits,
- supply plug connections, if any, are not interchangeable if hazard could result from incorrect plugging.
- the operator cannot touch parts at hazardous voltages, such as plug contacts, when one or more connectors are disconnected.

3.2.2 Equipment intended to be permanently connected to fixed wiring shall be provided:

- with a set of terminals allowing the connection of fixed wiring as specified in sub-clause 3.3, or
- with a non-detachable power supply cord.

Fixed equipment intended to be permanently connected to fixed wiring, except those delivered with flexible cords:

- shall permit the connection of the supply wires after the equipment has been fixed to its support;
- shall 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 entries shall be suitable for cables and conduits having a maximum overall diameter as shown in the following table:

Number of conductors including earthing wire	Maximum overall diameter (mm)	
	cable	conduit
2	13,0	16,0 (23,0)
3	14,0	16,0 (23,0)
4	14,5	19,0 (29,0)
5	15,5	19,0 (29,0)

The sizes in brackets are for North American knock-outs.

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 creepage distances and clearances below the values specified in sub-clause 2.9.

Compliance is checked by inspection, a practical installation test and by measurement.

3.2.3 Appliance inlets shall:

- be so located or enclosed that live parts are not accessible during insertion or removal of the connector;
- be so placed that the connector can be inserted without difficulty;
- be so placed that, after insertion of the connector, the appliance is not supported by the connector for any position of normal use on a flat surface.

Compliance is checked by inspection and, with regard to the first requirement, by means of the standard test finger shown in Fig. 1.

Equipment provided with appliance inlets complying with IEC Publication 320, Appliance Couplers for Household and Similar General Purposes, are considered to comply with the first requirement.

3.2.4 Power supply cords shall:

- be not lighter than ordinary tough rubber-sheathed flexible cord (designation 245 IEC 53), or ordinary polyvinylchloride-sheathed flexible cord (designation 227 IEC 53);
- include in the case of Class I equipment a green/yellow protective earthing conductor connected to the internal protective earthing terminal of the equipment and connected to the protective earthing contact of the plug, if any;
- have conductors with cross-sectional areas not less than those specified in the following table:

Rated current of equipment (A)	Nominal cross-sectional area (mm ²)
≤ 10	0,75
> 10 ≤ 13,5	1
> 13,5 ≤ 16	1,5
> 16 ≤ 25	2,5
> 25 ≤ 32	4
> 32 ≤ 40	6
> 40 ≤ 63	10
> 63 ≤ 80	16
> 80 ≤ 100	25
> 100 ≤ 125	35
> 125 ≤ 160	50

Up to 3 A a nominal cross section of 0,5 mm² is allowed, provided the length of the cord does not exceed 2 m.

- not be exposed to sharp points or cutting edges of surfaces within or on the surface of the machine. All points and edges with which the supply cord is in touch shall be shaped such that they are suitable for the type of cord supplied with the machine.

When necessary, inlet bushings shall be used which shall be reliably fixed and not be removable without the use of a tool.

Compliance is checked by inspection and by measurement.

- 3.2.5 A cord anchorage shall be provided for equipment with a non-detachable power supply cord such that the conductors are relieved from strain, including twisting, where they are connected within the equipment and that the insulation of the conductors is protected from abrasion.

In the event that the flexible cord should slip in its anchorage placing a strain on the conductors, the earth conductor shall be the last to take the strain.

Cord anchorages of power supply cords shall be so designed that:

- replacement does not impair the safety and the correct functioning of the equipment;
- the cord cannot touch clamping screws of the cord anchorage, if these screws are accessible or electrically connected to accessible metal parts;
- the cord is not clamped by a metal screw which bears directly on the cord;
- knots in the cord shall not be required.

Additionally, the cord anchorage on Class II equipment with a metal enclosure shall:

- be constructed from insulating material, or
- have a lining of insulating material, or
- be mounted on insulating material,

and shall meet the requirements for supplementary insulation.

Compliance is checked by inspection, by the relevant dielectric strength tests where required, and by the following tests:

The equipment is tested with the cord in place.

It shall not be possible to push the cord into the machine to such an extent that the cord or internal parts of the equipment could be damaged.

The cord is then subjected 25 times to a pull of the value shown in the table below. The pulls are applied in the most unfavourable direction without jerks, each time for 1 s.

Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in the table.

Mass of equipment (kg)	Pull (N)	Torque (Nm)
≤ 1	30	0,1
$> 1 \leq 4$	60	0,25
> 4	100	0,35

During the tests, the cord shall not be damaged.
After the tests, the cord shall not have been longitudinally displaced by more than 2 mm nor shall there be appreciable strain at the connection.

Creepage distances and clearances shall not be reduced below the values specified in sub-clause 2.9.

3.2.6 A cord guard at the power supply cord inlet opening shall be provided for hand-held equipment with non-detachable cords, unless the inlet or bushing is provided with a smoothly rounded bell-mouthed opening having a radius of curvature at least equal to 1,5 times the overall diameter of the cord specified for the equipment. Cord guards shall:

- be so designed as to protect the cord against excessive bending where it enters the equipment;
- be of insulating material;
- be fixed in a reliable manner;
- project outside the equipment for a distance beyond the inlet opening of at least five times the overall diameter or, for flat cords, at least five times the major overall dimension, of the cord specified for the equipment.

Compliance is checked by inspection and by measurement.

3.2.7 The overall sheath of a non-detachable power supply cord shall continue into the equipment through any inlet bushing or cord guard and extend by at least half the cord diameter beyond the clamp of the cord anchorage.

An inlet bushing on equipment with a non-metallic enclosure shall be of insulating material.

An inlet bushing or cord guard on Class II equipment with a metal enclosure shall meet the requirements for supplementary insulation.

3.2.8 The supply wiring space provided inside or as part of equipment for connection:

- to fixed wiring and of power cords
 - . shall be designed to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned;

- . shall be designed so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation;
 - . shall be so designed that the uninsulated end of a conductor in Class II equipment and in hand-held equipment, should it become free from its terminal, cannot come into contact with accessible metal parts, unless the cord is provided with terminations that are unlikely to slip free of the conductor.
- to fixed wiring
- . shall be adequate to allow the conductors to be easily introduced and connected;
 - . shall be designed to permit removal of covers, if any, giving access to terminals for external conductors without the use of a special purpose tool

Compliance is checked by inspection and for connections to fixed wirings by an installation test with cables or flexible cords of the largest cross-sectional area specified in sub-clause 3.3.2.

3.3 Terminals for Primary Power Supply Conductors

- 3.3.1 Equipment intended to be permanently connected to fixed wiring shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.
- 3.3.2 For equipment with 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 permissible temperature limits.

Soldered, welded, crimped and similar connections may be used for the connection of external conductors, provided that, for soldered or welded terminations, the conductor is so positioned or fixed that reliance is not placed upon the soldering or welding alone to maintain the conductor in position, unless barriers are provided such that creepage distances and clearances between live parts and other metal parts cannot be reduced to less than 50% of the values specified in sub-clause 2.9 should the conductor break away at a soldered or welded joint or slip out of a crimped connection.

- 3.3.3 Screws and nuts which clamp external conductors shall have a metric ISO thread or a thread comparable in pitch and mechanical strength. They shall not serve to fix any other component, except that they may also clamp internal conductors if these are so arranged that they are unlikely to be displaced when fitting the supply conductors.

The terminals of a component (e.g. a switch) built into the equipment on the assumption that they comply with the requirements of this clause - may be used as terminals intended for external conductors.

Provisionally, SI, BA and Unified threads are deemed to be comparable in pitch and mechanical strength to metric ISO thread.

- 3.3.4 For the purpose of the requirements for power supply cords:
- it is not to be expected that two independent fixings will become loose at the same time;
 - conductors connected by soldering are not considered to be adequately fixed, unless they are held in place near to the termination, independently of the solder, but "hooking in" before the soldering is, in general, considered to be a suitable means for maintaining the conductors of a power supply cord other than a tinsel cord in position, provided the hole through which the conductor is passed is not unduly large;
 - conductors connected to terminals or terminations by other means are not considered to be adequately fixed, unless an additional fixing is provided near to the terminal or termination; this additional fixing, in the case of stranded conductors, clamps both the insulation and the conductor.

3.3.5 Terminals shall allow the connection of conductors having nominal cross-sectional areas as shown in the following table:

Rated current of equipment (A)	Nominal cross-sectional area (mm ²)	
	Flexible cords	Cables for fixed wiring
≤ 3	0,5 to 0,75	1 to 2,5
> 3 ≤ 10	0,75 to 1,5	1 to 2,5
> 10 ≤ 13,5	1 to 1,5	1,5 to 4
> 13,5 ≤ 16	1,5 to 2,5	1,5 to 4
> 16 ≤ 25	2,5 to 4	2,5 to 6
> 25 ≤ 32	4 to 6	4 to 10
> 32 ≤ 40	6 to 10	6 to 16
> 40 ≤ 63	10 to 16	10 to 25

3.3.6 Terminals shall have dimensions as shown in the following table:

Rated current of equipment (A)	Minimum nominal thread diameter (mm)	
	Pillar type or Stud type	Screw type
≤ 10	3,0 *	3,5
> 10 ≤ 16	3,5	4
> 16 ≤ 25	4,0	5
> 25 ≤ 32	4,0	5
> 32 ≤ 40	5,0	5
> 40 ≤ 63	6,0	6

*For BA threads, this value is reduced to 2,8 mm.

Stud terminals shall be provided with washers.

3.3.7 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 placed that the conductor cannot slip out when the clamping screws or nuts are tightened.

Terminals shall be so fixed that, when the conductor clamping means is tightened or loosened:

- the terminal itself does not work loose,
- internal wiring is not subjected to stress,
- creepage distances and clearances are not reduced below the values specified in sub-clause 2.9.

3.3.8 Each terminal shall be located in proximity to its corresponding terminal, or terminals, of different potential and to the protective earthing terminal, if any.

Compliance is checked by inspection.

The reason for these requirements is to allow simultaneous visible inspection to verify that the earthing connection is made.

4 Construction

4.1 Stability and Mechanical Hazards

- 4.1.1 Units and assemblies of units shall not become physically unstable to the degree that they may become a hazard to operators and service personnel under conditions of normal use.

A reliable stabilizing means may be used to improve stability when doors, drawers, etc. are opened. Where it is not automatic in operation, suitable and conspicuous markings shall be provided to caution the personnel.

Compliance is checked by the following four tests, where relevant. Each test is carried out separately. During the tests containers shall contain the amount of substance, within their rated capacity, producing the most disadvantageous condition, and castors shall be in their most disadvantageous position.

- *A unit shall not overbalance when tilted to 10° from its normal upright position. Doors, drawers, etc. shall be closed during this test and the unit shall not be secured to the test floor or to the other units.*
- *A floor-standing unit shall not overbalance when a force equal to 20% of the weight of the unit but not more than 250 N is applied to any direction except upward at a height not exceeding 2 m from the floor, with jacks (if used under normal conditions) and all doors, drawers, etc. which may be opened by the operator in their most unfavourable position.*
- *A unit 1 m or more in height and having a mass of 25 kg or more shall not overbalance when a force equal to 20% of the weight of the unit but not more than 250 N is applied in any direction except upward, at a height not exceeding 2 m from the floor, with jacks (if used under normal conditions) and all doors, drawers, etc. which may be moved for any servicing in their most unfavourable position.*
- *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 working surface or surface offering an obvious foothold at a height not exceeding 1 m from the floor.*

Where units are designed to be fixed together on site and not used individually, the stability of individual units need not to be considered.

These requirements do not apply when the installation instructions for a unit specify that the equipment is to be secured to the building structure before operation.

- 4.1.2 The design shall be such that, as far as is reasonably practicable, in normal use adequate protection is provided against personal injury from moving parts.

Guards or portions of enclosure acting as guards for hazardous parts shall either:

- be mounted to the assembly so that the hazardous part cannot be operated with a guard removed, or
- be secured to the assembly using fasteners requiring a tool for removal, or
- be provided with interlocks to protect against access to the hazard.

An enclosure or guard for a moving member shall be sufficiently complete to contain or deflect parts which, because of failure of other reasons, might become loose, separated or thrown from a moving part.

Where moving parts which present an injury potential are normally protected by a service or loading door suitable means should be provided to ensure that access to danger shall be prevented.

If complete guarding of an obviously hazardous moving part would defeat the utility of the equipment, a suitable "STOP" control shall be provided in a location readily and easily accessible from the normal operating position.

Self-resetting thermal cutouts, overcurrent releases or automatic timer starting, etc., shall not be incorporated if their unexpected resetting might cause danger.

Compliance is checked by inspection and by a test with the standard test finger (Fig. 1). It shall not be possible to touch dangerous moving parts with the test finger.

4.1.3 Edges or corners (except those required for proper machine functioning) shall be rounded and smoothed (no abrupt discontinuity) when they are:

- on the external contours of the machine where they are likely to be contacted,
- on parts that will be contacted as a result of normal operator functions,
- hazardous because of location or application.

Compliance is checked by inspection.

4.1.4 The enclosure of a data processing unit that employs a high pressure lamp shall have adequate strength to contain an explosion of the lamp so as to prevent a hazard to an operator or person near the unit during normal use or operator servicing. A high pressure lamp is considered to be one in which the pressure exceeds 0,2 MPa cold or 0,4 MPa operating.

Compliance is checked by inspection.

The cold and operating pressure are under consideration.

4.2 Mechanical Strength

- 4.2.1 Data processing equipment shall have adequate mechanical strength and be so constructed as to withstand such temperatures and rough handling as may be expected in normal use.

Compliance is checked by the following three tests, where relevant, applied to separate samples of the covers and guards in operator access areas.

The test is not applied to transparent or translucent covers or enclosures of indicating or measuring devices unless parts at hazardous voltages are accessible by means of the test finger (Fig. 1) if the cover or enclosure is removed.

- *All materials:*

A steady force of 250 N shall be applied by means of a suitable test tool providing contact over a surface of 30 mm in diameter.

- *Materials, other than metallic or ceramic:*

A sample enclosure or a portion of an enclosure, or other barrier, of the relevant thickness, and mechanically supported as in normal use, shall be placed in a circulating air oven subjected to a temperature of at least 10° C higher than the maximum temperature observed on the part during normal operation, but not less than 70° C in any case for a period of 7 hours and allowed to cool to room temperature.

- *Materials other than metallic:*

A sample consisting of the complete enclosure or barrier, or a section thereof representing the largest, unreinforced area, and the thinnest wall section shall be supported so that the area that is to receive the impact is horizontal.

The impact shall be imparted to the sample by a solid, smooth, steel sphere 50 mm in diameter and mass approximately 0,5 kg. The sphere shall fall freely from rest through a vertical distance of 1300 mm.

The material is considered to comply if during and after the above tests, the sample shows no damage within the meaning of this document in particular, live parts at hazardous voltages or hazardous mechanical parts shall not have become accessible, so as to cause non-compliance with the requirements of sub-clauses 2.1.3, 2.4.1, 2.9 and 4.1.2. In case of doubt, supplementary insulation or reinforced insulation shall be subjected to an electric strength test as specified in sub-clause 5.3.

Damage to finish, small dents which do not reduce creepage distances and clearances below the values specified in sub-clause 2.9 and small chips which do not adversely affect the protection against electrical shock or moisture shall not be considered.

Cracks not visible to the naked eye and surface cracks in fibre-reinforced mouldings and the like shall be ignored.

If a decorative cover is backed by an inner cover, fracture of the decorative cover shall be ignored if the inner cover withstands the test after removal of the decorative cover.

4.3 Construction

4.3.1 Equipment shall be so constructed that it does not produce a hazard within the meaning of this document.

4.3.2 Equipment which can be adjusted to suit different primary power supply voltages shall be so constructed that changing of the setting requires the use of a tool if incorrect setting causes a hazard.

Compliance is checked by manual test.

4.3.3 Equipment shall be so constructed that manual adjustment of control devices requires the use of a tool if a hazard might be involved.

Compliance is checked by manual test.

4.3.4 Floor standing equipment shall be so constructed that in the event of liquid spillage onto the supporting surface from the equipment or from an external source, no electrical shock hazard results. If there is an opening in the base, all live parts shall be at least 6 mm vertical distance from the supporting surface.

Compliance is checked by inspection and by measurement.

4.3.5 Equipment employing powders, liquids or gases shall be so constructed as to ensure that no hazard within the meaning of this document is created by condensation, vaporisation, leakage, spillage or corrosion. In particular, creepage distances and clearances shall not be reduced below the requirements of sub-clause 2.9.

Compliance is checked by visual inspection.

4.3.6 Handles, knobs, grips, levers and the like shall be fixed in a reliable manner so that they will not work loose in normal use if this might result in a hazard.

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.

If the shape of these parts is such that an axial pull is unlikely to be applied in normal use, the force shall be:

*15 N for operating means of electrical components,
20 N in other cases.*

If the shape is such that an axial pull is likely to be applied the force shall be:

30 N for operating means of electrical components,
50 N in other cases.

Sealing compounds and the like, other than self-hardening resins, are not deemed to be adequate to prevent loosening.

- 4.3.7 Insulation materials assuring safety shall be suited to the climatic environment in which the equipment is to be used (as specified by the manufacturer).

Natural rubber shall not be used as insulation.

Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation, unless impregnated. Insulating material is considered to be impregnated if the interstices between the fibres or the material are substantially filled with a suitable insulant.

Asbestos is considered to be fibrous material within the meaning of this requirement.

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.

- 4.3.8 Parts which serve as supplementary insulation or reinforced insulation and which might be omitted during reassembly after servicing shall either:

- be fixed in such a way that they cannot be removed without being seriously damaged, or
- be so designed that they cannot be replaced in an incorrect position and that, if they are omitted, the equipment is rendered inoperable or manifestly incomplete.

Sleeving may, however, be used as supplementary insulation on internal wiring, if it is retained in position by positive means.

A sleeve is considered to be fixed by positive means if it can only be removed by breaking or cutting or if it is clamped at both ends.

Compliance is checked by inspection and by manual test.

- 4.3.9 Inside the equipment, the sheath (jacket) of a flexible cord shall only be used as supplementary insulation where it is not subject to undue mechanical or thermal stresses and if its insulating properties are not less than those specified in IEC Publications 227 and 245 for the sheaths of flexible cords.

Compliance is checked by inspection.

4.3.10 Any assembly gap with a width greater than 0,3 mm in supplementary insulation, shall not be coincidental with any such gap in functional insulation, neither shall any such gap in reinforced insulation give straight access to live parts.

Compliance is checked by inspection and by measurement.

4.3.11 Equipment shall be so designed that creepage distances and clearances over supplementary insulation or reinforced insulation cannot, as a result of wear, be reduced below the values specified in sub-clause 2.9. They shall be so constructed that, should any wire, screw, nut, washer, spring or similar part become loose or fall out of position, it cannot, in normal use, become so disposed that creepage distances or clearances over supplementary insulation or reinforced insulation are reduced to less than 50% of the value specified in sub-clause 2.9.

Compliance is checked by inspection, by measurement and by manual test.

For the purpose of this requirement:

- it is not to be expected that two independent fixings will become loose at the same time;
- parts fixed by means of screws or nuts provided with self-locking washers are regarded as not liable to become loose, provided these screws or nuts are not required to be removed during the replacement of the supply flexible cable or cord;
- wires connected by soldering are not considered to be adequately fixed, unless they are held in place near to the termination, independently of the solder;
- wires connected to terminals are not considered to be adequately secured, unless an additional fixing is provided near to the terminal, this additional fixing in the case of stranded conductors, clamping the insulation and not only the conductor;
- short rigid wires are not regarded as liable to come away from a terminal, if they remain in position when the terminal screw is loosened.

4.3.12 Supplementary insulation and reinforced insulation shall be so designed or protected that they are not likely to be impaired by deposition of dirt, or by dust resulting from wear of parts within the equipment, to such an extent that creepage distances and clearances are reduced below the values specified in sub-clause 2.9.

Parts of synthetic rubber used as supplementary insulation shall be resistant to ageing and be so arranged and dimensioned that creepage distances are not reduced below the values specified in sub-clause 2.9 whatever cracks may occur.

Compliance is checked by inspection and by measurement.

- 4.3.15 Equipment shall be so constructed that internal wiring, windings, commutators, slip-rings and the like, and insulation in general, are not exposed to oil, grease or similar substances, unless the construction necessitates that insulation be exposed to oil or grease, as in gears and the like, in which case the oil or grease shall have adequate insulating properties.

Compliance is checked by inspection.

- 4.3.14 Equipment shall be so designed as to provide protection against the harmful effects of ozone, ultra-violet light, flammable fluids, flammable gases and similar hazards to persons and damage to materials affecting safety.

- 4.3.15 Equipment using powder or producing dust, such as paper dust, shall be so designed that the dusts or powders are confined in those areas where the functioning of components, or electrical insulation, creepages or clearances will not be adversely affected so as to create a hazard.

Compliance is checked by inspection.

- 4.3.16 Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use.

Screws which make a mechanical connection between different parts of the equipment, shall be locked against loosening if the connection carries current.

Spring washers and the like may provide satisfactory locking.

- 4.3.17 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.

Thread-cutting (self-tapping) screws shall not be used for the electrical connection of current-carrying parts, unless they generate a full form standard machine screw thread. Such screws shall not, however, be used if they are operated by the user or installer unless the thread is formed by a swaging action.

Thread-cutting and spaced thread screws may be used to provide earthing continuity, provided that it is not necessary to disturb the connection in normal use and at least two screws are used for each connection.

4.3.18 There shall be no openings directly over hazardous live parts in the top of the enclosure of a floor mounted unit of 1200 mm or less in height.

Compliance is checked by inspection.

4.3.19 Openings directly over hazardous live parts in the top of the enclosure of a unit more than 1200 mm in height or of a desk-mounted unit shall not exceed 5 mm in any dimension unless the configuration is such that straight access to hazardous live parts is prevented.

Compliance is checked by inspection.

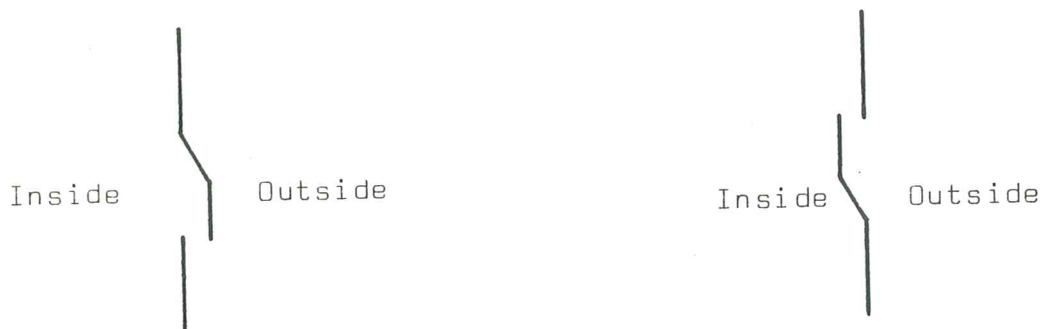


Cross-section of top cover designs preventing straight access.

4.3.20 In the side of the enclosure openings shall be so located and of such a size that accidental entry of a foreign object shall be prevented.

Compliance is checked by inspection.

Louvres may be used if shaped to deflect falling objects outwards.



LOUVRE DESIGN

4.4 Resistance to Fire

4.4.1 This sub-clause states requirements intended to minimise the risk of ignition and the spread of flame, both within the equipment and to the outside. This is achieved by:

- Avoiding high temperatures where this is possible, or by shielding or spacing flammable materials from high temperature parts (sub-clause 4.4.2 and Appendix A6).
- Using materials of low flammability for internal parts (sub-clause 4.4.3 and Appendices A6, A7, A8).
- Using enclosures of low flammability and low flame spread index (sub-clause 4.4.4 and Appendices A1, A2, A3, A6, A9).

- Using enclosures or barriers to limit the spread of fire within, and from, the equipment (sub-clauses 4.4.5, 4.4.6 and Appendices A4, A5).

4.4.2 The risk of ignition due to high temperature shall be minimised by the appropriate use of components or by suitable construction.

Electrical components shall be used so that their maximum working temperature under the worst case non-fault conditions is less than that necessary to cause ignition to them, their surroundings or lubricating materials with which they are likely to come into contact. The temperature limits of sub-clause 5.1 shall not be exceeded.

Combustible materials used shall not be subject in normal use to temperatures liable to cause combustion.

Components working at high temperatures shall be effectively shielded or separated to prevent overheating of their surrounding materials and components.

Where it is not practical to protect components against overheating under fault conditions, the components shall be mounted on material of flammability classification V-1 or better, and shall be adequately separated from less fire resistant material.

Compliance is checked by inspection and, where necessary, by test.

4.4.3 Components and parts of equipment shall be so constructed or make use of materials that the propagation of fire is minimised.

Compliance is checked by inspection and, where necessary, by test.

Except as noted below, all materials and components to which the tests are applicable shall have a flammability classification not less than V-2 or HF-2.

Electrical components meeting flammability requirements contained in individual IEC requirements pertaining to the components are exempted.

Printed wiring boards involving primary circuitry, or those located in secondary circuits where failure of the bond between the conductor and the base material could result in contact with uninsulated primary current-carrying parts are required to meet the relevant IEC Standards pertaining to the particular construction.

A wiring harness shall comprise individual materials which are class V-2 or better or which comply with the requirements of relevant IEC Standards.

Alternatively, the harness when tested as an assembly shall be class V-2 or better.

Individual clamps (not including helical wraps or other continuous forms), lacing tape, twine and cable ties need not comply.

Strain relief bushings applied over p.v.c. jacketed cord may be class HB.

Meter cases (if otherwise determined to be suitable for mounting of live parts), meter faces and indicator lamps and or jewels are exempt from flammability requirements.

An air filter is considered to comply, if, when attacked by flame while clean, it burns only moderately or emits only moderate amounts of smoke, or both.

The following requirements apply to parts which are isolated by 13 mm or more of air or by a solid barrier of V-1 materials from electrical parts other than insulated wires and cables which, under fault conditions, are likely to produce a temperature which could cause ignition.

- Gears, cams, belts, bearings, strain-relief applied over p.v.c. jacketed cords and other small parts which contribute negligible fuel to a fire are deemed to comply without test.
- Tubing for air or fluid systems and foamed plastic parts shall not be more flammable than HB or HBF.

Oil or equivalent fluids used for lubrication or cooling or in a hydraulic system shall have a flash point of 149 °C or higher and the container shall be of sealed construction. The system shall have provision for expansion of the fluid and shall incorporate means for automatic pressure relief.

This requirement does not apply to lubricating oils which are applied to points of friction in quantities which contribute negligible fuel to a fire.

Equipment using a liquid, powder, or other material that must be replenished, removed, or replaced shall be so designed that:

- spilt material is prevented from contacting live parts, and
- any other hazardous condition that can result from filling, emptying, storage, normal movement of the unit, etc. is

prevented from occurring. Replenishable liquids such as printing inks shall have a flash point of 60 °C or higher.

The component flammability requirements of this clause may be waived for the components within an enclosure of 0,06 m³ or less, totally enclosed in metal and having no vent openings, or within a sealed unit containing an inert gas.

Compliance is checked by inspection and, where necessary, by test.

- 4.4.4 Materials used in the construction of enclosures of equipment shall be such that the risk of ignition and the spread of fire or flames is minimised.

Compliance is checked by examination and, where necessary, by test.

Steel, aluminium, heat-resistant tempered, wired or laminated glass are deemed to comply without test.

The material shall comply with the Flame Test of Appendix A1.

If, under normal operating conditions any portion of the enclosure is subjected to a temperature rise of more than 40 °C the material shall be conditioned as specified in Appendix A1 before test, unless ageing characteristics of the material have been established.

Enclosure material of equipment with a total mass not exceeding 25 kg is deemed to comply without test if the material is flammability classification V-1.

Enclosures which do not serve to protect against contact with hazardous live parts, or enclosure materials used for mechanical or decorative purposes only, are deemed to comply without test if the material is flammability classification HB or better.

For ultimate enclosures having an exposed surface area of a single unbroken section in the same plane greater than 0,9 m² or a single horizontal or vertical dimension larger than 1,8 m the materials are considered to comply if they show a flame spread index not exceeding 50 when tested in accordance with the radiant panel furnace method as described in Appendix A9.

Specimens shall be representative of the thinnest wall section. The flame spread index shall be defined as the average value based on a sample of 6 specimens representative of the thinnest wall section, provided no specimen has a value greater than 75.

Enclosures having smaller surface areas than those specified are exempted from the above test. The dimensions refer to single unbroken sections of enclosures. If two sides of a single piece are exposed, only the larger side is measured.

Combined materials such as laminates are tested in their combined form.

Enclosure materials shall be resistant to ignition under any abnormal condition. Compliance is checked by the test of Appendix A3.

Metallic or ceramic materials are deemed to comply without test.

If uninsulated live parts which present a shock or energy hazard are located within 13 mm of a non-metallic material used as part or all of an enclosure the material shall comply with the test of Appendix A2.

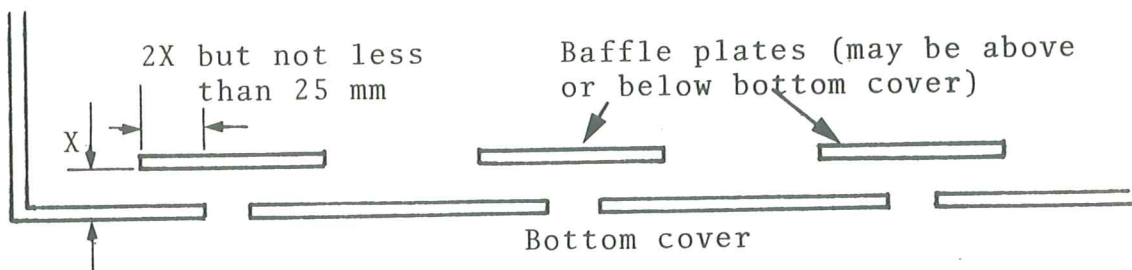
- 4.4.5 Enclosures shall be designed and constructed to minimise the possibility of emission of flame, molten metal, flaming or glowing particles or flaming drops.

Except as noted below, barriers shall be provided under all internal parts to prevent materials from falling directly from the equipment on to the supporting surface.

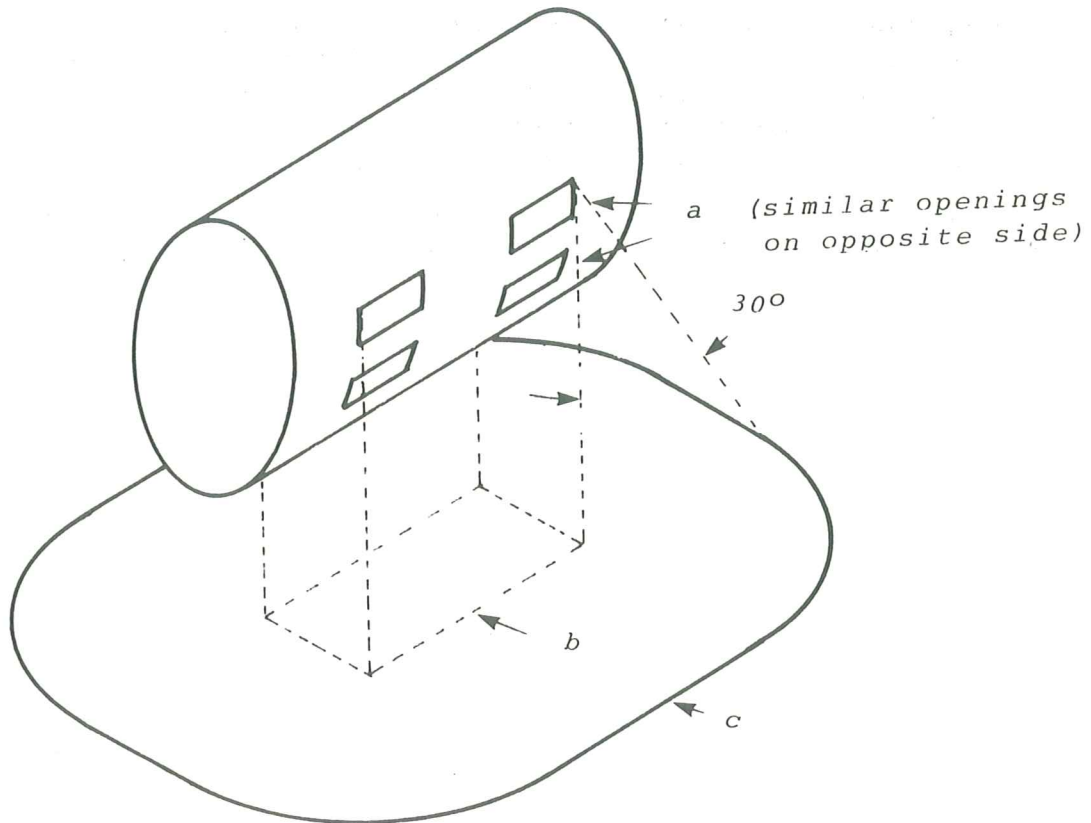
Compliance is checked by inspection and, where necessary, by the tests of either Appendix A4 or Appendix A5.

The following constructions are deemed to comply without test:

- *Openings of any size under
 - . thermoplastic insulated conductors and their receptacles
 - . impedance or thermally protected motors.*
- *Openings not larger than 40 mm² under
 - . components or parts of flammability classification V-1
 - . components or parts with individual barriers (see below).*
- *A sheet steel bottom panel at least 1 mm thick in which there are 2 mm or smaller round holes grouped no closer than 3 mm between centres.*
- *A baffle plate construction as illustrated.*



An example of an acceptable form of barrier for a partially enclosed component or assembly is illustrated below. Barrier material shall be classified as for other enclosure materials, and should be dished or lipped all round.



- a - Potential source of flaming parts - ventilation openings in metal-enclosed assembly.
- b - Vertical projection of potential source.
- c - Outline traced by 30° trajectory - minimum area of barrier, except where it may meet vertical barriers or side panels. Dimension b to c need not exceed 150 mm.

On desk and table-mounted equipment, bottom panels or barriers as described above may be flammable provided that they are

- flammability rating V-2 or better, and
- in compliance with the requirements of sub-clause 4.2.1, or
- in compliance with the requirements of sub-clause 4.4.4 for enclosures protecting against contact with hazardous live parts.

4.4.6 Equipment shall be so constructed that in the event of a fire it shall not explode or collapse, nor distort so as to increase the propagation of a fire.

Where enclosures are used to limit the spread of a fire, covers shall not fall off, nor distort so as to reduce their effectiveness in enclosing a fire.

4.5 Resistance to Tracking

Insulating parts retaining mains-connected live parts in position, and supplementary insulation of metal-encased Class II equipment, shall be of material resistant to tracking, if they are exposed to excessive deposition of moisture or dirt in normal use, unless the creepage distances are at least equal to twice the values specified in sub-clause 2.9.

Materials having a comparative tracking index of 175 or more when tested according to IEC Publication 112 are deemed to be adequate.

5 Live Tests

5.1 Heating

- 5.1.1 In normal use, the equipment shall not attain excessive temperatures.

Compliance is checked by determining the temperature rise of the various parts under the following conditions.

The equipment is operated under normal load until steady conditions are established.

Components and other parts may be tested independently provided the test conditions applicable to the equipment are adhered to.

Equipment intended for rack-mounting or for incorporation in larger units shall be tested under the most adverse conditions, actual or simulated, permitted in the manufacturer's installation instructions.

In determining the temperature rises of handles, knobs, grips and the like, consideration is given to all parts which are gripped in normal use and, if of insulating material, to parts in contact with hot metal.

The temperature rise of electrical insulation, other than that of windings, is determined on the surface of the insulation, at places where failure could cause a short-circuit, contact between live parts and accessible metal parts, bridging of insulation or reduction of creepage distances or clearances below the values specified in sub-clause 2.9.

- 5.1.2 During the test, thermal cutouts shall not operate. The temperature rises shall not exceed the values shown in the following table and sealing compound, if any, shall not flow out.

Parts	Temperature rise (°C)
Windings, if the winding insulation is: <ul style="list-style-type: none"> - of Class A material ¹ - of Class E material ¹ - of Class B material ¹ - of Class F material ^{1 3} - of Class H material ^{1 3} 	75 90 95 115 140
External parts <ul style="list-style-type: none"> - Outer surfaces of enclosures - Metallic knobs, handles, etc. touched in normal use - Non-metallic knobs, handles, etc. touched in normal use ² 	60 30 50
Thermoplastic materials used as insulation	see ⁴
Other parts	see ²

¹ The classification is in accordance with IEC Publication 85, "Recommendations for Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to their Thermal Stability in Service".
When temperature rises of windings are determined by thermocouples, these figures are reduced by 10 °C except in the case of a.c. motors.

² The temperature rise for a given insulating material is limited to that specified in IEC Publication 85.

³ Motors with windings of Class F or H are required to be so marked

⁴ Due to their wide variety, it is not possible to specify permissible temperature rises for thermoplastic materials. While the matter is under consideration, the following method is suggested:

- An arbitrary softening temperature of the material shall be determined on a separate sample, with a Vicat test:

- . cross-section of penetrating needle: 1 mm²
- . load: 10 N
- . heating rate: 50 °C per hour

The softening temperature is that for which the depth of penetration is 0,1 mm.

- The temperature limits to be considered for determining the temperature rises are:

- . under reference test conditions, a temperature 10 °C lower than the softening temperature;
- . under fault conditions, the softening temperature.

Consideration should be drawn to the fact that, on a long term basis, the electrical and mechanical properties of certain insulating materials may be adversely affected, e.g. by softeners, evaporating at temperatures below the softening temperature.

5.2 Earth Leakage Current

5.2.1 Equipment shall not have earth leakage current in excess of the following values:

- Class II equipment: 0,25 mA
- Class I hand held equipment: 0,75 mA
- Class I movable equipment: 3,5 mA
- Class I pluggable stationary equipment: 3,5 mA
- Class I permanently connected stationary equipment: 5% of unit load current, subject to the conditions in sub-clause 5.2.5.

Compliance is checked by the tests below which are carried out using the measuring instrument described in Appendix D, or any other circuit giving the same results and preferably using an isolating supply transformer as shown. If the use of an isolating transformer is not practicable the equipment shall be mounted on an insulating stand, not earthed, and due safety precautions shall be taken in view of the possibility of the body of the equipment being at a hazardous voltage.

For Class II units the test shall be made to accessible metal parts and to metal foil on accessible non-metal parts.

Where it is inconvenient to test equipment at the most unfavourable supply voltage (see sub-clause 1.4.5) it may be tested at any available voltage within the rated voltage range and the extreme results deduced by calculation.

Where from a study of the circuit diagrams it is clear that the earth leakage current will exceed 3,5 mA but will not exceed 5% of unit load current, the tests need not be made.

5.2.2 For single-phase equipment intended for operation between one phase conductor and neutral the test shall be carried out using the circuit of Fig. 5.1. With the equipment operating, the current in the measuring instrument shall be recorded for each position of the test switch S.

For equipment with a single pole on/off switch the test shall be repeated with this switch "off".

None of the current values recorded shall exceed the relevant limits specified in sub-clause 5.2.1.

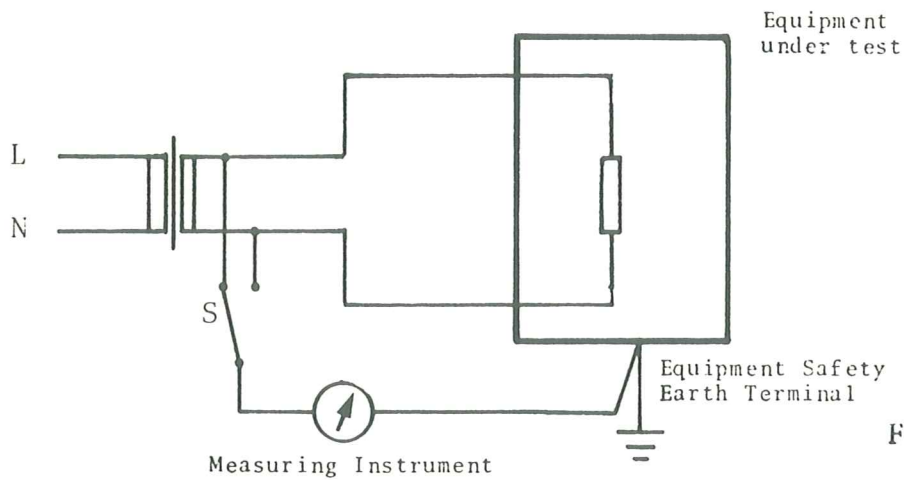


Fig. 5.1

5.2.3 Except as stated in sub-clause 5.2.4, three-phase equipment and equipment connected to two phase conductors shall be tested using the circuit of Fig. 5.2. With the equipment operating, the current in the measuring instrument shall be recorded with the switches a, b, c and d

- closed, and
- opened one at a time to simulate abnormal conditions.

The test shall be repeated with the equipment on/off switch "off". None of the current values recorded shall exceed the relevant limits specified in sub-clause 5.2.1.

Caution shall be exercised in carrying out this test, especially as to opening switch d, in case damage is caused to the equipment.

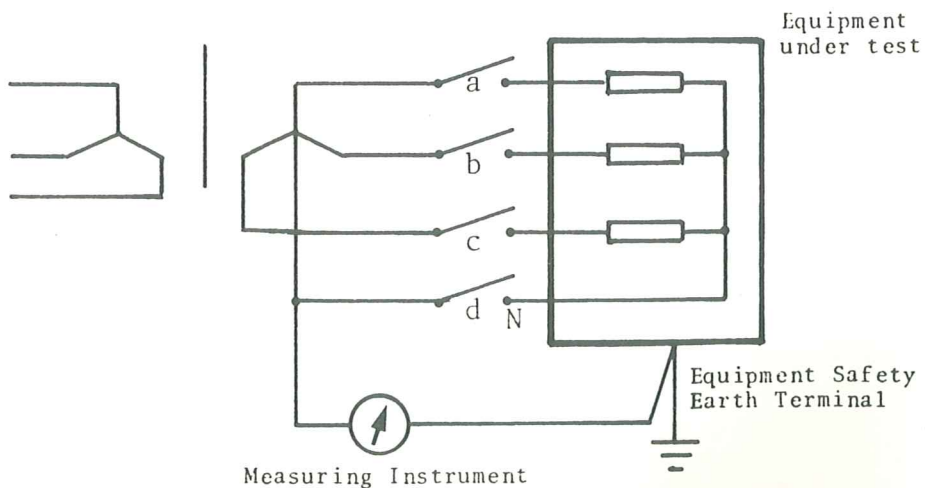


Fig. 5.2

5.2.4 Where equipment has protective devices which would normally disconnect primary power circuits when power is missing on one phase, it may not be possible to carry out the tests of sub-clause 5.2.3 without causing damage to the equipment. In this case an assessment of the leakage current shall be made by testing the r.f.i. filter, if any, independently of the equipment using the tests of sub-clause 5.2.3. The maximum measurement is taken as the filter leakage current.

The equipment less filter shall then be tested using the circuit of Fig. 5.3 with the equipment on/off switch "on". All live input terminals, including the neutral terminal, if any, are connected together to one side of a single phase test voltage appropriate for the equipment's rated phase to neutral voltage. The test shall then be repeated with the equipment on/off switch "off".

The current measured divided by the number of supply poles normally connected to the equipment is taken as the inherent leakage current of the equipment.

The leakage current of the equipment shall be taken as the arithmetic sum of the filter leakage current plus the inherent leakage current of the equipment as defined above.

This method of assessment does not take into account harmonic leakage currents which may flow in the filter or the phase relationship of the filter leakage current. Where these factors are likely to be significant more detailed investigation will be required.

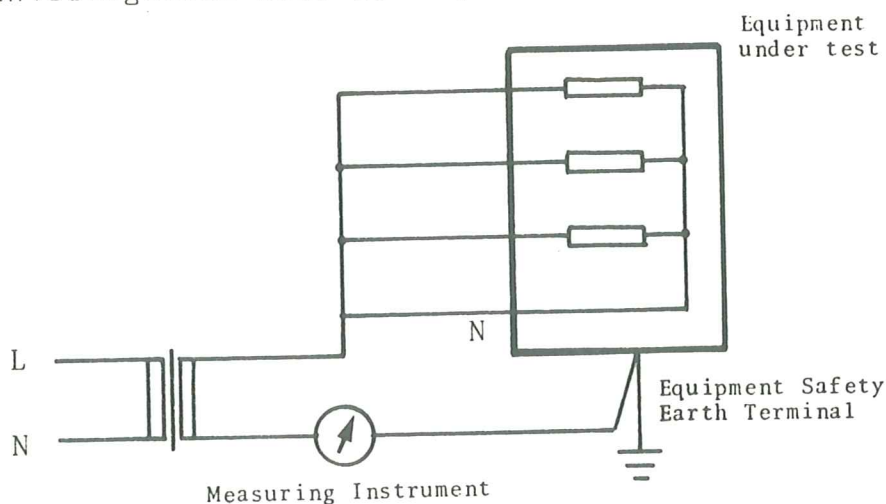


Fig. 5.3

5.2.5 Class I stationary equipment which exceeds a limit of 3,5 mA may be used subject to the following conditions:

- primary power and protective earthing conductors of the power supply cable shall be permanently connected to the equipment and to the building wiring.
- leakage current shall not exceed 5% of the normal unit load current per phase. Where the load is unbalanced the largest of the three phase currents is used for this calculation. Where necessary, the tests of sub-clauses 5.2.2 to 5.2.4

shall be used but with a measuring instrument of negligible impedance.

- a label bearing the warning:

"HIGH LEAKAGE CURRENT

Earth connection essential before connecting supply"

or similar wording shall be fixed adjacent to the unit protective earth terminal.

- the cross sectional area of the protective earthing conductor in the path of the leakage current shall be not less than $1,5 \text{ mm}^2$.
- in addition, it is recommended that a means of detecting failure of continuity of the protective earthing conductor should be installed with all units having high leakage current.

Methods for improving the integrity of earth continuity and a minimum cross-sectional area for the protective earthing conductor are under consideration.

- 5.2.6 Systems of interconnected units with individual pluggable primary power connectors shall have each unit tested as above. Sets of interconnected units with one mains connection are considered as a single unit.
- 5.2.7 The above requirements relate to equipment intended for connection to a supply system with an earthed neutral. Requirements for equipment intended to be connected to an IT supply system (unearthed or impedant neutral) are for further study.

Subclauses marked with a marginal line are provisional, requiring further consideration of recent technical contributions. The methods of earth leakage measurement are complex and are still under development within ECMA. Reports of users' experience in carrying out these tests is solicited to assist in further development.

5.3 Electric Strength

- 5.3.1 The electric strength of the equipment shall be adequate.

Compliance is checked by the conditioning of sub-clause 5.3.2 immediately followed by the tests of sub-clause 5.3.3.

In order to facilitate conditioning and dielectric strength testing, components and sub-assemblies operating at hazardous voltage may be conditioned and tested separately.

- 5.3.2 *Equipment shall be subjected to a 48-hours humidity treatment carried out in a cabinet or room containing air with a relative humidity of $93\% \pm 2\%$. 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.

Before the humidity treatment the sample is brought to a temperature between t °C and $(t + 4)$ °C.

Cable entries, if any, are left open; if knock-outs are provided, one of them is opened.

Electrical components, covers and other parts which can be removed without the aid of a tool, are removed and subjected, if necessary, to the humidity treatment with the main part.

After this treatment, the equipment shall show no damage within the meaning of this recommendation.

The electric strength tests described in 5.3.3 are made in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature, after the re-assembly of those parts which may have been removed.

The humidity treatment is not applied to equipment, which is intended, in accordance with the manufacturer's installation instructions, to be installed and operated under controlled conditions of ambient temperature and a maximum relative humidity of 60%.

5.3.3 After subjection to the conditioning of sub-clause 5.3.2, if any, and whilst the environment is maintained, the insulation is subjected for 1 min to a voltage of substantially sine-wave form, having a frequency of 50 Hz or 60 Hz or a d.c. voltage equal to the peak voltage of the prescribed a.c. test voltage detailed in the table.

Test voltages are specified as follows in terms of the grade of insulation (Functional, Supplementary or Reinforced) required and the working voltage across the insulation (U).

Grade of Insulation	Test Voltage (V)				
	Primary to Secondary and within Primary cir.		Within Secondary circuits		
	$U \leq 250$ V	$U > 250$ V	$U \leq 42,4$ V peak or d.c.	$42,4$ V < $U \leq 250$ V	$U > 250$ V
Functional	1250	$1,2U + 950$	no test	$10 U$ max 1250	$1,2U+950$
Supplementary	2500	$1,2U + 2200$	no test	$10 U$ max 1250	$1,2U+950$
Reinforced	3750	$2,4U + 3150$	no test	$20 U$ max 2500	$2,4U+1900$

Notes to the table

The test between live parts of different potential is only conducted between terminals and wiring where the necessary disconnections can be made without damaging the equipment.

Initially, not more than half the prescribed voltage is applied then it is raised rapidly to the full value. No flashover or breakdown shall occur during the test.

When testing insulation coatings, a metal foil may be pressed against the insulation by means of a sand bag of such a size that the pressure is about 5 uPa. The test may be limited to places where the insulation is likely to be weak, for example, where there are sharp metal edges under the insulation. If practicable, insulation linings are tested separately.

Care is taken that the metal foil is so placed that no flash-over occurs at the edges of the insulation.

For equipment incorporating both reinforced insulation and double insulation, care is taken that the voltage applied to the reinforced insulation does not overstress the functional insulation or the supplementary insulation.

Due to problems with capacitance balance, the revision of this test procedure is under consideration. Resistors in parallel with the insulation to be tested are disconnected.

Integrated circuits and the like in secondary circuits are disconnected or removed before carrying out the tests if they may be damaged or destroyed by capacitance charges or currents or other occurrences during this test.

5.4 Abnormal Operating and Fault Conditions

- 5.4.1 Equipment shall be so designed that the risk of fire or electrical shock due to mechanical or electrical overload or failure or abnormal or careless operation is limited as far as practicable.

Fusible links, thermal cutouts, overcurrent releases and the like may be used to provide adequate protection against the risk of fire.

- 5.4.2 Motors in primary circuits in permanently connected units, or in units remotely or automatically controlled, or in units where failure to operate would not be evident to an operator, shall be provided with overload protection unless otherwise specified in this Standard.

Protection of motors in secondary circuits is under consideration.

Motors may be protected against overheating due to overload either:

- by means of a device responsive to motor current and or temperature, or

- by a sensing circuit which disconnects power from the motor in a sufficiently short time to prevent overheating if, for example, it fails to perform its intended function, or
- by the use of motors which do not overheat under locked rotor conditions (protection by inherent or external impedance).

Compliance is checked by the applicable tests of Appendix B.

Direct drive motors which drive only a blower or fan are considered to have suitable overload protection if they comply only with the requirements of the locked rotor test.

5.4.3 Transformers shall be protected against overheating due to overload. Protection may be effected by:

- external overcurrent protection,
- internal temperature sensing devices,
- use of current limiting transformers,
- any other means which can be demonstrated to protect the transformer.

Compliance is checked by the applicable tests of Appendix C1.

5.4.4 *Compliance of parts of the equipment in primary circuits other than motors and transformers is checked by simulating faults. A short-circuit is applied between parts of different potential across creepage distances in air and clearances if they are less than the values indicated in the tables in sub-clause 2.9. Other faults which are the direct consequence of the deliberate short-circuit are also considered.*

The equipment, circuit diagrams, and component specifications should be examined to determine those fault conditions which might reasonably occur. These are applied one at a time. Simulated circuits may be used for this test.

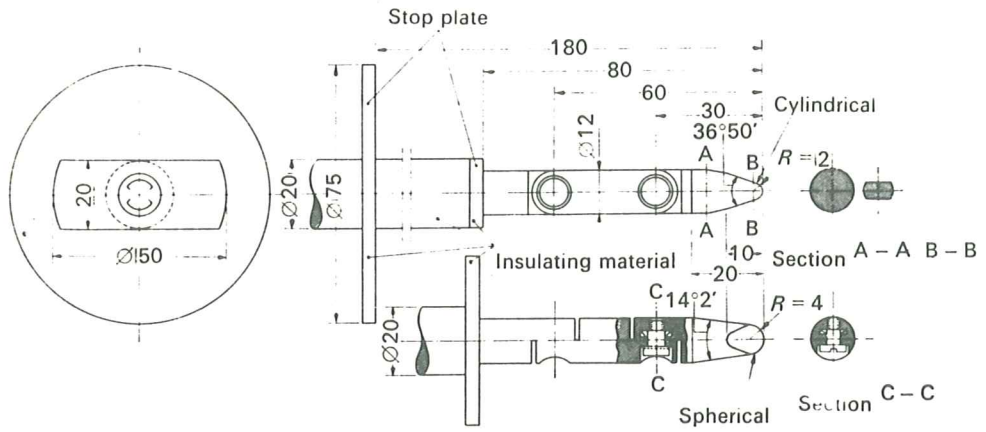
During the specified tests the equipment shall remain safe within the meaning of this document.

The temperature rises of supplementary and reinforced insulation other than thermoplastic material, shall not exceed 1,5 times the value in the table of sub-clause 5.1.

After the tests, the insulation, when cooled down to approximately room temperature, shall withstand the following test voltages applied between the supply connection and the body of the equipment:

Class I equipment	-	750 V
Class II equipment	-	2500 V

If more than one of the tests are applicable to the same equipment, these tests are made consecutively.



Dimensions in millimetres

Tolerances:

on angles $\pm 5'$

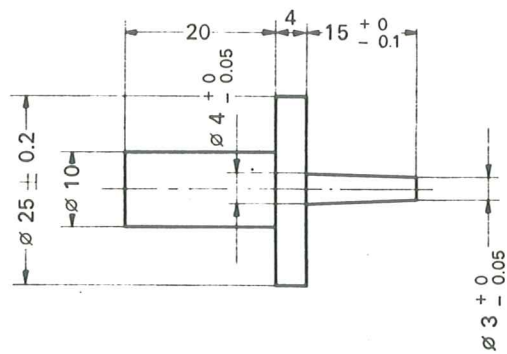
on linear dimensions:

less than 25 mm: $+0$

over 25 mm: -0.05

over 25 mm: ± 0.2

Fig. 1



Dimensions in millimetres

Fig. 2

APPENDICES

APPENDIX A - TESTS FOR RESISTANCE TO HEAT AND FIRE

A.1 Enclosure Flammability Test

A.1.1 Test samples shall consist of either complete enclosures or sections of the enclosures representing the least wall thickness and including any ventilation opening. If sections of the enclosures are used, they should also represent any horizontal and vertical parts.

Samples shall be mounted as they would be in actual use, in a room substantially free of draughts. A layer of surgical cotton shall be located 300 mm below the point of application of the test flame.

A.1.2 When the tests are required to be performed on conditioned samples, the samples of the material or enclosure shall be conditioned in an oven for a period of 1000 hours at the following temperature:

Maximum temperature rise during normal operation (°C)	Oven temperature (°C)
≥ 40 < 50	85,0 ± 1,0
≥ 50 < 60	95,0 ± 1,0
≥ 60 < 70	105,0 ± 1,0

A.1.3 The test flame shall be obtained by means of a Bunsen burner having a bore of 9,5 mm and a length of approximately 180 mm above the primary air inlets. A gas supply of approximately 37 MJ/m³ shall be used and the flame adjusted so that while the burner is vertical, the over-all height of flame is approximately 130 mm and the height of the inner blue cone is approximately 40 mm.

Technical Grade methane gas with suitable regulator and meter for uniform gas flow, or natural gas having a calorific value of approximately 37 MJ/m³ have been found to give similar results.

The test flame shall be applied to an inside surface of each of three samples of a horizontal section and to an inside surface of each of three samples of a vertical section. If a vertical part is involved, the flame shall be applied at an angle of 20° from the vertical. If ventilating openings are involved, the flame shall be applied to an edge of the openings, otherwise the application is to be made to a solid surface. In all cases, the tip of the inner blue cone shall be in contact with the sample. The flame shall be applied for 5 s and removed for 5 s. The operation shall be repeated until the samples have been subjected to five applications of

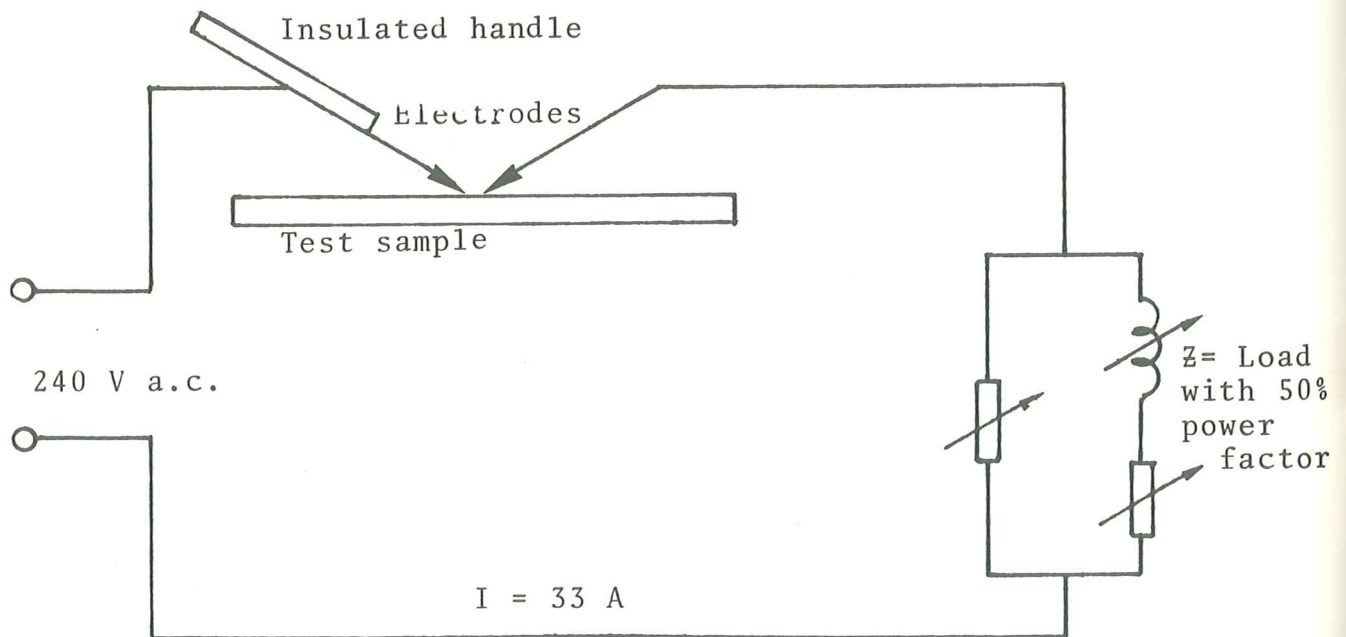
the test flame to the same location. Each set of three samples shall be tested with the flame applied to a different location on each sample.

A.1.4 During the test, the material shall not release flaming drops or particles capable of igniting the surgical cotton and shall not continue to burn for more than one minute after the fifth application of the test flame.

A.2 High Current Arcing Ignition Test

A.2.1 Three samples of each enclosure material shall be used. The samples shall be 150 mm long by 13 mm wide and of uniform thickness representing the thinnest section of the enclosure. Edges shall be free from burrs, fins, etc.

A.2.2 The test shall be made with a pair of test electrodes and a variable inductive impedance load connected in series to a high capacity-a.c. source.



One electrode shall be stationary and the second movable. The stationary electrode shall consist of 10 mm^2 solid copper conductor having a horizontal chisel point. The movable electrode shall be a 3 mm diameter stainless steel rod with a pyramidal point. The electrodes shall be located opposing each other, at an angle of 45° to the horizontal. The supply voltage shall be 240 V, 50 Hz - 60 Hz, and essentially sinusoidal. With electrodes short-circuited, the variable inductive impedance load shall be adjusted until the current is 33 A at a power factor of 0,5.

The samples under test shall be supported horizontally in air so that the stationary electrode is 1,6 mm above the top surface. The movable electrode is manually or otherwise controlled so that, with the circuit energized, it can be moved to contact the stationary electrode, making and breaking the electrical circuit at a rate of approximately 40 arcs per minute.

A.2.3 No test sample shall ignite with fewer than 30 electrical arcs.

A.3 Hot Wire Ignition Test

Three samples of each material shall be tested. The samples shall be 150 mm long by 13 mm wide and of a uniform thickness representing the thinnest section of the enclosure. Edges are to be free of burrs, fins, etc.

Each sample shall be wrapped with five turns of 0,5 mm nominal diameter nichrome wire spaced 6 mm between turns. The wire shall be iron free, 20% chromium, 80% nickel. The wire is then to be brought to a red heat by passing through it a current which has previously been determined as causing 65 W to be dissipated in the wire.

No sample shall ignite in less than 15 s.

A.4 Hot Flaming Oil Test

A sample of the complete, finished bottom panel shall be securely supported in a horizontal position under a hood or in another well-ventilated area free from draughts. Bleached cheesecloth of approximately 26 m² per kg shall be placed in one layer over a shallow, flat-bottomed pan approximately 5 cm below the sample and of sufficient size to cover completely the pattern of openings in the panel, but not large enough to catch any of the oil that runs over the edge of the panel or otherwise does not pass through the openings.

Use of a metal screen or wired-glass enclosure surrounding the test area is recommended.

A small metal ladle (preferably no more than 6,5 cm in diameter) with a pouring lip and a long handle whose longitudinal axis remains horizontal during pouring, shall be partially filled with 10 cm³ of a distillate fuel oil which is a medium volatile distillate having a density between 0,845 g/cm³ and 0,865 g/cm³, a flash point between 43,5 °C and 93,5 °C and an average calorific value of 9000 Kcal/l. The ladle containing the oil is heated and the oil ignited and allowed to burn for one minute, at which time all of the hot flaming oil shall be poured at the rate of approximately 1 cm³/s in a steady stream onto the centre of the pattern of openings, from a position approximately 10 cm above the openings.

The test shall be repeated twice at 5 minutes intervals, using clean cheesecloth.

During these tests the cheesecloth shall not ignite.

A.5 Molten PVC and Copper Test

A sample of the complete, finished bottom panel shall be securely supported in a horizontal position approximately 6,5 cm above a horizontal non-flammable surface located under a hood or in another well-ventilated area. Bleached cheesecloth of approximately 26 m² per kg shall be placed in two layers on the non-flammable surface. The cheesecloth shall cover somewhat more area than that immediately under the pattern of openings in the panel.

Use of a metal screen or wired-glass enclosure surrounding the area is recommended.

A bare 30 cm length of 4 mm² solid copper wire, and a 30 cm length of 4 mm² stranded copper wire insulated with approximately 1 mm of p.v.c., shall be melted simultaneously at an even rate by means of an oxy-acetylene torch and allowed to drip from a point approximately 15 cm above the pattern of openings in the panel.

During this test the cheesecloth shall not ignite.

A.6 Flammability Tests for Materials Classed V-1 or V-2

A.6.1 Ten samples of a material or assembly intended to be classified as V-1 or V-2 shall be tested as indicated below.

A.6.2 Material test samples shall be approximately 130 mm long by 13 mm wide, and of the smallest thickness used. For sound-deadening material other than foamed plastic, and which is normally attached to a panel of another material, the samples may consist of the material attached to a panel of the smallest thickness used. For testing an assembly, the samples may consist of the assembly or a portion thereof not smaller than the dimensions specified for a material sample. Gears, cams, belts, bearings, tubing, wiring harness, etc. may be tested as finished parts, or test samples may be cut from finished parts.

A.6.3 Five samples shall be conditioned for five hours at a temperature of 70 °C ± 1 °C. The oven shall be of a type with forced air circulation to ensure the correct temperature for all samples. Immediately afterwards, the samples shall be placed in a calcium chloride dessicator for at least 4 hours to cool to room temperature. Five additional samples shall be conditioned for at least 48 hours at a temperature of 23 °C ± 2 °C and a relative humidity of 50% ± 5% prior to testing.

A.6.4 The test shall be conducted under a hood or another well-ventilated area free from draughts.

One sample shall be supported with its longitudinal axis vertical by a clamp at its upper end so that its lower edge is 300 mm above a flat, horizontal layer of untreated surgical

cotton. An unlit Bunsen burner whose barrel has an inside diameter of 9,5 mm shall be supported under the sample with the longitudinal axis of the barrel vertical and coincident with the longitudinal axis of the sample. The tip of the barrel shall be 9,5 mm below the sample. The burner support shall be arranged to enable the burner to be quickly removed from and precisely returned to its position under the sample. A gas supply of approximately 37 MJ/m^3 shall be used. While not in proximity to the sample, the burner shall be ignited and adjusted to produce a steady blue flame with an overall height of 20 mm.

A supply of Technical Grade methane gas with suitable regulator and meter for uniform gas flow, or natural gas having a calorific value of approximately 37 MJ/m^3 have been found to give similar results.

A.6.5 The burner flame shall be moved into position under the sample for 10 s, and then removed.

The duration of any flaming or glowing of the sample after removal of the flame shall not exceed 30 s.

A.6.6 Immediately after flaming of the sample has ceased, the test of A.6.5 shall be repeated on the same sample.

A.6.7 The tests of A.6.5 and A.6.6 shall be repeated on the nine remaining samples.

A.6.8 The material is acceptable as class V-2 provided that each sample passes the above tests, that the average duration of flaming does not exceed 25 s, and that the material does not continue to burn to the 100 mm mark when tested according to Appendix A8.

A.6.9 The material is acceptable as class V-1 provided that each sample passes the tests in A.6.5, A.6.6 and A.6.7, that the average duration of flaming does not exceed 25 s and that the cotton is not ignited by any particles or drops released during or after application of the flame.

A.7 Flammability Tests for Materials Classed HF-1, HF-2 or HBF

A.7.1 Ten samples of a foamed plastic material intended to be classified as HF-1, HF-2 or HBF shall be tested as indicated below.

A.7.2 Material test samples shall be approximately 150 mm long by 50 mm wide, and of the smallest thickness used. For material which is normally attached to a panel of another material, the samples may consist of the material attached to a panel of the smallest thickness used.

A.7.3 Five samples shall be conditioned for 168 hours at a temperature of $70^\circ \text{C} \pm 1^\circ \text{C}$. The oven shall be of a type with forced air circulation to ensure the correct temperature for all samples. Immediately afterwards, the samples shall be placed in a calcium chloride dessiccator for at least 4 hours to cool to

room temperature. Five other samples shall be conditioned for at least 48 hours at a temperature of $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ and a relative humidity of $50\% \pm 5\%$ prior to testing.

A.7.4 The test shall be conducted under a hood or another well-ventilated area free from draughts.

Samples shall be supported on a horizontal wire screen (approximately 0,8 mm steel wire in 6,5 mm square mesh), 200 mm long by 75 mm wide, with 13 mm at one end turned up vertically. The screen shall be supported approximately 300 mm over a layer of surgical cotton.

A Bunsen burner with a fish-tail flame shall be used, its barrel having an inside diameter of 9,5 mm and the flame spreader a width of 50 mm. It shall be supported 13 mm under the bend in the wire screen so that the flame is parallel to and central on the bend.

The burner support shall be arranged to enable the burner to be quickly removed from and precisely returned to its position under the sample. A gas supply of approximately 37 MJ/m^3 shall be used. While not in proximity to the sample, the burner shall be ignited and adjusted to produce a steady blue flame with an overall height of 30 mm.

A supply of Technical Grade methane gas with suitable regulator and meter for uniform gas flow, or natural gas having a calorific value of approximately 37 MJ/m^3 have been found to give similar results.

One sample shall be placed flat on the screen, one end being in contact with the upturned end of the screen. Samples of combined materials shall be placed with the foamed plastic side facing up.

The burner flame shall be moved into position under the sample for 60 s, and then removed. The test shall then be repeated on the other nine samples.

A.7.5 During and after the test the following conditions shall apply:

- not more than one conditioned and one unconditioned sample shall flame longer than 2 s, and that for not longer than 10 s, after removal of the flame;
- no sample shall glow longer than 30 s after removal of the flame;
- no sample shall flame or glow for a distance greater than 60 mm from the end to which the flame is applied.

A.7.6 The material is acceptable as Class HF-2 if it meets the conditions of A.7.5.

A.7.7 The material is acceptable as Class HF-1 if it meets the conditions of A.7.5 and additionally, the cotton is not ignited by any particles or drops released during or after application of the flame.

A.7.8 The material is acceptable as Class HBF if despite failing to meet the conditions of A.7.5, all specimens either:

- burn at a rate of under 40 mm per minute over a 100 mm span, or
- cease to burn before reaching 120 mm from the end to which the flame is applied.

A.8 Materials Classed HB

A.8.1 Three samples of a material or assembly intended to be classified as HB shall be tested as indicated below.

A.8.2 Material test samples shall be approximately 130 mm long by 13 mm wide, with smooth edges and of the smallest thickness used. For materials used in a thickness greater than 3 mm the samples may be 3 mm thick. Alternatively, the finished part may be tested if of sufficient size. The samples are to be marked across their width with lines at 25 mm and 100 mm from one end.

A.8.3 The test shall be conducted under a hood or another well-ventilated area free from draughts.

A sample shall be supported by a clamp at the end farthest from the 25 mm mark, with its longitudinal axis horizontal and its transverse axis at 45° to the horizontal. A flat 130 mm square of steel-wire gauze (approximately 8 openings per cm) shall be supported horizontally 10 mm below the lowest edge of the sample, and with the free end of the sample immediately above the edge of the gauze.

An unlit Bunsen burner whose barrel has an inside diameter of 9,5 mm shall be supported with its longitudinal axis in the same vertical plane as the lowest edge of the sample, inclined at approximately 45° to the vertical, and with the lower edge of the barrel mouth 10 mm below the free end of the sample, so that the bottom edge of the sample is subjected to the test flame, when lit.

The burner support shall be arranged to enable the burner to be quickly removed from and precisely returned to its position under the sample. A gas supply of approximately 37 MJ/m^3 shall be used. When not in proximity to the sample, the burner shall be ignited and adjusted to produce a steady blue flame with an overall height of 25 mm.

A supply of Technical Grade methane gas with suitable regulator and meter for uniform gas flow, or natural gas having a calorific value of approximately 37 MJ/m^3 , have been found to give similar results.

A.8.4 The burner flame shall be moved into position at the end of the sample for 30 s, or until burning reaches the 25 mm if this occurs earlier, and then removed. By timing the progress of flaming or glowing from the 25 mm mark to the 100 mm mark,

or to the point of extinction if this occurs earlier, the rate of progress in mm/min shall be calculated.

The test shall be repeated on the two remaining samples.

A.8.5 The material is acceptable as Class HB provided that in the above test no sample has a calculated rate of flaming or glowing greater than:

- 40 mm/min for samples of a thickness of 3 mm or more
- 65 mm/min for samples of a thickness of less than 3 mm.

A.9 Surface Flammability of Materials

Materials shall be tested according to ASTM Standard E162 (Surface Flammability of Materials, using a Radiant Heat Source).

APPENDIX B - MOTOR TESTS

B.1 Temperature Rises Under Abnormal Conditions

The tests in this Appendix may be carried out either in the unit or under simulated conditions on the bench.

Temperature rises of windings are measured as specified in sub-clause 1.4.8, and determined at the end of the test period where specified; otherwise when the temperature has stabilized, or at the instant of operation of fuses, thermal cutouts, motor protection devices and the like.

The following temperature rises shall not be exceeded for each class of insulating material:

	Temperature Rise (°C)				
	A	E	B	F	H
Protection by inherent or external impedance	125	140	150		
Protection by protection device which operates:				Values under consideration	
- during the first hour, maximum	175	190	200		
- after first hour, maximum	150	165	175		
- after first hour, arithmetic average	125	140	150		

B.2 Locked-Rotor Test

A locked-rotor test shall be carried out starting at room ambient temperature.

The duration of the test shall be as follows:

- A motor protected by inherent or external impedance shall be operated on locked-rotor for 15 days.
- A motor with a self-reset protector shall be cycled on locked-rotor for 15 days.
- A motor with a manual reset protector shall be cycled on locked-rotor as rapidly as possible for 60 cycles.

Temperatures are observed at regular intervals during the first three days for motors with inherent or external impedance protection or with self-resetting protectors, or during the first ten cycles for motors with manual reset protectors.

The temperature rises shall not exceed the values specified in sub-clause B.1.

During the test, the motor protectors shall operate reliably meeting the requirements of sub-clause 2.1 and without causing an earth connection to the motor frame or introducing a fire hazard.

After the period specified for temperature measurement, the motor shall withstand the dielectric strength test in sub-clause 5.4.3. No further dielectric strength test is required.

B.3 Motors with Capacitors

Motors having capacitors in the circuit of an auxiliary winding shall additionally be tested with the capacitors short-circuited or open-circuited, whichever is the more unfavourable, and with locked rotor, unless the equipment is not intended for use unattended and the motor is provided with a capacitor complying with IEC Publication 252, a.c. Motor Capacitors (see sub-clause 1.5). Temperature rises shall not exceed the values specified in sub-clause B.1.

Locked-rotor is specified because some motors may not start and variable results could be obtained.

Further requirements for capacitors justifying exclusion from this test are under consideration.

Equipment which is started automatically or remotely is regarded as equipment which is intended for use unattended.

B.4 Three-phase Motors

Three-phase motors shall additionally be tested under normal load, with one phase disconnected, unless circuit controls prevent the application of voltage to the motor when one or more supply phases are missing.

Temperature rises shall not exceed the values specified in sub-clause B.1.

B.5 Overload Test

A running overload protection test shall be carried out by operating the motor under normal load and rated voltage. The load is then increased so that the current is increased in appropriate steps, the equipment supply voltage being maintained at its original value. When steady conditions are established, the load is again increased. The load is thus progressively increased in appropriate steps until the overload protection operates.

The motor windings temperature rise shall be determined during each steady period and the maximum temperature rise recorded shall not exceed the values specified in sub-clause B.1.

B.6 Series Motors

Series motors shall be operated at a voltage equal to 1,3 times rated voltage for 1 min. with the lowest possible load.

After the test, windings and connections shall not have worked loose and no hazard shall be present within the meanings of this document.

APP

C. 1



C.

APPENDIX C - TRANSFORMERS

C.1 Overload Test

The tests in this Appendix may be carried out either in the unit or under simulated conditions on the bench.

Temperature rises of windings are measured as specified in sub-clause 1.4.8, and determined under the test conditions specified below:

- with external overcurrent protection: at the moment of operation;
- with internal temperature sensing devices:
 - . non-resetting type: at moment of operation
 - . auto-resetting type: after 400 hours
- current-limiting transformers: after temperature has stabilized.

The following temperature rises shall not be exceeded:

Temperature Rise ($^{\circ}$ C)				
Class A	Class E	Class B	Class F	Class H
115	130	140	190	240

A conventional or safety isolating transformer shall have each secondary winding short-circuited in turn, with the other secondaries loaded to their specified maxima.

Ferro-resonant transformers shall have each secondary in turn loaded so as to give maximum heating effect, and with the following parameters at the most adverse value:

- . Primary voltage
- . Input frequency
- . Loads on other secondaries between ZERO and their specified maxima.

Secondaries which cannot or are unlikely to cause a hazard need not be tested in either type.

Secondary windings which exceed the temperature limits but which become open circuit or otherwise require replacement of the transformer shall not constitute a failure of this test, provided that no hazard is created in the meaning of this document.

C.2 Safety Isolating Transformers

Safety isolating transformers in data processing equipment shall comply with the following requirements.

Precautions shall be taken to prevent:

- displacement of input or output windings, or the turns thereof;
- displacement of internal wiring or wires for external connections, undue displacement of parts of windings or internal wiring, in the event of rupture of wires adjacent to connections or loosening of the connections;

- wires, screws, washers and the like from bridging any part of the required minimum insulation or clearances between the SELV windings and the other windings, including the connections of windings, should they loosen or become free.

Examples of constructions which comply with these requirements are the following (there are other forms of acceptable construction):

- - Windings isolated from each other by placing them on separate limbs of the core with or without spools.
- Windings on a single spool, with a partition wall, of adequate insulating material, whereby the spool and partition wall are pressed or moulded in one piece, or the pushed-on partition walls have an intermediate sheath or covering over the joint between the spool and the partition wall.
- Concentric windings on a spool of insulating material without flanges or on insulation applied in thin sheet form to the transformer iron core.
Suitable insulation of adequate thickness is provided between the SELV windings and other windings, by sheet insulation extending beyond the end turns of each layer.
- Concentric windings, whereby SELV windings are separated from other windings by an earthed metal screen with suitable insulation between each winding and the screen.
The metal screen may consist of a metal foil extending the full width of the transformer winding. The metal screen and its lead-out wire shall have a cross-section sufficient to ensure that on breakdown of the insulation an overload device will open the circuit before the screen is destroyed. The overload device may either be a part of the transformer or a part of the machine.
- Insulation used in transformers, if in the form of thin sheet, shall be used in the following manner:
 - . Reinforced insulation shall have at least 3 layers where two layers meet the requirements for dielectric strength for reinforced insulation at the appropriate working voltage.
 - . Supplementary insulation shall be at least 2 layers where one layer meets the dielectric strength requirements.
- All windings shall have the end turns retained by positive means.

It is not expected that two independent fixings will loosen at the same time.

Dielectric strength tests shall be applied in accordance with sub-clause 5.3 and the following table.

I T E M	Points of Application of Test Voltage	Test Voltage (V)	
		$U_p = \text{Insulation Working Voltage}$ ^{1 2}	
		$\leq 354 U_p$	$> 354 U_p$
1	Primary to body or earthed metal screen		
	a) in Class I equipment b) in Class II equipment ⁵	1250 ⁴ 3750	$0,85U_p + 950$ $1,7U_p + 3150$
2	Primary to non-SELV secondaries	1250	$0,85U_p + 950$
3	Primary to SELV secondaries without a metal screen between these windings	3750	$1,7U_p + 3150$
4	SELV secondaries to non-SELV secondaries	2500	$0,85U_p + 2200$
5	SELV secondaries to - body - metal screen, connected to the body - core	500 ⁴	-
6	Non-SELV secondaries to body,		
	a) in Class I equipment b) in Class II equipment	1250 ⁴ 2500	$0,85U_p + 950$ $0,85U_p + 2200$
7	Between secondaries, other than those in item 4	1250 ⁶	$0,85U_p + 950$
8	Between primary windings for series or parallel connection	500	$1,4U_p$
9	Core to		
	a) primary	1250 ⁴	$0,85U_p + 950$
	b) the body of Class II equipment c) non-SELV secondaries	2500 ⁷ 1250	$0,85U_p + 2200$ $0,85U_p + 950$

NOTES TO THE TABLE

- ¹ U_p is the peak value of the working voltage U, thus, for example, $0,85 U_p + 950 = 1,2 U + 950$
- ² For calculation of the working voltage, see sub-clause 1.5.3.
- ³ For transformers incorporating both reinforced insulation and double insulation, care is taken that the voltage applied to the reinforced insulation does not overstress the functional insulation or the supplementary insulation. Similarly, care is taken that the voltage applied for the test between SELV secondaries and other windings does not overstress the insulation. This may be achieved by the use of a suitable potential divider.
- ⁴ The values are minimum values. Where item 5 is used in combination with item 1a, 6a or 9a between SELV and other windings, the combination must withstand the test for item 3 or 4 as appropriate. It is the manufacturer's choice which of the two (item 5 or the other) is up-graded in order to achieve this.
- ⁵ An earthed metal screen in Class II equipment may be provided for functional purposes. This requirement is under consideration.
- ⁶ If the working voltage is not more than 71 V_{r,peak}, then the test voltage is 500 V.
- ⁷ No tests if core to primary insulation withstands 3750 V test ($1,7 U_p + 3150$).

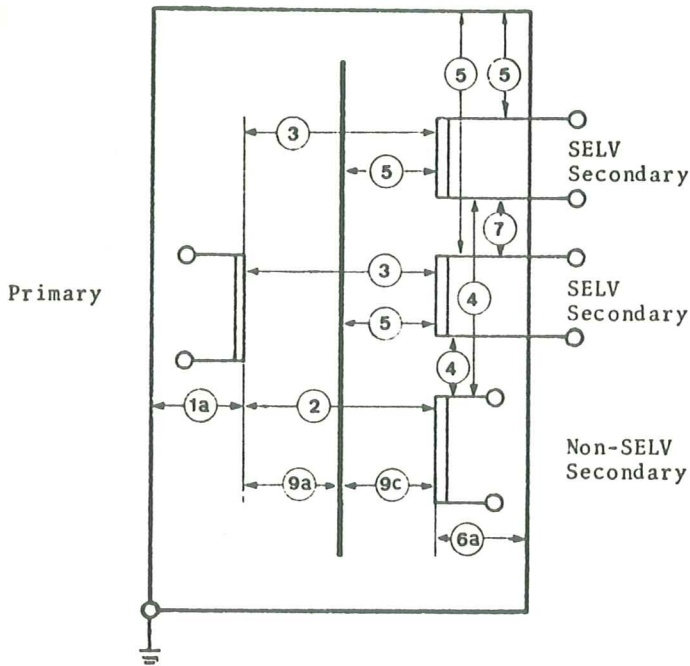


Fig. C 1 Transformer without metal screen in Class I equipment

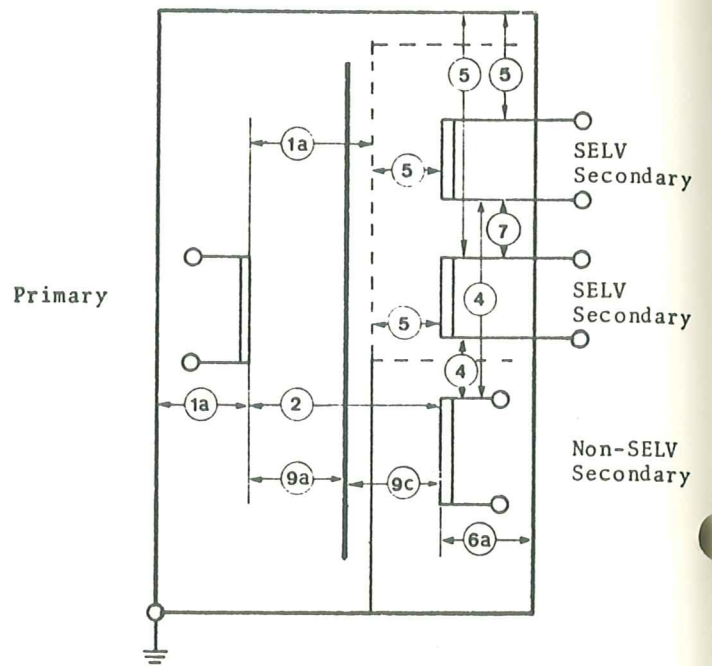


Fig. C 2 Transformer with earthed metal screen in Class I equipment

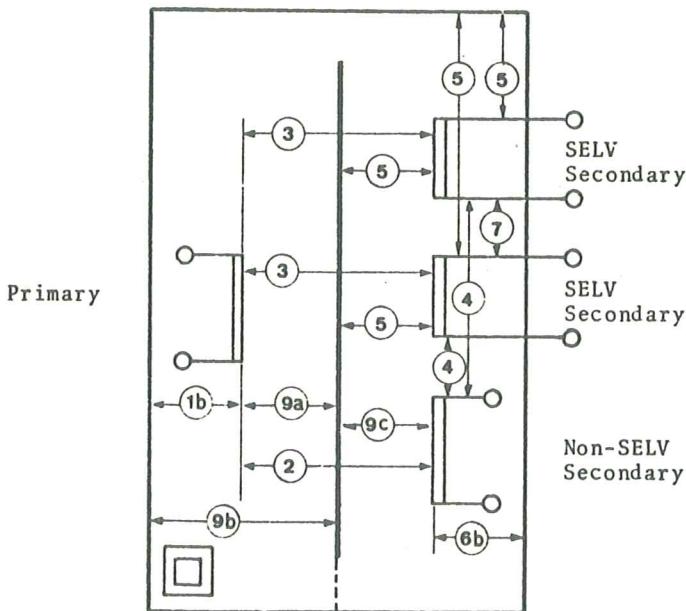


Fig. C 3 Transformer in Class II equipment with metal body

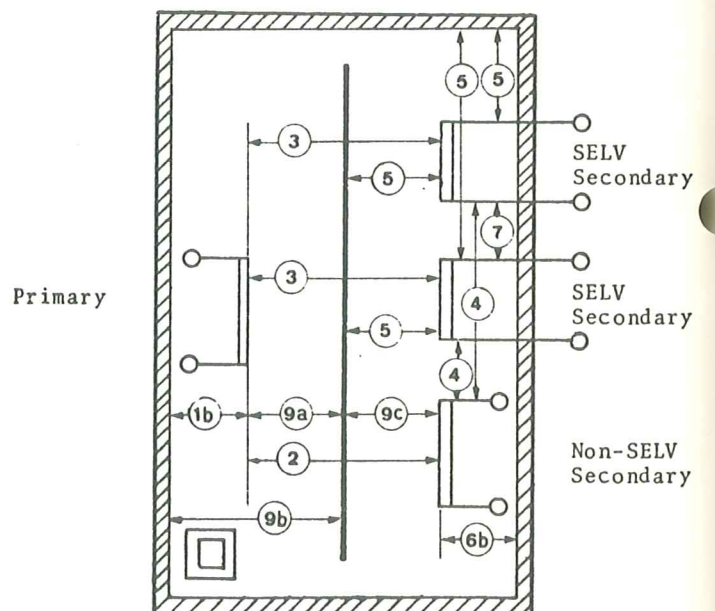
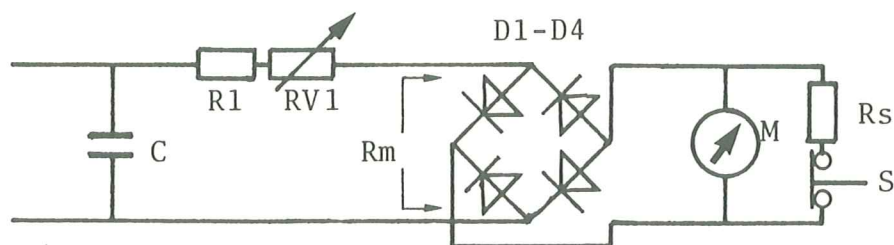


Fig. C 4 Transformer in Class II equipment with insulated body

NOTE : numbers in circles refer to the items of the table

APPENDIX D - MEASURING INSTRUMENT FOR LEAKAGE CURRENT TEST

D.1 The instrument comprises a rectifier/moving coil meter with additional series resistance, the two being shunted by a capacitor, as shown below. The effect of the capacitor is to reduce the sensitivity to harmonics and other frequencies above power frequency. The instrument should also include a x10 range obtained by shunting the meter coil by a non-inductive resistor. Overcurrent protection may also be included provided that the method used does not affect the basic characteristics of the instrument.



M	0-1 mA	moving coil movement
R1+RV1+Rm at 0,5 mA d.c.	1500 ohm ± 1%	2000 ohm ± 1%
	with	or with
	C = 150 nF ± 1%	C = 112 nF ± 1%
D1-D4	Meter rectifier	
Rs	Non-inductive shunt for x10 range	
S1	Sensitivity button (press for maximum sensitivity)	

RV1 is adjusted for the desired value of total resistance at 0,5 mA d.c.

The meter is to be calibrated at the following calibration points on the maximum sensitivity range at 50/60 Hz sinusoidal:

0,25 mA 0,5 mA 0,75 mA

The frequency response may be checked at the 0,5 mA calibration point as follows:

Sensitivity at 5 kHz sinusoidal: 3,6 mA ± 5%.

APPENDIX E - TEMPERATURE RISE OF A COPPER WINDING

The value of the temperature rise of a copper winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1} (234,5 + t_1) - (t_2 - t_1)$$

where:

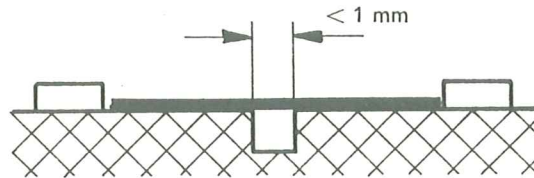
- Δt is the temperature rise
- R_1 is the resistance at the beginning of the test
- R_2 is the resistance at the end of the test
- t_1 is the room temperature at the beginning of the test
- t_2 is the room temperature at the end of the test.

At the beginning of the test, the windings are to be at room temperature.

It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

APPENDIX F - MEASUREMENT OF CREEPAGE DISTANCES AND CLEARANCES

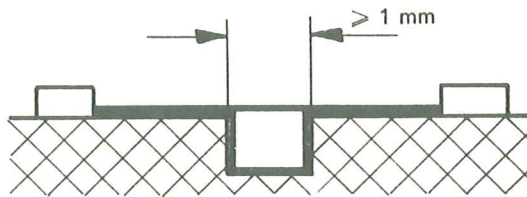
The methods of measuring creepage distances and clearances which are specified in the following figures F 1 to F 11 are used in interpreting the requirements of this Standard.



CONDITION : Path under consideration includes a parallel- or converging-sided groove of any depth with width less than 1 mm.

RULE : Creepage distance and clearance are measured directly across the groove.

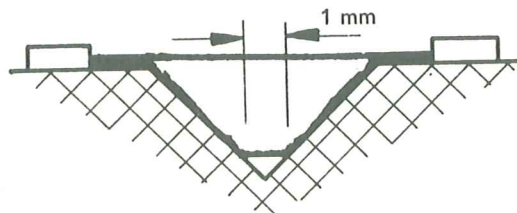
Fig. F 1



CONDITION : Path under consideration includes a parallel-sided groove of any depth, and equal to or more than 1 mm wide.

RULE : Clearance is a "line of sight" distance. Creepage path follows the contour of the groove.

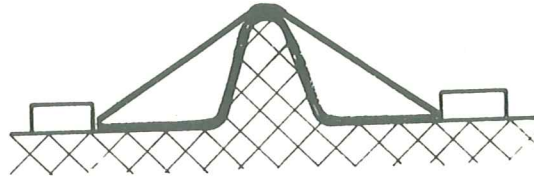
Fig. F 2



CONDITION : Path under consideration includes a V-shaped groove with internal angle of less than 80° and with a width greater than 1 mm.

RULE : Clearance is "line of sight" distance. Creepage path follows the contour of the groove but "short circuits" the bottom of the groove by 1 mm (0,25 mm for dirt-free situations) link.

Fig. F 3



CONDITION : Path under consideration includes a rib.

RULE : Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

Fig. F 4



CONDITION : Path under consideration includes an uncemented joint with grooves of less than 1 mm (0,25 mm) width on either side.

RULE : Creepage and clearance path is "line of sight" distance shown.

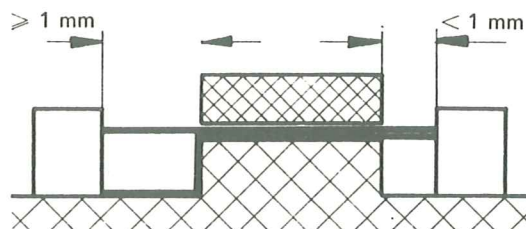
Fig. F 5



CONDITION : Path under consideration includes an uncemented joint with grooves equal to or more than 1 mm wide each side.

RULE : Clearance is the "line of sight" distance. Creepage path follows the contour of the groove.

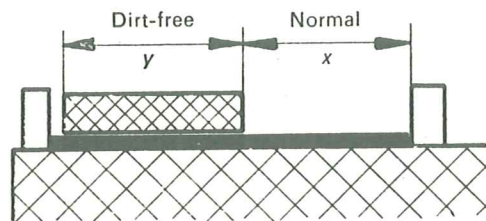
Fig. F 6



CONDITION : Path under consideration includes an uncemented joint with a groove on one side less than 1 mm wide, and a groove on the other equal to or more than 1 mm wide.

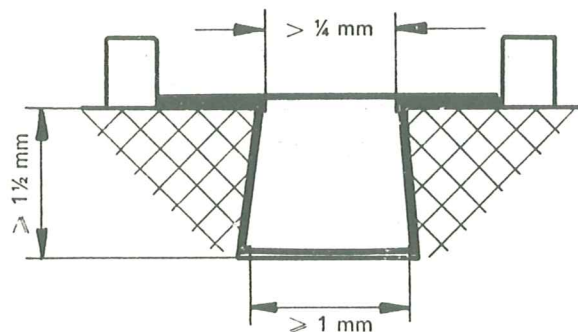
RULE : Clearance and creepage paths as shown.

Fig. F 7



To apply the creepage requirements given for dirt-free, normal or dirty situations, to a case where more than one situation exists, the limits shall be computed on a volt per millimetre basis according to the distances measured under each situation.

Fig. F 8

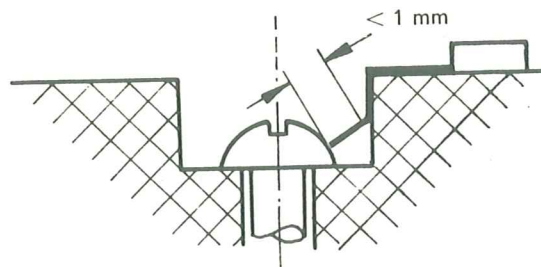
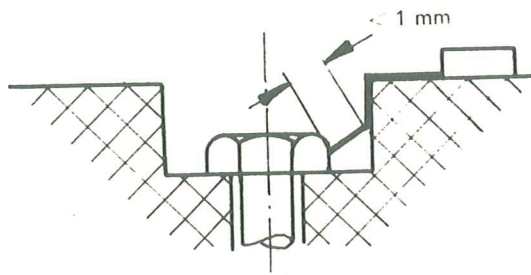


CONDITION : Path under consideration includes a diverging-sided groove equal to or greater than 1,5 mm deep and greater than 0,25 mm wide at the narrowest part and equal to or greater than 1 mm at the bottom.

RULE : Clearance is "line of sight" distance. Creepage path follows the contour of the groove.

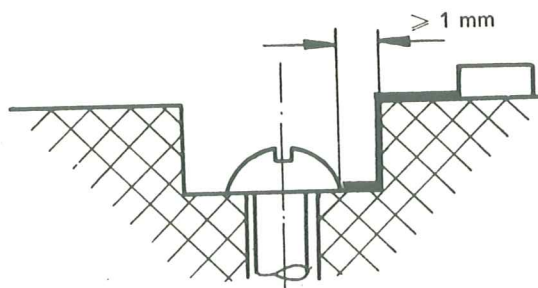
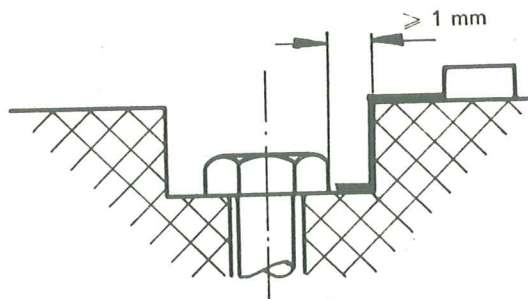
Figure F 3 applies as well to the internal corners if they are less than 80° .

Fig. F 9



Gap between head of screw and wall of recess too narrow to be taken into account.

Fig. F 10



Gap between head of screw and wall of recess wide enough to be taken into account.

Fig. F 11

