

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-57

SAFETY REQUIREMENTS FOR DATA PROCESSING EQUIPMENT

2nd Edition - September 1981

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BRIEF HISTORY

IEC 435, Safety of Data Processing Equipment, was originally published in 1973 and major revisions, taking the form of an amendment to IEC 435, were agreed in 1977 and published in 1978.

In 1976 ECMA offered to prepare a new document which could be the basis of a complete second edition of IEC 435 to follow the 1978 amendment. The objective, apart from incorporating the relevant requirements of IEC 435, was to provide a guide to equipment designers to enable them to realise safety principles at an early design stage and build them into the equipment. A new format was adopted and the opportunity was taken to eliminate all requirements which did not fully relate to data processing equipment and to ensure that its physical size, complexity and value were recognized.

To reflect the urgent need for such guidance for designers ECMA published a document in the new format in December 1977, TR9, superseded in January 1979 by Standard ECMA-57. Each embodied the latest technical thinking in IEC.

In 1980 IEC TC74 approved the publication of IEC 435, Second Edition, substantially the same as their 1978 draft in the ECMA format. This is expected to be published in 1981 or 1982.

Since March 1978 the work in IEC TC74 has advanced in many respects, and the present ECMA Standard reflects technical conclusions reached in the past three years, as well as all the requirements in IEC 435, second edition.

Sections of this Standard which contain important differences from the first edition are marked by asterisks in the margin.

It should be noted that the requirements for creepage distances and clearances (2.9) are not entirely consistent with modern electronic design technology. The matter is under study within IEC and the requirements will be reviewed when the new recommendations are available.

This second edition of Standard ECMA-57 was adopted by the General Assembly of ECMA on June 18, 1981.

FONTS USED IN THIS STANDARD

In order to emphasize the differences between the different parts of this Standard the following fonts have been used:

- DELEGATE for the requirements proper,
- *ITALIC* for the test specifications,
- LETTER GOTHIC for notes and explanatory matters.

TABLE OF CONTENTS

	Page
1. GENERAL	1
1.1 Scope	3
1.2 Definitions	4
1.3 General Requirements	10
1.4 General Notes on Requirements and Tests	10
1.5 Components	12
1.6 Power Interface	13
1.7 Marking and Instructions	13
2. SAFE ELECTRICAL DESIGN	17
2.1 Protection Against Electric Shock and Energy Hazards	19
2.2 Insulation	22
2.3 Safety Extra-Low Voltage (SELV) Circuits	24
2.4 Limited Current Circuits	26
2.5 Provisions for Protective Earthing	27
2.6 Primary Power Isolation	29
2.7 Protection of Internal Wiring	31
2.8 Safety Interlocks	33
2.9 Creepage Distances, Clearances and Distances through Insulation	35
3. WIRING AND CONNECTIONS	41
3.1 Internal Wiring	43
3.2 Supply Connection	44
3.3 Terminals for Primary Power Supply Conductors	49
4. CONSTRUCTION	53
4.1 Stability and Mechanical Hazards	55
4.2 Mechanical Strength	56
4.3 Construction	57
4.4 Resistance to Fire	61
4.5 Resistance to Tracking	67
4.6 Mechanical Strength of Cathode Ray Tubes	67
5. THERMAL AND ELECTRICAL TESTS	69
5.1 Heating	71
5.2 Earth Leakage Current	72
5.3 Electric Strength	75
5.4 Abnormal Operating and Fault Conditions	77
Fig. 1 Test Finger	81
Fig. 2 Test Pin	81
Fig. 3 Test Bar	81

Table of Contents (cont'd)

	Page
<u>APPENDICES</u>	
A. TESTS FOR RESISTANCE TO HEAT AND FIRE	85
A.1 Enclosure Flammability Test	85
A.2 High Current Arcing Ignition Test	86
A.3 Hot Wire Ignition Test	87
A.4 Hot Flaming Oil Test	87
A.5 Molten PVC and Copper Test	87
A.6 Flammability Tests for Materials Classed V-1 or V-2	88
A.7 Flammability Tests for Materials Classed HF-1, HF-2 or HBF	89
A.8 Flammability Tests for Materials Classed HB	90
A.9 Surface Flammability of Materials	91
B. MOTOR TESTS	93
B.1 Maximum Temperatures Under Abnormal Conditions	93
B.2 Overload Test	94
B.3 Locked-Rotor Test	95
B.4 Locked-Rotor Test for d.c. Motors in Secondary Circuits	95
B.5 Motors with Capacitors	96
B.6 Three-phase Motors	96
B.7 Series Motors	96
C. TRANSFORMERS	97
C.1 Overload Test	97
C.2 Safety Isolating Transformers	98
D. MEASURING INSTRUMENT FOR LEAKAGE CURRENT TEST	105
E. TEMPERATURE RISE OF A WINDING	107
F. MEASUREMENT OF CREEPAGE DISTANCES AND CLEARANCES	109
G. IONIZING RADIATION	113
H. TABLE ELECTROCHEMICAL POTENTIALS	115
J. PRINCIPLES OF SAFETY AS APPLIED TO DPE	117
K. EARTH LEAKAGE CURRENT FOR IT SYSTEMS	121
K.1 Limits	121
K.2 Single-Phase Equipment	122
K.3 Three-Phase Equipment	122
K.4 Equipment Exceeding 3,5 mA Leakage Current	123

1 General

1.1 Scope

- 1.1.1 This Standard ECMA-57 applies to data processing equipment and the associated electronic units, data preparation equipment and data terminal equipment with a rated voltage not exceeding 600 V and designed to be operated continuously under conditions of normal use.

Different requirements may apply to equipment designed for intermittent use.

This Standard specifies requirements intended to ensure safety for the operator and layman who may come into contact with the equipment and, where specifically stated service personnel. The design principles behind these requirements are set out in Appendix J.

This Standard 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 and maintaining the equipment in the manner described by the equipment manufacturer.

This Standard 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 Standard 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, except where these are integral parts of the data processing 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 data transmission equipment against faults in the data processing equipment.

- 1.1.2 ★ Compliance with this Standard implies that:

- ★ - the design meets the requirements of all relevant
- ★ sections and, for design features which affects saf-
- ★ ety and which are not specifically covered, the design
- ★ is in accord with the general Principles of Safety
- ★ set forth in Appendix J;

- * - information is provided to the user as required in
- * 1.3.3, 1.7.2, 1.7.10 and 1.7.12.

* When a revision occurs, adding or changing a requirement
* in this Standard or in one of the international Standards
* to which reference is made, compliance with either the
* earlier or the revised edition is acceptable for an in-
* terim period.

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

For the purpose of this Standard the following definitions apply.

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

- 1.2.1 Access Area, Operator: 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.
- 1.2.2 Access Area, Service: an area to which operators have no access but where it is necessary for service personnel to have access for maintenance purposes with the equipment switched on.
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- 1.2.3 Body: All conductive parts, shafts of handles, knobs, grips and the like in operator and service access areas, and metal foil in contact with all surfaces of insulating material in operator access areas.
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 - *
- 1.2.4 Clearance: 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.
- 1.2.5 Creepage distance: the shortest path between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured along the surface of the insulation.
- 1.2.6 Data processing equipment: 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.
- 1.2.7 Extra-Low Voltage (ELV): a voltage between conductors or between a conductor and earth not exceeding 42,4 V peak or d.c., existing in a secondary circuit which does not meet the requirements for an SELV circuit, nor those for a limited current circuit.

A voltage not exceeding 42,4 V peak or d.c., existing in a circuit which is conductively connected to a primary circuit is, considered to be a hazardous voltage unless the requirements for a limited current circuit are met.

1.2.8 Enclosure: a construction which protects against contact with hazardous parts. The construction may be an integral part of a component, a separate part of the component, the outer cabinet or a part of the outer cabinet.

1.2.9 Energy hazard: a hazard that exists at any conductive part of a piece of equipment if, between that part and an adjacent conductive part of different potential, 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.

1.2.10 Equipment, Class I: equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that conductive parts in operator and service access areas are connected to the protective earthing conductor in the fixed wiring of the installation in such a way that the accessible conductive parts cannot become hazardous in the event of a failure of the basic insulation.

Class I equipment may have parts with double insulation or reinforced insulation, or parts operating at safety extra-low voltage.

For equipment intended for use with a flexible cord, this provision includes a protective conductor as part of the flexible cord.

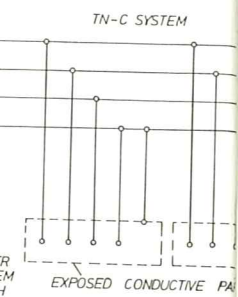
1.2.11 Equipment, Class II: equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

Such equipment may be of one of the following types:

- equipment having a durable and substantially continuous enclosure of insulating material which envelops all conductive parts, with the exception of small parts, such as nameplates, 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.

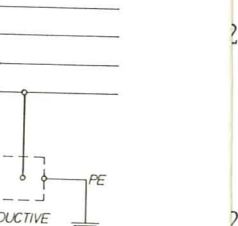
- Equipment having a substantially continuous metal enclosure, in which double or reinforced insulation is used throughout; such equipment is called metal-encased Class II equipment.
 - Equipment which is a combination of the above two types.
- 1.2.12 Equipment, fixed: equipment which is fastened or otherwise secured at a specific location.
- 1.2.13 Equipment, hand-held: movable equipment intended to be held in the hand during normal use.
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- 1.2.14 Equipment, movable: equipment which is either
- under 18 kg in mass and not fixed, or
 - equipment with wheels, castors or other means to facilitate movement by the operator as required to perform its intended use.
- 1.2.15 Equipment, stationary: either fixed equipment or equipment which is intended to be moved from one place to another only by authorized technical personnel.
- 1.2.16 Flammability classification of materials: the recognition of the ignition and burning resistance characteristics of materials other than metal or ceramic. Materials are classified as in 1.2.17, to 1.2.22 when tested in accordance with Appendix A.
- 1.2.17 HB Class Plastic: material that, when tested as indicated in Appendix A.8, complies with a specified maximum burning rate.
- 1.2.18 HBF Class Foamed Plastic: a foamed plastic material that, when tested as indicated in Appendix A.7, complies with a specified maximum burning rate.
- 1.2.19 HF-1 Class Foamed Plastic: 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; and flaming or glowing particles or flaming drops do not ignite surgical cotton.
- 1.2.20 HF-2 Class Foamed Plastic: 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.
- 1.2.21 V-1 Class Material: a material that, when tested in accordance with Appendix A.6, may flame or glow but will extinguish within prescribed period of time; and glowing particles or flaming drops released do not ignite surgical cotton.
- 1.2.22 V-2 Class Material: a material that, when tested in accordance with Appendix A.6, may flame or glow but will ex-

and protection combined in a system about the system.



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system having conductive parts protected.



which is direct other equipment (etc) which supply primary windings and the

- .36 Rated current: the input current of the equipment as declared by the manufacturer.
- .37 Rated frequency: the primary power frequency as declared by the manufacturer.
- .38 Rated frequency range: the primary power frequency range as declared by the manufacturer, expressed by its lower and upper limits, excluding tolerances.
- .39 Rated voltage: the primary power voltage (for three-phase supply, the phase-to-phase voltage) as declared by the manufacturer.
- .40 Rated voltage range: the primary power voltage range as declared by the manufacturer, expressed by its lower and upper limits, excluding tolerances.
- .41 Safety Extra-Low Voltage (SELV) circuit: a circuit which is so designed and protected that under normal and single fault conditions the voltage between any two parts in operator access area, one of which may be the body or earth, does not exceed a safe value.
 - Under normal conditions this limit is 42,4 V peak or d.c.
 - Under fault conditions higher limits are specified in the Standard for transient deviations.
 - This definition of SELV differs from that used in IEC Publication 364.
- *
*
.42 Safety interlock: a means of preventing access to a hazardous area until the hazard is removed, or automatically removing the hazardous condition when access is gained.
- .43 Safety Isolating Transformer: 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.
- .44 Secondary circuit: 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.
- .45 Thermal cut-out: 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.
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.46 Thermal cut-out, self-resetting: a thermal cut-out which automatically restores the current after the relevant part of the equipment has cooled down sufficiently.

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- 1.2.37 Rated frequency: the primary power frequency as declared by the manufacturer.
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- 1.2.47 Thermal cut-out, non self-resetting: a thermal cut-out which requires resetting by hand, or replacement of a part, in order to restore the current.
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- 1.2.48 Thermostat: 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.
- 1.2.49 Tool: a screwdriver or any other object which may be used to operate a screw, latch or similar fixing means.
- 1.2.50 Working voltage: the voltage to which the part under consideration is subjected when the equipment is operating at its rated voltage under conditions of normal use.

1.3 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 hazard within the meaning of this Standard to persons or surroundings.
- 1.3.2 Equipment containing ELV or 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 used as prescribed by the manufacturer, the equipment will not present a hazard within the meaning of this Standard.

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

1.4 General Notes on Requirements and Tests

- 1.4.1 The requirements and tests detailed in this Standard are to be considered only if safety is involved. If it is evident from the design of the equipment that a particular test is not applicable, the test is not made.
- 1.4.2 Tests according to this Standard 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.

In view of the large cost involvement in samples, discussion of the test program with the manufacturer is desirable.

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 indicate that such tests will ensure that the assembled equipment conforms 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 Standard, 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 Standard, limits for maximum temperatures or maximum temperature rises are specified for compliance with certain tests, and the ambient room air temperature during the tests need not be controlled, but shall be monitored and recorded.

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

* Where maximum temperatures and temperature rises are specified, these are based on the assumption that the room ambient air temperature is 25 °C when the equipment is in operation. If the equipment, in its final application is intended to be operated in a higher room ambient temperature the limits of temperature rise shall be reduced accordingly, so that maximum temperatures are not exceeded with the equipment operating at its maximum specified room ambient temperature (this may be checked by calcu-

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lation if measurement at maximum ambient temperature is impractical). For equipment operating below 25 °C, temperature rise limits shall not change and maximum temperatures shall be reduced accordingly.

The classification of insulating material (Classes A, E, B, F and H) is in accordance with IEC Publication 85, "Recommendation for Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to their Thermal Stability in Service".

- 1.4.8 Unless otherwise specified, temperatures of windings are determined by the resistance method (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 or equivalent.

1.5 Components

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

In order to establish whether or not safety is involved, a careful investigation of the circuit is recommended, to take into account the consequences of possible failure of components. This is generally only considered to be necessary for components operating at hazardous voltages.

- 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 Standard 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 consequences will not cause a hazardous voltage to appear on SELV windings. This may be achieved by separating the SELV windings from all other parts in conformity with the principles stated in 2.3.3.

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 electric strength tests.

- 1.5.4 Components which are to be connected to SELV and also to ELV or to a hazardous voltage shall be constructed according to the principles stated in 2.3.3.

An example of such component would be a relay with different supplies connected to different elements (coils and contacts).

1.6 Power Interface

- 1.6.1 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.
- 1.6.2 The rated voltage of hand-held equipment shall not exceed 250 V.
- 1.6.3 Neutral shall be insulated from earth and the body throughout the equipment, as if it were a live phase.
- 1.6.4 Equipment intended to operate directly from the main supply shall be designed for a supply voltage tolerance of at least $\pm 6\%$ of rated voltage.
- 1.6.5 For equipment to be connected to IT power systems, 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.

1.7 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 be easily legible from outside the equipment, if necessary after removal of a cover. The power rating plate 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 Where necessary to ensure that the equipment remains safe within the meaning of this Standard the manufacturer shall prepare and have available the necessary instructions for operation, installation, maintenance, transportation and storage.

★ Maintenance information is normally made available only to
★ service personnel.
★

- 1.7.3 For equipment intended for connection to multiple rated voltages or frequencies the method of adjustment 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

- 1.7.4 Standard supply outlets in the equipment, if 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.

- 1.7.5 ★ Fuseholders shall be marked with the rated current and the rated voltage (if exceeding 125 V) of the fuse. Where fuses with special fusing characteristics are necessary the type shall also be indicated.

The marking shall be placed on or adjacent to the fuseholder. For a group of fuses the marking shall:

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- ★
- ★ - be located so that it is obvious to which fuse or fuseholder the marking applies;
- ★
- ★ - not be placed on removable parts which can be replaced such that the marking would be misleading.
- ★

- 1.7.6 The terminal intended for connection of the external protective earthing conductor shall be indicated by the symbol \oplus No 5019 defined in IEC Publication 417. This symbol shall not be used for other earthing terminals. For an interim period the symbol ∇ No 5017 will be permitted in lieu of the symbol No 5019.

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.

- 1.7.7 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. Where symbols are used they shall be vertical line | for "ON" or circle ○ for "OFF" (IEC Publication 417 Nos 5007 and 5008).

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 higher figures.

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

- 1.7.8 Where there is more than one connection supplying hazardous voltages 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.
- 1.7.9 The equipment installation instructions shall state whether or not the equipment has been designed, or when required, modified for connection to an IT power system.
- 1.7.10 If it is necessary to take special precautions when installing the equipment, details of these shall be given in installation instructions.

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

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

- 1.7.11 Equipment with higher leakage current shall carry a warning label as defined in 5.2.4 and K4.
- 1.7.12 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.
- 1.7.13 Marking shall be durable and easily legible.

In considering the durability of the marking, the effect of normal use and cleaning shall be taken into account.

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2 Safe Electrical Design

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2.1 Protection Against Electric Shock and Energy Hazards

2.1.1 Circuit parts are divided into three groups with respect to protection against electric shock:

- parts which operate in SELV circuits or limited current circuits,
- parts which normally operate at hazardous voltages,
- parts which normally operate at ELV and which may assume hazardous voltages due to breakdown of basic insulation or the failure of a single component.

It is the intention of this Standard to prevent accidental operator contact with:

- bare parts operating at hazardous voltages,
- the operational or basic insulation of such parts, and
- bare parts normally operating at ELV.

Operator contact is not prohibited to:

- bare parts in SELV circuits,
- bare parts in limited current circuits,
- insulation of parts normally operating at ELV under conditions specified in 2.1.3.

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Precautions against accidental contact by service personnel are not required for any secondary circuits which operate at less than 42,4 V peak a.c. or 60 V d.c., including not more than 10% ripple.

2.1.2 Equipment shall be so constructed that there is adequate protection against accidental contact with parts at ELV or hazardous voltages and, for Class II equipment and, where applicable, for Class I equipment, with unearthed conductive parts separated from parts at hazardous voltages by basic 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 with operator access covers open.

This requirements precludes the use in operator access areas of fuseholders which are unable to withstand the accessibility tests with the test finger (Fig. 1).

Compliance is checked by inspection and by a test with the test finger (Fig. 1). In addition, apertures in Class II equipment and apertures in Class I equipment other than those in conductive 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 test 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 may be used to show contact.

Where an electrical contact indicator is used 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 ELV or hazardous voltages,
 - the operational or basic insulation of parts or wiring at ELV or hazardous voltages, except as permitted in 2.1.3.
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In addition, for Class II equipment and where applicable Class I equipment, it shall not be possible to touch with the test finger (Fig. 1) unearthed conductive parts separated from parts at hazardous voltages by basic insulation only. For apertures in insulating covers or unearthed conductive covers it shall not be possible to touch bare parts at hazardous voltages with the test pin (Fig. 2).

Parts at ELV or 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 conductive 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 Operator contact with the insulation of internal parts or wiring at ELV is permitted provided that this insulation is

- not subject to damage or stress nor required to be handled by the operator in performing normal operator functions and
- capable of withstanding the electric strength test for basic insulation at the hazardous voltage,

★ and that the insulation between the ELV and the hazardous
★ voltage is capable of withstanding the electric strength
★ test for supplementary insulation at the hazardous vol-
★ tages.

2.1.4 In service access areas uninsulated parts operating at more than 42,4 V peak a.c. or 60 V d.c. shall be so located or guarded that unintentional contact with such parts is unlikely during servicing operations involving other parts of the equipment.

★ Uninsulated parts that involve an energy hazard shall be
★ so located or guarded that they are not likely to be
★ bridged by conductive materials that might be present
★ during service operations.

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Required guards should be easily removable and replaceable if removal is necessary to service the protected parts.

Compliance is checked by inspection.

- 2.1.5 There shall be no energy hazard in operator access areas.

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Compliance is checked by means of the test bar (Fig. 3) applied without appreciable force. It shall not be possible to bridge with this test bar two bare parts, one of which may be an earthed conductive part, between which an energy hazard exists.

Clearances behind earthed or unearthed conductive covers shall be adequate to ensure that no energy hazard arises during the test of 4.2.1 involving a force of 250 N.

- 2.1.6 With regard to electrical requirements of this Standard, conducting liquids shall be treated as conductive parts.

Compliance is checked by inspection.

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

Compliance is checked by inspection.

- 2.1.8 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. This requirement does not apply to handles, levers and knobs, other than those of electrical components, which are either reliably connected to a protective earthing terminal or are separated from parts at hazardous voltages by earthed metal.

Compliance is checked by inspection.

- 2.1.9 For Class II equipment, capacitors operating in non-SELV circuits shall not be connected to conductive parts in operator access areas, and their casings, if conductive, shall be separated from conductive parts in operator access areas by supplementary insulation.

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

- 2.1.10 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 uF. 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. The test shall then be repeated ten times with the equipment ON/OFF switch left ON.

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.
- 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 electric strength requirements (5.3) and where appropriate with the requirements for creepage distance, clearance and distance through insulation (2.9).

Insulation in thin layers is considered to have adequate electric strength 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.

- 2.2.4 For the purpose of determining the test voltages, creepage distances, clearances and distance through insulation for a given piece of insulation, two parameters shall be considered:

- Application (see 2.2.5)
- Working Voltage (see 2.2.6)

- 2.2.5 Application of insulation is considered to be:

- Operational,
- Basic,
- Supplementary,
- Reinforced, or
- Double

See definitions 1.2.24 to 1.2.28.

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

Operational:

- Between parts of different potential.
- Between ELV or SELV circuits and earthed conductive parts.

Basic:

- Between parts at hazardous voltage and earthed conductive parts.
- Between 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.
- As an element of double insulation.

Supplementary:

- Generally, between a part in an operator access area and a part which could assume a hazardous voltage in the event of a failure of basic 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 surface of a flexible supply cord where the cord enters the enclosure of metal-encased Class II equipment,
 - . between a floating non-SELV secondary circuit and an un-earthed conductive part of the body.

Double or Reinforced:

- Generally, between a non-earthed part in an operator access area and part of a primary circuit.

Where double insulation is used ELV circuits or unearthed conductive parts are permitted between the two layers provided that the overall level of insulation is maintained.

- ★ Double insulation may have the basic and supplementary layers interchanged.
- ★

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 same working voltage applies to each of the constituent layers of basic and supplementary insulation and 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 point by which the highest insulation working voltage is obtained.

For working voltage in safety isolating transformers see Appendix C.2.

2.2.7 Insulation material 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 of the material are substantially filled with a suitable insulant.

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

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 In the event of a single failure of basic insulation or a component, the voltages in a SELV circuit shall not exceed 42,4 V peak or d.c. for more than 0,2 s with a limit of 65 V peak or d.c.

2.3.3 SELV circuits, whose uninsulated parts may be accessible to touch by operators, are required to exhibit safe touch voltages both under normal operating conditions and after a single fault, such as breakdown of a layer of basic insulation, or failure of a single component.

For normal conditions the requirements of 2.3.1 shall be satisfied.

For fault conditions the requirements of 2.3.2 shall be assured for each part of the SELV circuit by one of the following methods:

1) separation of the SELV circuit, by means detailed in 2.3.4:

- from primary circuits by double or reinforced insulation,
- from secondary circuits operating at hazardous voltages by supplementary insulation,
- from secondary circuits operating at ELV by basic insulation;

2) separation of the SELV circuit from other circuits by an earthed conductive screen or other earthed conductive parts, as detailed in 2.3.5 (Class I equipment only);

3) adequate earthing of the SELV circuit as detailed in 2.3.6 (Class I equipment only);

4) provision of a means of protection which prevents the voltage limits from being exceeded, as detailed in 2.3.7.

A safety isolating transformer (see 1.5.3) provides separation by method 1) or 2).

In a single circuit, (e.g. transformer-rectifier circuit) it is possible for some parts to be SELV and operator accessible, while others are not.

Different parts of the same SELV circuit may be protected by different methods, e.g.

- method 2) within a power transformer feeding a bridge rectifier,
- method 1) for the a.c. secondary circuit,
- method 3) at the output of the bridge rectifier,
- method 4) at a remote part of the SELV circuit.

For normal conditions the SELV voltage limit is the same for ELV; a SELV circuit may be regarded as an ELV circuit with an additional degree of safety under fault conditions.

2.3.4 Where part of a SELV circuit is separated from parts of other circuits by insulation only, this may be achieved by one of the following means (other means are not precluded):

- permanent separation by barriers, routing or fixing;
- insulation of all internal wiring rated for the highest working voltage present;
- insulation on either the wiring of the SELV circuit or that of the other circuits meeting the insulation requirements for the highest working voltage present;
- an additional layer of insulation, where required, over either the wiring of the SELV circuit or that of the other circuits.

2.3.5 Where parts of SELV circuits are separated from parts at hazardous voltage by an earthed screen or other earthed conductive parts, the parts at hazardous voltage shall be separated from the earthed parts by basic insulation.

2.3.6 Parts of SELV circuits protected by earthing shall be connected to the protective earth terminal in such a way that the requirements of 2.3.2 are met by relative circuit impedances and/or by the operation of a protective device; and shall be separated from parts of other circuits by basic insulation.

2.3.7 Parts of SELV circuits may be protected by a reliable means of protection such that the requirements 2.3.2 are met. Such parts shall be separated from parts of other circuits by basic insulation.

Reliable protective means may be components or circuits such as: fuses, circuit breakers, electronic over-voltage protection, electronic over-current protection.

2.3.8 Equipment shall be constructed as follows:

- Means shall be provided, other than terminal pressure, to prevent ring-tongue and similar termination pivoting so as to reduce creepage distances and clearances between SELV circuits and parts at ELV or hazardous voltage 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 parts at ELV or hazardous voltage and SELV circuits due to loosening of a terminal or breaking of a wire at a termination.
- Uninsulated parts at ELV or hazardous voltage shall be covered or shielded or so located as to avoid accidental shorting to SELV circuits, e.g. by tools or test probes.
- It shall not be possible to mate plugs and sockets in such a way that a SELV circuit is connected to parts at hazardous voltage. This may be achieved by the design or the location of the connector.

* The requirements of this sub-clause do not apply where the
* possibility of contact between SELV and ELV circuits is being
* considered and the SELV circuit is protected as described in
* 2.3.6 or 2.3.7.

2.3.9 SELV circuits may be connected to other circuits provided that the requirements of 2.3.1 are met, except that SELV circuits shall not be conductively connected to the primary power supply circuit (including the neutral) within the equipment.

2.4 Limited Current Circuits

- 2.4.1 The steady-state current drawn through a non-inductive resistor of 2 000 ohm connected between part of a limited current circuit in an operator access area and either pole of the limited current circuit or earth shall not exceed 0,7 mA peak a.c. or 2 mA d.c. For frequencies above 1 kHz, the limit of 0,7 mA is multiplied by the value of the frequency in kHz but shall not exceed 70 mA peak.
- 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 16 kV peak or d.c., the available stored charge shall not exceed 45 uC.
- 2.4.4 For accessible parts exceeding 15 kV 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 basic insulation or a single component failure.

Segregation of limited current circuits from parts at hazardous voltage shall be as described in 2.3.4 and 2.3.5 for SELV circuits.

Compliance is checked by inspection and measurements.

2.5 Provisions for Protective Earthing

- 2.5.1 Accessible conductive parts in operator and service access areas which may assume a hazardous voltage in the event of a fault of basic insulation, shall be reliably connected to an earthing terminal in the equipment. Such equipment is deemed to be Class I.

Conductive parts behind a cover which does not withstand the tests of 4.2 are deemed to be accessible.

- * Other parts such as signal circuits and EMI screens may
- * be connected to the earthing terminal but as such connec-
- * tions are not protective earth connections they are not
- * subjected to the requirements of 2.5.

Parts in operator access areas need not be earthed provided that they are separated from parts at hazardous voltages:

- either by earthed metal or solid supplementary insulation,
- or by a clearance of not less than 13 mm, in which case the accessible parts shall withstand the tests in 4.2 and all related parts shall be fixed in such a way that they cannot come into contact with each other due to a failure of fixing or termination or accidental displacement of removable covers.

For the purpose of the preceding paragraph, contact with operational or basic insulation of a conductor is regarded as contact with the conductor.

- * Class II equipment shall have no provision for protec-
- * tive earthing, except that it may be provided with the
- * means for maintaining the continuity of protective cir-
- * cuits. Also, Class II equipment may have an earth con-
- * nection for functional purposes, in which case the earth
- * circuit, if in an operator access area, shall be separat-
- * ed from parts at hazardous voltages by double or rein-
- * forced insulation.

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 is assured for all Class I units irrespective of the arrangement

of the units in the system.

Internal protective earthing conductors may be bare or insulated. If insulated the insulation shall be green/yellow except in the case of earthing braids, which may use transparent insulation, and in the case of special conductor assemblies such as ribbon cables, bus bars and flexible printing wiring, etc. where any colour may be used.

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

If operator-removable 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.

- 2.5.3 Earthing terminals for fixed supply conductors or for non-detachable power supply cords shall comply with the requirements of 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 manual test.

In general, the design 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 Conductive parts in contact at safety earth connections shall not be subject to significant corrosion due to electro-chemical action in any working, storage and transport environment conditions as specified in the instruction sheets.

Contact between aluminium and copper is an example of an unsuitable combination.

The earthing terminal shall be resistant to significant corrosion.

Corrosion resistance may be achieved by a suitable plating or coating process.

Compliance is checked by inspection and by reference to the table of electro-chemical potentials (Appendix H).

- 2.5.5 The connection between the earthing terminal or earthing contact, and parts required to be earthed 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 failure of basic insulation would make the earthed 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 be used.

The voltage drop between the earthing terminal or earthing contact and the part to be earthed shall be measured and the resistance calculated from the current and this voltage drop. The resistance of the protective earthing conductor of the power supply cord is not included in the resistance measurement.

In data processing systems where one unit of the system receives power from another unit by means of an interconnecting cable the resistance of the protective earthing conductor is not included in the resistance measurement.

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.

Primary parts remaining energized when the disconnect device is switched off shall be shielded to prevent accidental contact by service personnel.

The 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.

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 1.7.10.

External disconnect devices will not necessarily be supplied with the equipment.

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:

- a plug on a power supply cord,
- * - an appliance coupler,
- 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 equipment 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:

- on equipment supplied from an IT power system,
- on pluggable equipment supplied through a reversible plug (unless the plug itself is used as the disconnect device).

For three-phase equipment the disconnect device shall disconnect simultaneously all live poles of the supply. The neutral of an IT power system is considered to be a live pole.

If, for any reason, a disconnect device interrupts the neutral it shall simultaneously interrupt all poles.

- 2.6.3 For pluggable equipment the plug on the power supply cord may be used as the disconnect device. In this case the installation instructions shall comply with 1.7.10.

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 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 hazardous parts likely to be contacted while the unit under consideration is being serviced,

unless these parts are shielded and marked with appropriate warning labels. In addition a prominent label shall be provided on each unit giving adequate instructions for the removal of all power from the unit.

- 2.6.5 Where equipment receives power from more than one source (e.g. different voltages/frequencies or as redundant power), there shall be a prominent marking at each disconnect device giving adequate instructions for the removal of all power from the equipment.

When more than one such disconnect device is provided on the equipment, all these devices shall be grouped together. It is not necessary that they be in close proximity to one another nor that they be mechanically interconnected.

2.7 Protection of Internal Wiring

- 2.7.1 All internal wiring (including bus bars and inter-connecting cables) used in the distribution of primary power shall be protected against damage due to excess current and short circuit by suitable rated protection devices. These may be included as integral parts of the equipment or as part 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 protection of associated wiring.

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

- 2.7.2 For Class I equipment protection devices which protect against earth faults shall be connected in all phase conductors of the supply. If any such device interrupts the neutral conductor it shall also interrupt all other 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	2	1	Phase Conductor
Other single phase	2	2	Both conductors
Three-phase	3	3	All conductors
Three-phase earthed neutral	4	3*	All phase conductors
Three-phase with unearthed or impedant neutral	4	4	All conductors

* Applies only if neutral conductor is the same cross-sectional area as the phase conductors. If the neutral is smaller, a four-pole circuit breaker is required, with one pole in each conductor.

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* This sub-clause is under consideration to permit the use of single fuses provided in "other single phase" equipment when the fuse in question does not provide earth fault protection for the unit in which it is installed. It may provide earth fault protection for components installed within the unit.
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2.7.3 In situations where earth faults are unlikely (e.g. Class II equipment) the following minimum number of 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
Three-phase	3	2	Any two conductors
Three-phase and neutral	4	3*	Each phase conductor

* Applies only if neutral conductor is the same cross-sectional area as the phase conductors. If the neutral is smaller, a four-pole circuit breaker is required, with one pole in each conductor.

2.7.4 All protective devices which are not capable of breaking the prospective short circuit fault current shall be provided in turn with appropriate short circuit back-up protection.

2.7.5 If any protection required in 2.7 is obtained from protection devices which are part of the building installation they shall be specified in the equipment installation instructions.

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

2.7.6 Protection systems 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 protection devices may be combined in one component.

2.8 Safety Interlocks

2.8.1 Safety interlocks shall be provided where operator access is required to areas normally presenting hazards in the meaning of this Standard. Access may be gained without the use of a tool 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 contact of the test finger (Fig. 1) with a hazardous part.

- For electrical parts to which operator access is forbidden the design shall be such that removal, opening or withdrawal
 - . necessitates previous switching off of such parts, or
 - . initiates automatic disconnection of the supply to such parts.

- Where circuit capacitance might otherwise cause a hazardous voltage or energy hazard to persist between parts in operator access areas 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.
 - 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.
- 2.8.3 Safety interlocks shall be designed so that inadvertent reactivation of the hazard is unlikely to occur when covers, guards, doors, etc. are not in the closed position. Any interlock in an operator access area which can be operated by means of the test finger (Fig. 1) is considered as likely to cause inadvertent reactivation of the hazard.
- 2.8.4 Where it may be necessary for service personnel 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 device 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 a light source that would cause permanent eye damage).
- 2.8.5 The interlock design shall ensure that with interlocked guards, doors, etc. open no unexpected hazard can occur to operators or service personnel.
- Unexpected hazards may be caused by automatic reset thermal devices or by remote and programmed starts.
- 2.8.6 The design shall be such that the probable failure mode(s) of the interlock system shall not create a hazard within the meaning of this Standard.

Where the design is not fail-safe, 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, nor allow extreme hazard.

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Compliance is checked for interlocks with moving parts by examination or by cycling through 10 000 operations without failure other than in a safe mode.

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 Unless otherwise specified insulation distances shall be dimensioned according to the applications as specified in 2.2.5 and working voltage as specified in 2.2.6, in accordance with the table on page 36.

The clearances required do not apply to the air gap between the contacts of thermostats, thermal cut-outs, overload protection devices, switches of microgap construction and the like, where the clearance varies with the movement of the contacts. Similarly, in circuits involving a stylus or similar spark gap device which is necessary for the correct functioning of the equipment, creepage distances and clearances at the stylus or spark gap device are ignored.

Creepage distances and clearances smaller than those required in the table are allowed for operational insulation, provided the equipment does not show any defect within the meaning of this Standard if they are consecutively short-circuited.

In cases where no creepage distance, clearance or distance through insulation is specified and above 4000 V peak or d.c., compliance with the electric strength test in 5.3 is required, except that no test is required for the thickness of operational insulation.

Compliance is checked by measurement, taking into account the figures in Appendix F.

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 conductive 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 3.3.5 and also without conductors.

The clearances between terminals and conductive parts in operator access areas 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.

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

Cl. = Clearance

Cr. = Creepage distance

Th. = Distance through insulation

NOTES TO THE TABLE

¹ Figures in parentheses apply where the insulation is protected against deposition of dirt. In general the interior of equipment having a reasonable dust-free enclosure is deemed to be protected against deposition of dirt, provided the equipment does not generate dust within itself. Hermetic sealing is not required.

² 1,5 mm where live part is enamelled winding.

³ 2 mm where live part is enamelled winding.

⁴ 6 mm where live part is enamelled winding.

⁵ See note to 2.2.3.
 Not applicable to thickness of insulation in transformers. See 2.9.4. Not applicable to thickness of insulation on wiring. See 2.1.3, 3.1.5, 3.2.4.
 ★ Not applicable to certain internal parts under conditions specified in 2.1.3.
 ★
 ★

Distances through slots or openings in external parts of insulating materials are measured to conductive foil in contact with the external surface. For the purpose of this sub-clause, external surfaces of insulating material are treated as though they were covered with a layer of conductive 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 between terminals for primary power supply conductors, and between these terminals and adjacent conductive parts, shall have at least the following values:

Maximum rated voltage (V)	Creepage distance and clearance (mm)
250	6,0
380	8,0
440	9,5

The clearance between these terminals and the body for cables involving current values above 25 A, shall not be less than 9,5 mm.

2.9.4 Unless insulation in thin layers is used (see 2.2.3), distances through solid insulation in safety isolating transformers for use in data processing equipment shall not be less than the values in the following table.

Maximum Working Voltage (V)	Minimum Distance through Insulation (mm)		
	Supplementary insulation	Reinforced insulation between primary windings and SELV windings	Other reinforced insulation
50	No requirement	Not applicable	No requirement
250	0,5	0,5	1,0
660	0,8	0,8	1,5

2.9.5 For printed wiring boards whose conductors are coated with suitable coating material, the creepage distances of the following table apply instead of those in the table in 2.9.2. The coating process, the coating material and the base material shall be such that uniform quality is ensured and the creepage distances under consideration are effectively protected. The thickness of the coating material shall be not less than 0,03 mm.

In parts of a printed wiring board where the conductors are not coated, e.g. component soldering pads and edge connector tabs, the requirements in 2.9.2 still apply.

Maximum Working voltage (rms or dc)	Basic or Supplementary Insulation (mm)	Reinforced Insulation (mm)
50	no requirement	no requirement
63	0,04	0,08
80	0,063	0,13
100	0,1	0,2
125	0,16	0,32
160	0,25	0,5
200	0,4	0,8
250	0,56	1,12
320	0,75	1,5
400	1,0	2,0
500	1,3	2,6
630	1,8	3,6
800	2,4	4,8
1000	3,2	6,4

(Provisional values)

These distances, taken from document IEC 28A (CO)9 are related to working voltages but not necessarily to electric strength test voltages required across the various grades of insulation. Application of these values is still under consideration.

Clearance requirements are under consideration. Until defined they shall be not less than the creepage distances in the table.

Compliance is checked by measurement and by the following sequence of tests.

Preliminary Tests

Two test boards representing the manufacturing processes and the minimum creepage distances used with the coating material applied but without components, shall withstand the relevant electric strength tests in 5.3.3 (without the preceding humidity treatment in 5.3.2).

They shall then be subjected to a soldering operation at approximately 274°C for 3 seconds.

Thermal Cycling Test

Test board no. 1 shall be subjected 10 times to the following temperature cycle:

72 h	at	$110^{\circ}\text{C} \pm 2^{\circ}\text{C}$
1 h	at	$25^{\circ}\text{C} \pm 2^{\circ}\text{C}$
2 h	at	$0^{\circ}\text{C} \pm 2^{\circ}\text{C}$
1 h	at	$25^{\circ}\text{C} \pm 2^{\circ}\text{C}$

Thermal Ageing Test

Test board no. 2 shall be subjected to a temperature of $130^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 1000 h.

Electric Strength Test

Both test boards shall be subjected to the humidity treatment in 5.3.2 and shall then withstand the relevant electric strength test in 5.3.3.

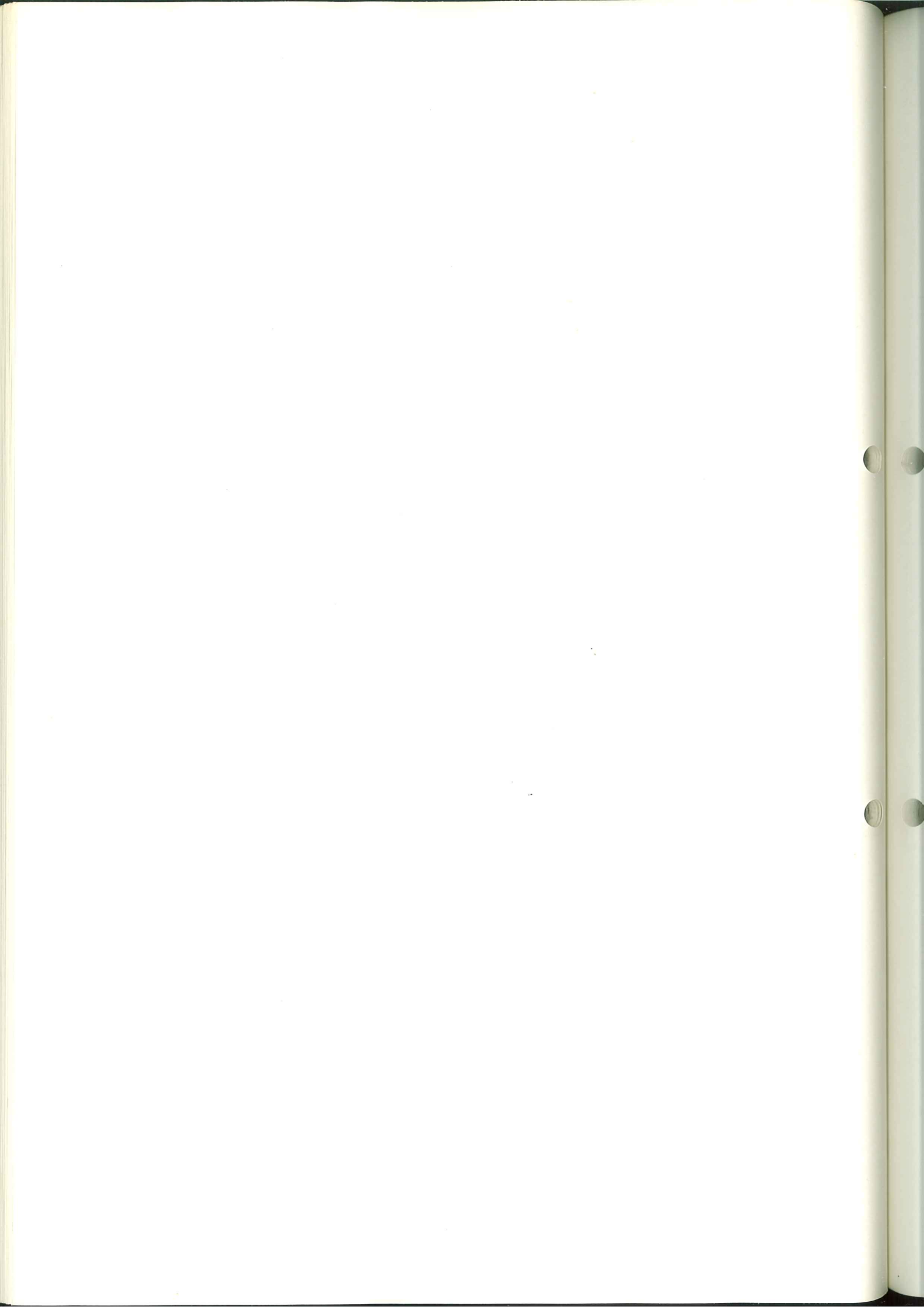
A visual inspection shall show that the coating has not loosened nor shrunk nor peeled away.

2.9.6

The creepage distance and clearance requirements in 2.9.2 do not apply to the internal dimensions of components or sub-assemblies which are enclosed and permanently sealed against ingress of dirt and humidity, provided that they pass the humidity treatment in 5.3.2 followed by the relevant electric strength test in 5.3.3.

The requirements in 2.9.2 still apply to the exterior surfaces of such parts, unless the external conductors

3 Wiring and Connections



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

Compliance with 3.1.1 to 3.1.6 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 for connection of a detachable power supply cord.

The detachable power supply cord is not necessarily supplied with the equipment.

Where equipment is supplied with more than one supply connection (e.g. with different voltages/frequencies or as redundant power) the design shall be such that:

- separate terminals are provided for the different circuits,
- supply plug connections, if any, are not interchangeable if hazard could result from incorrect plugging,
- the operator cannot touch bare parts at ELV or 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 3.3, or
- with a non-detachable power supply cord.

Fixed equipment intended to be permanently connected to fixed wiring, unless it has a non-detachable power supply cord:

- 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 protective earthing conductor	Maximum overall diameter (mm)	
	cable	conduit
2	13,0	16,0 (23,0)
3	14,0	16,0 (23,0)
4	14,5	20,0 (29,0)
5	15,5	20,0 (29,0)

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 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 parts at hazardous voltage 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 equipment 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 test finger (Fig. 1).

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

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Publication IEC 320 does not require appliance couplers to be internally marked for the connection of phase and neutral conductors. Consequently, in equipment employing such appliance couplers the phase and neutral conductors are not identifiable for the purposes of 2.6.2 and 2.7.2

3.2.4 Power supply cords shall:

- be not lighter than ordinary tough rubber-sheathed flexible cord (designation 245 IEC 53), or ordinary polyvinyl-chloride-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:

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

Up to 3 A a nominal cross-section of 0,5 mm² is allowed in some countries 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 equipment.

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.

* In the absence of particular requirements for flexible cords having an overall conductive screen, tests similar to those of IEC 227 shall be used to access their suitability. However, flexing tests need only be applied to power supply cords for hand-held and movable equipment.

* Damage to the screen during the flexing test (IEC 227, 17.2) is acceptable, provided that

- * - during the test the screen does not make contact with any conductor, and
- * - the sample, after the flexing test, withstands the electric strength test between the screen and all conductors.

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 protective earthing conductor, if any, 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 is not clamped by a metal screw which bears directly on the cord,
- knots in the cord are not used.

Additionally, the cord anchorage on metal encased Class II equipment shall:

- be constructed from insulating material, or
- having 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 electric strength tests where required, and by the following tests, to be made with the cord in place.

It shall not be possible to push the cord into the equipment 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 2.9.

- 3.2.6 A cord guard at the power supply cord inlet opening shall be provided for hand-held equipment with a non-detachable cord, 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. 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.

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 metal-encased Class II equipment shall meet the requirements for supplementary insulation.

Compliance is checked by inspection and measurement.

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

- to fixed wiring and non-detachable power supply 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 or in hand-held equipment, should it become free from its terminal, cannot come into contact with conductive parts in operator or service access areas.

* This requirement is deemed to be satisfied if the power supply
* cord is provided with terminators (e.g. ring lugs crimped on
* to the conductors, or the like) which are unlikely to become
* free.

- to fixed wiring shall be adequate to allow the conductors to be easily introduced and connected.

Compliance is checked by inspection and for connection to fixed wiring by an installation test with cables or flexible cords of the largest cross-sectional area specified in 3.3.5.

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 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 power supply 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 may be used as terminals for external power supply conductors, provided they comply with the requirements of 3.3.

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 tabel:

Maximum 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
6	0,75 to 1	1 to 2,5
10	0,75 to 1,5	1 to 2,5
13,5	1 to 1,5	1,5 to 4
16	1,5 to 2,5	1,5 to 4
25	2,5 to 4	2,5 to 6
32	4 to 6	4 to 10
40	6 to 10	6 to 16
63	10 to 16	10 to 25

*

Where heavier gauge conductors are used, the terminals shall be sized accordingly.

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

Maximum rated current of equipment (A)	Minimum nominal thread diameter (mm)	
	Pillar type or Stud type	Screw type
10	3,0 *	3,5
16	3,5	4
25	4,0	5
32	4,0	5
40	5,0	5
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 located 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 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.

- 3.3.9 Terminals shall be so located, shielded, or insulated, that should a wire of a stranded conductor escape when the conductor is fitted, there is no risk of accidental contact between such a wire and:

- ★ - conductive parts in operator or service access areas, or
- unearthed conductive parts separated from parts in operator access areas by supplementary insulation only.

Compliance is checked by inspection.

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 drawers, doors, etc. are opened. This shall be automatic in operation when associated with operator use. For service personnel use, where it is not automatic, 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 if used in the normal operation of the unit 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.*
- *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. Doors, drawers, etc. shall be closed during this test.*

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Where units are designed to be fixed together on site and not used individually, the stability of individual units need not 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 Moving parts of equipment shall, as far as is reasonably practicable, be so arranged or enclosed as to provide in normal use, adequate protection against personal injury.

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 or for 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 is prevented.

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

If complete guarding of an obviously hazardous moving part is not reasonably practicable because it 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.

Compliance is checked by inspection and by a test with the test finger (Fig. 1). Except where a "STOP" control is provided in accordance with the previous paragraph, 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 equipment functioning) shall be rounded and smoothed (no abrupt discontinuity) when they are:

- on the external contours of the equipment where they are likely to be contacted,
- on parts that will be contacted as a result of normal operator or service personnel functions.

Compliance is checked by inspection.

- 4.1.4 The enclosure of equipment which 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 equipment 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 pressures are under consideration.

4.2 Mechanical Strength

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 inspection and, if applicable, by the following tests, applied to separate samples of the covers and guards in operator access areas.

The tests are 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.

- Internal covers and guards of any material:

* A steady force of 30 N shall be applied, by means of a straight un-jointed
* version of the test finger (Fig. 1), to the cover or guard within the
* complete equipment or on separate sub-assembly.

* - External covers and guards of any material:

A steady force of 250 N shall be applied, by means of a suitable test tool providing contact over a circular surface 30 mm in diameter, to the cover or guard on the complete equipment.

- External covers and guards of any material:

* An impact test shall be applied to a sample consisting of the complete
* cover or guard, or a portion thereof representing the largest unreinforced
* area, supported so that the area that is to receive the impact is hori-
* zontal.

* 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.

- Covers and guards of any material other than metal or ceramic:

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

The material is considered to comply if after the above tests, no damage is visible such as would cause non-compliance with the requirements in 2.1.2, 2.1.5, 2.4.1, 2.5.1, 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 5.3.

Damage to finish, small dents and small chips which do not adversely affect the protection against electrical shock or moisture, 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.

4.3 Construction

4.3.1 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 hazard.

Compliance is checked by manual test.

- 4.3.2 Equipment shall be so constructed that manual adjustment of control devices requires the use of a tool if inadvertent adjustment might create a hazard.

Compliance is checked by manual test.

- 4.3.3 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.

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

Compliance is checked by visual inspection.

- 4.3.5 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.

- 4.3.6 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.

- 4.3.7 Where sleeving is used as supplementary insulation on internal wiring, it shall be retained in position by positive means.

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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.

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

Compliance is checked by inspection and by measurement.

- 4.3.9 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 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 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 or other locking means 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.

- 4.3.10 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 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 2.9 whatever cracks may occur.

Compliance is checked by inspection and by measurement.

- 4.3.11 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 insulation shall have adequate properties under conditions of normal lubrication.

Compliance is checked by inspection.

- 4.3.12 Equipment which may generate ozone or ionizing radiation, or in which flammable liquids, flammable gases or similar hazards are present, shall be so designed that harmful effects to persons and damage to materials affecting safety is prevented.

Compliance is checked as regards ionizing radiation by the test in Appendix G.

- 4.3.13 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 or components, or electrical insulation, creepages or clearances will not be adversely affected so as to create a hazard.

Compliance is checked by inspection.

- 4.3.14 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.

- 4.3.15 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 swageing 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.

4.3.16 There shall be no penings directly over parts at hazardous voltages in the top of the enclosure of a floor-mounted unit of 1200 mm or less in height.

Compliance is checked by inspection.

4.3.17 Openings directly over parts at hazardous voltages 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 parts at hazardous voltages is prevented.

Compliance is checked by inspection.

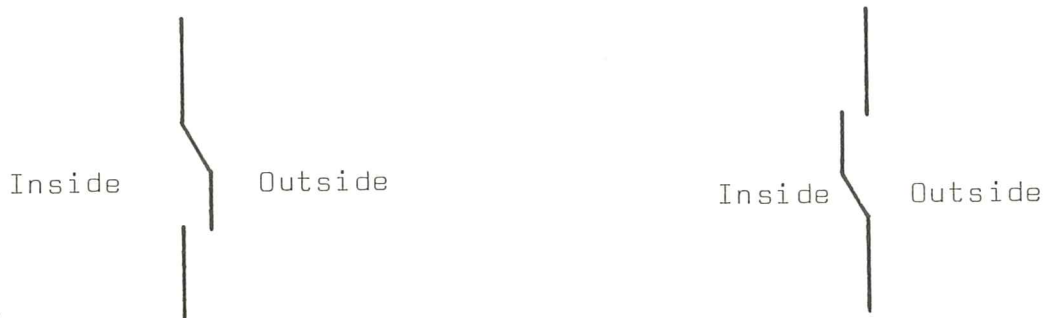


Cross-section of top cover designs preventing straight access

4.3.18 In the side of the enclosure openings shall be so located and of such a size that accidental entry of a foreign object likely to be present and likely to cause a hazard 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 minimize 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 (4.4.2 and Appendix A6);
 - using materials of low flammability for internal parts (4.4.3 and Appendices A6, A7, A8);
 - using enclosures of low flammability and low flame spread index (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 (4.4.5, 4.4.6 and Appendices A4, A5).

4.4.2 The risk of ignition due to the high temperature shall be minimized by the appropriate use of components and 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 in 5.1 shall not be exceeded.

Combustible materials used shall not be subject in normal use to temperature 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 at least flammability classification V-1 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 minimized.

Except as noted below, all materials and components to which the tests are applicable shall have a flammability classification of at least V-2 or HF-2.

Electrical components meeting flammability requirements contained in individual IEC or equivalent applicable national Standards 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 at least class V-2 or which comply with the requirements of relevant IEC Standards.

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

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 cords 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, 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 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 be at least flammability classification 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 and shall not be under pressure sufficient to cause the liquid to atomize with the following exception:

Replenishable flammable liquids having a flash point less than 60 °C and/or under sufficient pressure to cause atomization may be used, if appropriate investigation shows no liquid sprays or build-up of flammable vapour-air mixtures which could cause explosion or fire hazard. This investigation shall also consider the integrity of the liquid handling system.

The component flammability requirements of this clause may be waived for the components within an enclosure of 0,06 m³ or less consisting totally of metal and having no ventilation 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 minimized.

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

Steel and aluminium, and glass which is heat-resistant tempered, wired or laminated, 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 K the material shall be conditioned as specified in Appendix A1 before test, unless ageing characteristics of the material have been established.

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

Enclosures which do not serve to protect against contact with parts at hazardous voltages, or enclosure materials used for mechanical or decorative purposes only, are deemed to comply without test if the material is of at least flammability classification HB, and if the exposed surface area is less than 0,9 m² and no single horizontal or vertical dimension exceeds 1,8 m.

*
*

For outer 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 deemed 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 wall section used. The flame spread index shall be defined as the average value based on a sample of 6 specimens provided that no specimen has a value greater than 75.

Enclosures having smaller surface areas than those specified are exempt 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 likely to occur in the application.

Compliance is checked by the test of Appendix A3.

Metallic or ceramic materials are deemed to comply without test.

If uninsulated parts at hazardous voltage or parts which present an 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 minimize 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.

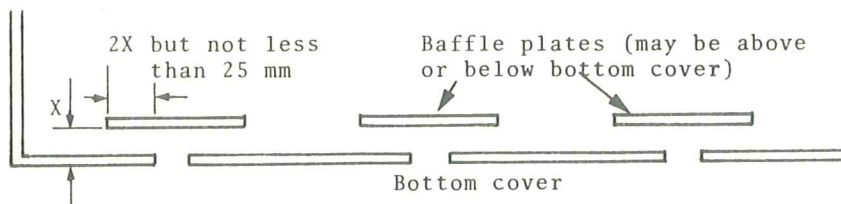
Compliance is checked by inspection and, where necessary, by the tests of either Appendix A4 or Appendix A5.

The following constructions are deemed to comply without test:

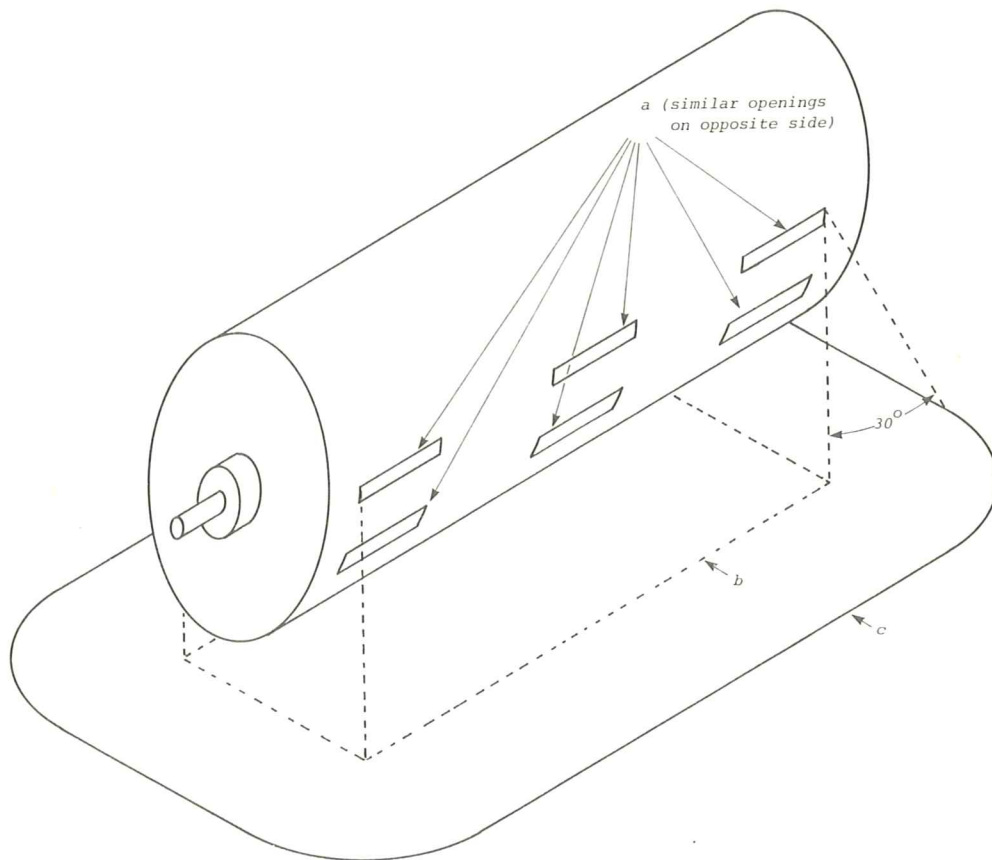
- Openings of any size under
 - . thermoplastic insulated conductors and their receptacles
 - . impedance or thermally protected motors.
- Openings not larger than 40 mm² under
 - . components or parts of at least flammability classification V-1
 - . components or parts with individual barriers (see below)
- Sheet steel bottom panels conforming with the dimensional limits of any line in the following table:

Minimum thickness (mm)	Maximum diameter of holes (mm)	Minimum spacing of holes centre to centre (mm)
0,76	1,15	1,7
0,76	1,2	2,36
0,89	1,9	3,17
1	1,6	2,7
1	2	3

- 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.



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 or 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 have a:

- flammability classification at least V-2, and
- are in compliance with the requirements in 4.2.1, or
- are in compliance with the requirements in 4.4.4 for enclosures protecting against contact with parts at hazardous voltages.

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 supporting conductive parts in primary circuits 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 2.9.

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

4.6 Mechanical Strength of Cathode Ray Tubes

- ★ Equipment containing cathode ray tubes having a maximum face dimension exceeding 160 mm shall provide adequate protection against the effects of implosion and mechanical impact.
- ★ Either the cathode ray tube shall be of an implosion-protected type, or the enclosure of the equipment shall provide the required protection.
- ★ *Compliance is checked by inspection, by measurement and by the relevant tests of IEC Publication 65, clause 18:*
- ★ - either, for implosion-protected cathode ray tubes, the tests in 18.2,
- ★ - or, for equipment containing cathode ray tubes which are not implosion protected, the tests in 18.3.

5 Thermal and Electrical Tests

5.1 Heating

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, failure of which could cause a hazard within the meaning of this Standard, is measured on the surface of the insulation. For temperature rise of windings, see 1.4.8.

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

Parts	Temperature rise (K)
Windings, if the winding insulation is	
- of Class A material	75 ¹
- of Class E material	90 ¹
- of Class B material	95 ¹
- of Class F material ³	115 ¹
- of Class H material ³	140 ¹
External parts	
- Outer surface of enclosures	60
- Metallic knobs, handles, etc. touched in normal use	30
- Non-metallic knobs, handles, etc. touched in normal use ²	50
Thermoplastic materials used as insulation	see ⁴
Other parts	see ²

¹ ★ When temperature rises of windings are determined by thermocouples, these ★ figures are reduced by 10 K 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 test similar to the Vicat test (ISO R 306):

- . cross-section of penetrating needle: 1 mm^2
- . load: 10 N
- . Heating rate: 50 K 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 K 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

The tests specified in 5.2.1 to 5.2.4 apply to equipment to be connected to TT or TN power supply systems. For equipment to be connected directly to IT power supply systems the tests in Appendix K shall be applied.

5.2.1 Equipment shall not have earth leakage current in excess of the following values when measured as defined in 5.2.2 or 5.2.3:

- 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:
 - . 3,5 mA, or
 - . 5% of unit input current, subject to the conditions in 5.2.4.

Systems of interconnected units with individual primary power connections shall have each unit tested. Systems of interconnected units with one primary power connection shall be considered as a single unit.

Units designed for multiple (redundant) supplies shall be tested with only one supply connected.

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.

★
★ For the purpose of this requirement Class I equipment is considered
★ to be permanently connected if supplied through a non-detachable
★ power supply cord and an industrial plug and socket. Plugs and
★ sockets conforming with IEC Publication 309 are deemed to comply.
★

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 equipment the test shall be made to conductive parts, and to metal foil on non-conductive parts, in operator access areas.

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

5.2.2 Single-phase equipment intended for operation between one phase conductor and neutral shall be tested using the circuit of Fig. 5.1.

During the test, switch S and any switches within the equipment controlling primary power and likely to be operated in normal use are opened and closed in all possible combinations.

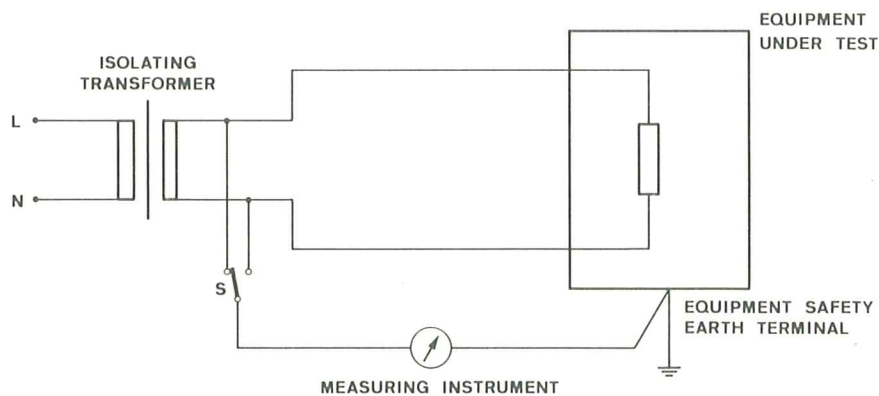


Fig. 5.1

None of the current values shall exceed the relevant limit specified in 5.2.1.

5.2.3 Three phase equipment and equipment intended for operation between two phase conductors shall be tested using the circuit of Fig. 5.2. During the test any switches within the equipment controlling primary power and likely to be operated in normal use are opened and closed in any combination.

Any components used for EMI suppression and connected between phase and earth shall be disconnected one at a time; for this purpose groups of components in parallel connected through a single connection shall be treated as single components.

- Where filters are normally encapsulated it may be necessary to provide an unencapsulated unit for this test or to simulate the filter network.
- Each time a line to earth component is disconnected the sequence of switch operation should be repeated.

None of the current values shall exceed the relevant limit specified in 5.2.1.

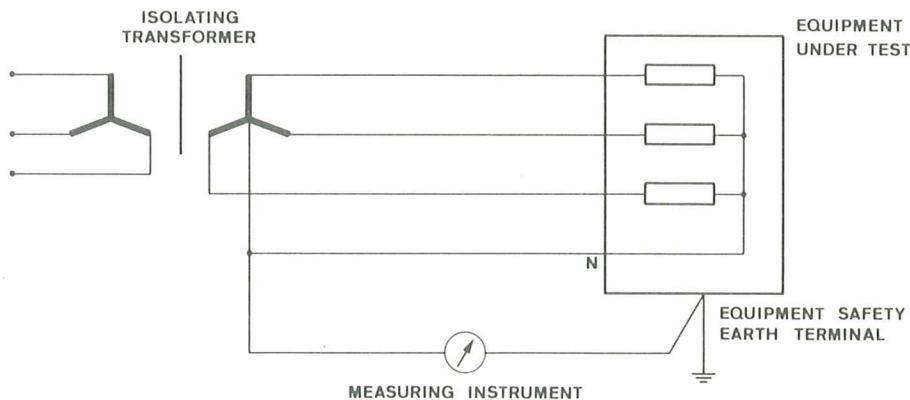


Fig. 5.2

5.2.4 Class I stationary equipment which exceeds a limit of 3,5 mA is 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 unit input current per phase. Where the load is unbalanced the largest of the three phase currents is used for this calculation. Where necessary, the tests in 5.2.2 and 5.2.3 shall be used but with a measuring instrument of negligible impedance;
- a label bearing the warning

<p>HIGH LEAKAGE CURRENT Earth connection essential before connecting supply</p>

or similar wording shall be affixed adjacent to the unit power input;

- the cross-sectional area of the internal protective earthing conductor shall not be less than 1,2 mm² in the path of high leakage current;
- in addition it is recommended that a means of detecting failure of continuity of the external protective earthing conductor should be installed in all units having more than 3,5 mA of leakage current.

5.3 Electric Strength

5.3.1 The electric strength of the equipment shall be adequate.

Compliance is checked by the conditioning in 5.3.2 immediately followed by the tests in 5.3.3, or, for transformers, of Appendix C.

In order to facilitate conditioning and electric strength testing, components and sub-assemblies 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 K of any convenient value t between $20\text{ }^{\circ}\text{C}$ and $30\text{ }^{\circ}\text{C}$ such that condensation does not occur.*

Before the humidity treatment the sample is brought to a temperature between $t\text{ }^{\circ}\text{C}$ and $(t + 4)\text{ }^{\circ}\text{C}$.

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 Standard.

The electric strength tests described in 5.3.3 and Appendix C 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 in 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 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 (Basic, Supplementary or Reinforced) required and the working voltage across the insulation (U).

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 these tests if they may be damaged or destroyed by capacitance charges of currents or other occurrences during this test.

Where there are capacitors across the insulation being tested (e.g. radio frequency filter capacitors) d.c. test voltages are used.

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.

*
* After abnormal operation or a fault it is not required that
* the equipment should still be in full working order, only
* that it remain safe for an operator within the meaning of
* this Standard.

Fusible links, thermal cutouts, overcurrent protection devices and the like may be used to provide adequate protection.

Compliance is checked according to the following sub-clauses.

- 5.4.2 Motors shall be so designed or protected as to avoid hazards due to overload conditions up to and including locked-rotor. This may be effected by:

- the use of motors which do not overheat under locked-rotor conditions (protection by inherent or external impedance), or
- * - the use in secondary circuits of motors which may exceed
* the temperature limits but which do not create a hazard, or
- a device responsive to motor current, or
- an integral thermal cutout, or
- 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
- * - any other means which can be demonstrated to protect the
* motor.

Compliance is checked by the applicable tests of Appendix B as noted below:

- * Motors other than d.c. motors in secondary circuits shall satisfy the
* tests of B.2 and B.3 and where applicable B.5, B.6 and B.7, except
* that motors which
*
* - are used for air-handling only and where the air propelling component
* is directly coupled to the motor shaft, or

- * - have a difference of not more than 1 ampere and 2:1 or smaller ratio
- * between locked-rotor and no-load currents
- * are not required to satisfy the test of B.2.
- * D.c. motors in secondary circuits shall satisfy the test in B.4 except
- * that motors which normally operate under locked-rotor conditions, such
- * as stepper motors, shall not be tested.

5.4.3 Transformers shall be protected against overload, Protection may be effected by:

- external overcurrent protection, or
- internal thermal cutouts, or
- use of current limiting transformers, or
- any other means which can be demonstrated to protect the transformer.

Compliance is checked by the applicable tests of Appendix C1.

5.4.4 *Parts of the equipment in primary circuits other than motors and transformers shall be checked by simulating faults.*

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

During the test, equipment shall not show any defect within the meaning of this Standard.

5.4.5 *For electromechanical components other than motors in secondary circuits where a hazard is likely to occur compliance with 5.4.1 shall be checked by applying the following conditions one at a time either in the equipment or to simulated circuits:*

- * *- the mechanical movement is locked in the most disadvantageous position*
- * *whilst the component is energized normally,*
- * *- in the case of a component which is normally energized intermittent-*
- * *ly: with a simulated fault in the drive circuit such as will cause*
- * *continuous energizing of the component.*

The duration of each test shall be:

- * *- For machines automatically or remotely controlled and for components*
- * *whose failure to operate is not evident to the operator: as long as*
- * *necessary to establish steady conditions or up to the interruption*
- * *of the circuit due to other consequences of the simulated fault con-*
- * *dition, whichever is the shorter.*
- * *- For other machines and components: 5 minutes or up to interruption*
- * *of the circuit due to a failure of the component (e.g. burns-out)*
- * *or to other consequences of the simulated fault condition, whichever*
- * *is the shorter.*

* *Temperatures in the transformer supplying the component under test shall*

* *not exceed those specified in Appendix C1 (subject to the exception*

* *detailed in C1).*

- * During the test the equipment shall not show any defect within the mean-
* ing of this Standard.
*
- 5.4.6 After the tests in 5.4.4 and 5.4.5 an electric strength test shall be
* carried out if
*
* - any clearance or creepage distance which is relied upon to maintain
* the integrity of double or reinforced insulation has been reduced
* below the value specified in 2.9.2, or
*
* - where the insulation involved shows visible signs of damage, or
*
* - where the insulation involved cannot be inspected.
*
* This test shall be made as specified in 5.3.7 after the insulation has
* cooled to room temperature but without prior environmental condition-
* ing and with the test voltages reduced to 0,6 times the specified va-
* lues.
*
* If after tests carried out on simulated circuits there is doubt whether
* damage to other parts of the equipment could be caused to the extent
* that safety may be affected, the tests in 5.4.4 or 5.4.5 shall be re-
* peated in the equipment.
*
* During this test, the equipment shall not show any defect within the
* meaning of this Standard. Temperatures in the transformer supplying
* the component under test shall not exceed those specified in Appendix C1
* (subject to the exception detailed in C1).

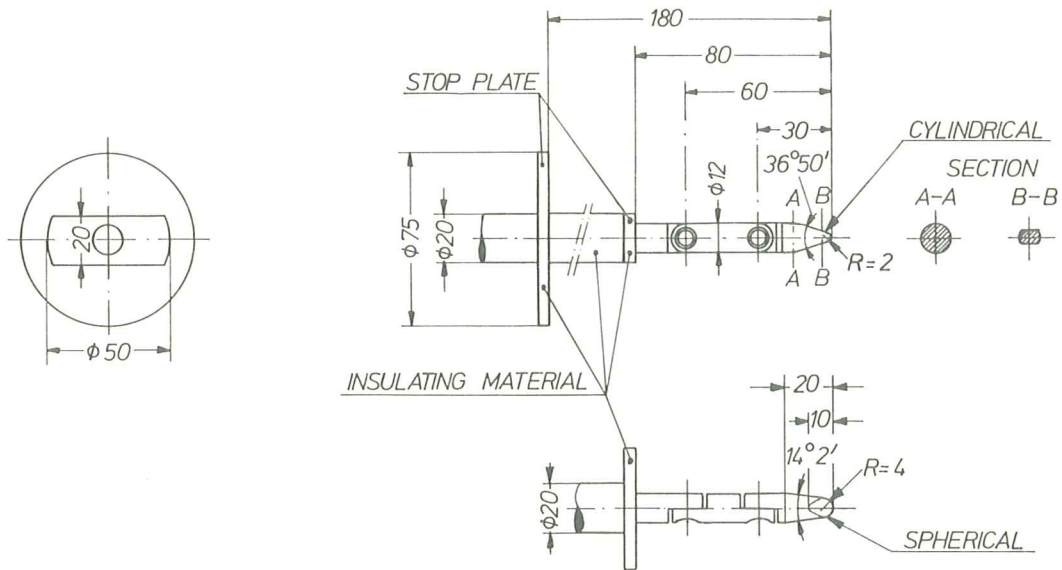


Fig. 1 Test Finger

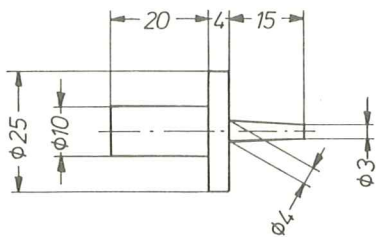


Fig. 2 Test Pin

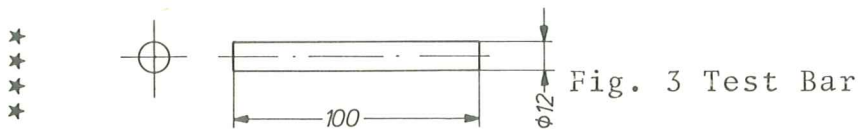


Fig. 3 Test Bar

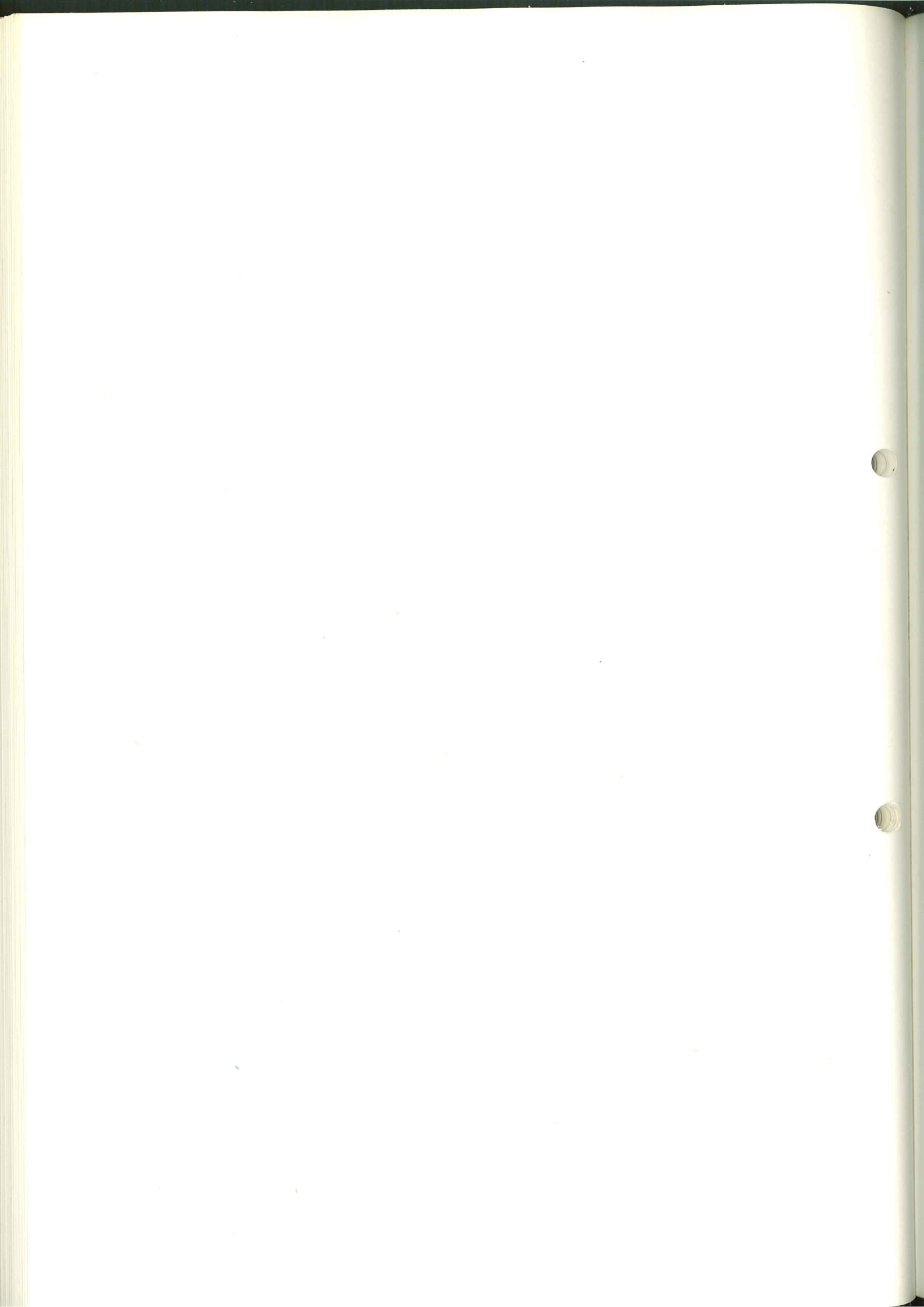
Tolerances:

on angles $\pm 5'$

on linear dimensions:

- less than 25 mm ± 0
- 0,05
- over 25 mm $\pm 0,2$

All dimensions are in millimeters.



APPENDICES

APPENDIX A - TESTS FOR RESISTANCE TO HEAT AND FIRE

It should be noted that toxic fumes might be given off during the tests. Where appropriate the tests should be carried out under a hood or in a well ventilated room free from draughts.

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. 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:*

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

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 100 mm³ 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 the 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.

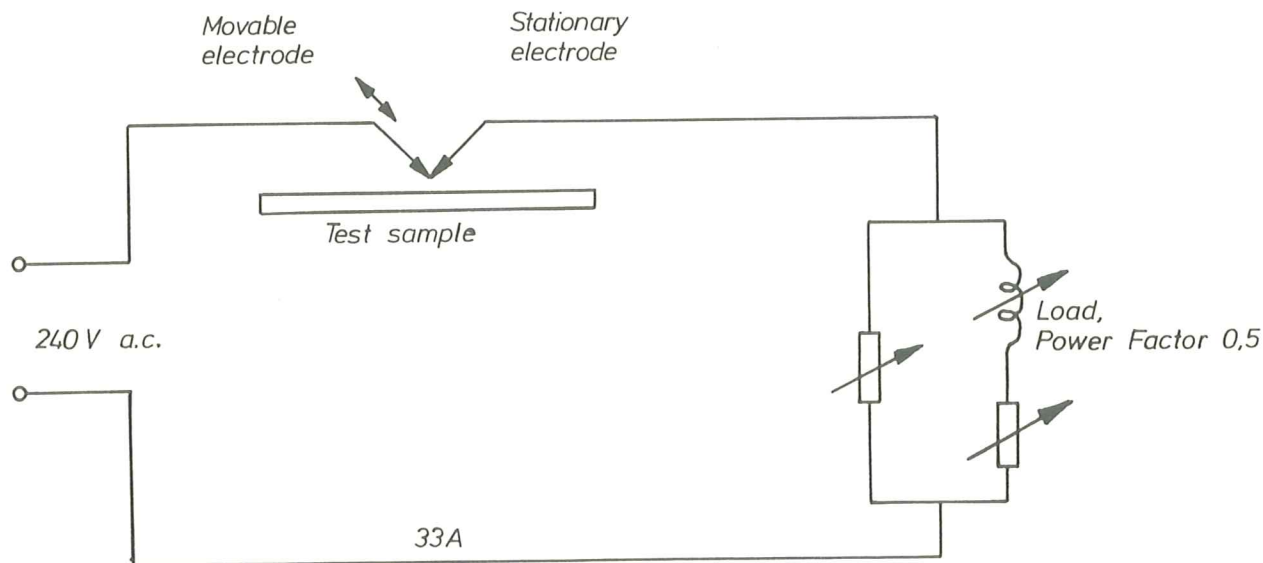
The test flame shall be applied to an inside surface of each of three samples of horizontal section and to an inside surface of each of three samples of a vertical section. If a vertical part is involved, the flame shall be applied at an angle of 20° from the vertical. If ventilating openings are involved, 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 burr, 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.



An equivalent circuit may be used.

One electrode shall be stationary and the second movable. The stationary electrode shall consist of 10 mm² 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 sample under test shall be supported horizontally in air so that the electrodes, when touching each other, are 1,6 mm above the

- * surface of the sample. The movable electrode is manually or other-
- * wise controlled so that it can be withdrawn from contact with the
- * stationary electrode to break the circuit and lowered to remake the
- * circuit, so as to produce a series of arcs at a rate of approxima-
- * tely 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. Bleached cheesecloth of approximately 26m² 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 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 medium₃ 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 2,1 MJ/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. 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 K. 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 K and a relative humidity of 50% + 5% prior to testing.

A.6.4 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 swatch 50 mm x 50 mm thinned out to a maximum free-standing thickness of 6 mm. 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/m³ 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/m³ 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 A.8.

A.6.9 The material is acceptable as class V-1 provided that all of the following apply:

- each sample passes the tests in A.6.5, A.6.6 and A.6.7
- the average duration of flaming does not exceed 25 s and
- 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 A shall be conditioned for 168 hours at a temperature of $70^{\circ}\text{C} \pm \text{K}$. 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 other samples B shall be conditioned for at least 48 hours at a temperature of $23^{\circ}\text{C} \pm 2 \text{ K}$ and a relative humidity of $50\% \pm 5\%$ prior to testing.

A.7.4 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 38 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/m³ 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 sample A and one sample B 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 Flammability Tests for 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 the end.

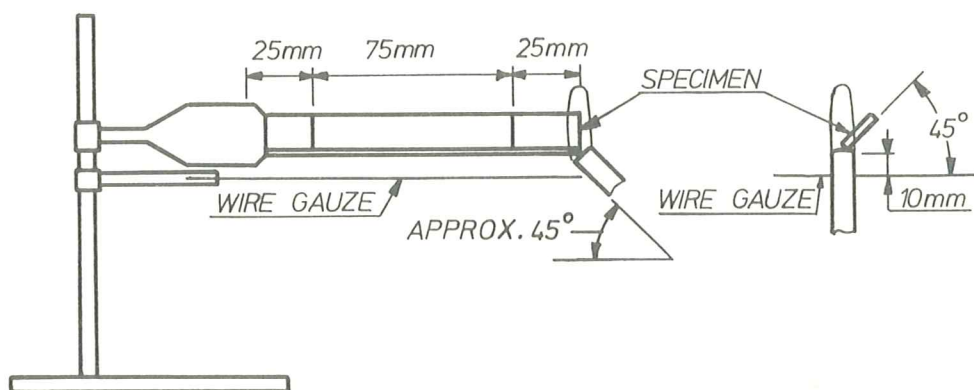
A.8.3 A sample shall be supported by a clamp at the end farthest from the 25 mm mark, with its longitudinal axis horizontal and its transverse axis at 45° to the horizontal. A flat 130 mm square of steel-wire gauze (approximately 8 openings per cm) shall be supported horizontally 10 mm below the lowest 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.

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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 mark 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.
- 75 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 Maximum Temperatures Under Abnormal Conditions

★ Unless otherwise specified the equipment shall be operated during the tests at rated voltage, or at the highest voltage of the rated voltage range.
★
★

★ The tests may be carried out either in the equipment or under simulated conditions on the bench. Simulated conditions should include any protection devices which would protect the motor in the complete equipment. Separate samples may be used for these tests.
★
★

★ Temperatures of windings shall be measured by thermocouples applied to the surface of the motor windings, 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.
★

★ For totally enclosed, impedance protected motors, the temperatures shall be measured by thermocouples applied to the motor case.
★
★

★ Internal temperatures are of no interest in a totally enclosed motor.
★
★

★ For the tests in B.3, B.5 and B.6 the following temperatures limits shall apply for each class of insulating material:
★

Table B.1

	Maximum Temperature (^o C)				
	Class A	Class E	Class B	Class F	Class H
Protection by inherent or external impedance	150	165	175		
Protection by protective device which operates during the first hour	200	215	225		
Protection by any protective device					
- maximum after first hour	175	190	200		
- arithmetic average during the 2nd hour and during the 72nd hour	150	165	175		

★ Values for F and H are under consideration.
★

Arithmetic average temperature is determined as follows:

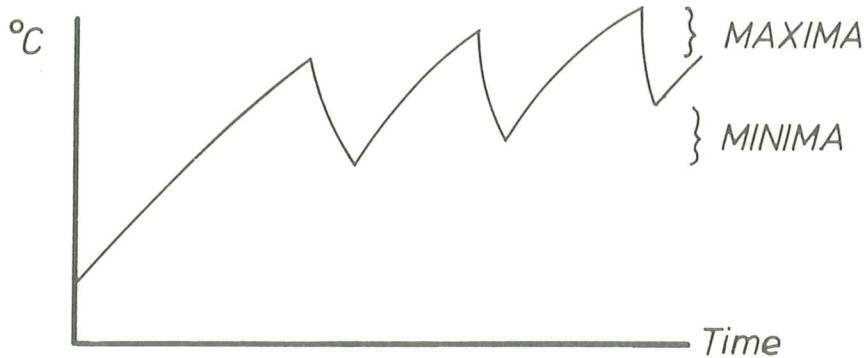
The graph of temperature against time, while the power to the motor is cycling on and off, is plotted for the period of test under consideration. The arithmetic average temperature (t_A) is determined by the formula:

$$t_A = \frac{t_{max} + t_{min}}{2}$$

where

- t_{max} is the average of the maxima

- t_{min} is the average of the minima



For the tests in B.2 the following temperature limits shall apply:

Maximum Temperature °C				
Class A	Class E	Class B	Class F	Class H
140	155	165		

Table B.2

Values for classes F and H are under consideration.

B.2 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 motor 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 device operates.

The motor winding temperatures shall be determined during each steady period and the maximum temperature recorded shall not exceed the values specified in B.1, table B.2.

B.3 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-resetting protection device shall be cycled on locked-rotor for 15 days;
- A motor with a manual resetting protection device shall be cycled on locked-rotor for 60 cycles, the protection device being reset after each operation as soon as possible for it to remain closed, but not less than 30 s;
- ★ - A motor with a non-resettable protection device shall be operated
- ★ until the device operates.

Temperatures are observed at regular intervals during the first three days for a motor with inherent or external impedance protection or with a self-resetting protection device, or during the first ten cycles for a motor with a manual resetting protection device, or at the time of operation of a non-resettable protection device.

★ The temperatures shall not exceed the values specified in B.1, table B.1.

★ During the test, protection devices shall operate reliably.

★ After the period specified for temperature measurement, the motor
★ shall withstand the electric strength test in 5.3.3 after the insulation
★ has cooled to room temperature but without prior environmental condition-
★ ing and with test voltages reduced to 0,6 times the specified values. No
★ further electric strength test is required.

Continuation of the test of an automatic protection device beyond 72h, and of a manual reset protection device beyond 10 cycles, is for the purpose of demonstrating the capability of the device to make and break locked rotor current for an extended period of time.

B.4 Locked-Rotor Test for d.c. Motors in Secondary Circuits (Provisional Test)

★
★ The motor shall be placed on a wooden board covered with a single
★ layer of tissue paper as per ISO/R 135-1959 and the motor, in turn,
★ covered with a layer of bleached cotton cheesecloth of approximately
★ 40 g/m².

★ The motor shall be operated at its working voltage and with the rotor
★ locked for 7 hours or until steady conditions are established.

★ At the conclusion of the test, there shall be no evidence of burning
★ of the tissue paper or cheesecloth. In addition, if the voltage ex-
★ ceeds 42,4 V peak or d.c., the motor shall withstand the electric
★ strength test in 5.3.3 but without prior environmental conditioning
★ and with test voltages reduced to 0,6 times the specified values.
★

B.5 Motors with Capacitors

Motors having phase-shifting capacitors shall be tested with the capacitors short-circuited or open-circuited (whichever is the more unfavourable) and with locked-rotor, unless the motor is provided with a capacitor complying with IEC Publication 252, a.c. Motor Capacitors.

- * The short-circuit test of the capacitor need not be made
- * if a capacitor is used which is designed and marked such
- * that, upon failure, it will not remain short-circuited.

Temperatures shall not exceed the values specified in B.1, table B.1.

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

B.6 Three-phase Motors

Three-phase motors shall 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.

- * The effect of other loads and circuits within the equipment
- * may necessitate that the motor be tested within the equipment
- * and with all three supply phases disconnected in turn.

Temperatures shall not exceed the values specified in B.1, table B.1.

B.7 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 meaning of this Standard.

APPENDIX C - TRANSFORMERS

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

Simulated conditions should include any protection device which would protect the transformer in the complete unit.

C.1 Overload Test

Maximum temperatures of windings are measured as specified in 1.4.8, and determined under the test conditions specified below:

- with external overcurrent protection: at the moment of operation;
- with self-resetting cutouts: as shown in the table below and after 400 h;
- with non-self-resetting thermal cutout: at the moment of operation;
- current-limiting transformers: after temperature has stabilized.

The following temperatures shall not be exceeded:

	Maximum Temperatures (C°)				
	Class A	Class E	Class B	Class F	Class H
Protection by inherent or external impedance	150	165	175		
Protection by protection device which operates:					
- during the first hour, maximum	200	215	225		
- after first hour, maximum	175	190	200		
- after first hour, arithmetic average	150	165	175		

The limits for Classes F and H are under consideration.

Arithmetic average temperature is determined as follows:

The graph of temperature against time, while the power to the motor is cycling on and off, is plotted for the period of test under consideration. The arithmetic average temperature (t_A) is determined by the formula:

- 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 constructions):

- 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 conductive screen with suitable insulation between each winding and the screen. The conductive screen may consist of metal foil extending the full width of the transformer winding. The conductive 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 equipment.

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 electric strength for reinforced insulation at the appropriate working voltage.
- . Supplementary insulation shall have at least two layers where one layer meets the electric strength requirements for supplementary insulation.

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.

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An earthed metal screen may be provided in Class II equipment for functional purposes. Insulation between a functional screen and other parts of the transformer shall be provided and tested as if it were a secondary winding. If a functional screen is to be connected to an SELV circuit or to any accessible part it shall be insulated as if it were an SELV secondary.

Electric strength tests shall be applied in accordance with 5.3 and the table in this Appendix. In the table the term "body" means the body of the equipment together with any conductive parts of the transformer which are conductively connected to it as part of the protective earth system.

The working voltage for insulation between windings is determined by the maximum peak voltage which occurs in normal operation 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 conductive parts is determined by maximum peak voltage occurring in normal operation at any point on the winding relative to earth.

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 the point by which the highest insulation voltage is obtained.

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.

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

In some cases the electric strength test voltages are higher than in the corresponding tests in 5.3.3, in order to give increased confidence in the concealed insulation in a transformer.

Grade of Insulation	Points of Application Between: and:	Test Voltage V_{rms}	
		$U_p \leq 354 V$	$U_p > 354 V$
Operational OP	SELV Secondary - core* - body - screen* - another SELV secondary Body-core (Class II only)* - screen (Class II only)* ELV secondary - another ELV secondary Hazardous voltage secondary - another hazardous voltage secondary Between series/parallel primary windings	See note 5	
Basic B	Primary - hazardous voltage secondary - ELV secondary* (see note 6) - core* - body (Class I only) - protective screen (Class I only) - functional screen* (see note 4) Hazardous voltage secondary - ELV secondary - core - body (Class I only) ELV secondary - SELV secondary* - core - body (Class II only)*	1250	$0,85 U_p + 950$
Supplementary S	Hazardous voltage secondary - SELV secondary unless protected by earthed screen (Class I only) - SELV secondary (Class II only) - body (Class II only)	2500	$0,85 U_p + 2200$
Reinforced R	Primary - SELV secondary unless protected by earthed screen (Class I only) - SELV secondary (Class II only) - body (Class II only)	3750	$1,7 U_p + 3150$

* See note 2

Notes to the Table

¹ U_p is the peak value of the insulation working voltage.

² Where Reinforced insulation is used it must not be bypassed by insulation of lower grades than Basic plus Supplementary. This could occur if the minimum operational or Basic insulation were used in connection with ELV secondaries, cores or functional screens; such insulation must be upgraded, and tested accordingly. Such situations are shown by asterisks in figures C1 and C2. Study of a figure similar to fig. C1 or fig. C2 for the transformer in question will assist in deciding where the upgrading should be applied.

Care must then be taken when testing the transformer that the test voltage for the reinforced insulation is correctly shared between the Basic and Supplementary insulation.

³ The core is assumed to be unearthed.
 ★ If reliably earthed, it may be regarded as part of the body.

⁴ More stringent requirements appear in some other Standards.

⁵ Since operational insulation is not provided for safety purposes, no electric strength test is specified.

⁶ Supplementary insulation may be required, see 2.1.3.

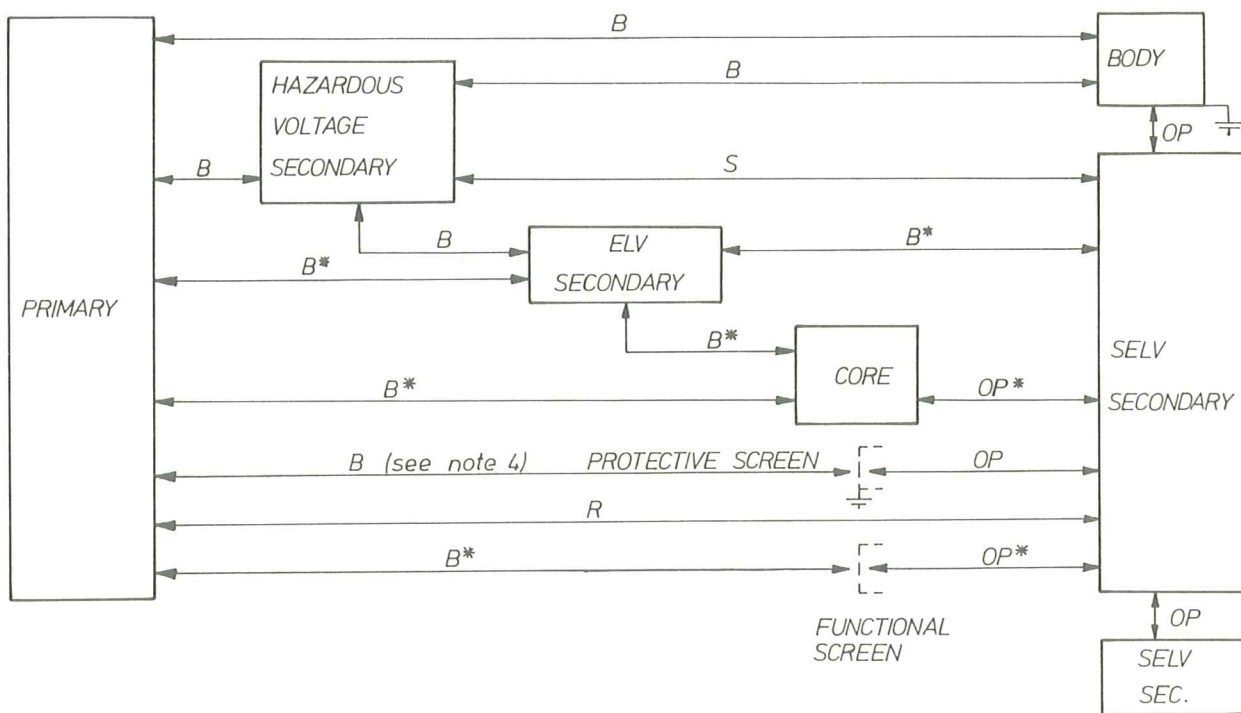


Fig. C.1 Example of transformer for Class I equipment

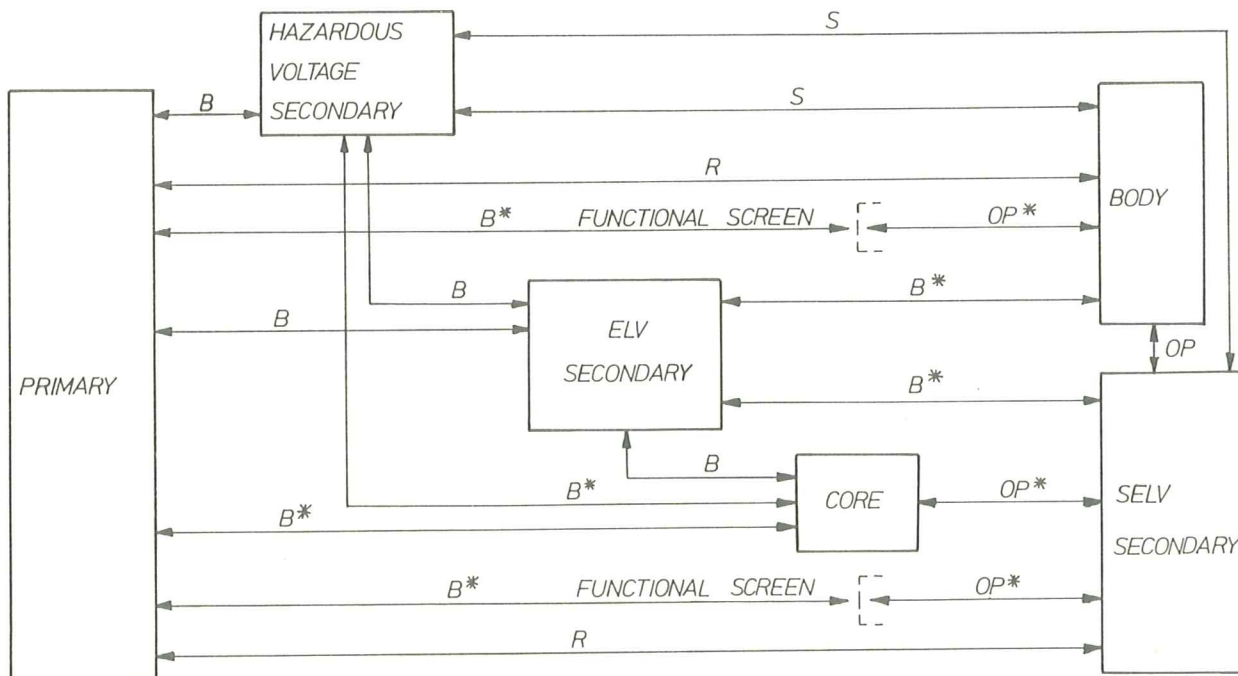
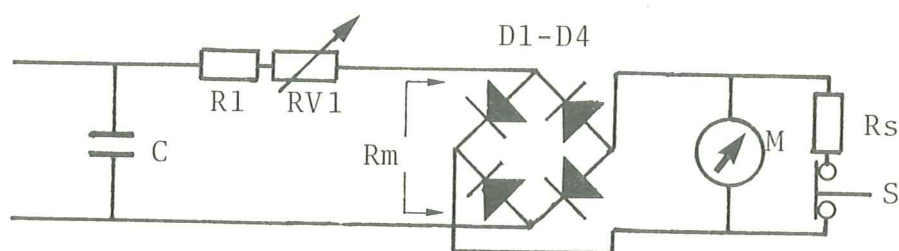


Fig. C.2 Example of transformer for Class II equipment

- OP - Operational insulation or no insulation
- B - Basic insulation
- S - Supplementary insulation
- R - Reinforced insulation
- * - see note 2 page 101

APPENDIX D - MEASURING INSTRUMENT FOR LEAKAGE CURRENT TEST

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.



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

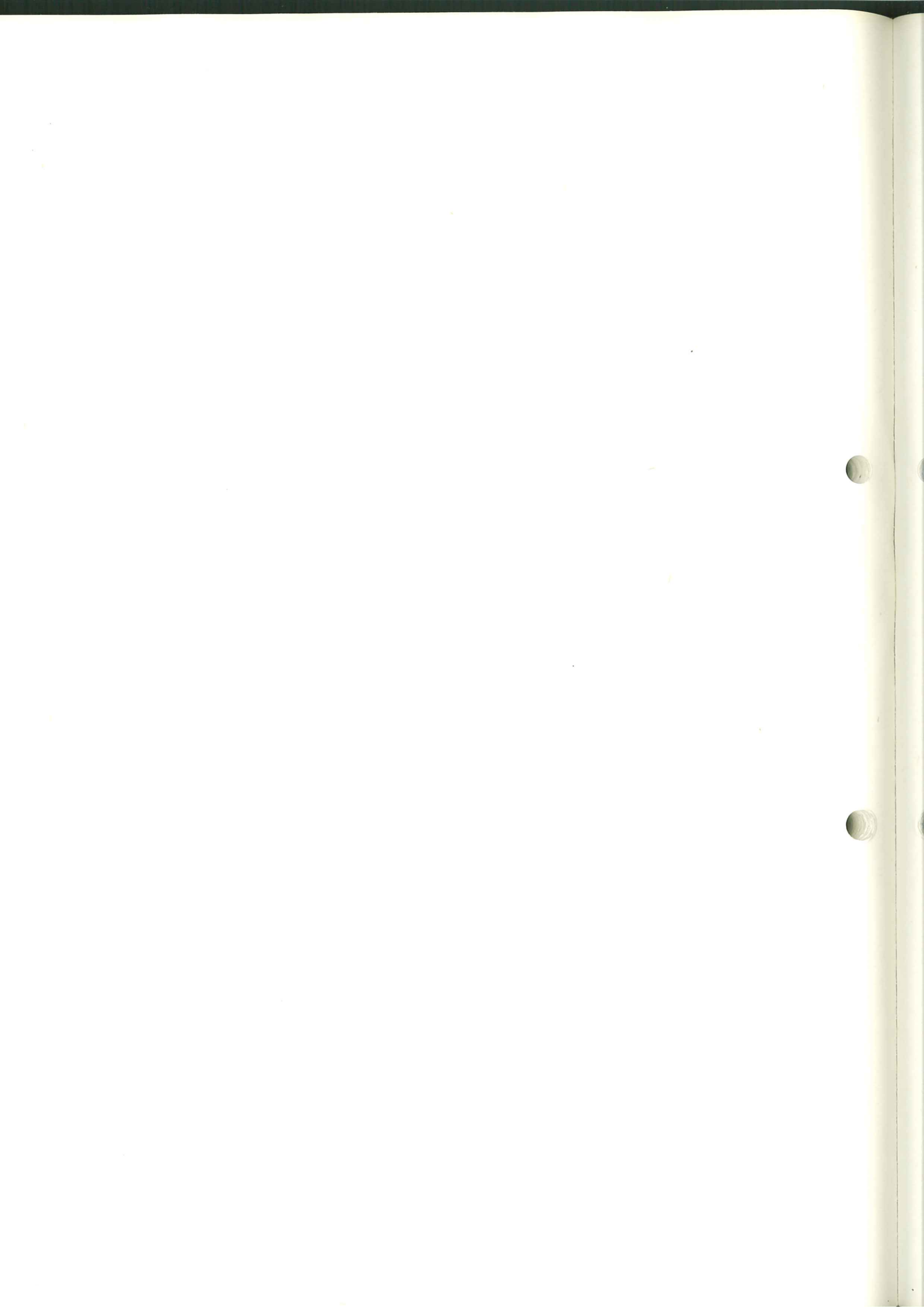
RV1 is adjusted for the desired value of total resistance at 0,5 mA d.c.

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 WINDING

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

$$\Delta t = \frac{R_2 - R_1}{R_1} (234,5 + t_1) - (t_2 - t_1) \text{ for a copper winding}$$

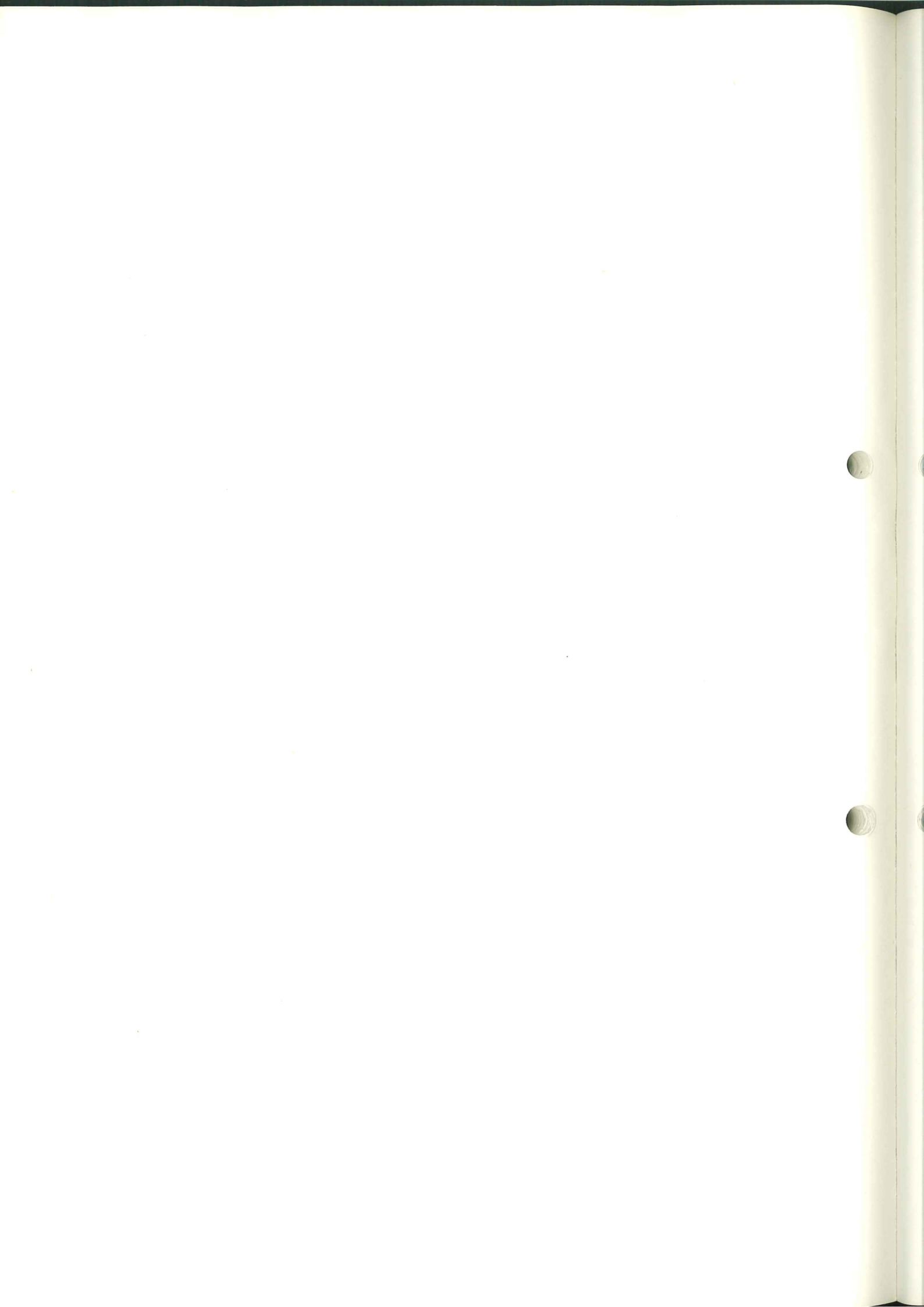
$$\begin{array}{l} \star \\ \star \\ \star \\ \star \end{array} \Delta t = \frac{R_2 - R_1}{R_1} (225 + t_1) - (t_2 - t_1) \text{ for an aluminium winding}$$

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.

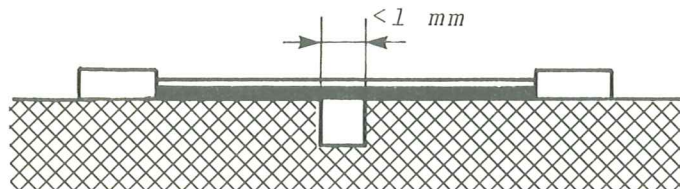
At the beginning of the test, the windings are to be at room temperature.

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

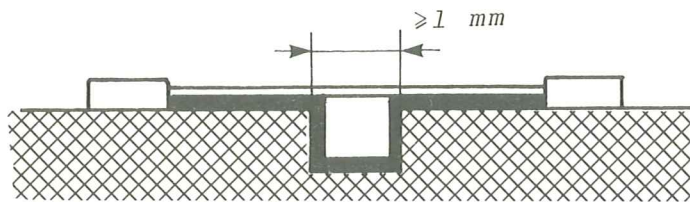
The methods of measuring creepage distances and clearances which are specified in the following figures F 1 to F 11 are used in interpreting the requirements of this Standard.



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.

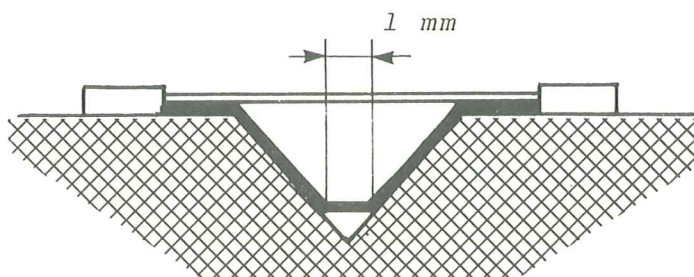
Fig. F 1



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

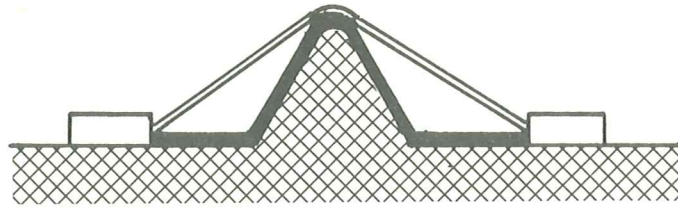
Fig. F 2



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.

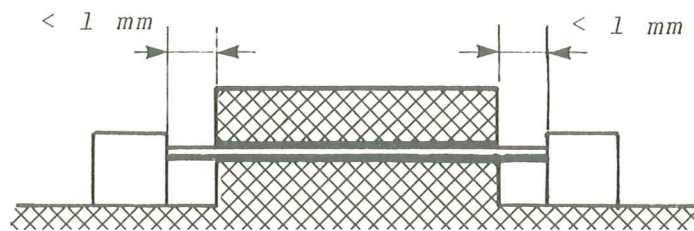
Fig. F 3



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.

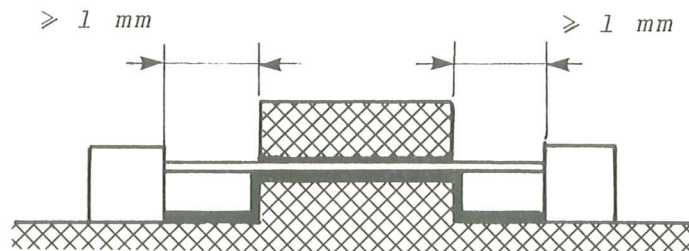
Fig. F 4



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.

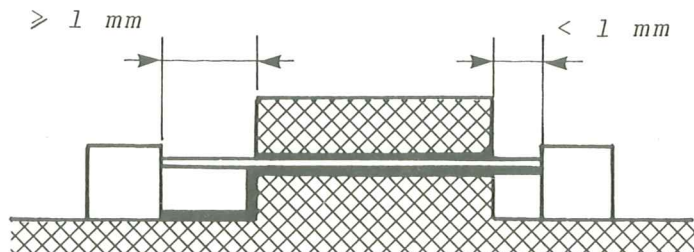
Fig. F 5



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.

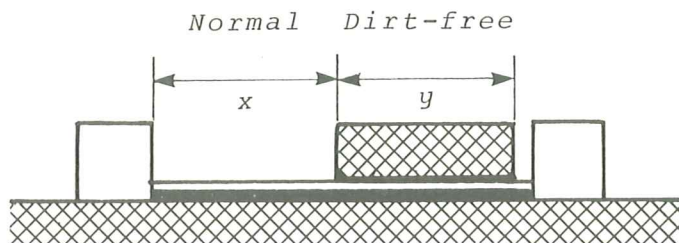
Fig. F 6



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 or more than 1 mm wide.

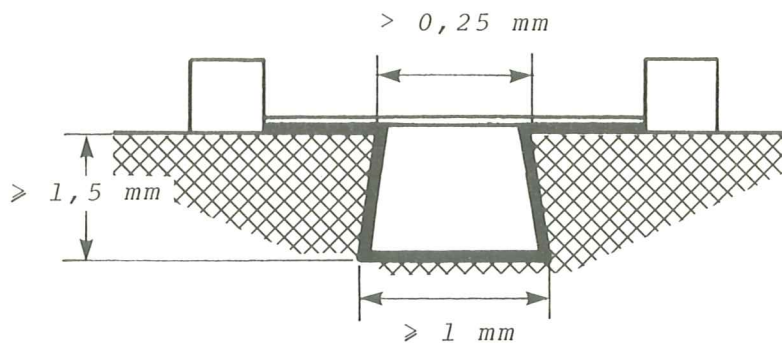
RULE : Clearance and creepage paths as shown.

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

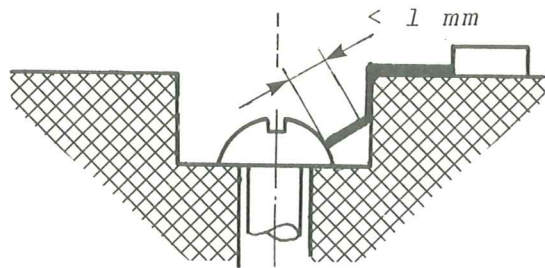
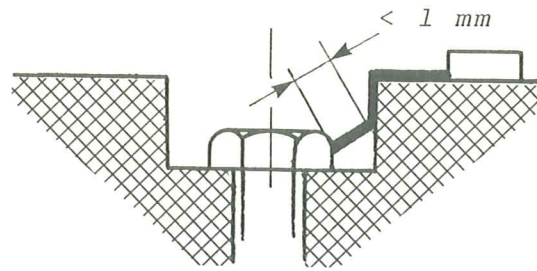


CONDITION: Path under consideration includes a diverging-sided groove equal to or greater than 1,5 mm deep and greater than 0,25 mm wide at the narrowest part and equal to or greater than 1 mm at the bottom.

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

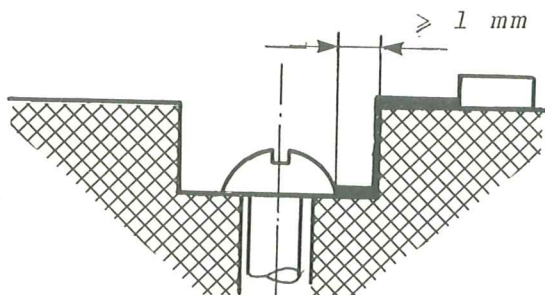
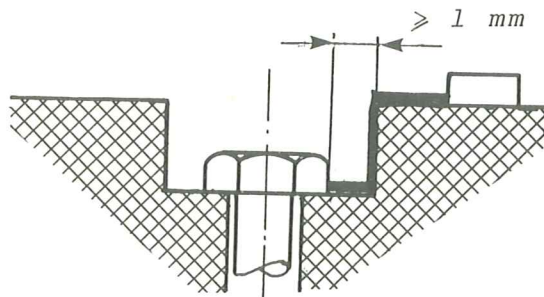
Figure F 3 applies as well to the internal corners if they are less than 80° .

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

APPENDIX G - IONIZING RADIATION

Equipment which may produce ionizing radiation is checked by measuring the amount of radiation.

The amount of radiation is determined by means of a radiation monitor of the ionizing chamber type with an effective area of 10 cm^2 , or measuring equipment of other types giving equivalent results.

Measurements shall be made with the equipment operating at the most unfavourable supply voltage (see 1.4.5) and with operator controls and service controls adjusted so as to give maximum radiation whilst maintaining the equipment operative for normal use.

Internal preset controls not intended to be adjusted during the life time of the equipment are not considered service controls.

At any point 5 cm from the surface of the operator access area the dose-rate shall not exceed $36\text{ }\mu\text{A/kg}$ ($0,5\text{ mR/h}$). (ICRP Publication 15 (1969) clause 289).*

* Account shall be taken of the background level.

* International Commission on Radiological Protection.



APPENDIX H - TABLE OF ELECTROCHEMICAL POTENTIALS

Corrosion due to electrochemical action between dissimilar metals which are in contact is minimized if the combined electrochemical potential is below about 0,6 V. In the following table the combined electrochemical potentials are listed for a number of pairs of metals in common use; combinations above the dividing line should be avoided.

Magnesium, Magnesium alloys	Zinc, Zinc alloys	80 tin/20 Zn on steel, Zn on iron or steel	Aluminium	Cd on steel	Al/Mg alloy	Mild steel	Duralumin	Lead	Cr on steel, soft solder	Cr on Ni on steel, tin on steel, 12% Cr stainless steel	High Cr stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Ni on steel	Silver	Rh on Ag on Cu, silver/gold alloy	Carbon	Gold, platinum	
0	0,05	0,55	0,7	0,8	0,85	0,9	1,0	1,05	1,1	1,15	1,25	1,35	1,4	1,45	1,6	1,65	1,7	1,75	Magnesium, Magnesium alloys
0	0,05	0,2	0,3	0,35	0,4	0,5	0,55	0,6	0,65	0,75	0,85	0,9	0,95	1,1	1,15	1,2	1,25		Zinc, Zinc alloys
0	0,15	0,25	0,3	0,35	0,45	0,5	0,55	0,6	0,7	0,8	0,85	0,9	1,05	1,1	1,15	1,2			80 tin/20 Zn on steel, Zn on iron or steel
0	0,1	0,15	0,2	0,3	0,35	0,4	0,45	0,55	0,65	0,7	0,75	0,9	0,95	1,0	1,05				Aluminium
0	0,05	0,1	0,2	0,25	0,3	0,35	0,45	0,55	0,6	0,65	0,8	0,85	0,9	0,95					Cd on steel
0	0,05	0,15	0,2	0,25	0,3	0,4	0,5	0,55	0,6	0,75	0,8	0,85	0,9						Al/Mg alloy
0	0,1	0,15	0,2	0,25	0,35	0,45	0,5	0,55	0,6	0,7	0,75	0,8	0,85						Mild steel
0	0,05	0,1	0,15	0,25	0,35	0,4	0,45	0,6	0,65	0,7	0,75								Duralumin
0	0,05	0,1	0,2	0,3	0,35	0,4	0,45	0,55	0,6	0,65	0,7								Lead
0	0,05	0,15	0,25	0,3	0,35	0,4	0,45	0,55	0,6	0,65									Cr on steel, soft solder
0	0,1	0,2	0,25	0,3	0,45	0,5	0,55	0,6	0,75	0,8	0,85	0,9							Cr on Ni on steel, tin on steel, 12% Cr stainless steel
0	0,1	0,15	0,2	0,35	0,4	0,45	0,5												High Cr stainless steel
0	0,05	0,1	0,25	0,3	0,35	0,4	0,45												Copper, copper alloys
0	0,05	0,2	0,25	0,3	0,35	0,4	0,45												Silver solder, austenitic stainless steel
0	0,15	0,2	0,25	0,3	0,35	0,4	0,45												Ni on steel
0	0,05	0,1	0,15	0,2	0,25	0,3	0,35												Silver
0	0,05	0,1	0,05	0,1															Rh on Ag on Cu, silver/gold alloy
0	0,05	0,1																	Carbon
0																			Gold, platinum

Ag Silver
Al Aluminium
Cr Chromium
Cd Cadmium
Cu Copper
Mg Magnesium
Ni Nickel
Rh Rhodium
Zn Zinc

APPENDIX J - PRINCIPLES OF SAFETY AS APPLIED TO DPE

General Principles

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

* Safety is considered to be freedom from unacceptable risks.

* It is impossible to make any product absolutely safe. There is
* always some element of risk, and it cannot be assumed that com-
* pliance with this or any other Standard gives absolute safety.
* The aim is to achieve a balance between safety, operational re-
* quirements and convenience to provide a level of safety the user
* is reasonably entitled to expect.

* The maximum touch voltages and body currents used in this Standard
* and widely used in IEC would not necessarily be unnoticed by a
* person in very poor health, but the chances of such a person ex-
* perienceing these voltages or currents are assumed to be acceptably
* low.

* In general, the requirements are intended to ensure that the equip-
* ment remains safe in the presence of a single fault and no require-
* ments call for safety in the presence of two independent faults.

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

Hazards

This Standard 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 human 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, operators and service personnel.

"Operator" is the term applied to all other than service personnel 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 assigned operators.

It is assumed that service personnel 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 terminals, segregation of safety extra low and hazardous voltages, etc. More important, service personnel must be protected against unexpected hazards.

It is normal to provide two levels of protection for operators to prevent electric shock caused by a fault. Thus a single fault and its resulting faults will not create a hazard. However, provision of additional protective measures, such as protective earthing or supplementary insulation, is not considered a substitute for, or a relief from, properly designed basic insulation.

Movable equipment is considered to present a slightly increased risk of shock due to possible extra strain on the supply cord, leading to rupture of the 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 units were dropped.

Electric Shock: Causes and Prevention

Cause

Prevention

Contact with parts normally at hazardous voltage.

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

Breakdown of insulation between parts normally at hazardous voltage and accessible metal.

Either connect the accessible 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 parts normally at hazardous voltages and accessible metal-work, so that breakdown is not likely to occur.

Breakdown of insulation between parts normally at hazardous voltages and SELV circuits, thereby putting accessible parts at hazardous voltage.

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 parts at hazardous voltage.

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

Leakage current from hazardous 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 primary power circuits 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 risk 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.

These design objectives should be met by:

- taking all reasonable steps to avoid high temperature which might cause ignition,
- controlling the position of combustible materials in relation to possible ignition sources,
- limiting the quantity of combustible materials used,
- ensuring that such combustible materials as are used have as low flammability as practicable,
- using enclosure or barriers if necessary to limit the spread of fire within the equipment,
- using suitable materials for the outer enclosures of the equipment.

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. Requirements for the protection of the service engineer are under consideration.

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 vapours and fumes. Controls including appropriate warning labels are required to limit such contact, as far as 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 a risk of energy hazard or electric shock developing, and such that they would not contribute significantly to the development of a serious fire hazard.

APPENDIX K - EARTH LEAKAGE CURRENT FOR IT SYSTEMS

This Appendix provisionally covers the requirements for equipment to be connected directly to IT power supply systems. Equipment which meets these requirements will also meet the requirements, specified in 5.2, for connection to TT or TN power supply systems. Equipment which is not to be connected to IT systems should be tested according to 5.2, not this Appendix.

The test procedures in this Appendix will, under the adopted conditions, determine the leakage current which could flow through a person in the event of accidental breakage of the equipment safety earth conductor. On an IT system the current which flows through the equipment safety earth conductor when it is correctly connected may be higher.

K.1 Limits

Equipment shall not have earth leakage current in excess of the following values when measured as defined in K.2 and K.3.

- 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:
 - . 3,5 mA, or
 - . 5% of unit input current, subject to the conditions in K.4.

Systems of interconnected units with individual pluggable primary power connectors shall have each unit tested. Systems of interconnected units with one primary power connection shall be considered as a single unit.

Units designed for multiple (redundant) supplies shall be tested with only one supply connected.

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 input current, the tests need not be made.

- * For the purpose of this requirement Class I equipment is
- * considered to be permanently connected if supplied through
- * a non-detachable power supply cord and an industrial plug
- * and socket.

Plugs and sockets conforming with IEC Publication 309 are deemed to comply.

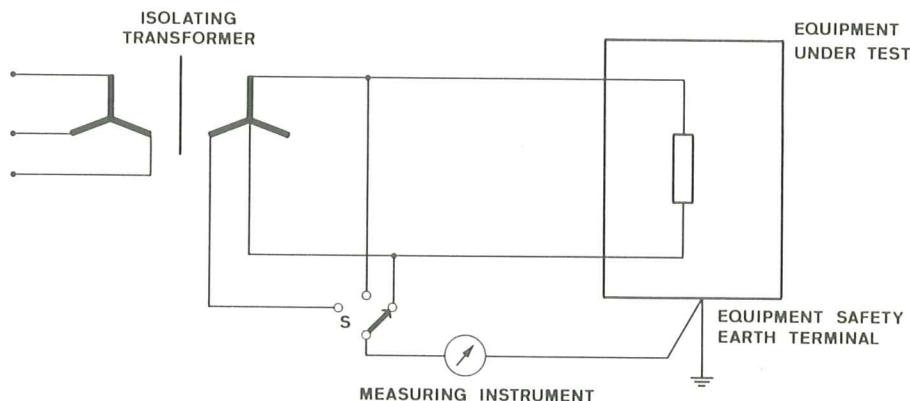
Compliance is checked by the tests below which are carried out using the measuring instrument described in Appendix D, or any other circuit giving the same results, and preferably using an isolating supply transformer as shown. If the use of an isolating transformer is not practicable the equipment shall 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 equipment the test shall be made to operator accessible metal parts and to metal foil on operator accessible non-metal parts. Where it is inconvenient to test equipment at the most unfavourable supply voltage (see 1.4.5) it may be tested at any available voltage within the rated voltage range and the extreme results deduced by calculation.

K.2 Single-Phase Equipment

Single-phase equipment intended for operation between one phase conductor and neutral shall be tested using the circuit of Fig. K.1.

During the test switch S and any switches within the equipment controlling primary power and likely to be operated in normal use are opened and closed in all possible combinations.

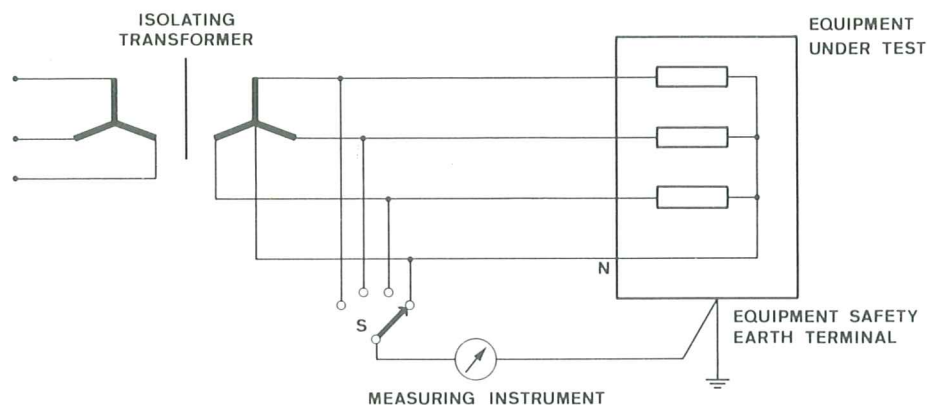


K.3 Three-Phase Equipment

Three-phase equipment and equipment to be connected to two-phase conductors shall be tested under the following conditions, using the circuit of Fig. K.2.

- K.3.1 During the test switch S and any switches within the equipment
- ★ controlling primary power and likely to be operated in normal
 - ★ use are opened and closed in all possible combinations.

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K.3.2 As K.3.1 in combination with the disconnection one at a time of any components used for EMI suppression and connected between phase and earth; for this purpose groups of components in parallel connected through a single connection shall be treated as single components.

Each time a line to earth component is disconnected the full sequence of K.3.1 shall be repeated.

Where filters are normally encapsulated it may be necessary to provide an unencapsulated unit for this test or to simulate the filter network.

None of the current values shall exceed the relevant limits specified in K.1.

K.4 Equipment exceeding 3,5 mA Leakage Current

Class I stationary equipment which exceeds a limit of 3,5 mA is 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 unit input 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 K.2 and K.3 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 affixed adjacent to the unit power input.

- The cross sectional area of the internal protective earthing conductor shall not be less than $1,5 \text{ mm}^2$ in the path of high leakage current.
- In addition it is recommended that a means of detecting failure of continuity of the external protective earthing conductor shall be installed in all units having more than 3,5 mA of leakage current.

Method for improving the integrity of external earth continuity are under consideration.

