CAN/CSA-C22.2 No. 234-M90

Safety of Component Power Supplies

Consumer and Commercial Products

A National Standard of Canada

General Instruction No. 1

CAN/CSA-C22.2 No. 234-M90

August 1990

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Affiliation:

Re: Request for an Amendment, Deletion, or Addition to Clause(s) _________

(Additional sample headings to follow "Requirement": **Test; Pass/Fail Criteria;** and **Rationale**)

Requirement:

(Use additional pages for more space.)

(over)

To assist our volunteer members on these Subcommittees to properly assess proposals to change requirements in a Standard and to reduce or more effectively utilize their time, it is recommended that each proposal for change be submitted in writing and consist of

(a) the related clause number to determine the subtopic area;

(b) the proposed wording of the clause (Requirement, Tests, and Pass/Fail Criteria) using mandatory language and underlining those words changed from the existing clause (if applicable); and

(c) rationale for the change, including all supporting data necessary to be considered.

The proposal should be submitted to the Standards Administrator at least one month prior to the next meeting of the Subcommittee in order that it may be sent to the members for their deliberations prior to the meeting. It is common CSA practice within Committees that proposals handed out at a meeting are not discussed and that only those sent out to members prior to a meeting can be the subject of discussion and action. This is to allow the members time to consider the proposal and to do any research they may feel necessary.

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Preface

This is the first edition of CAN/CSA-C22.2 No. 234 in a Series of Standards issued by the Canadian Standards Association under Part II of the *Canadian Electrical Code.*

To a large extent this Standard is based on IEC Publication 950-1986, and similar clause numbering is used. However, there are numerous differences, both because of the special needs of component power supplies, and to ensure compatibility with the *Canadian Electrical Code.* Furthermore, the intent is that power supplies shall be suitable for application outside the information technology field, in conjunction with further end-use equipment requirements where appropriate.

For general information on the Standards of the *Canadian Electrical Code, Part II,* see the Preface of C22.2 No. 0, *General Requirements — Canadian Electrical Code, Part II.*

This Standard was prepared by a Subcommittee of the Technical Committee on Consumer and Commercial Products under the jurisdiction of the Standards Steering Committee on the Canadian Electrical Code, Part II and was formally approved by these Committees. It has been approved as a National Standard of Canada by the Standards Council of Canada.

August 1990

Notes:

(1) *Use of the masculine gender in this Standard is not meant to exclude the feminine gender when applied to persons. Similarly, use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the user of the Standard to judge its suitability for his particular purpose.*

(3) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(4) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, Standards Division, 178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3.*

Requests for interpretation should

(a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;

(b) provide an explanation of circumstances surrounding the actual field condition; and

(c) be phrased where possible to permit a specific "yes" or "no" answer.

Interpretations are published in CSA Information Update. *For subscription details and a free sample copy, write to CSA Sales Promotions or telephone (416) 747-4116.*

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

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Publication Date—*August 31, 1990*
(ie, the date on or after which this Standard may, at the discretion of the applicant, be used for certification).

Effective Date—*as mandated by the end-use Standard.**
(ie, the date on which this Standard shall be applicable to equipment being submitted for certification and to equipment already certified and manufactured on or after that date).
**Unless otherwise noted in the text or General Instruction.*

Reference Material

Print Types
In this Standard, the following print types are used:

— Requirements proper: in Roman type.
— *Test specifications: in italic type.*
— Explanatory matter: indicated by the word **Note**, and in smaller Roman type.

Reference Publications
This Standard refers to the following publications, and where such reference is made it shall be to the edition listed below, including all amendments published thereto:

CSA Standards
C22.1-1990,
Canadian Electrical Code, Part I;

C22.2 No. 0-M1982,
General Requirements — Canadian Electrical Code, Part II;

C22.2 No. 0.4-M1982,
Bonding and Grounding of Electrical Equipment (Protective Grounding);

C22.2 No. 0.6-M1982,
Flammability Testing of Polymeric Materials;

C22.2 No. 0.11-M1985,
Classification of Polymeric Compounds;

C22.2 No. 0.12-M1985,
Wiring Space and Wire Bending Space in Enclosures for Equipment Rated 750 V or Less;

C22.2 No. 0.15-M90,
Adhesive Labels;

C22.2 No. 1-M1981,
Radio, Television, and Electronic Apparatus;

C22.2 No. 21-M1984,
Cord Sets and Power Supply Cords;

C22.2 No. 42-M1984,
General Use Receptacles, Attachment Plugs, and Similar Wiring Devices;

C22.2 No. 77-1988,
Motors with Inherent Overheating Protection;

C22.2 No. 153-M1981,
Quick-Connect Terminals;

C22.2 No. 182.3-M1987,
Special Use Attachment Plugs, Receptacles, and Connectors;

CAN/CSA-C22.2 No. 950-M89,
Information Technology Equipment, Including Electrical Business Equipment;

CAN3-C235-83,
Preferred Voltage Levels for AC Systems 0 to 50,000 V.

IEC* Publications

65-1985,
Safety Requirements for Mains Operated Electronic and Related Apparatus for Household and Similar General Use;

83-1975,
Plugs and Socket-Outlets for Domestic and Similar General Use Standards;

85-1984,
Thermal Evaluation and Classification of Electrical Insulation;

112-1979,
Method for Determining the Comparative and the Proof Tracking Indices of Solid Insulating Material under Moist Conditions;

309,
Plugs, Socket-Outlets and Couplers for Industrial Purposes;

320-1981,
Appliance Couplers for Household and Similar General Purposes;

328-1972,
Switches for Appliances;

364,
Electrical Installations of Buildings;

417-1973,
Graphical Symbols for Use on Equipment. Index, Survey and Compilation of the Single Sheets;

529-1976,
Classification of Degrees of Protection Provided by Enclosures;

664-1980,
Insulation Coordination within Low-Voltage Systems including Clearances and Creepage Distances for Equipment;

664A-1981,
First Supplement.

ISO† Standards

261-1973,
ISO General Purpose Metric Screw Threads — General Plan;

262-1973,
ISO General Purpose Metric Screw Threads — Selected Sizes for Screws, Bolts and Nuts;

4046-1978,
Paper, Board, Pulp and Related Terms — Vocabulary;

7001-1980,
Public Information Symbols.

* *International Electrotechnical Commission.*
† *International Organization for Standardization.*

Introduction

Principles of Safety

General principles

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

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

Hazards

Application of this Standard is intended to prevent injury or damage due to the following hazards:

(a) Electric shock
(b) Energy hazards
(c) Fire
(d) Mechanical and heat hazards
(e) Radiation hazards
(f) 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 60 V dc, 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 electrically powered equipment, operators and service personnel.

"Operator" is the term applied to all other than service personnel, and requirements for protection assume that the operator is oblivious to electrical hazards, but does not act intentionally in the sense of creating a hazard. 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 against mishap by use of warning labels, shields for hazardous voltage terminals, segregation of safety extra-low voltage circuits from hazardous voltages, etc. More important, service personnel should 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 by fixed or locked covers, interlocks, etc. Discharge capacitors at hazardous voltages.
Breakdown of insulation between parts normally at hazardous voltage and accessible conductive parts.	Either connect the accessible conductive parts to earth so that the voltage which can develop is limited to a safe value and the circuit overcurrent protection will disconnect the parts having low impedance faults; or use double or reinforced insulation between parts normally at hazardous voltages and accessible conductive parts, 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.	For parts at hazardous voltage, insulation which is accessible to the operator should have adequate mechanical and electrical strength to eliminate this danger.
Leakage current from parts at hazardous voltage to the body of Class II equipment. Failure of protective earth connection carrying leakage current. (Leakage	Limit leakage current to body to a safe value, or provide high integrity protective earth connection.

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 arcing or ejection of molten metal resulting in burns. 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 the equipment should not spread beyond the immediate vicinity of the source of the fire, nor cause damage to the surroundings of the equipment.

These design objectives should be met by:

(a) taking all reasonable steps to avoid high temperature which may cause ignition;
(b) controlling the position of combustible materials in relation to possible ignition sources;
(c) limiting the quantity of combustible materials used;
(d) ensuring that if combustible materials are used they have the lowest flammability practicable;
(e) using enclosures or barriers, if necessary, to limit the spread of fire within the equipment;
(f) 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 or interlocking of dangerous moving parts.

Radiation Hazards

If equipment emits some forms of radiation, requirements are necessary to keep operator and service personnel exposures to acceptable levels.

The types of radiation that can be encountered are sonic, radio frequency, infrared, high intensity visible and coherent light, ultraviolet and ionizing, etc.

Chemical Hazards

Hazardous chemicals cause injuries and damage through contact with them, their 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 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.

CAN/CSA-C22.2 No. 234-M90
Safety of Component Power Supplies

1. General

1.1 Scope

1.1.1

This Standard applies to:
(a) Power supplies that are primarily to be used in equipment which itself is to be used in accordance with the *Canadian Electrical Code;*
(b) Power supplies with:
 (i) rated input voltage not exceeding 750 V rms or dc;
 (ii) rated input not exceeding 200 kV•A;
 (iii) rated output voltage not exceeding 30 kV rms or dc;
(c) Power supplies which can be:
 (i) built-in; or
 (ii) integral with a host equipment;
where the suitability of the combination is to be determined in the final application.

This Standard specifies requirements intended to reduce the risk to the user and to the layman who may come into contact with the power supply or the equipment incorporating a power supply and, where specifically stated, for service personnel.

This Standard is intended to reduce the risk of fire, electric shock, or injury to persons subject to installation, operation, and maintenance of the power supply in the manner prescribed by the manufacturer.

1.1.2

Other or additional requirements to those specified in this Standard may be necessary for:
(a) Power supplies intended for use in vehicles, on board ships or aircraft, in tropical countries, or at elevations greater than 2000 m;
(b) Power supplies intended for operation while exposed, for example, to extremes of temperature; to excessive dust, moisture, or vibration; to flammable gases; to corrosive or explosive atmospheres;
(c) Power supplies intended for toys or electromedical applications with physical connections to the patient;
(d) Remote feeding power supplies;
(e) Sections of the power supply that form part or all of the enclosure of the host equipment.

1.1.3

This Standard does not apply to:
(a) motor-generator sets;
(b) transformers that are not an integral part of the power supply; and
(c) power distribution systems.

1.2 Definitions

For the purpose of this Standard the following definitions apply. Where the terms “voltage” and “current” are used, they imply the rms values, unless otherwise specified.

Note: Care should be taken that measuring instruments give true rms readings in the presence of nonsinusoidal waveforms.

Definitions in Alphabetical Order of Nouns

1.2.1 Equipment Electrical Ratings

1.2.1.1 Rated Input Voltage

The primary power voltage (for three-phase supply, the phase-to-phase voltage) as declared by the manufacturer.

1.2.1.2 Rated Input Voltage Range

The primary power voltage range as declared by the manufacturer, expressed by its lower and upper rated voltages.

1.2.1.3 Rated Output Voltage/Voltage Range

The output power voltage/voltage range, ac or dc, under specified load conditions, as declared by the manufacturer.

1.2.1.4 Rated Input Current/Current Range

The input current/current range of the equipment as declared by the manufacturer.

1.2.1.5 Rated Output Current/Current Range

The output current/current range of the power supply as declared by the manufacturer.

1.2.1.6 Rated Input Frequency

The primary power frequency as declared by the manufacturer.

1.2.1.7 Rated Output Frequency

The output frequency as declared by the manufacturer.

1.2.1.8 Rated Input Frequency Range

The primary power frequency range as declared by the manufacturer, expressed by its lower and upper rated frequencies.

1.2.1.9 Rated Output Frequency Range

The output frequency range as declared by the manufacturer, expressed by its lower and upper rated frequencies.

1.2.2 Operating Conditions

1.2.2.1 Normal Load

The mode of operation which approximates as closely as possible the most severe conditions of normal use in accordance with the manufacturer's operating instructions. However, when the conditions of actual use can obviously be more severe than the maximum load conditions recommended by the manufacturer, a load is used that is representative of the maximum that can be applied.

1.2.2.2 Rated Operating Time

The operating time assigned to the equipment by the manufacturer.

1.2.3 Equipment Mobility

1.2.3.1 Movable Equipment

Equipment which is either
(a) 18 kg or less in mass, and not fixed; or
(b) equipment with wheels, castors, or other means to facilitate movement by the operator as required to perform its intended use.

1.2.3.2 Hand-Held Equipment

Movable equipment intended to be held in the hand during normal use.

1.2.3.3 Stationary Equipment

Equipment that is not movable equipment.

1.2.3.4 Fixed Equipment

Stationary equipment which is fastened or otherwise secured at a specific location by means which does not provide for ready removal for maintenance and repair.

1.2.3.5 Equipment for Building-In

Equipment intended to be installed in a prepared recess, such as in a wall, or similar situation.

Note: In general, equipment for building-in does not have an enclosure on all sides, as some of the sides will be protected after installation.

1.2.4 Classes of Power Supplies — Protection Against Electric Shock

Note: Classes of equipment in this Standard apply only to power supplies. The end-use equipment in which the power supply is installed may have a different class.

1.2.4.1 Class I Power Supply (Grounded)

A power supply where protection against electric shock is achieved by:
(a) using basic insulation; and also
(b) providing a means of connecting to the protective earthing conductor in the building wiring those conductive parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails.

Notes:

(1) Class I power supplies may have parts with double insulation or reinforced insulation, or parts operating in safety extra-low voltage circuits.

(2) For power supplies intended for use with a power supply cord, this provision includes a protective earthing conductor as part of the cord.

(3) For the purpose of this Standard, grounding and bonding are considered to be protective earthing.

1.2.4.2 Class II Power Supply (Double Insulated)

A power supply 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.

Note: Such power supplies may be of one of the following types:
(a) Power supplies having a durable and substantially continuous electrical 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 parts at hazardous voltage by insulation at least equivalent to reinforced insulation; such power supplies are called insulation-encased Class II power supplies.
(b) Power supplies having a substantially continuous metallic electrical enclosure, in which double or reinforced insulation is used throughout; such power supplies are called metal-encased Class II power supplies.
(c) Power supplies which are a combination of the two types described above.

1.2.4.3 Class III Power Supply (SELV Accessible)

A power supply in which protection against electric shock relies upon supply from SELV circuits and in which hazardous voltages are not generated.
Note: No tests are required for such power supplies once it is established that they are Class III.

1.2.5 Connection to Primary Power

1.2.5.1 Pluggable Power Supply Type A

A power supply which is intended for connection to the building primary power wiring via nonindustrial plugs and socket-outlets or via appliance couplers, or both.

15 A and 20 A, 125 volt nonlocking type plugs and outlets are considered to be nonindustrial plugs and socket-outlets.

1.2.5.2 Pluggable Power Supply Type B

A power supply which is intended for connection to the building primary power wiring via industrial plugs and socket-outlets.
Note: Industrial plugs and socket-outlets are those complying with IEC Publication 309, or similar nationally approved standards.

1.2.5.3 Permanently Connected Power Supply

A power supply which is intended for connection to the building primary power wiring by screw terminals.

1.2.5.4 Detachable Power Supply Cord

A flexible cord, for supply purposes, intended to be connected to the power supply by means of a suitable appliance coupler.

1.2.5.5 Nondetachable Power Supply Cord

A flexible cord, for supply purposes, fixed to or assembled with the power supply.

Such a cord may be:
(a) Ordinary: A flexible cord which can be easily replaced without special preparation of the cord or special tools; or
(b) Special: A flexible cord which is specially prepared, or requires the use of specially designed tools for replacement, or is such that it cannot be replaced without damage to the equipment.
Note: The term "specially prepared" includes, for example, provision of an integral cord guard, the use of cable lugs, formation of eyelets, etc, but not the reshaping of the conductor before introduction into a terminal or the twisting of a stranded conductor to consolidate the end.

1.2.6 Enclosures

1.2.6.1 Enclosure

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

1.2.6.2 Fire Enclosure

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

1.2.6.3 Mechanical Enclosure

A part of the equipment intended to reduce the risk of injury due to mechanical and other physical hazards.

1.2.6.4 Electrical Enclosure

A part of the equipment intended to reduce the risk of contact with parts at hazardous voltage or hazardous energy levels.

1.2.6.5 Decorative Part

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

1.2.7 Accessibility

1.2.7.1 Operator Access Area

An area to which, under normal operating conditions, either:
(a) access can be gained without the use of a tool; or
(b) the means of access is deliberately provided to the operator; or
(c) the operator is instructed to enter, regardless of whether or not tools are needed to gain access.

Note: In this Standard the terms "access" and "accessible", unless qualified, relate to operator access as defined above.

1.2.7.2 Service Access Area

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

1.2.7.3 Tool

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

1.2.7.4 Body

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

1.2.7.5 Safety Interlock

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

1.2.8 Circuit Characteristics

1.2.8.1 Primary Circuit

An internal circuit which is directly connected to the external supply mains or other equivalent source (such as a motor-generator set) which supplies the electric power. It includes the primary windings of transformers, motors, other loading devices, and the means of connection to the supply mains.

1.2.8.2 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.
Note: Some solid-state devices may provide equivalent isolation.

1.2.8.3 Hazardous Voltage

A voltage exceeding 42.4 V peak, or 60 V dc, existing in a circuit which does not meet the requirements for a limited current circuit.

1.2.8.4 Extra-Low Voltage (ELV)

A voltage between conductors or between a conductor and earth not exceeding 42.4 V peak, or 60 V dc, existing in a secondary circuit which is separated from hazardous voltage by at least basic insulation, but which does not meet the requirements for a SELV circuit nor those for a limited current circuit.
Note: Field wiring will be installed in accordance with CSA Standard C22.1, which defines Extra-Low Voltage differently.

1.2.8.5 Safety Extra-Low Voltage (SELV) Circuit

A secondary circuit which is so designed and protected that under normal and single fault conditions the voltage between any two accessible parts, or between one accessible part and the equipment protective earthing terminal for Class I equipment, does not exceed a safe value.
Notes:
(1) Under normal conditions this limit is either 42.4 V peak, or 60 V dc. Under fault conditions higher limits are specified in this Standard for transient deviation.
(2) This definition of SELV circuit differs from the term SELV as used in IEC Publication 364.

1.2.8.6 Limited Current Circuit

A circuit which is so designed and protected that under both normal conditions and a likely fault condition, the current which can be drawn is not hazardous.
Note: The limiting values are specified in Clause 2.4.

1.2.8.7 Hazardous Energy Level

A stored energy level of 20 J or more, or an available continuous power level of 240 V•A or more at a potential of 2 V or more.

1.2.9 Insulation

1.2.9.1 Operational Insulation

Insulation needed for the correct operation of the equipment.
Note: Operational insulation by definition does not protect against electric shock. It may, however, serve to minimize exposure to ignition and fire.

1.2.9.2 Basic Insulation

Insulation to provide basic protection against electric shock.

1.2.9.3 Supplementary Insulation

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

1.2.9.4 Double Insulation

Insulation comprising both basic insulation and supplementary insulation.

1.2.9.5 Reinforced Insulation

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

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

1.2.9.6 Working Voltage

The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use (see Clause 2.2.7).

1.2.9.7 Tracking

The progressive formation of conducting paths on the surface of a solid insulating material due to the combined effects of electric stress and electrolytic contamination on this surface.

1.2.10 Creepage Distances and Clearances

1.2.10.1 Creepage Distance

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

1.2.10.2 Clearance

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

1.2.10.3 Bounding Surface

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

1.2.11 Components

1.2.11.1 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.

1.2.11.2 Not used.

1.2.11.3 Not used.

1.2.11.4 Thermal Cut-Out

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

Note: A thermal cut-out may be of the automatic reset or of the manual reset type.

1.2.11.5 Thermal Cut-Out, Automatic Reset

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

1.2.11.6 Thermal Cut-Out, Manual Reset

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

1.2.12 Power Distribution

1.2.12.1 TN Power System

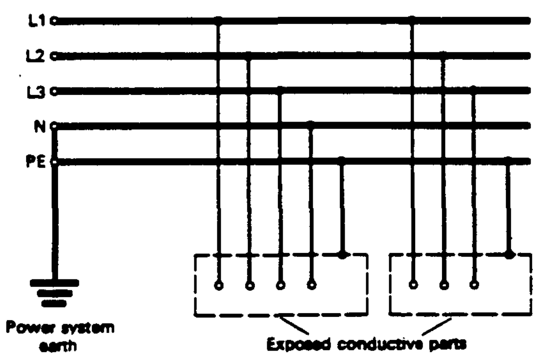
A power distribution system having one point directly earthed, the exposed conductive parts of the installation being connected to that point by protective earth conductors. Three types of TN systems are recognized according to the arrangement of neutral and protective earth conductors, as follows:

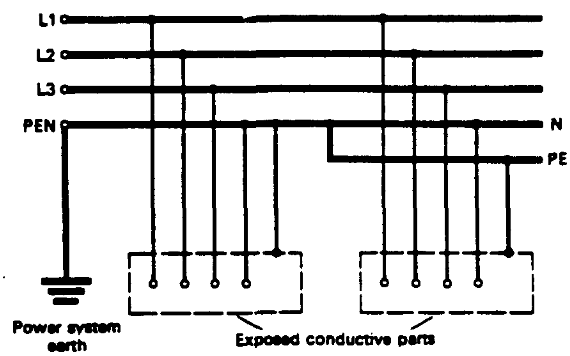
(a) TN-S system: having separate neutral and protective earth conductors throughout the system;

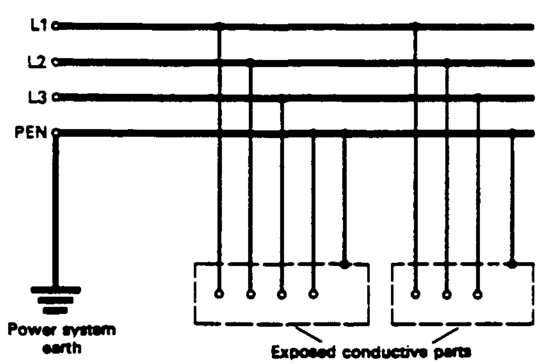
Note: The TN-S system is the power system permitted in Canada.

(b) TN-C-S system: in which neutral and protective functions are combined in a single conductor in a part of the system;

(c) TN-C system: in which neutral and protective functions are combined in a single conductor throughout the system.

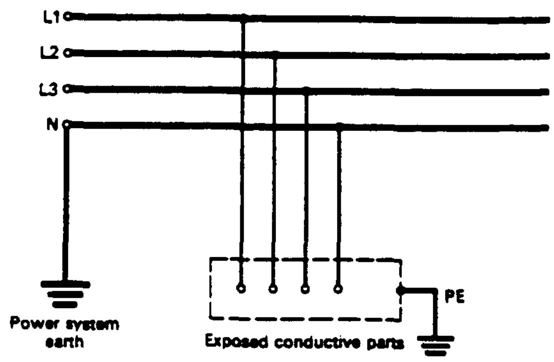






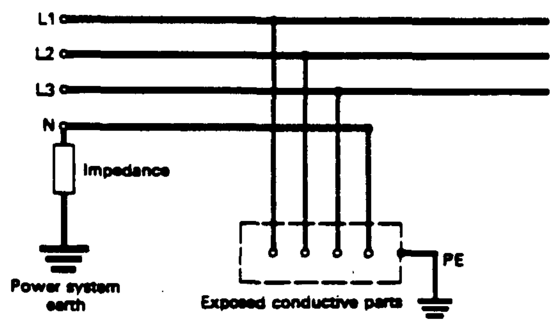
1.2.12.2 TT Power System

A power distribution system having one point directly earthed, the exposed conductive parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the power system.



1.2.12.3 IT Power System

A power distribution system having no direct connection to earth, the exposed conductive parts of the electrical installation being earthed.



1.2.13 Flammability

1.2.13.1 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 Clauses 1.2.13.2 to 1.2.13.9 when tested in accordance with Appendix A.

Notes:

(1) When applying the requirements in this Standard, foamed materials of Class HF-1 are regarded as better than those of Class HF-2, and HF-2 better than HBF.

(2) Similarly, other materials, including rigid (engineering structural) foam of Classes 5V or V-0, are regarded as better than those of Class V-1, V-1 better than V-2, and V-2 better than HB.

1.2.13.2 V-0 Class Material

A material that, when tested in accordance with Clause A6, may flame or glow but will extinguish in an average period of time not exceeding 5 s; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.13.3 V-1 Class Material

A material that, when tested in accordance with Clause A6, may flame or glow but will extinguish in an average period of time not exceeding 25 s; glowing particles or flaming drops released do not ignite surgical cotton.

1.2.13.4 V-2 Class Material

A material that, when tested in accordance with Clause A6, may flame or glow but will extinguish within an average period of time not exceeding 25 s; glowing particles or flaming drops released may ignite surgical cotton.

1.2.13.5 Not used.

1.2.13.6 HF-1 Class Foamed Material

A foamed material that, when tested in accordance with Clause A7, may flame or glow but will extinguish within a prescribed period of time; flaming or glowing particles or flaming drops released do not ignite surgical cotton.

1.2.13.7 HF-2 Class Foamed Material

A foamed material that, when tested in accordance with Clause A7, 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.

1.2.13.8 HB Class Material

Material that, when tested in accordance with Clause A8, does not exceed a specified maximum burning rate.

1.2.13.9 HBF Class Foamed Material

A foamed material that, when tested in accordance with Clause A7, does not exceed a specified maximum burning rate.

1.2.13.10 Explosion Limit

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

1.2.14 Miscellaneous

1.2.14.1 Type Test

Testing of a representative sample of the equipment with the objective of determining if the equipment, as designed and manufactured, can meet the requirements of this Standard.

1.2.14.2 DC Voltage

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

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

1.2.14.3 Service Personnel

Trained persons who are expected to have knowledge and experience necessary to perform tasks in service access areas of the equipment. Service personnel are expected to be aware of hazards to which they are exposed when performing a task and of steps necessary to minimize the danger to themselves or other persons.

1.2.14.4 Operator

Any person other than service personnel.

1.3 General Requirements

1.3.1

A power supply shall be so designed and constructed that, under all conditions of normal use and under a likely fault condition, it reduces risk of personal injury from electric shock and other hazards and from fire originating in the power supply, within the meaning of this Standard.

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

Notes:

(1) Where the power supply involves safety situations not specifically covered, the design should provide a level of safety not less than that generally afforded by this Standard.

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

1.3.2

Information shall be provided to the user concerning the intended installation, operation, and repair of the power supply such that the risks of electric shock, hazardous energy level, injury to persons, and fire are reduced. (See Clause 1.7.2.)

Compliance is checked by inspection.

1.3.3

A power supply is classified according to its protection from electric shock as:

(a) Class I;
(b) Class II; or
(c) Class III.

Note: A power supply containing ELV or hazardous voltage is Class I or Class II. There are no requirements in this Standard for protection against electric shock for a Class III power supply.

1.3.4

Where a power supply uses earthing as a protective measure, the requirements of this Standard related to protective earthing shall apply. (Also see CSA Standard C22.2 No. 0.4.)

1.4.11

Where the power supply is designed to supply mains power to other units of a system, the input current of the power supply shall include the sum of the rated currents of those other units where this could have an influence on the test results. Artificial loads may be used to simulate the other units.

1.4.12

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

1.5 Components

1.5.1

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

Note: A CSA component standard is considered relevant only if the component in question clearly falls within its scope.

Components which are to be connected to SELV circuits and either to ELV or to a hazardous voltage shall comply with the requirements of Clause 2.3.

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

1.5.2

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

(a) a component complying with the relevant CSA 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 power supply, with the exception of those tests which are part of the relevant CSA component standard;

(b) a component which has not been found to comply with a relevant standard, as above, shall be checked for correct application and use in accordance with its specified rating. It shall be subjected to the applicable tests of this Standard, as part of the power supply, and to the applicable tests of the component standard, under the conditions occurring in the power supply;

Note: The applicable test for compliance with a component standard is, in general, carried out separately. The number of test samples is, in general, the same as that required in the component standard.

(c) where no 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 power supply. The number of samples required for test is, in general, the same as required by an equivalent standard.

1.5.3

Transformers, including safety isolating transformers, shall be of a type suitable for their intended application and shall comply with the relevant requirements of this Standard and of Appendix C.

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.

Note: This may be achieved by separating the SELV windings from all other windings in conformity with the principles stated in Clause 2.3.

1.5.4

High voltage components operating at peak-to-peak voltages exceeding 4 kV either shall have a flammability class of V-2 (see Clause A6), or better, or of HF-2 (see Clause A7), or better, or they shall comply with the requirements of Appendix Z.

1.5.5

Components and insulations shall be suitable for the repetitive peak voltage and frequency in the application.

1.6 Power Interface

1.6.1

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

Compliance is checked by measuring the input current of the power supply at normal load and at nominal system voltage or at the lowest voltage of the rated voltage range, when input current has stabilized. If the current varies during the normal operating cycle, the steady state input current shall be taken as the mean indication of the value, measured on a recording rms ammeter, during a representative period.

1.6.2

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

1.6.3

The neutral conductor, if any, shall be insulated from earth and the body throughout the power supply as if it were a phase conductor. Components connected between neutral and earth shall be rated for a working voltage equal to the phase-to-neutral voltage.

1.6.4

For power supplies to be connected to IT power systems, components connected between phase and earth shall be capable of withstanding the stress due to a working voltage equal to the phase-to-phase voltage.

1.6.5

Power supplies intended to operate directly from the mains supply shall be designed for a minimum supply tolerance of +6%, −10%. Power supplies intended to operate from batteries shall be designed for a minimum supply tolerance of ±15% unless the manufacturer specifies a different tolerance and marks it accordingly.

1.6.5.1

Notwithstanding the requirements of Clause 1.6.5, power supplies intended to be operated directly from the mains supply shall be designed for nominal system voltage ranges as specified in Table 2 of CSA Standard C235.

1.7 Marking and Instructions

1.7.1

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

The marking shall include the following:

(a) rated input voltage(s) or rated input voltage range(s), in volts;
(b) rated input current(s) or rated input current range(s) in milliamperes or amperes;

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

Note: *Examples of voltage ratings:*

(i) Rated input voltage/current range: 220–240 V, 1.0-0.9 A. This means that the power supply is designed to be connected to any source of primary power having a nominal voltage between 220 V and 240 V, and the corresponding current range is between 1.0 A and 0.9 A respectively.

(ii) Multiple rated input voltage/current: 120/220/240 V, 1.9/1.0/0.9 A. This means that the power supply is designed to be connected to a source of primary power having a nominal voltage of 120 V or 220 V or 240 V, usually after internal adjustment, and the corresponding current values are 1.9 A, 1.0 A, and 0.9 A respectively.

(c) for dc only, symbol for nature of input/output voltage;
(d) rated input frequency or rated input frequency range, in hertz, unless the power supply is designed for dc only;
(e) rated output voltage(s), in volts;
(f) rated output frequency or rated output frequency range(s), in hertz, unless the power supply is designed for dc only;
(g) rated output current(s), in milliamperes or amperes;
(h) rated maximum ambient temperature, if other than 25°C;
(i) output short-circuit current(s), in milliamperes or amperes;
(j) manufacturer's name, trademark, or identification mark;
(k) manufacturer's model or type reference;
(l) symbol for Class II construction, for Class II equipment only;
(m) if the total maximum output power is less than the sum of the power of the individual output circuits, then it must be specified;
(n) the month and year of manufacture, at least, shall be marked on the power supply. Date coding, serial numbers, or equivalent means shall be permitted;
(o) requirements for suitable overcurrent protection, if not provided as an integral part of the unit;
(p) one of the following classification levels:
  (i) LEVEL 0: Classification Level 0 shall be used for power supplies that require special additional features or that depend on the host equipment to meet the applicable requirements;
  (ii) LEVEL 1: Classification Level 1 shall be used for power supplies with output circuits that are either not suitable for, or have not been investigated for SELV;
  (iii) LEVEL 3: Classification Level 3 shall be used for power supplies with all output circuits that meet the requirements for SELV and that, under any condition of output loading, do not exceed 240 V•A;
  (iv) LEVEL 5: Classification Level 5 shall be used for power supplies with all output circuits that meet the requirements for SELV;
  (v) LEVEL 6: Classification Level 6 shall be used for power supplies with all output circuits in any combination of Levels 1, 3, and 5. The output classification level shall be marked adjacent to the output rating.

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

Items (j), (k), and (n) shall be marked on the power supply. All other items shall be listed on the data sheet or specification and may optionally be marked on the power supply. If all the required information has been marked on the power supply, no data sheet or specification shall be required.

Where symbols are used, they shall conform with ISO Standard 7001 and IEC Publication 417.

1.7.2

If it is necessary to take special precautions to avoid the introduction of hazards when operating, installing, maintaining, transporting, or storing equipment, the manufacturer shall have available the necessary installation instructions.

1.7.3 Not used.

1.7.4 Not used.

1.7.5 Not used.

1.7.6

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

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

1.7.7

The wiring terminal intended for connection of the protective earthing conductor associated with the supply wiring shall be indicated by the symbol ⏚ defined in IEC Publication 417 No. 5019a.

This symbol shall not be used for other earthing terminals.

Notes:

(1) This requirement is applicable to terminals for connection of a protective earthing conductor, whether run as an integral part of a power supply cord or with conductors intended for connection to primary power.

(2) Because the symbol ⏚ has been widely used by power supply manufacturers and by manufacturers of components such as terminal blocks, it is expected that its use will continue to be permitted.

(3) For the purpose of this Standard, grounding and bonding are considered to be protective earthing.

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

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

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

1.7.8 Not used.

1.7.9 Not used.

1.7.10

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

1.7.11

If a pluggable power supply Type B or a permanently connected power supply relies on the building installation for protection of the internal wiring of the power supply, the power supply installation instructions shall so state, and shall also specify the necessary requirements for short-circuit protection or overcurrent protection or, where necessary, both (see Clauses 1.7.2 and 2.7.1).

1.7.12

Power supplies in which leakage current exceeding 3.5 mA exists shall carry a warning label as defined in Clauses 5.2.5 or G5.

1.7.13 Not used.

1.7.14 Not used.

1.7.15

Marking required by this Standard shall be durable and legible. In considering the durability of the marking, the effect of normal use shall be taken into account. Conductive labels shall meet the requirements of CSA Standard C22.2 No. 0.15 for adhesive labels.

1.7.16

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

2. Fundamental Design and Construction Requirements

2.1 Protection Against Electric Shock and Energy Hazards

2.1.1 Not used.

2.1.2 Not used.

2.1.3 Not used.

2.1.4 Not used.

2.1.5 Not used.

2.1.6 Not used.

2.1.7

Shafts of operating knobs, handles, levers, and the like shall not be at ELV or hazardous voltages.
Compliance is checked by inspection.

2.1.8

Conductive handles, levers, control knobs, and the like, which are manually moved in normal use and which are earthed only through a pivot or bearing, shall be either:
(a) separated from hazardous voltages within the component or elsewhere by creepage distances and clearances of double or reinforced insulation; or
(b) covered by supplementary insulation over accessible parts.
Compliance is checked by inspection and by the applicable electric strength tests of Clause 5.3.2.

2.1.9 Not used.

2.1.10

Power supplies shall be so designed that, at an external point of disconnection of the source of primary power, there shall be no risk of electric shock from stored charge on capacitors connected to the mains circuit.

Compliance is checked by inspection of the power supply and relevant circuit diagrams, taking into account the possibility of disconnection of the source of primary power with the on/off switch in either position.

The power supply shall be considered to comply if any capacitor having a rated capacitance exceeding 0.1 µF *and connected to the external mains circuit has a means of discharge resulting in a time-constant not exceeding:*

(a) 1 s *for pluggable power supplies Type A; and*

(b) 10 s *for permanently connected power supplies and for pluggable power supplies Type B.*

Note: The relevant time-constant is the product of the effective capacitance in microfarads and the effective discharge resistance in megohms. Where it is difficult to determine the effective capacitance and resistance values, a measurement of voltage decay may be used. The measuring instrument should have a minimum input resistance of 10 MΩ or a minimum of ten times the value of the discharge resistor, if known, whichever is the less. In one time-constant the voltage will have decayed to 37% of its original value.

2.2 Insulation

2.2.1

Electrical insulation shall be achieved by provision of either one of the following, or a combination of the two:

(a) solid or laminated insulating materials having adequate thickness and adequate creepage distances over their surfaces;

(b) adequate clearances through air.

2.2.2

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

The electrical parameters to be considered include rate of change of voltage dv/dt and frequency.

Neither natural rubber nor materials containing asbestos shall be used as insulation.

Hygroscopic material shall not be used as insulation.

Compliance is checked by inspection and by evaluation of the data for the material. If such data is not available, the hygroscopic nature of an insulating material shall be determined by subjecting the component or subassembly employing the insulation in question to the humidity treatment of Clause 2.2.3.

The insulation shall then be subjected to the electric strength test of Clause 5.3.2 or C3, as appropriate, while still in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature.

2.2.3

Where required by Clauses 2.2.2, 2.9.5, or 2.9.6, humidity treatment shall be carried out for 48 h *in a cabinet or room containing air with a relative humidity of 91% to 95%. The temperature of the air, at all places where samples can be located, shall be maintained within* 1°C *of any convenient value, t, between* 20°C *and* 30°C *such that condensation does not occur. During this treatment the component or subassembly shall not be energized.*

Before the humidity treatment, the sample shall be brought to a temperature between t°C *and* (t + 4)°C.

2.2.4

Insulation in equipment shall comply with the applicable electric strength requirements of Clause 5.3, with the creepage distance, clearance, and distance through insulation requirements of Clause 2.9, and with the heating requirements of Clause 5.1.

2.2.5

For the purpose of determining the test voltages, creepage distances, clearances, and distance through insulation for a given piece of insulation, the following parameters shall be considered:
(a) application (see Clause 2.2.6);
(b) working voltage (see Clause 2.2.7);
(c) transient overvoltages.

Notes:
(1) Mains-borne transients are automatically covered by selection of the appropriate mains supply voltage column in Tables 3(a) and 4.
(2) Consideration of internally generated transients and transients from external signal cables is included in Clause 2.9.2.
(3) When selecting and dimensioning solid insulation, the peak and rms value and the frequency of the working voltage should be taken into account.
(4) The electric strength of solid insulation should be adequate to withstand the tests of Clause 5.3 and the anticipated level of transient overvoltages.

2.2.6

Application of insulation shall be considered to be operational, basic, supplementary, reinforced, or double.

Note: Examples of situations where these types of insulation are required are as follows:
(a) OPERATIONAL:
(i) between parts of different potential;
(ii) between ELV or SELV circuits and earthed conductive parts;
(iii) between any part of an earthed secondary circuit at hazardous voltage and an accessible earthed conductive part.
(b) BASIC:
(i) between a part at hazardous voltage and an earthed conductive part;
(ii) between a part at hazardous voltage and an SELV circuit which relies on being earthed for its integrity;
(iii) between a primary power conductor and the earthed screen or core of a primary power transformer;
(iv) as an element of double insulation.
(c) SUPPLEMENTARY:
(i) generally, between an accessible conductive part and a part which could assume a hazardous voltage in the event of a failure of basic insulation, for example:
— between the outer surface of handles, knobs, grips, and the like, and their shafts unless earthed;
— between the power supply body and the surface of a flexible supply cord where the cord enters a metal-encased Class II power supply;
— between an ELV circuit and an unearthed conductive part of the body;
(ii) as an element of double insulation.
(d) DOUBLE OR REINFORCED:
(i) generally, between an unearthed accessible conductive part or a floating SELV circuit, and 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.

2.2.7

For the purpose of determining working voltage:
(a) when determining working voltage, the bandwidth of the measuring instrument shall be such that all components of the measured parameter — dc, supply frequency, and high frequency — are taken into account;
(b) where the rms value is used, measuring instruments shall give true rms readings in the presence of nonsinusoidal waveforms and have adequate bandwidth;
(c) where the dc value is used, the peak value of any superimposed ripple shall be included;
(d) transients shall be disregarded;

(e) the voltage of an ELV or SELV circuit may be regarded as zero for determination of clearances and electric strength test voltages. However, the voltage of an ELV or SELV circuit shall be taken into account for determination of creepage distances;
(f) unearthed accessible conductive parts shall be assumed to be earthed;
(g) where a transformer winding or other part is floating, ie, not connected to a circuit which establishes its potential relative to earth, it shall be assumed to be earthed at the point by which the highest working voltage is obtained;
(h) where double insulation is used, the working voltage across the basic insulation shall be determined by imagining a short-circuit across the supplementary insulation, and vice versa. For insulation between transformer windings, the short-circuit shall be assumed to take place at the point by which the highest working voltage is produced in the other insulation;
(i) for insulation between two transformer windings, the highest voltage between any two points in the two windings shall be used, taking into account external voltages to which the windings may be connected;
(j) for insulation between a transformer winding and another part, the highest voltage between any point on the winding and the other part shall be used;
(k) nominal values of mains supply voltage shall be used.

2.3 Safety Extra-Low Voltage (SELV) Circuits

2.3.1

SELV circuits, whose uninsulated parts may be accessible to touch by operators, shall exhibit voltages safe to touch 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.

2.3.2

In a single SELV circuit or in interconnected SELV circuits, the voltage between any two accessible parts, or between one accessible part and the power supply protective earthing terminal for a Class I power supply, shall not exceed 42.4 V peak, or 60 V dc, under normal conditions.

2.3.3

In the event of a single failure of basic or supplementary insulation or of a component (excluding components with double or reinforced insulation), the voltages in accessible parts of a SELV circuit shall not exceed 42.4 V peak, or 60 V dc, for longer than 0.2 s. Moreover, a limit of 71 V peak, or 120 V dc, shall not be exceeded.

One of the following methods shall be used:
(a) Method 1: separation of the SELV circuit from parts at hazardous voltage by double or reinforced insulation, as detailed in Clause 2.3.4;
(b) Method 2: separation of the SELV circuit from other circuits by an earthed conductive screen or other earthed conductive parts, as detailed in Clause 2.3.5 (Class I power supplies only);
(c) Method 3: adequate earthing of the SELV circuit, as detailed in Clause 2.3.6 (Class I power supplies only);
(d) Method 4: provision of a means of protection which prevents the voltage limits from being exceeded, as detailed in Clause 2.3.7.

Notes:
(1) Methods 1 and 2 can be provided by a safety isolating transformer (see Clause 1.5.3).
(2) Method 1 can be provided by two separate transformers in tandem, where one transformer provides basic insulation and the other transformer provides supplementary insulation. The two transformers should follow, as a pair, the principles of construction for a single safety isolating transformer in Clause C2, taking into account the voltage in the intermediate circuit.
(3) In a single circuit (eg, transformer-rectifier circuit), it is possible for some parts to comply with the requirements for SELV circuits and to be operator accessible, while other parts are not.
(4) Different parts of the same SELV circuit may be protected by different methods, for example:

(a) Method 2 — within a power transformer feeding a bridge rectifier;
(b) Method 1 — for the ac secondary circuit;
(c) Method 3 — at the output of the bridge rectifier;
(d) Method 4 — at a remote part of the SELV circuit.
(5) For normal conditions the SELV circuit voltage limit is the same for ELV; a SELV circuit may be regarded as an ELV circuit with additional protection under fault conditions.
(6) Method 4 is not acceptable in EC and EFTA countries except Switzerland.

2.3.4

(Method 1 of Clause 2.3.3) Where a SELV circuit is separated from other circuits by double or reinforced insulation only, one of the following methods shall be employed:
(a) provide permanent separation by barriers, routing, or fixing;
(b) provide insulation of all adjacent wiring involved that is rated for the highest working voltage present;
(c) provide insulation on either the wiring of the SELV circuit or that of the other circuits that meets the insulation requirements for supplementary or reinforced insulation, as appropriate, for the highest working voltage present;
(d) provide an additional layer of insulation, where required, over either the wiring of the SELV circuit or that of the other circuits;
(e) use any other means providing equivalent insulation.

2.3.5

(Method 2 of Clause 2.3.3) 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 at least basic insulation. The earthed parts shall comply with Clause 2.5.

2.3.6

(Method 3 of Clause 2.3.3) Parts of SELV circuits protected by earthing shall be connected to the protective earth terminal in such a way that the requirements of Clause 2.3.3 are met by relevant circuit impedances, or by the operation of a protective device, or both. They shall also be separated from parts of other non-SELV circuits by at least basic insulation. The SELV circuit shall have adequate fault current-carrying capacity to ensure operation of the protective device, if any, and to ensure that the fault current path to earth will not open.
Note: In Denmark, Method 3 is not considered acceptable.

2.3.7

(Method 4 of Clause 2.3.3). Where SELV circuits are separated from other circuits by only basic insulation, protection shall be provided where necessary to ensure that the requirements of Clause 2.3.3 are met in the event of failure of the basic insulation.
Notes:
(1) Such protection may be achieved by using components or circuits such as fuses, circuit breakers, electronic overvoltage protection, or electronic overcurrent protection.
(2) Method 4 is not acceptable in EC and EFTA countries except Switzerland.

2.3.8

The equipment shall also be constructed as follows:
(a) Ring-tongue and similar terminations shall be prevented from any pivoting that would reduce creepage distances and clearances between SELV circuits and parts at hazardous voltage below the specified minimum values.
(b) In multiway plugs and sockets and wherever shorting could otherwise occur, means shall be provided to prevent contact between parts at hazardous voltage and SELV circuits due to loosening of a terminal or breaking of a wire at a termination.

(c) Uninsulated parts at hazardous voltage shall be so located or guarded as to avoid accidental shorting to SELV circuits, for example by tools or test probes used by service personnel.
(d) SELV circuits shall not use connectors obviously intended for connection to primary power (eg, those specified in IEC Publication 83 or 320).

2.3.9

If SELV circuits are connected to other circuits, they shall continue to comply with the requirements of Clauses 2.3.2 and 2.3.3. SELV circuits shall not be conductively connected to any primary circuit (including the neutral) within the equipment.

2.3.10

Compliance with Clauses 2.3.1 to 2.3.9 is checked by inspection and appropriate tests.

2.3.11

Double or reinforced insulation shall not be bridged by capacitors, except that capacitors in compliance with Clauses 6.1.3 and 10 of CSA Standard C22.2 No. 1 shall be permitted when failure of any one capacitor does not cause a hazard within the meaning of this Standard.

2.4 Limited Current Circuits

2.4.1

For frequencies not exceeding 1 kHz, the steady-state current drawn through a noninductive resistor of 2000 Ω connected between an accessible part of a limited current circuit and either pole of the limited current circuit or earth, shall not exceed 0.25 mA peak ac or 0.7 mA dc. For frequencies above 1 kHz, the limit of 0.25 mA is multiplied by the value of the frequency in kilohertz, but shall not exceed 25 mA peak.

2.4.2

For accessible parts not exceeding 450 V peak or dc, the circuit capacitance shall not exceed 0.1 μF.

2.4.3

For accessible parts not exceeding 15 000 V peak or dc, the available stored charge shall not exceed 45 μC.

2.4.4

For accessible parts exceeding 15 000 V peak or dc, 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, together with any faults which are the direct consequence of such breakdown or failure.

Segregation of accessible parts of limited current circuits from other circuits shall be as described in Clause 2.3 for SELV circuits.

Compliance is checked by inspection and measurement.

2.5 Provision for Protective Earthing

2.5.1 Not used.

2.5.2

Power supplies intended for use in Class II equipment shall have no provision for protective earthing, except that they may be provided with a means for maintaining the continuity of protective earthing circuits to other equipment in a system. If a power supply intended for use in Class II equipment has an earth connection for functional purposes, the functional earth circuit shall be separated from parts at hazardous voltages by double or reinforced insulation.

Note: In Denmark, a national deviation will apply.

Compliance is checked by inspection.

2.5.3

Protective earthing conductors shall not contain switches or fuses.

Compliance is checked by inspection.

2.5.4 Not used.

2.5.5

Protective earthing conductors may be bare or insulated. If insulated, the insulation shall be green/yellow except in the following cases:

(a) for earthing braids, the insulation shall be either green/yellow or transparent;

(b) for internal protective conductors in assemblies such as ribbon cables, busbars, flexible printed wiring, etc, any colour may be used provided that no misinterpretation of the use of the conductor is likely to arise;

(c) the protective earthing conductor in a supply cord shall be green with or without one or more yellow stripes.

Note: In Canada, solid green insulation is permitted.

Compliance is checked by inspection.

2.5.6

Protective earth connections shall be such that disconnection of a protective earth at one assembly does not break the protective earthing connection to other assemblies, unless hazardous voltages are removed from the other assemblies at the same time.

Compliance is checked by inspection.

2.5.7

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.

Compliance is checked by inspection.

2.5.8

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 protect, unless hazardous voltage is removed from that part at the same time.

Compliance is checked by inspection.

2.5.9

Protective earthing terminals for fixed supply conductors or for nondetachable power supply cords shall comply with the requirements of Clause 3.3.

The clamping means, if any, of such terminals shall prevent accidental loosening of the conductor.

Compliance is checked by inspection and manual test.

Note: In general, the designs commonly used for current-carrying terminals, other than some terminals of the pillar type, provide sufficient resilience 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.

2.5.10

Conductive parts in contact at protective earth connections shall not be subject to significant corrosion due to electrochemical action in any working, storage, or transport environment conditions as specified in the manufacturer's instructions. Combinations above the line in Appendix K shall be avoided.

The protective earthing terminal shall be resistant to significant corrosion.

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

Compliance is checked by inspection and by reference to the Table of Electrochemical Potentials (Appendix K).

2.5.11

Bonding shall meet the requirements of CSA Standard C22.2 No. 0.4.

In addition, the resistance of the connection between the earthing terminal or earthing contact, and parts required to be earthed, shall not exceed 0.1 Ω.

When the protection of a SELV circuit is achieved by earthing in accordance with Clause 2.3.6, the 0.1 Ω earth path resistance shall apply between the earthed side of the SELV circuit and the earthing terminal or earthing contact, and not from the unearthed side of the SELV circuit.

Care shall 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 Not used.

2.6.2

If a disconnect device is provided with the power supply, it shall have a contact separation of at least 3 mm and, when incorporated in the power supply, shall be connected as closely as practicable to the incoming supply.

Notes:

(1) Functional switches may serve as disconnect devices provided that they comply with all the requirements for disconnect devices. However, these requirements do not apply to functional switches where other means of isolation are provided.

(2) Examples of disconnect devices are:

(a) the plug on the power supply cord;

(b) an appliance coupler;

(c) isolating switches;

(d) circuit breakers;

(e) any equivalent device offering a degree of safety equal to the above.

(3) Some disconnect devices complying with IEC Publication 328 are examples of those considered to comply with the requirements of this Standard.

Cord-connected units shall be considered to comply without the specified disconnect device, provided that

(a) the input to the unit does not exceed 12 A; and

(b) if it is motor-operated, the motor has a nominal voltage rating of 120 V or less and is rated at 1/3 hp or less (locked rotor current does not exceed 43 A).

2.6.3 Not used.

2.6.4 Not used.

2.6.5 Not used.

2.6.6

For single-phase power supplies, the disconnect device shall disconnect both poles simultaneously, except that a single-pole disconnect device may be used to disconnect the phase conductor when it is possible to rely on the identification of the neutral in the mains supply. In this case, instructions shall be given for the provision of an additional two-pole disconnect device in the building installation when the equipment is used where identification of the neutral in the mains supply is not possible.

Note: Three examples of cases where a two-pole disconnect device is required are:
(a) on a power supply intended for use in an IT power system;
(b) on pluggable equipment connected to primary power through a reversible appliance coupler or a reversible plug (unless the plug itself is used as the disconnect device);
(c) on a power supply intended for use with a socket-outlet with indeterminate polarity.

2.6.7

For a three-phase power supply, the disconnect device shall disconnect simultaneously all phase conductors of primary power and, for a power supply intended to be used with an IT power system, the neutral conductor.

If a disconnect device interrupts the neutral conductor, it shall simultaneously interrupt all phase conductors.

2.6.8 Not used.

2.6.9 Not used.

2.6.10

For a Class I power supply, the attachment plug or appliance coupler, if used as the disconnect device, shall make the protective earthing connection earlier than the supply connections and shall break it later than the supply connections.

2.6.11 Not used.

2.6.12 Not used.

2.6.13

Compliance with the requirements of Clause 2.6 is checked by inspection.

2.7 Overcurrent and Earth Fault Protection in Primary Circuits

2.7.1

To protect against excess current, short circuits, and earth faults in primary circuits, protection devices shall either be included as integral parts of the power supply or be specified. When specified, the marking shall be provided as required by Clause 1.7.1.

Compliance is checked by inspection.

2.7.2

Protective devices shall

(a) operate automatically at current values which are suitably related to the safe current ratings of the circuits;

(b) be capable of reliably breaking the maximum fault current which may flow, unless appropriate back-up protection has been provided as an integral part of the equipment or is specified in the installation instructions;

(c) be so constructed and positioned that their operation does not cause a hazard;

(d) be so constructed and positioned that their protective characteristics are not adversely affected by normal operating conditions.

Where protective devices are used in more than one pole of a supply to a given load, those devices shall be located together.

Compliance is checked by inspection.

Note: Two or more protective devices may be combined in one component.

2.7.3

Protection systems or devices shall be in such a number and so located as to detect and to interrupt the excessive current flowing in any possible fault current path (eg, phase-to-phase, phase-to-neutral and, for Class I only, phase-to-protective earthing conductor).

Note: In IT power systems the unearthed neutral is considered as a phase conductor.

Suitable warning shall be provided to alert service personnel to a possible hazard under the following conditions:

(a) where fuses are employed in the neutral of a Class I single-phase power supply connected to a polarized supply; and

(b) where, after operation of the protective device, parts of the power supply that remain under voltage might represent a hazard during servicing.

Note: The following or similar wording is regarded as suitable: "CAUTION: Double-pole/neutral fusing" and "ATTENTION: Double pôle/fusible sur le neutre".

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

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

Note: Examples of the minimum number and location of fuses or circuit-breaker poles when they are an integral part of the equipment, are given in Table 1 for single-phase power supplies or subassemblies and in Table 2 for three-phase power supplies.

Table 1
Protective Devices in Single-Phase Power Supplies or Subassemblies

	Protection against	Minimum number of fuses or circuit breaker poles	Location
Equipment to be connected to any supply	Earth faults	2	Both conductors
	Overcurrent	1	Either of the two conductors
Equipment to be connected only to power systems with earthed neutral reliably identified	Earth faults	1	Phase conductor
	Overcurrent	1	Either of the two conductors

Table 2
Protective Devices in Three-Phase Power Supplies

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

Note: Attention is drawn to the fact that, in IT power systems, in case of interruption of the neutral fuse in the building installation, components from phase to neutral can be subjected to higher than normal voltage: in such a case the requirements of Clause 4.4.2 relating to fire risk apply.

2.8 Not used.

2.9 Creepage Distances, Clearances, and Distances Through Insulation

2.9.1

Clearances shall be dimensioned in accordance with Clause 2.9.2.

Creepage distances shall be dimensioned in accordance with Clause 2.9.3.

Distances through insulation shall be dimensioned in accordance with Clause 2.9.4.

Notes:

(1) Clearance and electric strength requirements are based on the expected overvoltage transients which may enter the power supply from the mains supply. According to IEC Publication 664, the magnitude of these transients is determined by the normal supply voltage and the supply arrangements. The latter are categorized into four groups as Installation Categories I to IV (also known as Overvoltage Categories I to IV). This Standard assumes Installation Category II at the power supply primary power terminals.

(2) The design of solid insulation and clearances should be coordinated in such a way that, if an incident overvoltage transient exceeds the limits of Installation Category II, the solid insulation can withstand a higher voltage than the clearances.

Interpolation is not permitted for creepage distances or clearances, except where explicitly stated.

For operational insulation, creepage distances and clearances smaller than those specified in Clause 2.9 are allowed subject to the requirements of Items (b) or (c) of Clause 5.4.4.

If the creepage distance derived from Table 5 is less than the applicable clearance, then the dimension for clearance shall be used as the minimum creepage distance.

Note: Creepage distance is greater than or equal to clearance.

The values for Pollution Degree 1 are applicable to components and assemblies which are sealed so as to exclude dust and moisture (see Clause 2.9.6).

The values for Pollution Degree 2 are generally applicable to power supplies covered by the scope of this Standard.

The values for Pollution Degree 3 are applicable where a local internal environment within the power supply is subject to conductive pollution, or to dry nonconductive pollution which could become conductive due to expected condensation.

For power supplies sourced from a dc source (other than dc mains), the requirements of Clause 2.9.2, Table 4, and Clause 5.3, Table 15 for secondary circuits apply subject to the conditions in Table 3.

For IT power systems, the mains supply voltage shall be considered as equal to the phase-to-phase voltage.

Note: The requirements given are for insulation operating at frequencies up to 30 kHz. They may be used for insulation operating at frequencies over 30 kHz until additional data is available.

The following conditions are applicable during the assessment for compliance with Clauses 2.9.2 and 2.9.3:

Movable parts shall be placed in the most unfavourable position.

For equipment incorporating ordinary nondetachable power supply cords, creepage distance measurements shall be made with supply conductors of the largest cross-sectional area specified in Clause 3.3.5, and also without conductors.

2.9.2 Clearances

Clearances in primary circuits and secondary circuits shall be dimensioned in accordance with Table 3 and Table 4 respectively, taking into account the relevant specified conditions that follow the Tables.

The specified clearances are not applicable to the air gap between the contacts of thermostats, thermal cut-outs, overload protection devices, switches of microgap construction, and similar components where the clearance varies with the contacts.

The values are the minimum values which shall be applied after taking account of manufacturing tolerances and deformation which can occur due to handling, shock, and vibration likely to be encountered during manufacture, transport, and normal use.

Note: Power supplies may have their own enclosures or be of an open construction to be housed in the enclosure of the host equipment.

Compliance is checked by measurement taking into account the Figures in Appendix F, subject to conditions detailed in Clause 2.9.1.

If necessary, a force shall be applied to any point on internal parts and to the outside of conductive enclosures, in an endeavour to reduce the clearance while taking measurements. The force shall have a value of

(a) 10 N *for internal parts;*

(b) 30 N *for enclosures.*

The force shall be applied to enclosures by means of a rigid test finger having outline dimensions as in Figure 10.

In addition, the overall enclosure of a power supply shall meet the deflection test of CSA Standard C22.2 No. 950, if requested by the manufacturer of the power supply.

Circuits shall not be subject to internally generated transient overvoltages exceeding the appropriate value for the mains supply voltage and installation category.

Note: If the transient overvoltages exceed the test voltages in Clause 5.3.2, reference to IEC Publication 664 will be necessary to determine the transient limits.

Where necessary compliance is checked by measurement.

Table 3
Minimum Clearances for Insulation in Primary Circuits and Between Primary and Secondary Circuits (mm)

Insulation working voltage up to and including		Circuits subject to installation Category II (see Conditions 1, 5 and 6)									
		Nominal mains supply voltage ≤ 150 V (Transient rating 1 500 V)				Nominal mains supply voltage > 150 V ≤ 300 V (Transient rating 2 500 V)				Nominal mains supply voltage > 300 V ≤ 600 V Transient rating 4 000 V)	
Peak or d.c.	r.m.s. (sinus-oidal)	Pollution degrees 1 and 2		Pollution degree 3		Pollution degrees 1 and 2		Pollution degree 3		Pollution degrees 1, 2 and 3	
		Op	B/S	Op	B/S	Op	B/S	Op	B/S	Op	B/S
71	50	0.4	1.0 (0.7)	1.0	1.3 (1.0)	1.0	2.0 (1.7)	1.3	2.0 (1.7)	2.0	3.2 (3.0)
210	150	0.7	1.0 (0.7)	1.0	1.3 (1.0)	1.4	2.0 (1.7)	1.7	2.0 (1.7)	2.0	3.2 (3.0)
420	300	Op 1.7 B/S 2.0 (1.7)								2.5	3.2 (3.0)
840	600	Op 3.0 B/S 3.2 (3.0)									
1 400	1 000	Op/B/S 4.2									
2 800	2 000	" 8.4									
7 000	5 000	" 17.5									
9 800	7 000	" 25.0									
14 000	10 000	" 37.0									
28 000	20 000	" 80.0									
42 000	30 000	" 130.0									

Conditions Applicable to Table 3

1. This Table is applicable to power supplies that will not be subject to transients exceeding Installation Category II, according to IEC Publication 664. The appropriate transient voltage ratings are given in parentheses at the top of each supply voltage column. Where higher transients are possible, additional protection might be necessary in the mains supply to the power supply or to the installation.
2. The values in the Table are applicable to operational (Op), basic (B), and supplementary (S) insulation.
3. For working voltages up to and including 840 V peak or dc, the minimum clearances for reinforced insulation are double the values in the Table for basic or supplementary insulation.

   For working voltages above 840 V peak or dc up to and including 1400 V peak or dc, the minimum clearance for reinforced insulation is 6.4 mm.

   For working voltages above 1400 V peak or dc, the minimum clearances for reinforced insulation are the values in the Table for basic or supplementary insulation.
4. The values in parentheses are applicable only where manufacturing is subject to a formal quality control program. In particular, double and reinforced insulation shall be subject to 100% electric strength testing.
5. For basic, supplementary, and reinforced insulation, all parts of the primary circuit are assumed to be at not less than the nominal supply voltage with respect to earth.
6. For working voltages between 2800 V peak or dc and 42 000 V peak or dc, interpolation may be used between the nearest two points.
7. For an air gap serving as reinforced insulation between a part at a hazardous voltage and an accessible conductive part of the enclosure of floor-standing equipment or the nonvertical top surface of desktop equipment, the clearance shall be not less than 10 mm.

Table 3(a)
Additional Clearance Distances for Primary Circuits with Repetitive Peak Voltages Exceeding the Peak Value of the Supply Voltage

Nominal mains supply voltage not more than 150 V				Nominal mains supply voltage over 150 V and not more than 300 V		Additional clearance in mm to be added to minimum clearances from Table 3 for operational, basic and supplementary insulation; add double this value for reinforced insulation
Pollution degrees 1 and 2		Pollution degree 3		Pollution degrees 1, 2 and 3		
Maximum repetitive peak voltage V		Maximum repetitive peak voltage V		Maximum repetitive peak voltage V		
210	(210)	210	(210)	420	(420)	0
298	(290)	294	(300)	493	(497)	0.1
386	(370)	379	(390)	567	(574)	0.2
474	(450)	463	(480)	640	(651)	0.3
562	(530)	547	(570)	713	(728)	0.4
650	(610)	632	(660)	787	(805)	0.5
738	(690)	716	(750)	860	(881)	0.6
826	(770)	800	(840)	933	(958)	0.7
914	(850)	—	—	1,006	(1,035)	0.8
1,002	(930)	—	—	1,080	(1,112)	0.9
1,090	(1,010)	—	—	1,153	(1,189)	1.0
—	—	—	—	1,226	(1,266)	1.1
—	—	—	—	1,300	(1,343)	1.2
—	—	—	—	—	(1,420)	1.3

Conditions Applicable to Table 3(a)

1. The values in parentheses are applicable to the voltage across basic, supplementary, or reinforced insulation only where manufacturing is subject to a formal quality control program. In particular, double and reinforced insulation shall be subject to 100% electric strength testing.
2. The values in parentheses are applicable to the voltage across operational insulation without the 100% electric strength testing.

Table 4
Minimum Clearances in Secondary Circuits (mm)

Insulation working voltage up to and including		Circuits subject to Installation Category 1 (see condition 7)					Circuits not subject to transient overvoltage; Pollution degrees 1 and 2 only (see condition 6)
		Nominal mains supply voltage ≤ 150 V (Transient Rating 800 V)		Nominal mains supply voltage > 150 V ≤ 300 V (Transient Rating 1500 V)		Nominal mains supply voltage > 300 V ≤ 600 V (Transient Rating 2500 V)	
V peak or dc	V rms (sinusoidal)	Pollution degrees 1 and 2	Pollution degree 3	Pollution degrees 1 and 2	Pollution degree 3	Pollution degrees 1, 2, and 3	
71	50	0.7 (0.4)	1.3 (1.0)	1.0 (0.7)	1.3 (1.0)	2.0 (1.7)	0.4
140	100	0.7 (0.6)	1.3 (1.0)	1.0 (0.7)	1.3 (1.0)	2.0 (1.7)	0.7 (0.6)
210	150	0.9 (0.6)	1.3 (1.0)	1.0 (0.7)	1.3 (1.0)	2.0 (1.7)	0.9 (0.6)
280	200	1.4 (1.1)	1.4 (1.1)	1.4 (1.1)	1.4 (1.1)	2.0 (1.7)	1.1
420	300	1.9 (1.6)	1.9 (1.6)	1.9 (1.6)	1.9 (1.6)	2.0 (1.7)	1.4
700	500	2.5	2.5	2.5	2.5	2.5	2.5
840	600	3.2	3.2	3.2	3.2	3.2	3.2
1,400	1,000	4.2	4.2	4.2	4.2	4.2	4.2
2,800	2,000	8.4	8.4	8.4	8.4	8.4	8.4
7,000	5,000	17.5	17.5	17.5	17.5	17.5	17.5
9,800	7,000	25	25	25	25	25	25
14,000	10,000	37	37	37	37	37	37
28,000	20,000	80	80	80	80	80	80
42,000	30,000	130	130	130	130	130	130

Conditions Applicable to Table 4

1. The values in the Table are applicable to operational, basic, and supplementary insulation.
2. For working voltages up to and including 420 V, the minimum clearances for reinforced insulation shall be double the values in the Table.
   For working voltages above 420 V up to and including 1400 V, the minimum clearances for reinforced insulation shall be 5.0 mm.
   For working voltages above 1400 V, the minimum clearances for reinforced insulation shall be the values in the Table. Condition 7 of Table 3(a) shall also apply.
3. The values in parentheses are applicable to basic, supplementary, or reinforced insulation only where manufacturing is subject to a formal quality control program. In particular, double and reinforced insulation shall be subject to 100% electric strength testing.
4. The values in parentheses are applicable to operational insulation without the 100% strength testing.
5. For voltages between 2800 V and 42 000 V, interpolation may be used between the nearest two points.
6. The values are applicable to dc secondary circuits which are reliably connected to earth and have capacitive filtering which limits the peak-to-peak ripple to 10% of the dc voltage.
7. Secondary circuits will normally be Installation Category I when the primary is Installation Category II. A floating secondary circuit shall be subject to the requirements for primary circuits in Table 3(a), unless separated from primary circuits by an earthed metal screen.
8. External signal cables should be prevented from introducing into secondary circuits transients that exceed the applicable transient overvoltage limit, where they might result in a hazard.

2.9.3 Creepage Distances

Creepage distances shall be not less than the appropriate minimum values specified in Table 5, taking into account the relevant conditions specified under the Table.

Compliance is checked by measurement, taking account of the Figures in Appendix F and subject to the conditions in Clause 2.9.1.

2.9.4 Distance Through Insulation

Unless otherwise specified (see Clauses 2.9.5 and 3.1.5), distance through insulation shall be dimensioned according to working voltage and to application of the insulation (see Clauses 2.2.6 and 2.2.7), and as follows:

(a) for working voltages not exceeding 50 V (71 V peak or dc), there is no thickness requirement;

(b) supplementary insulation shall have a minimum thickness of 0.4 mm;

(c) reinforced insulation shall have a minimum thickness of 0.4 mm when not subject to any mechanical stress which, at nominal operating temperature, would be likely to lead to deformation or deterioration of the insulating material.

Note: Under mechanical stress conditions, the thickness may have to be increased to comply with the requirements of Clauses 4 and 5.

The above requirements are not applicable to insulation in thin sheet material, irrespective of its thickness, provided that it is used within the equipment protective enclosure and is not subject to handling or abrasion during operator servicing, and one of the following applies:

(a) supplementary insulation comprises at least two layers of material, each of which will pass the electric strength test for supplementary insulation; or

(b) supplementary insulation comprises three layers of material, for which all combinations of two layers together pass the electric strength test for supplementary insulation; or

(c) reinforced insulation comprises at least two layers of material, each of which will pass the electric strength test for reinforced insulation; or

(d) reinforced insulation comprises three layers of insulation material, for which all combinations of two layers together pass the electric strength test for reinforced insulation.

The enamel or other insulating coating on winding wire, such as is normally used in transformer construction, is not considered to be insulation in thin sheet material.

There is no requirement for all layers of insulation to be of the same insulation material.

For printed boards employing glass fibre construction, no minimum thickness is specified, but reinforced insulation shall comprise not less than three layers and supplementary insulation shall comprise not less than two layers. The overall insulation shall withstand the appropriate electric strength requirements of Clause 5.3.2.

For other boards, the minimum thickness through insulation, when used as supplementary or reinforced insulation, shall be 0.4 mm.

Compliance is checked by measurement and, where specified, by electric strength tests.

Table 5
Minimum Creepage Distances (mm)

Working voltage up to and including V r.m.s. or d.c.	Operational, basic and supplementary insulation						
	Pollution degree 1	Pollution degree 2			Pollution degree 3		
	Material group I, II, IIIa and IIIb	Material group I	II	IIIa and IIIb	Material group I	II	IIIa and IIIb
50	Use the appropriate clearance from Table 3 or Table 4	0.6	0.9	1.2	1.5	1.7	1.9
100		0.7	1.0	1.4	1.8	2.0	2.2
125		0.8	1.1	1.5	1.9	2.1	2.4
150		0.8	1.1	1.6	2.0	2.2	2.5
200		1.0	1.4	2.0	2.5	2.8	3.2
250		1.3	1.8	2.5	3.2	3.6	4.0
300		1.6	2.2	3.2	4.0	4.5	5.0
400		2.0	2.8	4.0	5.0	5.6	6.3
600		3.2	4.5	6.3	8.0	9.6	10.0
1000		5.0	7.1	10.0	12.5	14.0	16.0

Conditions Applicable to Table 5
1. For reinforced insulation, the values for creepage distances are twice the values in the Table for basic insulation.
2. If the creepage distance derived from Table 5 is less than the applicable clearance from Table 3 or Table 4, as appropriate, then the value for that clearance shall be applied as the value for the minimum creepage distance.
3. Material group I 600 ≤ CTI (Comparative Tracking Index)
   Material group II 400 ≤ CTI < 600
   Material group IIIa 175 ≤ CTI< 400
   Material group IIIb 100 ≤ CTI < 175
   The CTI rating refers to the value obtained in accordance with Method A, IEC Publication 112.
4. For working voltages of 127, 208, and 415 V, creepage distances corresponding to 125, 200, and 400 V may be used.
5. Minimum creepage distances equal to the applicable clearance may be used for glass, mica, ceramic, or similar materials.

2.9.5

For printed boards whose conductors are coated with a suitable coating material, the minimum separation distances of Table 6 are applicable to conductors before they are coated, subject to the following requirements:
(a) Either one or both conductive parts and at least 80% of the distances over the surface between the conductive parts shall be coated. Between any two uncoated conductive parts and over the outside of the coating, the minimum distances in Tables 3, 4, or 5 apply;
(b) The values in Table 4 shall be used only if manufacturing is subject to a formal quality control program. In particular, double and reinforced insulation shall be subject to 100% electric strength testing.
In default of the above conditions, the requirements of Clauses 2.9.2 and 2.9.3 shall apply.

Table 6
Minimum Separation Distances for Coated Printed Boards (mm)

Maximum working voltage V r.m.s. or d.c.	Operational, basic or supplementary insulation	Reinforced insulation
63	0.1	0.2
125	0.2	0.4
160	0.3	0.6
200	0.4	0.8
250	0.6	1.2
320	0.8	1.6
400	1.0	2.0
500	1.3	2.6
630	1.8	3.6
800	2.4	3.8
1000	2.8	4.0
1250	3.4	4.2
1600	4.1	4.6
2000	5.0	5.0
2500	6.3	6.3
3200	8.2	8.2
4000	10.0	10.0
5000	13.0	13.0
6300	16.0	16.0
8000	20.0	20.0
10000	26.0	26.0
12500	33.0	33.0
16000	43.0	43.0
20000	55.0	55.0
25000	70.0	70.0
30000	86.0	86.0

The coating process, the coating material, and the base material shall be such that uniform quality is assured and the separation distances under consideration are effectively protected.

The coating material shall also be tested to the requirements of IEC Publication 112 for Material Group IIIa or IIIb, as defined in Table 5, Condition 3 of this Standard.

Compliance is checked by measurement, taking into account Figures F12 and F13 in Appendix F and by the following series of tests:

Preliminary Tests

Three sample boards (or, for Clause 2.9.8, two components and one board) identified as samples No. 1, 2, and 3 are required. They shall each be representative of the minimum separations used, and shall be coated. They shall be subjected to the full sequence of manufacturing processes, including soldering and cleaning, to which they are normally subjected during equipment assembly.

When visually inspected, they shall show no evidence of pinholes or bubbles in the coating or breakthrough of conductive tracks at corners.

Note: Either actual boards, or specially produced samples with representative minimum separations, may be used.

Thermal Cycling Test

Sample No. 1 shall be subjected ten times to the following sequence of temperature cycles:

(a) 68 h *at* 100 ± 2°C;
(b) 1 h *at* 25 ± 2°C;
(c) 2 h *at* 0 ± 2°C;
(d) 1 h *at* 25 ± 2°C.

Thermal Aging Test

Sample No. 2 shall be subjected to a temperature of 130 ± 2°C *for* 1000 h.

Electric Strength Test

Samples Nos. 1 and 2 shall then be subjected to the humidity treatment of Clause 2.2.3 (48 h *treatment) and shall then withstand between conductors the relevant electric strength test of Clause 5.3.2.*

Abrasion Resistance Test

Sample board No. 3 shall be subjected to the following test:

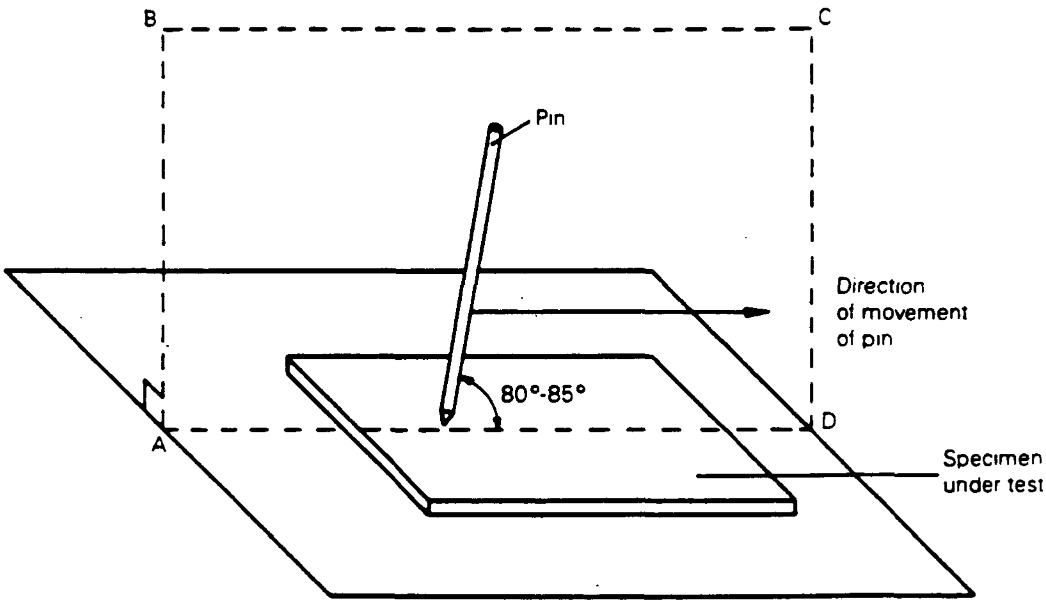
Scratches shall be made across five pairs of conducting parts and the intervening separations at points where the separations will be subject to the maximum potential gradient during the tests.

The scratches shall be made by means of a hardened steel pin, the end of which has the form of a cone having a top angle of 40°, *its tip being rounded and polished with a radius of* 0.25 ± 0.02 mm.

Scratches shall be made by drawing the pin along the surface in a plane perpendicular to the conductor edges at a speed of 20 ± 5 mm/s *as shown in Figure 1. The pin shall be so loaded that the force exerted along its axis is* 10 ± 0.5 N. *The scratches shall be at least* 5 mm *apart and at least* 5 mm *from the edge of the specimen.*

After this test, the coating layer shall neither have loosened nor have been pierced, and it shall withstand between conductors an electric strength test as specified in Clause 5.3.2.

Note: The pin is in the plane A B C D, which is perpendicular to the specimen under test.



Note: The pin is in the plane A B C D which is perpendicular to the specimen under test.

Figure 1
Abrasion Resistance Test for Coating Layers

2.9.6

For components or subassemblies which are enclosed or hermetically sealed against ingress of dirt and moisture, and which satisfy the following compliance requirements, the minimum internal creepage distances and clearances can be the values for Pollution Degree 1. Internal connections shall be fixed or insulated to inhibit degradation of insulation by mechanical shock or vibration.

Compliance is checked by inspection, measurement, and by subjecting the component or subassembly to the thermal cycling test of Clause 2.9.5. However, the 100°C *storage temperature is replaced by the highest temperature measured under normal conditions on the component or subassembly under consideration with a minimum of* 85°C. *In the case of transformers, the* 100°C *storage temperature is replaced by the highest winding temperature measured under normal conditions, plus* 10 K, *with a minimum of* 85°C. *The component or subassembly is then subjected to the humidity treatment of Clause 2.2.3* (48 h *treatment) and the relevant electric strength test of Clause 5.3.2.*

For transformers, magnetic couplers, and similar devices where the insulation is relied upon for safety, a voltage of 500 V rms *at* 50 Hz *to* 60 Hz *shall be applied between windings during the thermal cycling test. No evidence of insulation breakdown shall occur during this test.*

2.9.7

The distances between conducting parts internal to components or assemblies which are treated with an insulating compound filling all internal clearances, excluding air and preventing the ingress of dirt and moisture, shall be subject only to the requirements of Clause 2.9.4.

Note: Traces on the same layer internal to a printed wiring board are considered to be such conducting parts.

Such treatment might include potting, encapsulation, or impregnation.

Distances between conductive parts along uncemented joints shall be considered as clearances and creepage distances for which the values in Tables 3, 4, and 5 for Pollution Degree 1 shall apply.

Compliance shall be checked in accordance with the compliance clauses of Clause 2.9.6, together with the following:

A visual inspection shall show that there are no cracks in the encapsulating, impregnating, or other material and that coatings have not loosened or shrunk, and (after sectioning the sample) that there are no significant voids in the material.

2.9.8

The requirements of Clauses 2.9.2 and 2.9.3 are applicable to the spacings between external terminations of components conforming to Clause 2.9.7, except when they have a coating of material satisfying the requirements of Clause 2.9.5, including the quality control requirements. In such a case the insulation distance of Table 4 shall be applicable to the component before coating. Between any two uncoated conductive parts and over the outside of the coating, the minimum distances of Tables 3, 4, and 5 shall be applied.

Where coatings are employed over terminations to increase effective creepage distances and clearances, the mechanical arrangement and rigidity of the terminations shall be adequate to ensure that, during normal handling and assembly into equipment and subsequent use, the terminations will not be subject to deformation which would crack the coating or reduce the spacing between conducting parts below the values in Table 6.

Compliance is checked by inspection taking into account Figures F12 and F13, and by applying the first sequence covered by the preliminary tests, thermal cycling test, thermal aging test, and electric strength test of Clause 2.9.5. These tests shall be carried out on a completed assembly including the component(s).

The abrasion resistance test shall be carried out using a specially prepared sample printed circuit board as described for sample No. 3 in Clause 2.9.5, except that the separation between *the conductive parts shall be representative of the minimum separations and maximum potential gradients used in the assembly.*

3. Wiring, Connections, and Supply

3.1 Wiring

3.1.1

For internal wires and for external cables other than power supply cords (see Clause 3.2.4), the cross-sectional area shall be adequate for the current they are intended to carry when the equipment is operating under normal load, such that the maximum permitted temperature of conductor insulation is not exceeded.

Note: Resistance of a wire is a function of frequency and wiring diameter (skin effect).

All internal wiring (including busbars and interconnecting cables) used in the distribution of primary power shall be protected against overcurrent and short circuit by suitably rated protective devices.

Wiring not directly involved in the distribution path need not require protection where it can be shown that no risk of fire is involved (eg, indicating circuits).

Notes:

(1) Devices for overload protection of components may also provide protection of associated wiring.

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

Compliance is checked by inspection and, as appropriate, by the tests of Clause 5.1.

3.1.1.1

Except as provided in Clauses 3.1.1.2 through 3.1.1.4, the protection of primary circuit internal wiring and conductors of external interconnecting cords and cables shall be in accordance with the requirements of the *Canadian Electrical Code, Part I.*

3.1.1.2

The protection of internal wiring sized No. 14 AWG and smaller may be rated 20 A.

3.1.1.3

The protection of internal wiring smaller than No. 12 AWG but not smaller than No. 18 AWG nor over 1220 mm in length, shall be rated no more than 60 A.

3.1.1.4

The limits specified in Table CAN-1 shall apply to busbars, and to conductors that:

(a) are no longer than 7.6 m;

(b) are completely within the enclosure of one unit or are totally enclosed and protected in raceways assembled to and running between two or more units; and

(c) terminate at the load end in one or more overcurrent protective devices.

3.1.1.5

The protection of conductors of external interconnecting cords and cables connected to secondary circuits shall be considered to comply with this Standard if the power supply conforms to one or more of the following conditions:

(a) overcurrent protection is provided in the equipment in conformity with the *Canadian Electrical Code, Part I;*

(b) the secondary circuit is supplied by a single source consisting of an isolating transformer, in which the open circuit voltage is not more than 42.4 V peak and the power available to the circuit is limited so that current under any condition of load, including short circuit, is not more than 8 A; or

(c) the secondary circuits, other than those specified in Item (b), are derived from power supplies or other sources that

(i) are either inherently limited or include sensing devices, the operation of which achieves the same result (prevention of burnout and injury to insulation as a result of overload) or de-energizes the unit or system; and

(ii) the output wiring is capable of carrying the maximum current available from the power supply without flaking, embrittlement, or charring of the insulation.

Table CAN-1
Largest Acceptable Protective Device

Kinds of conductor	Conductor within the unit, AWG		Current rating of largest acceptable overcurrent protective device, A
Wires	Copper	Aluminum	
	14	12	50
	12	-	60
	-	10	80
	10	8	90
	8	6	125
	6	4	175
	4	3	200
Solid busbars	Copper		Low enough to limit the current density in the busbar to 3000 A per 645 mm^2 of busbar cross section
	Aluminum 1350 having a conductivity of 61% of IACS		Low enough to limit the current density in the busbar to 2000 A per 645 mm^2 of busbar cross section
	Aluminum having a conductivity of 55% of IACS		Low enough to limit the current density in the busbar to 1776 A per 645 mm^2 of busbar cross section

3.1.2

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

Note: In electronic assemblies, it is permissible for wires to be in close contact with wire wrapping posts and the like if any breakdown of insulation will not result in a hazard, or if adequate mechanical protection is provided by the insulation system employed.

Compliance is checked by inspection.

3.1.3

Internal wiring shall be routed, supported, clamped, or secured in a manner that prevents
(a) excessive strain in wires and on terminal connections;
(b) loosening of terminal connections;
(c) damage of conductor insulation.

Compliance is checked by inspection.

3.1.4

For uninsulated conductors it shall not be possible to reduce, in normal use, creepage distances and clearances below the relevant values specified in Clause 2.9.

Compliance is checked by inspection.

3.1.5

Insulation of individual conductors shall be suitable for the application and working voltage involved.

The insulation under consideration shall be capable of withstanding the appropriate electric strength test specified in Clause 5.3.2.

3.1.6

Wires identified by the colour combination green/yellow shall be used only for protective earth connections (see Clause 2.5.5).

Compliance is checked by inspection.

3.1.7

Beads and similar ceramic insulators on conductors shall be so fixed or supported that they cannot change their position. Moreover, they shall not rest on sharp edges or sharp corners. If beads are inside flexible metal conduits, they shall be contained within an insulating sleeve, unless the conduit is prevented from movement in normal use.

Compliance is checked by inspection and by manual test.

3.2 Connection to Primary Power

The requirements of Clauses 3.2.1 to 3.2.8 inclusive apply to power supplies which include the means of connection of the equipment to primary power.

For built-in power supplies designed to take primary power via an internal primary power distribution system within the host equipment, the requirements of Clause 3.2.9 apply.

3.2.1

For safe and reliable connection of primary power, the power supply shall be provided with one of the following:
(a) terminals for permanent connection to the supply;
(b) a nondetachable power supply cord for connection to the supply by means of a plug;
(c) an appliance inlet for connection of a detachable power supply cord and either a detachable power supply cord or instructions for selection of a suitable power supply cord.

3.2.1.1

Where a power supply is intended to be connected to primary power by a power supply cord, the attachment plug shall be rated no less than 125% of the rated current of the equipment.

Where the power supply is provided with more than one supply connection (eg, with different voltages/frequencies or as redundant power), the design shall be such that all of the following conditions are met:
(a) separate means of connection are provided for different circuits;
(b) supply plug connections, if any, are not interchangeable if a hazard could result from incorrect plugging;
(c) means are provided to reduce the risk of the operator touching bare parts at ELV or hazardous voltages, such as plug contacts, when one or more connectors are disconnected.
Compliance is checked by inspection.

3.2.2

Power supplies intended for permanent connection shall be provided with a set of terminals, as specified in Clause 3.3, that shall
(a) permit the connection of the supply wires after the equipment has been fixed to its support;
(b) be provided with conduit entries, knock-outs, or glands, which allow the use of a wiring method in accordance with the *Canadian Electrical Code, Part I.*

Conduit entries and knock-outs for supply connections shall be so designed or located that the introduction of the conduit shall not affect the protection against electric shock, or reduce creepage distances and clearances below the values specified in Clause 2.9.

The metal plate to which conduit or armoured cable is secured shall be suitable for that duty, and shall be not less than 0.75 mm thick if of sheet steel and not less than 1.09 mm thick if of nonferrous metal.

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

3.2.3

Appliance inlets (equipment male connectors) shall be all of the following:
(a) so located or enclosed that parts at hazardous voltage are not accessible during insertion or removal of the connector;

Note: Appliance inlets (equipment male connectors) complying with IEC Publication 320 and CSA Standard C22.2 No. 182.3 are considered to comply with this requirement.

(b) so placed that the connector can be inserted without difficulty.

Appliance inlets for Class I power supplies shall have an earthing terminal connected to the protective earthing terminal within the power supply.

Compliance is checked by inspection and, for accessibility, by means of the test finger (Figure 10).

3.2.4 Cord-Connected Equipment

A power supply intended to be cord-connected shall be supplied with either
(a) a power supply cord or a cord set approved for the application and furnished by the manufacturer; or
(b) a male connector (appliance inlet) (see Clause 3.2.3).

Notes:
(1) Requirements for power supply cords or cord sets are contained in CSA Standard C22.2 No. 21.
(2) Requirements for general use receptacles, attachment plugs, and similar wiring devices are contained in CSA Standard C22.2 No. 42.

3.2.5

For equipment with a nondetachable power supply cord, a cord anchorage shall be provided such that:
(a) the connecting points of the cord conductors are relieved from strain;
(b) the outer covering of the cord is protected from abrasion.

It shall not be possible to push the cord back into the equipment if this could create a hazard within the meaning of this Standard.

For Class I power supplies, the construction shall be such that, if the power supply cord should slip in its anchorage and thereby place a strain on conductors, the protective earthing conductor will be the last to take the strain.

The cord anchorage shall either be made of insulating material or have a lining of insulating material complying with the requirements for supplementary insulation. However, where the cord anchorage is a bushing that includes the electrical connection to the screened power cord, this requirement shall not apply.

3.2.5.1

The construction of the cord anchorage shall be such that:
(a) cord replacement does not impair the safety and the correct functioning of the equipment;
(b) for ordinary replacement cords, it is clear how the relief from strain is to be obtained;
(c) the cord is not clamped by a screw which bears directly on the cord;
(d) methods, such as tying the cord into a knot or tying the cord with a string, are not used;
(e) the cord anchorage cannot rotate in relation to the body of the equipment, and the cord cannot rotate in cord anchorage.

Notwithstanding the requirements of Clause 3.2.5, strain relief shall be provided so that mechanical strain on the power supply cord, including rotation, will not be transmitted to terminals, splices, or interior wiring.

3.2.5.2

Compliance is checked by inspection, and by applying the following tests, which are made with the type of power supply cord supplied with the equipment:

The strain relief shall:
(a) withstand a direct pull of 150 N *for* 1 min; *and*
(b) prevent the cord from being pushed into the equipment through the cord entry hole if such displacement is liable to
(i) subject the cord to mechanical injury;
(ii) expose it to a temperature higher than that for which it is recognized; or
(iii) reduce spacings (such as from bare live parts to a metal strain relief clamp) below the acceptable minimum values of Clause 2.9.

3.2.6

Power supply cords shall not be exposed to sharp points or cutting edges within or on the surface of the power supply (see Clause 3.2), or at the inlet opening or inlet bushing.

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

Inlet bushings, where used, shall:
(a) be reliably fixed;
(b) not be removable without the use of a tool.

An inlet bushing in a nonmetallic enclosure shall be of insulating material.

An inlet bushing or cord guard in metal-encased Class II equipment shall meet the requirements for supplementary insulation.

Compliance is checked by inspection and measurement.

3.2.7

A cord guard shall be provided at the power supply cord inlet opening for power supplies (see Clause 3.2) having a detachable power supply cord, and which is incorporated into equipment which is intended to be hand-held or intended to be moved while in operation. Alternatively, the inlet or bushing shall be provided with a smoothly rounded bell-mouthed opening having a radius of curvature equal to at least 1.5 times the overall diameter of the cord with the largest cross-sectional area to be connected.

Cord guards shall

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

3.2.7.1

Compliance is checked by inspection, by measurement, and, where necessary, by the following test:
(a) The equipment shall be tested with the cord as delivered by the manufacturer.
(b) The equipment shall be so placed that the axis of the cord guard, where the cord leaves it, projects at an angle of 45° *when the cord is free from stress. A mass equal to* $10 \times D^2$ g *shall then be attached to the free end of the cord,* D *being, in millimetres, the overall diameter of or, for flat cords, the minor overall dimension of the cord delivered with the equipment.*
(c) If the cord guard is of temperature-sensitive material, the test shall be made at 23 ± 2°C.
(d) Flat cords shall be bent in the plane of least resistance.
(e) Immediately after the mass has been attached, the radius of curvature of the cord shall nowhere be less than 1.5 D.

3.2.8

The supply wiring space provided inside, or as part of, the equipment for permanent connection or for connection of ordinary nondetachable power supply cords shall be designed

(a) to allow the conductors to be introduced and connected easily;
(b) so that for permanently connected equipment, wire-bending space shall be provided and shall be no less than as specified in CSA Standard C22.2 No. 0.12;
(c) so that, for Class II power supplies or for power supplies to be incorporated in hand-held or Class II equipment, the uninsulated end of a conductor is unlikely to become free from its terminal, or, should it do so, cannot come into contact with accessible conductive parts;
(d) to permit checking before fitting the cover, if any, that the conductors are correctly connected and positioned;
(e) so that covers, if any, can be fitted without risk of damage to the supply conductors or their insulation; and
(f) so that covers, if any, giving access to the terminals can be removed without the use of a special tool.

Compliance is checked by inspection and by an installation test with cords of the largest cross-sectional area of the appropriate range specified in Clause 3.3.5.

3.2.9

Power supplies for building-in, that take their primary power from a primary power distribution system within the host equipment, can use supply connections that meet the requirements of Clause 3.2, excepting Clauses 3.2.5 and 3.2.7. Alternatively, where the connection arrangements are not accessible to the operator, any method of connection meeting the other requirements of this Standard is permitted.

3.3 Wiring Terminals for External Primary Power Supply Conductors

This Clause applies to power supplies which include the means of connection to primary power for the host equipment.

Note: In this Clause, terminals refers to wiring terminals.

3.3.1

Power supplies intended for permanent connection and power supplies with ordinary nondetachable power supply cords shall be provided with terminals in which connection is made by means of screws, nuts, or equally effective devices.

Wire-binding screws shall not be provided to attach conductors larger than No. 10 AWG (5.3 mm^2).

Compliance is checked by inspection.

3.3.2

For power supplies with special nondetachable 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. For soldered or crimped connections, barriers shall be provided such that creepage distances and clearances cannot be reduced to less than the values specified in Clause 2.9 should the conductor break away at a soldered joint or slip out of a crimped connection. Alternatively, for soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position.

Compliance is checked by inspection, by applying a pull of 5 N *to the connection, for* 1 min, *and by measuring the temperature of the connection, which shall not exceed the values of Clause 5.1.*

Note: Connectors in compliance with CSA Standard C22.2 No. 153 are considered to comply with the requirements of Clause 3.3.2.

3.3.3

Screws and nuts which clamp external power supply conductors shall have a thread conforming with ISO Standard 261 or 262, 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.

Notes:

(1) The terminals of a component (eg, a switch) built into the power supply may be used as terminals for connection of primary power conductors, provided that they comply with the requirements of Clause 3.3.

(2) Unified threads are considered to be comparable in pitch and mechanical strength with threads conforming with ISO Standards 261 and 262.

Compliance is checked by inspection.

3.3.4

For the purpose of applying the requirements for power supply cords

(a) it is assumed that two independent fixings will not become loose at the same time;

(b) conductors connected by soldering are not considered to be adequately fixed unless they are held in place near 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 in position, provided that the hole through which the conductor is passed is not unduly large;

(c) 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 Table 10, and shall allow the connection of conductors which comply with conductor size requirements contained in the *Canadian Electrical Code, Part I.*

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

Compliance is checked by inspection, by measurement, and by fitting cords of the smallest and largest cross-sectional areas of the appropriate range shown in Table 10.

Table 10
Range of Conductor Sizes to be Accepted by Terminals

Rated current of equipment A	Nominal cross-sectional area mm^2	
	Flexible cords	Other cables
Up to and including 3	0.5 to 0.75	1 to 2.5
Over 3 up to and including 6	0.75 to 1	1 to 2.5
Over 6 up to and including 10	1 to 1.5	1 to 2.5
Over 10 up to and including 13	1.25 to 1.5	1.5 to 4
Over 13 up to and including 16	1.5 to 2.5	1.5 to 4
Over 16 up to and including 25	2.5 to 4	2.5 to 6
Over 25 up to and including 32	4 to 6	4 to 10
Over 32 up to and including 40	6 to 10	6 to 16
Over 40 up to and including 63	10 to 16	10 to 25

Table 11
Sizes of Terminals for Primary Power Supply Conductors

Rated current of equipment A	Minimum nominal thread diameter mm	
	Pillar type or stud type	Screw type
Up to and including 10	3.0	3.5
Over 10 up to and including 16	3.5	4.0
Over 16 up to and including 25	4.0	5.0
Over 25 up to and including 32	4.0	5.0
Over 32 up to and including 40	5.0	5.0
Over 40 up to and including 63	6.0	6.0

3.3.6

Terminals shall have minimum sizes as shown in Table 11.

Stud terminals shall be provided with means suitable to retain the wire.

If a wire-binding or binding-head screw is employed at field-wiring terminals intended for the connection of supply circuit conductors, it shall not be smaller than No. 8 if the supply circuit conductors are No. 14 AWG, and not smaller than No. 10 if the supply circuit conductors are No. 12 or No. 10 AWG. Screws made of steel shall be suitably plated.

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 means of clamping the conductor is tightened or loosened

(a) the terminal itself does not work loose;
(b) internal wiring is not subjected to stress;
(c) creepage distances and clearances are not reduced below the values specified in Clause 2.9.

Compliance is checked by inspection and measurement.

3.3.8

For ordinary nondetachable power supply cords, 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.

3.3.9

Terminals shall be so located, guarded, or insulated that, should a strand of flexible conductor escape when the conductor is fitted, there is no risk of accidental contact between such a strand and:

(a) accessible conductive parts; or
(b) unearthed conductive parts separated from accessible conductive parts by supplementary insulation only.

Compliance is checked by inspection and, unless a special cord is prepared in such a way as to prevent the escape of strands, by the following test.

An approximately 8 mm *length of insulation shall be removed from the end of a flexible conductor having the appropriate nominal cross-sectional area. One wire of the stranded conductor shall be left free and the other wires shall be fully inserted into, and clamped in, the terminal.*

Without tearing the insulation back, the free wire shall be bent in every possible direction, but without making sharp bends around the guard.

If the conductor is at hazardous voltage, the free wire shall not touch any metal part which is accessible or is connected to an accessible metal part or, in the case of double-insulated equipment, any metal part which is separated from accessible metal parts by supplementary insulation only.

If the conductor is connected to an earthing terminal, the free wire shall not touch any live part.

4. Physical Requirements

4.1 Not used.

4.2 Mechanical Strength and Stress Relief

4.2.1

Enclosures, where provided, shall have adequate mechanical strength and shall be so constructed as to withstand such rough handling as may be expected during normal handling and installation.

Note: Acceptance criteria are given in Clause 4.2.7.

4.2.2

Enclosures, if provided, shall be subjected to a steady force of 30 ± 3 N for a period of 5 s applied by means of a straight unjointed version of the test finger (Figure 10), and meet the requirements of Clause 4.2.7.

4.2.3 Not used.

4.2.4 Not used.

4.2.5 Not used.

4.2.6 Not used.

4.2.7

After the test of Clause 4.2.2, the sample shall comply with the requirements of Clauses 2.5.2, 2.9, and 3.2.5, and shall show no signs of interference with the operation of safety features such as thermal cut-outs, overcurrent protection devices, or interlocks. In case of doubt, supplementary or reinforced insulation shall be subjected to an electric strength test as specified in Clause 5.3.2.

Damage to finish, dents, and chips that do not adversely affect safety or protection against water, cracks not visible to the naked eye, and surface cracks in fibre-reinforced mouldings and the like, shall be ignored.

Note: If a separate enclosure or part of an enclosure is used for a test, it may be necessary to reassemble such parts on the power supply in order to check compliance.

4.2.8 Not used.

4.3 Construction Details

4.3.1

For multivoltage power supplies with primary voltage selection means such as switches or tapped transformers, the power supply shall be tested at the worst combination(s) of nominal system voltage applied and voltage selection means. The most unfavourable fuse rating shall be used. *There shall be no shock or fire hazard.*

Compliance is checked by an appropriate test.

4.3.2 Not used.

4.3.3 Not used.

4.3.4

Power supplies employing liquids or gases shall be so constructed as to reduce the risk from dangerous concentration of these materials and to reduce the risk created by condensation, vapourization, leakage, spillage, or corrosion during normal operation, storage, filling, or emptying. In particular, creepage distances and clearances shall not be reduced below the requirements of Clause 2.9.

Compliance is checked by inspection and, where spillage of liquid could affect electrical insulation during replenishment, by the following test.

The power supply shall be ready to use according to its installation instructions, but not energized.

The liquid container of the power supply shall be completely filled with the liquid specified by the manufacturer, and a further quantity, equal to 15% of the capacity of the container, shall be poured in steadily over a period of 1 min. *For liquid containers having a capacity not exceeding* 250 mL, *and for containers without drainage and for which the filling cannot be observed from outside, a further quantity of liquid, equal to the capacity of the container, shall be poured in steadily over a period of* 1 min.

Immediately after this treatment, the power supply shall withstand an electric strength test as specified in Clause 5.3.2 on any insulation on which spillage could have occurred, and inspection shall show that the liquid has not created a hazard within the meaning of this Standard.

The power supply shall be allowed to stand in normal test-room atmosphere for 24 h *before being subjected to any further electrical test.*

4.3.5

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

If handles, knobs, and the like are used to indicate the position of switches or similar components, it shall not be possible to fix them in a wrong position if this might result in a hazard.

Compliance is checked by inspection, by manual test, and by trying to remove the handle, knob, grip, or lever by applying for 1 min *an axial force as follows:*

(a) 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 the operating means of electrical components,*

20 N *in other cases.*

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

30 N *for the operating means of electrical components,*

50 N *in other cases.*

Note: Sealing compounds and the like, other than self-hardening resins, are not considered to be adequate to prevent loosening. A lock washer is considered adequate to prevent loosening.

A switch that meets the following conditions is considered to comply with this requirement:

(a) the switch is to be of a plunger, slide, or other type that does not tend to rotate during intended operation (a toggle switch is considered to be subjected to forces that tend to turn the switch);

(b) the means of mounting the switch is to make it unlikely that operation will loosen the switch;

(c) creepage distances and clearances are not to be reduced below the minimum required values if the switch rotates;

(d) intended operation of the switch is to be by mechanical means rather than by direct contact.

Rotary controls and toggle switches shall be prevented from turning by means other than friction or lock washer.

4.3.6 Not used.

4.3.7

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

Note: A sleeve is considered to be retained by positive means if it can be removed only 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 gap with a width greater than 0.3 mm in supplementary insulation shall not coincide with any such gap in basic insulation, nor shall any such gap in reinforced insulation give straight access to parts at hazardous voltage.

Compliance is checked by inspection and by measurement.

4.3.9

Power supplies 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 the values specified in Clause 2.9.

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

Note: For the purpose of assessing compliance:

(a) it is assumed that two independent fixings will not become loose at the same time;

(b) it is assumed that parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose, provided these screws or nuts are not required to be removed during the replacement of the supply flexible cable or cord;

(c) wires connected by soldering are not considered to be adequately fixed unless they are held in place near to the termination, independently of the soldered connection;

(d) wires connected to terminals are not considered to be adequately secured unless either 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; or the wires are provided with terminators (eg, ring lugs crimped onto the conductors, or the like) which are unlikely to become free;

(e) short rigid wires are not regarded as likely 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 Clause 2.9.

Compliance is checked by inspection and by measurement.

4.3.11

Where internal wiring, windings, commutators, slip-rings, and the like, and insulation in general, are exposed to oil, grease or similar substances, the insulation shall have adequate properties to resist deterioration under these conditions.

Compliance is checked by inspection.

4.3.12 Not used.

4.3.13

Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use if their loosening or failure could affect safety.

Compliance is checked by inspection.

Note: Spring washers and the like may provide satisfactory locking.

4.3.14

Where electrical contact pressure is required, a screw shall engage at least two complete threads into a metal plate or a metal nut or a metal insert. Screws of insulating material shall not be used where electrical connections including protective earthing are involved, nor where their replacement by metal screws could impair supplementary or reinforced insulation. Where screws of insulating material contribute to other safety aspects, they shall be engaged by at least two complete threads.

Compliance is checked by inspection.

4.3.15

Electrical connections shall be so designed that contact pressure is not transmitted through insulating material unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

Compliance is checked by inspection.

4.3.16

The end of a stranded conductor shall not be consolidated by soft soldering at places where the conductor is subject to contact pressure, unless the method of clamping is designed so as to obviate the risk of a bad contact due to cold flow of the solder.

Compliance is checked by inspection.

Notes:

(1) Spring terminals that compensate for the cold flow are deemed to satisfy this requirement.

(2) Preventing the clamping screws from rotating is not considered adequate.

4.3.17

Spaced thread (sheet metal) screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other and are provided with a suitable means of locking.

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

Thread-cutting and spaced thread screws are permitted to provide earthing continuity, but in such cases it shall not be necessary to disturb the connection in normal use and at least two screws shall be used for each connection.

Note: The screws do not need to be adjacent.

Compliance is checked by inspection.

4.3.18 Not used.

4.3.19 Not used.

4.3.20 Not used.

4.3.21 Not used.

4.3.22

Power supplies that, in normal use, contain liquid shall incorporate adequate safeguards against the risk of build-up of excessive pressure.

Compliance is checked by inspection and, if necessary, by an appropriate test.

4.3.23 Not used.

4.3.24

Power supplies employing lithium cells or similar batteries shall be designed to prevent reverse polarity installation of the battery and to prevent forced charge or forced discharge if either would result in a hazard. The short- or open-circuiting of any protective component, one at a time, shall not result in a fire or explosion hazard through the resultant forced discharge or forced charge over an extended period.

Compliance is checked by inspection and test.

4.4 Resistance to Fire

4.4.1 Methods of Achieving Resistance

Notes:

(1) When applying the requirements in this Standard, foamed materials of Class HF-1 are regarded as better than those of Class HF-2, and HF-2 better than HBF.

(2) Similarly, other materials, including rigid (engineering structural) foam, of Classes 5V or V-O are regarded as better than those of Class V-1, V-1 better than V-2, and V-2 better than HB.

This Clause specifies requirements intended to minimize the risk of ignition and the spread of flame, both within the power supply and to the outside. This is achieved as follows:

(a) by avoiding high temperatures where possible, or by shielding or spacing flammable materials from high temperature parts (Clause 4.4.2);

(b) by using materials of low flammability for internal parts (Clause 4.4.3).

Note: *As an alternative to meeting the requirements of Clauses 4.4.2 and 4.4.3, the power supply is considered to provide equivalent protection if it meets the requirements of Clause 5.4.6, Item (c). See also the Note to Clause 5.4.1.*

4.4.2 Minimizing the Risk of Ignition

The risk of ignition due to 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 normal load conditions is less than that necessary to cause ignition of their surroundings or of lubricating materials with which they are likely to come into contact. The limits in Clause 5.1 shall not be exceeded for the surrounding material.

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

Where it is not practical to protect components against overheating under fault conditions, the components shall be mounted on material of flammability Class V-1 (see Clause A6), or better, and shall be separated from less fire-resistant material by at least 13 mm of air.

Notes:

(1) See also Clause 1.5.4.

(2) For component power supplies intended for use in telecommunication equipment where the available power exceeds 15 W, printed wiring boards may be required to be rated V-0 or better.

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

4.4.3 Flammability of Materials and Components

Components and parts inside a fire enclosure shall be so constructed, or shall make use of such materials, that the propagation of fire is minimized.

Except as specified in Clause 1.5.4 and elsewhere in Clause 4.4.3, all materials and components shall have a flammability class of V-2 (see Clause A6) or better, or of HF-2 (see Clause A7) or better.

These flammability requirements need not be applied to materials and components within an enclosure of 0.06 m^3 or less consisting totally of metal and having no ventilation openings, or within a sealed unit containing an inert gas.

Note: Where a relevant CSA component Standard includes flammability requirements, components meeting such requirements are exempted.

4.4.3.1.

A wiring harness shall comprise individual materials which are of flammability Class V-2 or better, or which comply with the flammability requirements of relevant CSA standards. Exempt from this requirement are:

(a) PVC, TFE, PTFE, FEP, and neoprene insulation on wiring;

(b) individual clamps (not including helical wraps or other continuous forms), lacing tape, twine, and cable ties.

Note: Cord anchorage bushings applied over PVC jacketed power supply cords should be of flammability Class HB (see Clause A8), or better.

4.4.3.2

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

4.4.3.3

Air filter assemblies shall be constructed of materials of flammability Class V-2 or better, or of HF-2 or better, except that:

(a) air filter assemblies in closed systems need not comply with this requirement;

Note: A closed system is an air circulating system that, although not necessarily airtight, is not intended to be vented outside the fire enclosure.

(b) air filter frames may be constructed of materials of flammability Class HB, provided that they are separated from electrical parts (other than insulated wires and cables) which under fault conditions are likely to produce a temperature that could cause ignition, by at least 13 mm of air or by a solid barrier of material of flammability Class V-1 or better;

(c) air filter assemblies located external to the fire enclosure may be constructed of materials of flammability Class HB or better, or of flammability Class HBF (see Clause A7) or better.

4.4.3.4.

The following parts are exempt from the requirement for a flammability Class V-2 or HF-2, provided that they are separated from electrical parts (other than insulated wires and cables) which under fault conditions are likely to produce a temperature that could cause ignition, by at least 13 mm of air or by a solid barrier of material of flammability Class V-1 or better:

(a) gears, cams, belts, bearings, and other small parts which would contribute negligible fuel to a fire;

(b) tubing for air or fluid systems, and foamed plastic parts, provided that they are of flammability Class HB or better, or of flammability Class HBF or better.

Integrated circuit packages, transistor packages, optocoupler packages, capacitors, and other small parts are exempt from the flammability Class V-2 requirement if the parts are mounted on material of flammability Class V-1 or better.

Note: In considering how to minimize the propagation of fire and what are small parts, account should be taken of the cumulative effect of small parts when they are adjacent to each other, and also of the possible effect of propagating fire from one part to another.

Compliance with Clause 4.4.3 is checked by inspection and, where necessary, by the appropriate tests of Appendix A.

4.4.4 Not used.

4.4.5 Not used.

4.4.6 Not used.

4.4.7 Not used.

5. Thermal and Electrical Requirements

5.1 Heating

In normal use, a power supply and its component parts shall not attain excessive temperatures.

Compliance is checked by determining and recording the temperature rise of the various parts under the following conditions:

Taking into account the requirements of Clause 1.4.5, the equipment or parts of the equipment shall be operated under normal load as follows:

(a) for continuous operation, until steady conditions are established;

(b) for intermittent operation, until steady conditions are established, the on and off periods being the rated on and off periods;

(c) for short-time operation, for the rated operating time.

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

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

Temperature rises of handles, knobs, grips, and the like shall be determined for all parts which are gripped in normal use and, if of insulating material, to parts in contact with hot metal.

The temperature rise of electrical insulation (other than that of windings), failure of which could cause a hazard, shall be measured on the surface of the insulation at a point close to the heat source.

During the test, thermal cut-outs shall not operate and sealing compound, if any, shall not flow out.

The temperature rises shall not exceed the values shown in Table 13, Parts 1 and 2.

Note: For temperature rise of windings, see Clause 1.4.8.

Table 13
Temperature-Rise Limits
Part 1

Parts	*Maximum temperature rise* K
Insulation, including winding insulation: – *of Class A material* – *of Class B material* – *of Class F material* – *of Class H material*	 75 95 115 140 (see notes(1) and(2))
Synthetic rubber or PVC insulation of internal and external wiring including power supply cords – *without T-marking* – *with T-marking*	 50 T-25
Other thermoplastic insulation	(see note(3))
Terminals, including earthing terminals for external earthing conductors of stationary equipment, unless provided with a non-detachable power supply cord	60
Components	(see Clause 1.5.1)

Notes:
(1) When temperature rises of windings are determined by thermocouples, these figures are reduced by 10 K, except in the case of motors.
(2) The classification of insulating material is in accordance with IEC Publication 85.
(3) Due to their wide variety, it is not possible to specify permissible temperature rises for thermoplastic materials; these should withstand the tests specified in Clause 5.4.10.
Consideration should be given to the fact that, on a long-term basis, the electrical and mechanical properties of certain insulating materials may be adversely affected, eg, by softeners evaporating at temperatures below their normal softening temperature.

Table 13
Temperature-Rise Limits
Part 2

External parts	Maximum temperature rise K		
	Metal	Glass, porcelain vitreous material	Plastic [5] rubber
Outer surface of equipment which may be touched [4]	45	55	70
Handles, knobs, grips, etc. held or touched for short periods only	35	45	60
Handles, knobs, grips, etc. continuously held in normal use	30	40	50

(4) For areas having no dimension exceeding 50 mm and which are not likely to be touched in normal use, temperature rises up to 75 K are allowed.
(5) For each material, account should be taken of data for that material to determine the appropriate maximum temperature rise.

5.2 Earth Leakage Current

5.2.1

Power supplies intended to be connected to TT or TN power systems shall comply with the requirements in Clauses 5.2.2 to 5.2.5. Power supplies intended to be connected directly to IT power systems shall comply with the requirements in Appendix G.

5.2.2

Power supplies shall not have earth leakage current in excess of the values in Table 14 when measured as defined in Clauses 5.2.3 or 5.2.4.

Note: The power supply is to be at normal operating temperature when the leakage current tests are performed.

Table 14
Maximum Earth Leakage Current

Class	Type of equipment	Maximum leakage current mA
II	All	0.25
I	Hand-held	0.75
I	Movable (other than hand-held)	3.5
I	Stationary, pluggable Type A	3.5
I	Stationary, permanently connected or pluggable Type B:	
	– not subject to the conditions in Clause 5.2.5	3.5
	– subject to the conditions in Clause 5.2.5	5% of input current

Systems of interconnected power supplies with individual connections to primary power shall have each power supply tested separately. Systems of interconnected power supplies with one common connection to primary power shall be treated as a single power supply.

Power supplies designed for multiple (redundant) connection to primary power shall be tested with only one connection at a time to primary power.

Where, from a study of the circuit diagrams of Class I power supplies intended to be permanently connected or pluggable power supplies Type B, it is clear that earth leakage current will exceed 3.5 mA but will not exceed 5% of the input current, the tests need not be made.

Compliance is checked by the following tests, 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 power supply 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 power supply being at a hazardous voltage.

For power supplies intended for use with Class II equipment, the test shall be made on conductive parts, and to metal foil with an area not exceeding 10 cm x 20 cm *on accessible nonconductive parts. The metal foil shall have the largest possible part of its area on the surface under test, without exceeding the dimensions specified. If its area is smaller than the surface under test, it shall be moved so as to test all parts of the surface. Precautions shall be taken to avoid the metal foil affecting the heat dissipation of the power supply.*

Note: Where it is inconvenient to test power supplies at the most unfavourable supply voltage (see Clause 1.4.5), it is acceptable to test at any available voltage within the rated voltage range or within the tolerance of rated voltage, and then calculate the results.

5.2.3

Single-phase power supplies intended for operation between one phase conductor and neutral shall be tested using the circuit of Figure 7, with the selector switch in each of the positions 1 and 2.

For each position of the selector switch, any switches within the power supplies controlling primary power and likely to be operated in normal use shall be opened and closed in all possible combinations.

None of the current values shall exceed the relevant limit specified in Table 14.

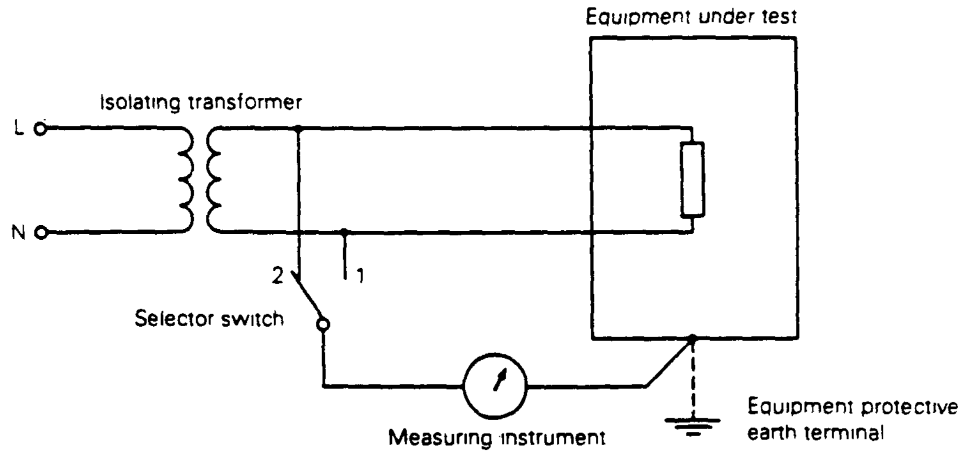


Figure 7
Test Circuit for Earth Leakage Current on Single-Phase Power Supplies

5.2.4

Three-phase power supplies and power supplies intended for operation between two phase conductors shall be tested using the circuit of Figure 8. During the test, any switches within the power supply controlling primary power and likely to be operated in normal use shall be opened and closed in all possible combinations.

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.

Note: 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 shall be repeated.

None of the current values shall exceed the relevant limit specified in Table 14.

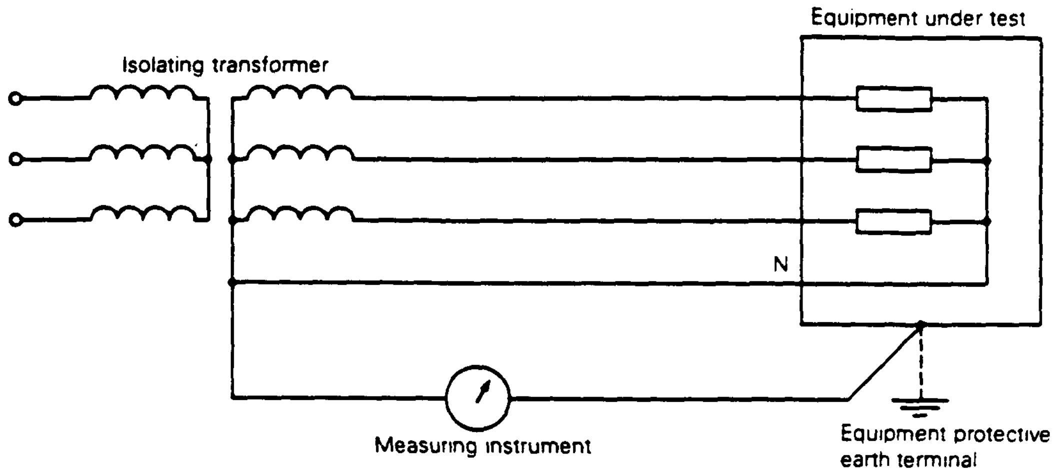


Figure 8
Test Circuit for Earth Leakage Current on Three-Phase Power Supplies

5.2.5

Power supplies, other than those intended to be pluggable Type A, may have earth leakage current exceeding 3.5 mA subject to the following conditions:
(a) leakage current shall not exceed 5% of the input current per phase. Where the load is unbalanced, the largest of the three-phase currents shall be used for this calculation. Where necessary, the tests in Clauses 5.2.3 and 5.2.4 shall be used but with a measuring instrument of negligible impedance;
(b) the cross-sectional area of the internal protective conductor shall be not less than 1.0 mm^2 in the path of high leakage current; and
(c) a label bearing the following warning, or similar wording, shall be affixed adjacent to the equipment primary power connection:

HIGH LEAKAGE CURRENT
Earth connection essential before connecting supply

and

COURANT DE FUITE ÉLEVÉ
Raccordement à la terre indispensable avant le raccordement au réseau.

5.3 Electric Strength

5.3.1

The electric strength of the insulating materials used within the power supply shall be adequate.
Compliance is checked by testing the power supply in accordance with Clause 5.3.2, or, for safety isolating transformers, in accordance with Clause C2 while the equipment is still in a well-heated condition immediately following the heating test as specified in Clause 5.1.

Note: In order to facilitate electric strength testing, components and subassemblies may be tested separately. In such a case, the components and subassemblies should be in a well-heated condition by simulating the heating test prior to the electric strength test.

5.3.2

The insulation shall be subjected for 1 min *either to a voltage of substantially sine-wave form having a frequency of* 50 Hz *or* 60 Hz *or to a dc voltage equal to the peak voltage of the prescribed ac test voltage.*

Test voltages shall be as specified in Table 15 for the appropriate grade of insulation (operational, basic, supplementary, or reinforced) and the working voltage, U, as specified in Clause 2.2.7, across the insulation.

Table 15 (Part 1)
Test Voltage for Electric Strength Tests

	Test voltage V (in volts, r.m.s.) Points of application (as appropriate)						
	Primary to body Primary to secondary Between parts in primary circuits					*Secondary to body Between independent secondaries (see condition 3)*	
Working voltage / *Grade of insulation*	*$U \leq 130$ V r.m.s.*	*130 V $< U \leq 250$ V r.m.s.*	*$250 < U \leq 1000$ V r.m.s.*	*1 kV $< U \leq 7$ kV r.m.s.*	*7 kV $< U \leq 35$ kV r.m.s.*	*$U \leq 42.4$ V peak, or 60 V d.c.*	*42.4 V or 60 V d.c. $< U \leq 7$ kV r.m.s.*
Operational (see condition 1)	*1000*	*1500*	*see Va in Table 15 Part 2*	*see Va in Table 15 Part 2*	*1.5 U*	*500*	*see Va in Table 15 Part 2*
Basic. Supplimentary	*1000*	*1500*	*see Va in Table 15 Part 2*	*see Va in Table 15 Part 2*	*1.5 U*	*No test*	*see Va in Table 15 Part 2*
Reinforced	*2000*	*3000*	*3000*	*see Vb in Table 15 Part 2*	*1.5 U*	*No test*	*see Vb in Table 15 Part 2*

Conditions Applicable to Table 15

1. In general, no test is applied to operational insulation, unless option (b) of Clause 5.4.4 has been selected.
2. The test voltages are for application to solid insulation at any altitude. For clearances the voltages may be reduced for altitude by the following multipliers:

Altitude (m)	Sea level (0)	500	1000	2000
Coefficient	1	0.94	0.89	0.79

3. For working voltages exceeding 7 kV in secondary circuits, the same values as for primary circuits shall apply.

Table 15 (Part 2)
Test Voltages* for Electric Strength Tests (in Volts, rms)

U	Va	Vb	*U*	Va	Vb	*U*	Va	Vb
24	500	800	218	1 391	2 226	1 652	3 959	3 959
25	510	815	227	1 418	2 268	1 701	4 037	4 037
26	519	830	237	1 446	2 314	1 751	4 117	4 117
27	528	845	247	1 474	2 359	1 803	4 199	4 199
28	537	859	257	1 502	2 403	1 856	4 283	4 283
29	546	873	268	1 531	2 450	1 912	4 369	4 369
30	558	887	280	1 563	2 500	1 968	4 455	4 455
31	563	901	292	1 593	2 549	2 026	4 544	4 544
32	571	914	305	1 626	2 601	2 087	4 636	4 636
33	580	927	319	1 660	2 656	2 149	4 728	4 728
35	596	953	333	1 693	2 709	2 213	4 823	4 823
37	611	978	347	1 726	2 762	2 279	4 920	4 920
39	626	1 002	362	1 760	2 816	2 347	5 018	5 018
41	641	1 026	378	1 796	2 873	2 416	5 118	5 118
43	655	1 048	395	1 833	2 933	2 488	5 220	5 220
45	669	1 071	415	1 875	3 000	2 562	5 325	5 325
47	683	1 093	433	1 913	3 000	2 639	5 432	5 432
49	696	1 114	452	1 951	3 000	2 718	5 541	5 541
51	709	1 135	472	1 991	3 000	2 799	5 652	5 652
53	722	1 155	493	2 031	3 000	2 882	5 765	5 765
55	735	1 175	515	2 073	3 000	2 967	5 880	5 880
58	753	1 205	537	2 114	3 000	3 056	5 998	5 998
61	771	1 233	561	2 157	3 000	3 147	6 118	6 118
64	788	1 261	585	2 199	3 000	3 240	6 240	6 240
67	805	1 288	610	2 242	3 000	3 337	6 365	6 365
70	821	1 314	637	2 288	3 000	3 436	6 492	6 492
73	838	1 340	665	2 334	3 000	3 538	6 622	6 622
76	853	1 365	694	2 381	3 000	3 643	6 754	6 754
79	869	1 390	725	2 429	3 000	3 751	6 889	6 889
82	884	1 414	757	2 478	3 000	3 863	7 027	7 027
86	904	1 446	790	2 528	3 000	3 978	7 168	7 168
90	923	1 477	825	2 579	3 000	4 056	7 311	7 311
94	942	1 507	861	2 631	3 000	4 218	7 457	7 457
98	960	1 536	899	2 684	3 000	4 343	7 606	7 606
102	978	1 565	938	2 738	3 000	4 472	7 758	7 758
107	1 000	1 600	979	2 792	3 000	4 605	7 913	7 913
112	1 000	1 634†	1 000	2 820	3 000	4 742	8 071	8 071
117	1 000	1 668†	1 030	2 877	3 000	4 883	8 232	8 232
122	1 000	1 701†	1 061	2 935	3 000	5 028	8 397	8 397
127	1 000	1 733†	1 096	3 000	3 000	5 178	8 565	8 565
130	1 000	1 751	1 129	3 061	3 061	5 332	8 736	8 736
131	1 099	1 758	1 163	3 123	3 123	5 491	8 911	8 911
137	1 122	1 795	1 197	3 184	3 184	5 654	9 089	9 089
143	1 144	1 831	1 233	3 249	3 249	5 822	9 271	9 271
149	1 166	1 866	1 270	3 314	3 314	5 995	9 456	9 456
155	1 188	1 900	1 308	3 381	3 381	6 173	9 645	9 645
162	1 212	1 940	1 347	3 449	3 449	6 357	9 838	9 838
169	1 236	1 978	1 387	3 518	3 518	6 546	10 035	10 035
176	1 260	2 016	1 428	3 587	3 587	6 741	10 236	10 236
184	1 286	2 058	1 470	3 658	3 659	6 942	10 441	10 441
192	1 312	2 099	1 513	3 730	3 730	7 000	10 500	10 500
200	1 337	2 139	1 558	3 805	3 805			
209	1 364	2 183	1 604	3 880	3 880			

*Interpolation is allowed between adjacent points in this Table.
†At these voltages the values of Vb are determined by the general curve $Vb = 183.2\ U^{0.4638}$ and are not 1.6 Va.

Notes:
(1) Where there are capacitors across the insulation under test (eg, radio frequency filter capacitors), it is recommended that the dc test voltages are used.
(2) Components providing a dc path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices, should be disconnected.

The voltage applied to the insulation on test shall be gradually raised from zero to the prescribed voltage, and held at that value for 60 s.

Note: For production test purposes, the duration of the electric strength test may be reduced to 1 s. Alternative methods of production test are under consideration.

There shall be no insulation breakdown during the test.

Insulation breakdown is considered to have occurred when the current which flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner, ie, the insulation does not restrict the flow of the current. Corona discharge or a single momentary flashover is not regarded as insulation breakdown.

When testing insulation coatings, metal foil shall be pressed against the insulation by means of a sandbag of such a size that pressure is about 0.5 N/cm^2. *This procedure shall be limited to places where the insulation is likely to be weak, for example, where there are sharp metal edges under the insulation. If practicable, insulation linings shall be tested separately. Care shall be taken that the metal foil is so placed that no flashover occurs at the edges of the insulation.*

Notes:
(1) For power supplies incorporating both reinforced insulation and lower grades of insulation, care should be taken that the voltage applied to the reinforced insulation does not overstress basic insulation or supplementary insulation.
(2) Before carrying out these tests, where necessary, integrated circuits and the like in secondary circuits may be disconnected or removed to avoid damage or destruction by capacitive charging currents or other occurrences during this test.
(3) During the tests, equipotential bonding may be used to avoid damage to components and insulation which are not involved in the test.

5.4 Abnormal Operating and Fault Conditions

5.4.1

Power supplies shall be so designed that the risk of fire or electric shock due to mechanical or electrical overload or failure, or due to abnormal operation or careless use, is limited as far as practicable.

After abnormal operation or a fault, the power supply shall not introduce a hazard for an operator within the meaning of this Standard, but it is not required that the power supply should still be in full working order.

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

Compliance is checked by inspection and by the tests of Clause 5.4. If more than one of the tests is applicable to the same power supply, these tests shall be made consecutively. At the start of each test, the power supply shall be operating normally.

If a component or subassembly is so enclosed that short-circuit or disconnection, as specified in this Clause, is not practicable or is difficult to perform without damaging the power supply, the tests may be made on sample parts provided with special connecting leads. If this is not possible or not practical, the component or subassembly as a whole shall withstand the tests.

Note: There are two alternative methods of providing protection against faults that could affect electronic components such as integrated circuits, transistors, thyristors, diodes, resistors, and capacitors. For power supplies with a large number of electronic components, it may be preferable to rely on selection and application of components and materials which minimize the possibility of ignition and spread of flame. The appropriate requirements are detailed in Clauses 4.4.2 and 4.4.3. The alternative method, which may be preferred for equipment with a small quantity of electronic components, is to carry out the simulated fault tests in Clause 5.4.6, Item (c).

5.4.2

Under overload, locked rotor, and other abnormal conditions, motors shall not cause hazard because of excessive temperatures.

Note: Methods of achieving this include the following:

(a) the use of motors which do not overheat under locked-rotor conditions (protection by inherent or external impedance);
(b) the use in secondary circuits of motors which may exceed the permissible temperature limits but which do not create a hazard;
(c) the use of a device responsive to motor current;
(d) the use of an integral thermal cut-out;
(e) the use of a sensing circuit which disconnects power from the motor in a sufficiently short time to prevent overheating if, for example, the motor fails to perform its intended function.

Compliance is checked by the applicable tests of Appendix B.

5.4.3

Transformers shall be protected against overload, for example by:
(a) overcurrent protection;
(b) internal thermal cut-outs;
(c) use of current-limiting transformers.

Compliance is checked by the applicable tests of Clause C1.

5.4.4

For operational insulation, creepage distances and clearances shall satisfy one of the following alternative requirements (a), (b), or (c):
(a) they shall meet the appropriate creepage distance and clearance requirements of Clause 2.9;
(b) they shall withstand the appropriate electric strength tests of Clause 5.3.2;
(c) they shall be short-circuited:
(i) where short-circuiting might cause infringement of the requirements for protection against overheating, except where the insulation affected is of flammability Class V-1 or better;
(ii) where short-circuit might cause infringement of the requirements for protection against electric shock. This includes possible thermal damage to supplementary or reinforced insulation.

The tests for option (c) shall be applied, one at a time, with the power supply operating at rated voltage or at the upper limit of the rated voltage range.

Other faults which are the direct consequence of the deliberate short circuit shall also be taken into account.

5.4.5

In secondary circuits, when a hazard is likely to occur, electromechanical components other than motors shall be checked for compliance with Clause 5.4.1 by applying the following conditions one at a time, either in the power supply or to simulated circuits, with the power supply operating at rated voltage or at the upper limit of the rated voltage range:
(a) mechanical movement shall be locked in the most disadvantageous position while the component is energized normally;
(b) in the case of a component which is normally energized intermittently, a fault shall be simulated in the drive circuit to cause continuous energizing of the component.

5.4.5.1

The duration of each test shall be as follows:
(a) For power supplies or 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 condition, whichever is the shorter;
(b) For other power supplies and components: 5 min *or up to interruption of the circuit due to a failure of the component (eg, burnout) or to other consequences of the simulated fault condition, whichever is the shorter.*

5.4.6

For components and circuits other than those covered by Clauses 5.4.2, 5.4.3, and 5.4.5, compliance is checked by simulating the following conditions:
(a) faults in any components in primary circuits;
(b) faults in any components where failure could adversely affect supplementary or reinforced insulation;
(c) additionally, for power supplies that do not comply with the requirements of Clauses 4.4.2 and 4.4.3, faults in all components;
(d) faults arising from connection of the most unfavourable load impedance to terminals and connectors that deliver power or signal outputs from the power supply, other than mains power outlets (see Clause 5.4.6.1).

Note: Where there are multiple outlets having the same internal circuitry, the test need be made to only one sample outlet.

The power supply, circuit diagrams, and component specifications shall be examined to determine those fault conditions that might reasonably be expected to occur.

Note: Examples are short circuits and open circuits of transistors, diodes, and capacitors (particularly electrolytic capacitors), faults causing continuous dissipation in resistors designed for intermittent dissipation, and internal faults in integrated circuits causing excessive dissipation.

The tests shall be applied one at a time with the power supply operating at rated voltage or at the upper limit of the rated voltage range. Either real or simulated circuits shall be used.

In addition to the compliance criteria given in Clause 5.4.8, temperatures in the transformer supplying the component under test shall not exceed those specified in Table C1, and account shall be taken of the exception detailed there.

5.4.6.1

The power supply shall be operated with its output(s) short-circuited one at a time. The duration of the test depends upon the type of protective device that operates to provide protection and is defined as one of the following:
(a) 24 h *for mechanical and electronic automatic reset devices, or for current-limiting devices;*
(b) 50 cycles for manual reset devices;
(c) one cycle if a fuse or a one-shot thermal protector opens;
(d) until thermal equilibrium is reached, for electronic current-limiting devices.

5.4.6.2

The power supply shall be operated for the duration and at the output current loading specified in Item (a) or in Item (b) below as applicable:
(a) 4 h *at the maximum continuous output permitted by an automatic reset protector, or by a current-limiting device, or by a semiconductor device;*
(b) either
(i) for a fuse or manual reset device it shall be determined from the manufacturer's specification at which value of current, I, the device will open in 1 h. *A similar type of fuse or manual reset shall be selected with a rating equal to or greater than I. With the selected protector in place the output shall be set for the current I for* 1 h; *or*
(ii) 7 h *at 110% of the current rating of the fuse or manual reset device with the protector in place.*

5.4.7 Not used.

5.4.8

During the tests of Clauses 5.4.4, 5.4.5, and 5.4.6
(a) if a fire occurs it shall not propagate beyond the power supply;
(b) the power supply shall not emit molten metal.

The tests are to be conducted with the power supply placed on a white tissue-paper-covered softwood surface. A single layer of cheesecloth is to be draped loosely over the equipment. The power supply is determined not to comply if the cheesecloth or the tissue-paper glows or flames;
(c) there shall be no opening of a trace on the printed wiring board unless the following conditions are met:
(i) the test is conducted three times with no reduction in spacings;
(ii) the test is repeated with the trace replaced by a bare jumper wire to determine the condition that would have occurred if the trace had not opened;
(d) enclosures shall not deform in such a way as to cause noncompliance with Clause 2.9.2.

5.4.8.1

If the power supply does not meet the flammability requirements of Clauses 4.4.2 and 4.4.3, then the temperature rises of insulating materials other than thermoplastic materials shall not exceed 125 K *for Class A,* 150 K *for Class B,* 165 K *for Class F, and* 185 K *for Class H insulations.*

If the failure of the insulation would not result in the exposure to hazardous voltages or hazardous energies, a maximum temperature of 300°C *is acceptable.*

If tests carried out on simulated circuits indicate likely overheating or damage to other parts of the power supply to the extent that safety might be affected, the test shall be repeated in the equipment.

After the tests of Clauses 5.4.4, 5.4.5, and 5.4.6, an electric strength test shall be made if:
(a) 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 Clause 2.9; or
(b) where the insulation involved shows visible signs of damage; or
(c) where the insulation involved cannot be inspected.

This test shall be made as specified in Clause 5.3.2 after the insulation has cooled to room temperature.

5.4.9 Not used.

5.4.10

Thermoplastic parts, on which parts at hazardous voltage are directly mounted, shall be resistant to abnormal heat.

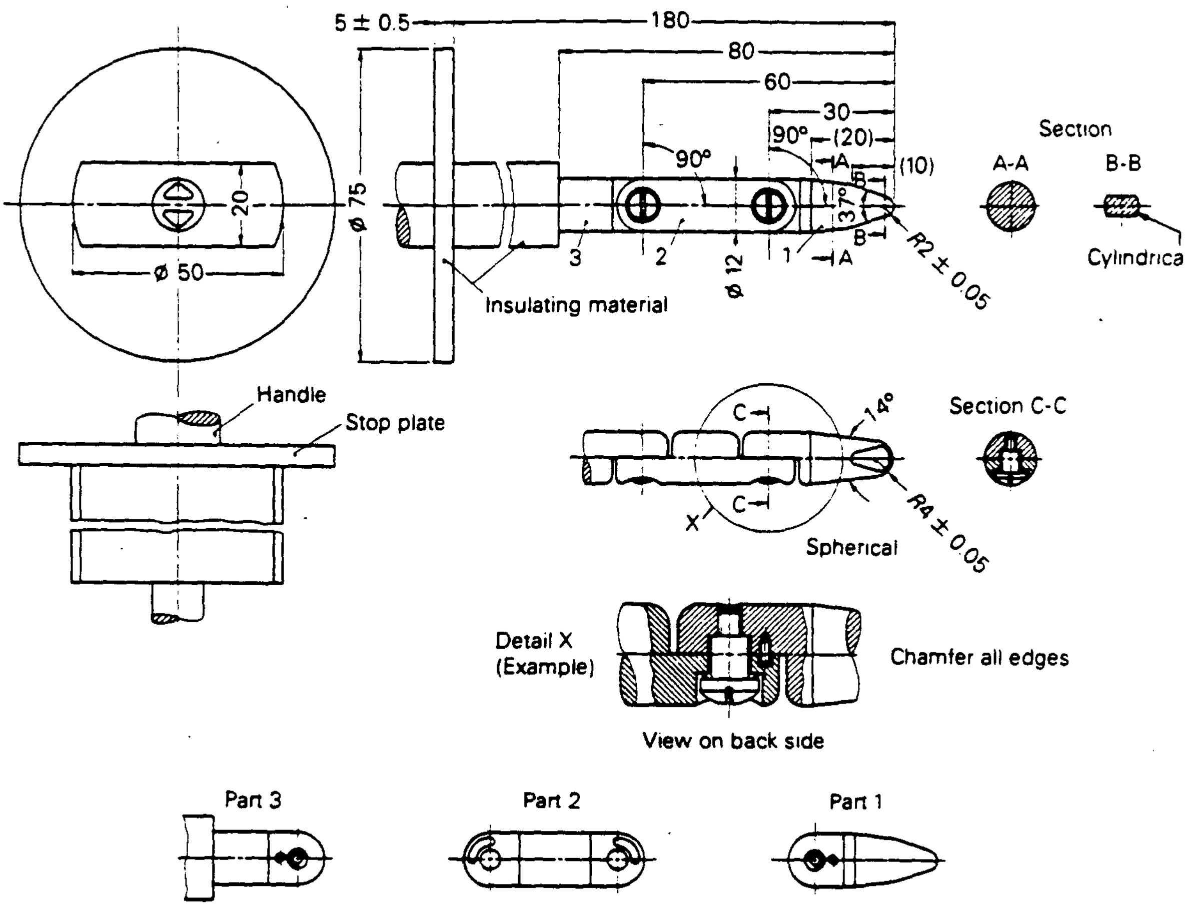
Compliance is checked by subjecting the part to the following ball-pressure test by means of the test apparatus shown in Figure 12.

The surface of the thermoplastic part to be tested shall be placed in a horizontal position and a steel ball 5 mm *in diameter pressed against this surface by a force of* 20 N.

The test shall be made in a heating cabinet at a temperature which is 40 ± 2 K *greater than the maximum temperature rise of the part determined during the test of Clause 5.1. However, a thermoplastic part supporting parts at primary voltage shall be tested at least at* 125°C.

After 1 h, *the ball shall be removed and the sample cooled down to approximately room temperature within* 10 s *by immersion in cold water. The diameter of the impression caused by the ball shall not exceed* 2 mm.

The test shall not be made if it is clear from examination of the physical characteristics of the material that it will meet the requirements of the test.



Linear dimensions in millimetres.

Tolerances on dimensions without specific tolerance:
(a) on angles: +0, −10′
(b) on linear dimensions:
up to 25 mm: +0, −0.05
over 25 mm: ± 0.2

Material of finger: for example, heat-treated steel

Notes:

(1) Both joints of this finger may be bent through an angle of 90°, with a 0 to +10° tolerance, but in one and the same direction only.

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

Figure 10
Test Finger (as in IEC Publication 529, Amendment No. 2)

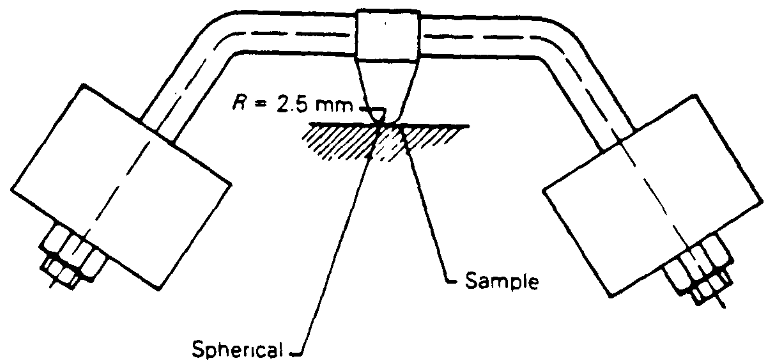


Figure 12
Ball-Pressure Apparatus

Appendix A
Tests for Resistance to Heat and Fire

It should be noted that toxic fumes may be given off during the tests. Where appropriate, the tests should be carried out either under a ventilated hood or in a well-ventilated room, but free from draughts which could invalidate the tests.

Where the tests use a gas flame, technical grade methane with a suitable regulator and meter for gas flow, or natural gas having a calorific value of approximately 37 MJ/m^3, may be used. Technical grade methane has a minimum purity of 98.0 mole % and a typical analysis would be

Methane	98.5 mole %
Ethane	0.5
Nitrogen	0.6
Oxygen	0.1
Carbon dioxide	0.1
Propane	0.1
Higher alkanes	0.1

A1. Not used.

A2. Not used.

A3. High Current Arcing Ignition Test

Materials that withstand 30 electrical arcs without ignition in accordance with the test method in CSA Standard C22.2 No. 0.11, are considered to comply with this test without additional testing.

A3.1

Three samples of each 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 material. Edges shall be free from burrs, fins, etc.*

A3.2

The test shall be made with a pair of test electrodes and a variable inductive impedance load connected in series to a source of 220 V *to* 240 V ac, 50 Hz *or* 60 Hz *(see Figure A1).*

Note: An equivalent circuit may be used.

One electrode shall be stationary and the second movable. The stationary electrode shall consist of 10 mm^2 *solid copper conductor having a horizontal chisel point. The movable electrode shall be a* 3 mm *diameter stainless steel rod with a pyramidal point, and shall be capable of being moved along its own axis. The electrodes shall be located opposing each other, at an angle of* 45° *to the horizontal. With the 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 shall be manually or otherwise 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 approximately* 40 arcs/min, *with a separation speed of* 254 ± 25 mm/s.

The test shall be repeated on the remaining two samples.

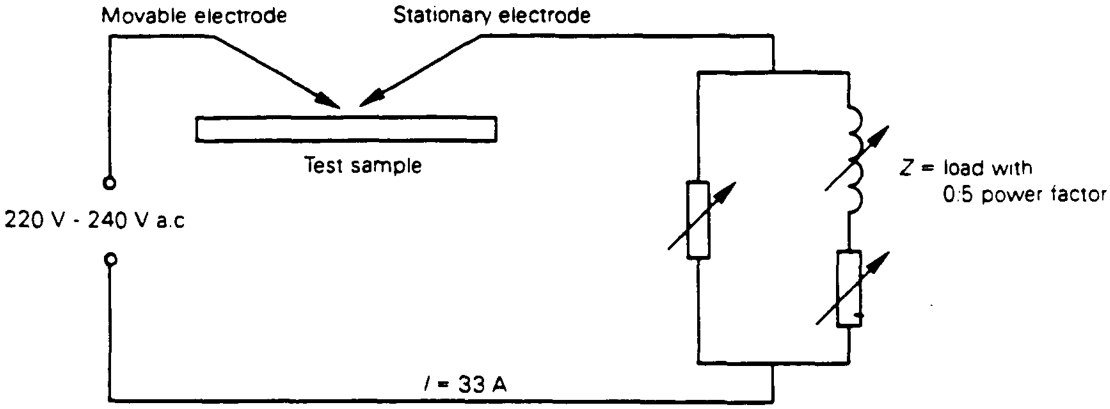


Figure A1
Circuit for High Current Arcing Test

A3.3

Each test sample shall withstand 30 electrical arcs without ignition.

A4. Hot Wire Ignition Test

Material that has a hot-wire ignition rating of 15 s when tested as specified in CSA Standard C22.2 No. 0.6, is considered to comply with this test without additional testing.

A4.1

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 material. Edges shall be free from burrs, fins, etc.*

A4.2

A 200 ± 5 mm *length of nichrome wire (80% nickel, 20% chromium, iron-free) approximately* 0.5 mm *diameter and having a cold resistance of approximately* 5.28 Ω/m *shall be used. The wire shall be connected in a straight length to a variable source of power which is adjusted to cause a power dissipation of* 65 W *in the wire for a period of* 8 s *to* 12 s. *After cooling, the wire shall be wrapped around a sample to form five complete turns spaced* 6 mm *apart.*

A4.3

The wrapped sample shall be supported in a horizontal position and the ends of the wire connected to the variable power source, which is again adjusted to dissipate 65 W *in the wire (see Figure A2).*

The test shall be repeated on the two remaining samples.

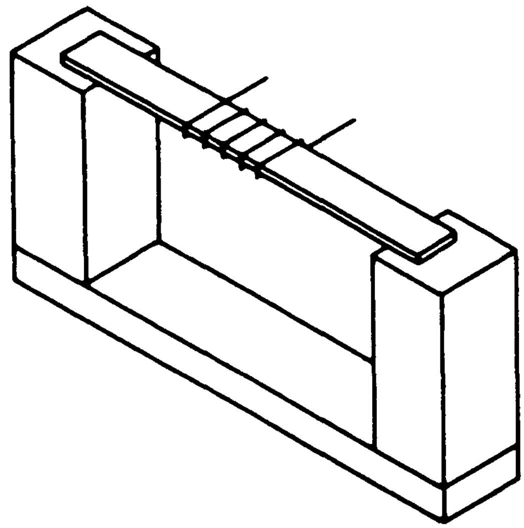


Figure A2
Test Fixture for Hot Wire Ignition Test

A4.4

Each sample shall withstand the test for at least 15 s *without ignition.*

A5. Not used.

A6. Flammability Tests for Classifying Materials V-0, V-1, or V-2

Materials complying with the requirements for V-0, V-1, or V-2 as specified in CSA Standard C22.2 No. 0.6, are considered to comply with the following tests for V-0, V-1, or V-2, respectively.

A6.1

Ten samples of a material or assembly intended to be classified V-0, V-1, or V-2 shall be tested as indicated below.

A6.2

Material test samples shall be approximately 130 mm *long by* 13 mm *wide, and of the smallest thickness used. For sound-deadening materials other than foamed plastic, 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.*

A6.3

Prior to being tested, a set of five samples shall be conditioned in a circulating air oven for 7 d (168 h) *at a uniform temperature of* 70 ± 1°C. *Immediately afterwards, the samples shall be placed in a calcium chloride desiccator for at least* 4 h *to cool to room temperature. The other set of five samples shall be conditioned for* 48 h *at a uniform temperature of* 23 ± 2°C *and a relative humidity between 45% and 55%.*

A6.4

One sample shall be held 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* 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 ± 0.5 mm *and a length of approximately* 100 mm *above the primary air inlets, 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 calorific value 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 approximately* 20 mm.

A6.5

The burner flame shall be moved into position under the sample for 10 s, *and then removed. The duration of any flaming combustion of the sample after removal of the test flame shall not exceed* 10 s *for Class V-0 and* 30 s *for Class V-1 or V-2.*

A6.6

Immediately after flaming of the sample has ceased, the test of Clause A6.5 shall be repeated on the same sample except that, in addition, the duration of any glowing combustion of the sample after the second removal of the test flame shall not exceed 30 s *for Class V-0 and* 60 s *for Classe V-1 or V-2.*

A6.7

The tests of Clauses A6.5 and A6.6 shall be repeated on the four remaining samples of each set.

A6.8

The material is of Class V-2 in the thickness tested if all of the following apply:
(a) each sample passes the tests of Clauses A6.5, A6.6, and A6.7;
(b) the average duration of flaming does not exceed 25 s *for each set of five samples; and*
(c) the material does not continue to burn to the holding clamp.

Note: For Class V-2, ignition of the surgical cotton is permitted to occur.

A6.9

The material is of Class V-1 in the thickness tested if all of the following apply:
(a) each sample passes the tests of Clauses A6.5, A6.6, and A6.7;
(b) the average duration of flaming does not exceed 25 s *for each set of five samples;*
(c) the material does not continue to burn to the holding clamp; and
(d) the surgical cotton is not ignited by any particles or drops released during or after application of the test flame.

A6.10

The material is of Class V-0 in the thickness tested if all of the following apply:
(a) each sample passes the tests in Clauses A6.5, A6.6, and A6.7;
(b) the average duration of flaming does not exceed 5 s *for each set of five samples;*
(c) the material does not continue to burn to the holding clamp; and
(d) the surgical cotton is not ignited by any particles or drops released during or after application of the test flame.

A6.11

If only one sample of a set of five samples fails to comply with the requirements of Clauses A6.5, A6.6, A6.8, A6.9, or A6.10, another set of five samples, subjected to the same conditioning, shall be tested. All samples in this second set shall comply with the appropriate requirements in order for the material in that thickness to be classified V-0, V-1, or V-2.

A7. Flammability Test for Classifying Foamed Materials HF-1, HF-2, or HBF

Materials tested according to the methods specified in CSA Standard C22.2 No. 0.6 are considered to comply with the classification for HF-1, HF-2, or HBF if they meet the requirements specified in Clauses A7.6 to A7.8.

A7.1

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

A7.2

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.*

A7.3

Prior to being tested, five samples (reference A) shall be conditioned in a circulating air oven for 7 d (168 h) *at a uniform temperature of* 70 ± 1°C. *Immediately afterwards, the samples shall be placed in a calcium chloride desiccator for at least* 4 h *to cool to room temperature. Five other samples (reference B) shall be conditioned for* 48 h *at a uniform temperature of* 23 ± 2°C *and a relative humidity between 45% and 55%.*

A7.4

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 ± 0.5 mm, *a length of approximately* 100 mm *above the primary air inlets, and a flame spreader having a width of approximately* 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 calorific value 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 test flame with an overall height of approximately* 38 mm.

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.*

A7.5

During and after the test the following conditions shall apply:

(a) not more than one sample reference A and not more than one sample reference B shall flame longer than 2 s *after removal of the test flame;*

(b) no sample shall flame longer than 10 s *after removal of the test flame;*

(c) no sample shall glow longer than 30 s *after removal of the test flame;*
(d) no sample shall flame or glow for a distance greater than 60 mm *from the end to which the test flame was applied.*

A7.6

The material is of Class HF-2 if it meets the conditions of Clause A7.5.

Note: For Class HF-2, ignition of the surgical cotton is permitted to occur.

A7.7

The material is of Class HF-1 if it meets the conditions of Clause A7.5 and additionally, the cotton is not ignited by any particles or drops released during or after application of the test flame.

A7.8

The material is of Class HBF if, despite failing to meet the conditions of Clause A7.5, all specimens either:
(a) burn at a rate of under 40 mm/min *over a* 100 mm *span, or*
(b) cease to burn before reaching 120 mm *from the end to which the test flame is applied.*

A7.9

If only one sample from a set of five samples has failed to comply with the requirements in Clause A7.8, a second set of five samples, subjected to the same conditioning, shall be tested. All samples from this second set of samples shall comply with the appropriate requirements in Clause A7.8 in order for the material of that thickness and density to be classified HBF.

A7.10

A second set of five samples, subjected to the same conditioning, shall be tested if a set of five samples fails to comply with the requirements of Clauses A7.6 or A7.7 because of one of the following situations:
(a) one sample out of a set of five samples flames for more than 10 s; *a second sample out of the same set may flame for more than* 2 s *but less than* 10 s *as permitted by Clause A7.5; or*
(b) two samples out of a set of five samples flame for more than 2 s *but less than* 10 s; *or*
(c) one sample out of a set of five samples flames or glows for a distance greater than 60 mm *from the end to which the test flame was applied; or*
(d) one sample out of a set of five samples glows for longer than 30 s *after removal of the test flame; or*
(e) for Class HF-1, the cotton is ignited by particles or drops released from one sample out of a set of five samples.

All samples from this second set shall comply with the appropriate requirements in order for the material of that thickness and density to be classified HF-1 or HF-2.

A8. Flammability Test for Classifying Materials HB

Materials complying with the requirements for HB as specified in CSA Standard C22.2 No 0.6, are considered to comply with the following tests for HB.

A8.1

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

A8.2

Material test samples shall be approximately 130 mm *long by* 13 mm *wide, with smooth edges, and of the smallest thickness used or less. For materials used in a thickness greater than* 3 mm, *the samples shall be reduced to* 3 mm *thick. The samples shall be marked across their width with lines at* 25 mm *and* 100 mm *from one end.*

A8.3

Prior to being tested, the samples shall be conditioned for 48 h *at a uniform temperature of* 23 ± 2°C *and a relative humidity between 45% and 55%.*

A8.4

A sample shall be held 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 sheet of steel wire gauze (approximately* 130 mm *square and having eight openings per centimetre) 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 (see Figure A3).*

An unlit Bunsen burner whose barrel has an inside diameter of 9.5 ± 0.5 mm *and a length of approximately* 100 mm *above the primary air inlets 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 calorific value approximately 37 MJ/m^3 *shall be used. When not in proximity to the samples, the burner shall be ignited and adjusted to produce a steady blue flame with an overall height of approximately* 25 mm.

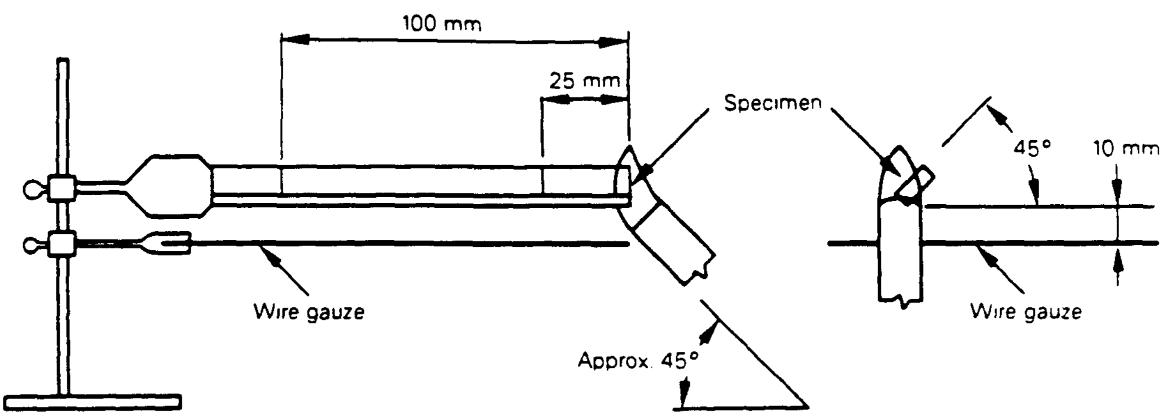


Figure A3
Test Arrangement for Flammability Test for Classifying Materials HB

A8.5

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 at the lower edge of the sample, the rate of progress in millimetres per minute shall be calculated.*

The test shall be repeated on the two remaining samples.

A8.6

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

(a) 40 mm/min *for samples of a thickness of* 3 mm;

(b) 75 mm/min *for samples of a thickness of less than* 3 mm *or if the flaming or glowing does not reach the* 100 mm *reference mark.*

A8.7

If only one sample of a set of three samples does not comply with the requirements in Clause A8.6, another set of three samples shall be tested. All samples of this second set shall comply with the requirements in order for the material in that thickness to be classified HB.

A9. Not used.

Appendix B
Motor Tests Under Abnormal Conditions

Motors complying with the requirements of CSA Standard C22.2 No. 77 are considered to comply with the following requirements, without additional testing.

B1. General Requirements

Motors, other than dc motors in secondary circuits, shall satisfy the tests of Clauses B4 and B5 and, where applicable, Clauses B8, B9, and B10, except that the following motors are not required to satisfy the test of Clause B4:
(a) motors which are used for air-handling only and where the air propelling component is directly coupled to the motor shaft; and
(b) shaded-pole motors which have a difference of not more than 1 A, and a ratio of not more than 2/1, between locked-rotor and no-load currents.

DC motors in secondary circuits shall satisfy the tests of Clauses B6, B7, and B10 except that motors which by their intrinsic operation normally operate under locked-rotor conditions, such as stepper motors, shall not be tested.

B2. Test Conditions

Unless otherwise specified in this Appendix, during the test the equipment shall be operated at rated voltage, or at the highest voltage of the rated voltage range.

The tests shall be carried out either in the equipment or under simulated conditions on the bench. Separate samples may be used for bench tests. Simulated conditions shall include:
(a) any protection devices which would protect the motor in the complete equipment; and
(b) use of any mounting means which may serve as a heat sink to the motor frame.

Temperatures of windings shall be measured as specified in Clause 1.4.8. Where thermocouples are used they shall be applied to the surface of the motor windings. Temperatures shall be 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 cut-outs, motor protection devices, and the like.

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

When motors without inherent thermal protection are tested under simulated conditions on the bench, the measured winding temperature shall be adjusted to take into account the ambient temperature in which the motor is normally located within the equipment as measured during the tests of Clause 5.1.

B3. Maximum Temperatures

For the tests in Clauses B5, B7, B8, and B9 the temperature limits as specified in Table B1, shall not be exceeded for each class of insulating material.

Table B1
Permissible Temperature Limits for Motor Windings (Except for Running Overload Test)

	Maximum temperature °C			
	Class A	Class B	Class F	Class H
Protection by inherent or external impedance	150	175	190	210
Protection by protective device which operates during the first hour	200	225	240	260
Protection by any protective device:				
– maximum after first hour	175	200	215	235
– arithmetic average during the 2nd hour and during the 72nd hour	150	175	190	210

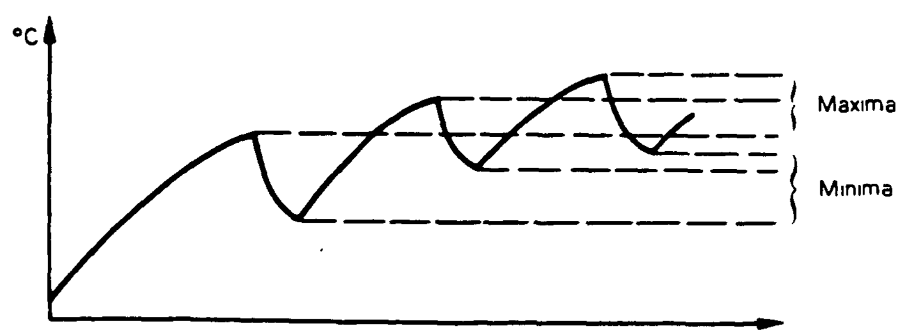
Arithmetic average temperature shall be determined as follows:

The graph of temperature against time, while the power to the motor is cycling on and off, shall be plotted for the period of test under consideration. The arithmetic average temperature (t_A) shall be 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 Clauses B4 and B6 the temperature limits, as specified in Table B2 shall not be exceeded for each class of insulating material.

Table B2
Permissible Temperature Limits for Running Overload Tests

Maximum temperature °C			
Class A	*Class B*	*Class F*	*Class H*
140	*165*	*180*	*200*

B4. Running Overload Test

A running overload protection test shall be carried out by operating the motor under normal load. The load shall then be increased so that the current is increased in appropriate gradual 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 but without reaching locked-rotor condition (see Clause B5) 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 Table B2.

B5. Locked-Rotor Overload Test

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

The duration of the test shall be as follows:

(a) a motor protected by inherent or external impedance shall be operated on locked-rotor for 15 d, *except that testing may be discontinued when the windings of the motor, of either the open or totally enclosed type, reach a constant temperature, provided that the constant temperature is not more than that specified in Clause 5.1 for the insulation system used;*

(b) a motor with an automatic reset protection device shall be cycled on locked-rotor for 18 d*;*

(c) a motor with a manual reset 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 after not less than 30 s*;*

(d) a motor with a nonresettable protection device shall be operated until the device operates.

Temperatures shall be recorded at regular intervals during the first three days for a motor with inherent or external impedance protection or with an automatic reset protection device, or during the first ten cycles for a motor with a manual reset protection device, or at the time of operation of a nonresettable protection device.

The temperatures shall not exceed the values specified in Table B1.

During the test, protection devices shall operate reliably without insulation fault to the motor frame or permanent damage to the motor, including excessive deterioration of the insulation.

Permanent damage to the motor includes:

(a) severe or prolonged smoking or flaming;

(b) electrical or mechanical breakdown of any associated component part such as a capacitor or starting relay;

(c) flaking, embrittlement, or charring of insulation.

Note: Discolouration of the insulation is permitted, but charring or embrittlement to the extent that insulation flakes off or material is removed when the winding is rubbed with the thumb is not acceptable.

After the period specified for temperature measurement, the motor shall withstand the electrical strength test in Clause 5.3.2 after the insulation has cooled to room temperature, but without prior environmental conditioning and with test voltages reduced to 0.6 times the specified values. No further electric strength test is required.

Note: Continuation of the test of an automatic protection device beyond 72 h, 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.

B6. Running Overload Test for DC Motors in Secondary Circuits

The running overload test shall be carried out only if a possibility of an overload occurring is determined by inspection or by review of the design.

Note: An example of a design where the test need not be carried out is where electronic drive circuits maintain a substantially constant drive current.

The test shall be carried out by operating the motor at its working voltage under normal load. The load is then increased so that the current is increased in appropriate gradual 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 either the overload protection device operates or the winding becomes an open circuit.

The motor winding temperatures shall be determined during each steady period and the maximum temperature recorded shall not exceed the value in Table B2, except that where difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the following test may be used instead of temperature measurement.

During the running overload test, the motor shall be covered with a single layer of bleached cotton cheesecloth of approximately 40 g/m^2. *There shall be no ignition of the cheesecloth during the test or at its conclusion.*

Compliance with either method is acceptable; it is not necessary to comply with both methods.

B7. Locked-Rotor Overload Test for DC Motors in Secondary Circuits

B7.1

Motors shall satisfy the test in Clause B7.2, except that where difficulty is experienced in obtaining accurate temperature measurements, due to the small size or unconventional design of the motor, the method of Clause B7.3 may be used instead. Compliance with either method is acceptable; it is not necessary to comply with both methods.

Following the test of Clauses B7.2 or B7.3, as applicable, if the motor working voltage exceeds 42.4 V *peak, or* 60 V dc, *and after the motor has cooled to room temperature, the motor shall withstand the electric strength test in Clause 5.3.2, but without prior environmental conditioning and with test voltages reduced to 0.6 times the specified values.*

B7.2

The motor shall be operated at its working voltage and with its rotor locked for 7 h *or until steady conditions are established, whichever is the longer. Temperatures shall not exceed the values specified in Table B1.*

B7.3

The motor shall be placed on a wooden board which is covered with a single layer of wrapping tissue, and the motor in turn covered with a single layer of bleached cotton cheesecloth of approximately 40 g/m^2.

Note: Wrapping tissue is defined in ISO Standard 4046 as follows: A soft and strong lightweight wrapping paper of grammage generally between 12 g/m^2 and 30 g/m^2, primarily intended for protective packaging of delicate articles and for gift wrapping.

The motor shall then be operated at its working voltage and with the rotor locked for 7 h *or until steady conditions are established, whichever is the longer.*

At the conclusion of the test there shall be no ignition of the wrapping tissue or cheesecloth.

B8. Test for Motors with Capacitors

Motors having phase-shifting capacitors shall be tested under locked-rotor conditions with the capacitor short-circuited or open-circuited (whichever is the more unfavourable).

Note: 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 Table B1.

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

B9. Test for 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.

Note: 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 Table B1.

B10. Test for 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 shall be carried out either in the equipment or under simulated conditions on the bench.

Simulated conditions shall include any protection device which would protect the transformer in the complete equipment.

Note: For the relevant value of working voltage, see Clause 2.2.7.

C1. Overload Test

C1.1

A conventional or safety isolating transformer shall have each secondary winding short-circuited in turn, with the other secondaries loaded to their specified maxima, taking into account the effect of any protection device provided.

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

(a) primary voltage;
(b) input frequency;
(c) loads on other secondaries between zero and their specified maxima.

Where a short-circuit or overload of a secondary winding cannot occur or is unlikely to cause a hazard, this test shall not be made.

C1.2

Maximum temperatures of windings shall not exceed the values in Table C1 when measured as specified in Clause 1.4.8, and determined as specified below:

(a) with external overcurrent protection: at the moment of operation;

Note: For determination of the time until the overcurrent protection operates, a datasheet of the overcurrent protection device manufacturer may be used which shows the trip time versus the current characteristics.

(b) with an automatic reset thermal cut-out: as shown in Table C1 and after 400 h;
(c) with a manual reset thermal cut-out: at the moment of operation;
(d) with current-limiting transformers: after temperature has stabilized.

Table C1
Permissible Temperature Limits of Transformer Windings

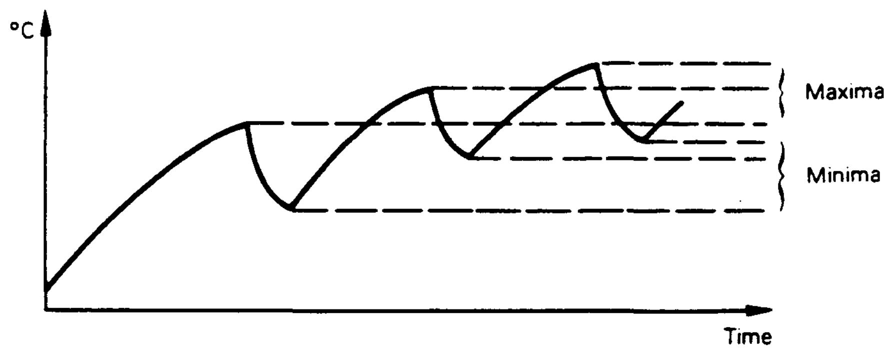
	Maximum temperature, °C			
	Class A	*Class B*	*Class F*	*Class H*
Protection by inherent or external impedance	150	175	190	210
Protection by protective device which operates during the first hour	200	225	240	260
Protection by any protective device -maximum after first hour	175	200	215	235
-arithmetic average during the 2nd hour and during the 72nd hour	150	175	190	210

Arithmetic average temperature shall be determined as follows:

The graph of temperature against time, while the power to the transformer is cycling on and off, shall be plotted for the period of test under consideration. The arithmetic average temperature (t_A) shall be 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



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

C2. Safety Isolating Transformers

Safety isolating transformers shall comply with the following requirements:

Precautions shall be taken to prevent:

(a) displacement of windings or their turns;

(b) displacement of internal wiring or wires for external connections, undue displacement of parts of windings or internal wiring, in the event of rupture of wires adjacent to connections or loosening of the connections;

(c) 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.

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

(a) Windings isolated from each other by placing them on separate limbs of the core, with or without spools.

(b) Windings on a single spool, with a partition wall, of adequate insulating material, whereby the spool and partition wall are pressed or molded 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.

(c) Concentric windings on a spool of insulating material without flanges or on insulation applied in thin sheet form to the transformer iron core.

(d) 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.

(e) 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.

All windings shall have the end turns retained by positive means.

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

If a safety isolating transformer is fitted with an earthed screen for protective purposes, the transformer shall be subject to the test of Clause 2.5.11 between the earthed screen and the earthing terminal of the transformer.

C3. Electric Strength Requirements

Electric strength tests shall be applied in accordance with Clause 5.3 and Table C2, taking into account Figure C1.

Note: In Table C2 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.

When carrying out a test between two points of application, other points may be connected together or to earth.

Table C2
Electric Strength Tests

Grade of insulation	Insulation[1][2][3] between:	and:	Test voltage	Key to Figure C1
1. Operational	SELV winding	– earthed body, core or screen	See note[1]	1a
		– double-insulated body, core or screen		1b
		– any other SELV winding	See note[4]	1c
	ELV winding	– earthed body, core or screen		1d
		– basic-insulated body, core or screen		1e
		– earthed SELV winding		1f
		– another ELV winding		1g
	Earthed hazardous voltage secondary winding	– another earthed hazardous voltage secondary winding		1h
	Between series/parallel sections of a winding			
2. Basic	Mains winding	– hazardous voltage secondary winding	Table 15 Primary Basic	2a
		– ELV winding		2b
		– earthed SELV winding		2c
		– basic-insulated body, core or screen		2d
		– earthed body, core or screen		2e
	Earthed or unearthed hazardous voltage winding	– unearthed hazardous voltage secondary winding	Table 15 Secondary Basic	2f
		– ELV winding		2g
		– earthed SELV winding		2h
		– basic-insulated body, core or screen		2j
		– earthed body, core or screen		2k
3. Supplementary	ELV winding	– double-insulated body, core or screen	Table 15 Supplementary See note[6]	3a
		– unearthed SELV winding		3b
	Basic-insulated body or screen	– double-insulated body, core or screen		3c
		– unearthed SELV winding		3d
4. Supplementary or reinforced	Unearthed hazardous voltage secondary winding	– unearthed SELV winding	See note[5]	4a
		– double-insulated body, core or screen		4b
5. Reinforced	Mains winding	– unearthed SELV winding	Table 15 Primary Reinforced	5a
		– double-insulated body, core or screen		5b
	Earthed hazardous voltage secondary winding	– unearthed SELV winding	Table 15 Secondary reinforced	5c
		– double-insulated body, core or screen		5d

Notes:

(1) The expression "SELV winding" is used as a simplification (for convenience) in Table C2 and should be read as "winding connected in, or to, a SELV circuit". Similarly, "ELV winding" should be read as "winding working at ELV".

(2) Bodies, cores, and screens may have one or two levels of protection from parts at hazardous voltage. If they are protected by double or reinforced insulation, they are termed "double-insulated" in the Table. If they are protected by basic insulation plus protective earthing, they are termed "earthed" in the Table. If they have no second level of protection, they are termed "basic-insulated" and must not be accessible.

(3) In the Table, a part of a winding is termed "unearthed" unless it is connected to a protective earthing terminal or contact in such a way as to meet the requirements in Clause 2.5.11 (though it will not necessarily be at earth potential). An ELV winding is therefore unearthed: an earthed ELV winding would be an SELV winding.

(4) See Clause 5.4.4 for requirements for operational insulation.

(5) Insulation between an unearthed hazardous voltage secondary and an unearthed accessible part or SELV winding has to satisfy the more onerous of the following requirements:

(a) reinforced insulation based on the working voltage equal to the voltage of the hazardous voltage secondary; or

(b) supplementary insulation based on the working voltage equal to the voltage between the hazardous voltage secondary and another hazardous voltage secondary or a mains winding.

Which of these is more onerous will depend on the relative voltages of the windings.

(6) Where unearthed parts of ELV windings are separated from hazardous voltages by basic insulation only, the working voltage of the supplementary insulation between such parts and unearthed accessible parts or SELV windings is the same as the most onerous working voltage for the basic insulation. The most onerous working voltage may be due to a mains primary winding or to a secondary circuit, and the test voltage is selected accordingly.

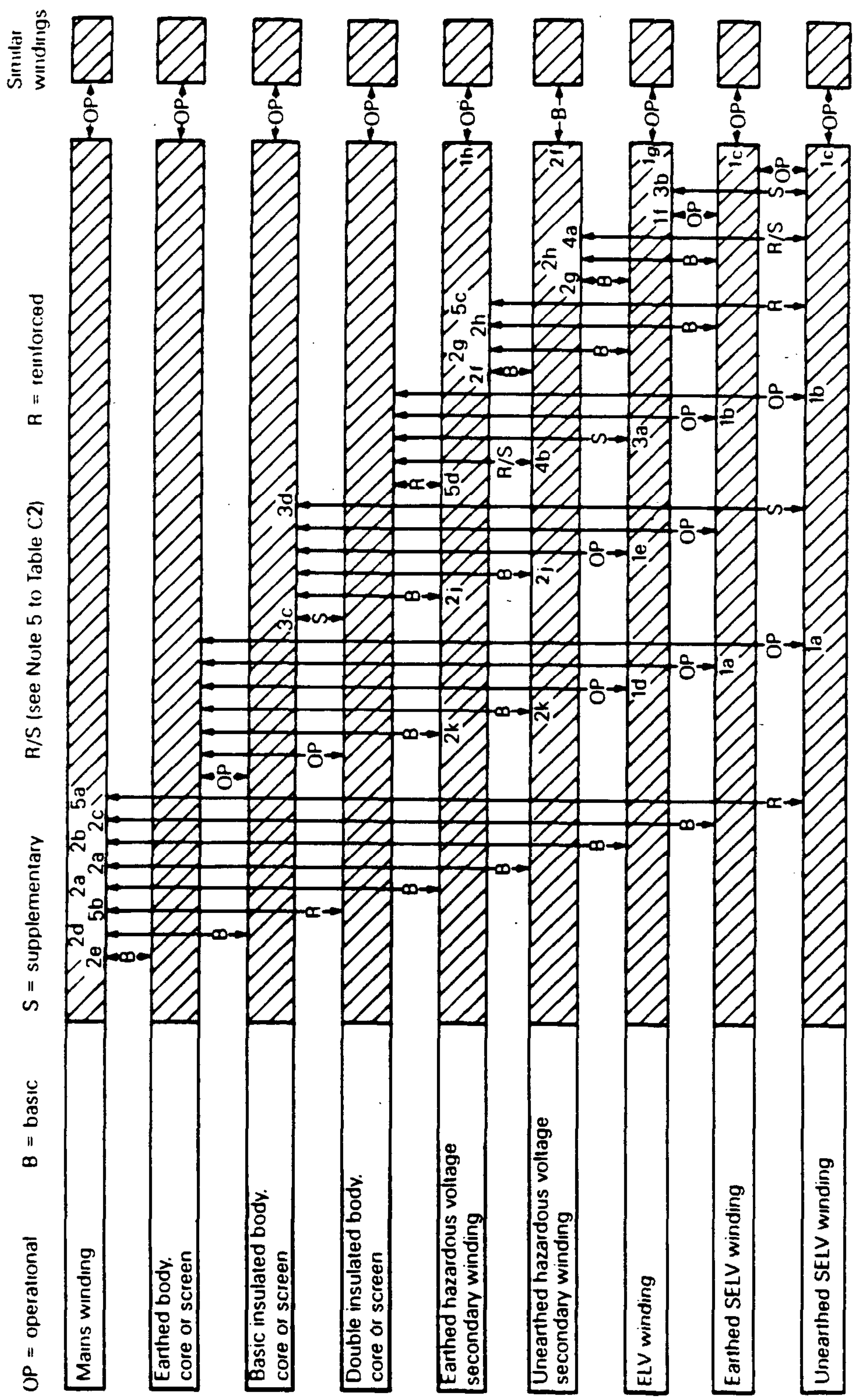
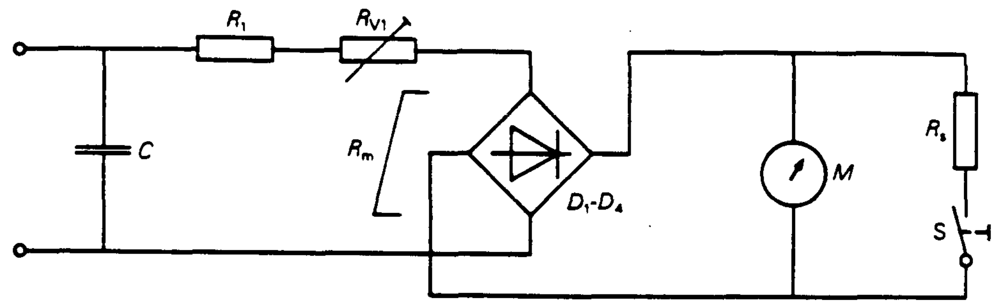


Figure C1
Grades of Insulation in Transformers
(See Table C2 and related notes.)

Appendix D
Measuring Instrument for Earth Leakage Current Test

The instrument shall comprise a rectified/moving coil meter with additional series resistance, the two being shunted by a capacitor, as shown in Figure D1. The effect of the capacitor is to reduce the sensitivity to harmonics and other frequencies above power frequency. The instrument should also include a x 10 range obtained by shunting the meter coil by a noninductive resistor. Overcurrent protection may also be included, provided that the method used does not affect the basic characteristics of the instrument.



where:

M =	0 mA – 1 mA moving coil movement
$R_1 + R_{V1} + R_m$ at 0.5 mA dc =	1500 Ω ± 1% with C* = 150 nF ± 1% or
	2000 Ω ± 1% with C* = 112 nF ± 1%
$D_1 - D_4$ =	Rectifier
R_s =	Noninductive shunt for x 10 range
S =	Sensitivity button (press for maximum sensitivity)

Figure D1
Measuring Instrument for Earth Leakage Current Test

**If the measured current exceeds* 1.0 mA, *the shunt capacitor shown in Figure D1 shall be disconnected and the leakage current measured a second time.*

R_{V1} shall be adjusted for the desired value of total resistance at 0.5 mA dc.

The meter shall be calibrated at the following calibration points on the maximum sensitivity range at 50 Hz–60 Hz *sinusoidal:*

0.25 mA 0.5 mA 0.75 mA

The following response shall be checked at the 0.5 mA *calibration point as follows:*

Sensitivity at 5 kHz *sinusoidal:* 3.6 mA 5%

Note: Test methods for measurement of leakage current are under consideration.

Appendix E
Temperature Rise of a Winding

The value of the temperature rise (see also CSA Standard C22.2 No. 0) of a winding shall be calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1}(234.5 + t_1) - (t_2 - t_1)$$ *for a copper winding,*

$$\Delta t = \frac{R_2 - R_1}{R_1}(225 + t_1) - (t_2 - t_1)$$ *for an aluminum winding,*

where:

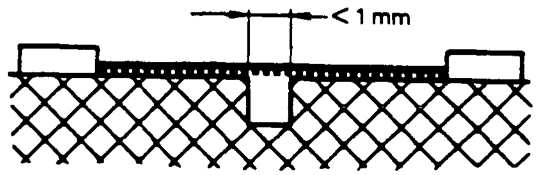
Δt is the temperature rise (K)
R_1 is the resistance at the beginning of the test
R_2 is the resistance at the end of the test
t_1 is the room temperature at the beginning of the test (°C)
t_2 is the room temperature at the end of the test (°C)

At the beginning of the test, the windings shall 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.

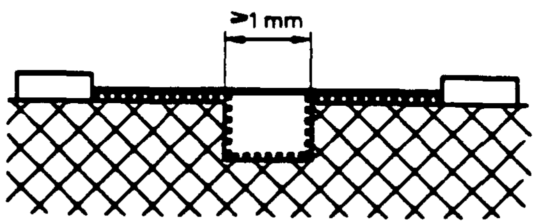
Appendix F
Measurement of Creepage Distances and Clearances

The methods of measuring creepage distances and clearances which are specified in the following Figures F1 to F13 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.

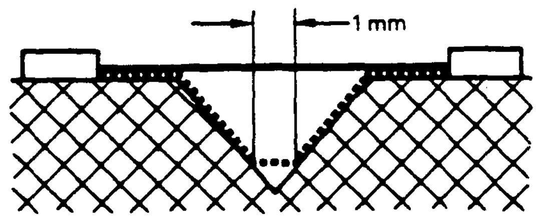
Figure F1



Condition: Path under consideration includes a parallel-sided groove of any depth, and equal to or more than 1 mm wide.
Rule: Clearance is the "line of sight" distance. Creepage distance path follows the contour of the groove.

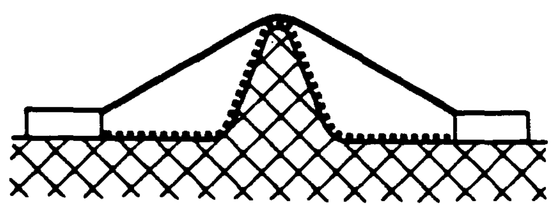
Figure F2

.... Creepage distance
__________ Clearance



Condition: Path under consideration includes a V-shaped groove with internal angle of less than 80° and a width greater than 1 mm.
Rule: Clearance is the "line of sight" distance. Creepage distance path follows the contour of the groove but "short-circuits" the bottom of the groove by a 1 mm (0.25 mm for dirt-free situations) link.

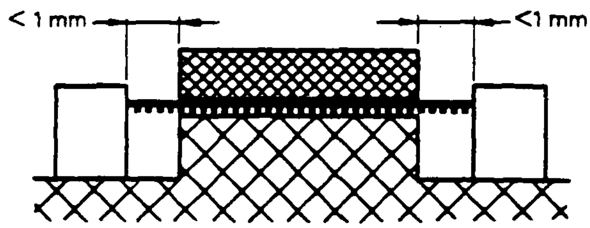
Figure F3



Condition: Path under consideration includes a rib.
Rule: Clearance is the shortest direct air path over the top of the rib. Creepage distance path follows the contour of the rib.

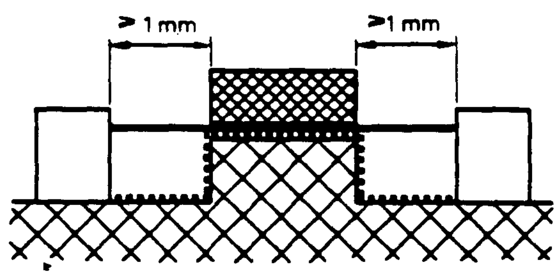
Figure F4

.... Creepage distance
__________ Clearance



Condition: Path under consideration includes an uncemented joint with grooves less than 1 mm (0.25 mm for dirt-free situations) wide on either side.
Rule: Creepage distance and clearance path is the "line of sight" distance shown.

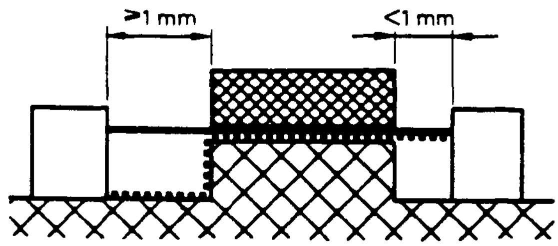
Figure F5



Condition: Path under consideration includes an uncemented joint with a groove 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.

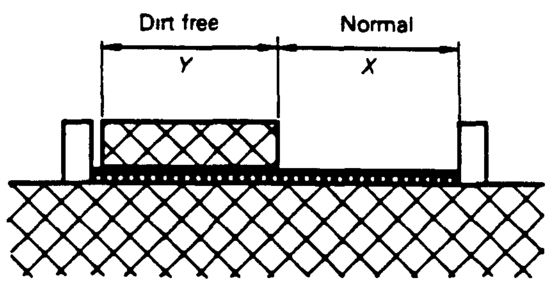
Figure F6

.... Creepage distance
____________ Clearance



Condition: Path under consideration includes an uncemented joint with grooves on one side less than 1 mm wide, and a groove on the other equal to or more than 1 mm wide.
Rule: Clearance and creepage paths are as shown.

Figure F7



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

Figure F8

.... Creepage distance
________ Clearance

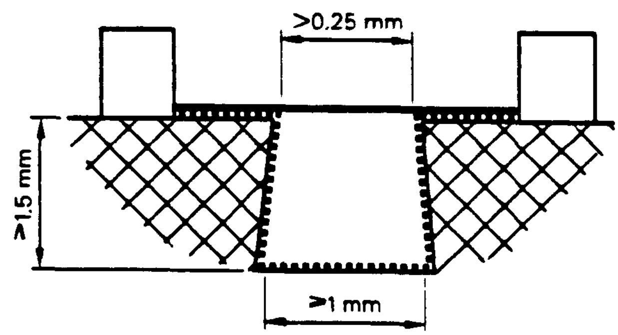
For the requirements of Clause 2.9.3 for a working voltage of 250 V for operational, basic, and supplementary insulation, material group II, the corresponding limiting volts/millimetre are:

Situation	V/mm
Pollution degree 1	150
Pollution degree 2	138
Pollution degree 3	69

The creepage distance in each situation shall be measured and the corresponding voltage computed from the Table above. The sum of these computed voltages shall be not less than the working voltage between the parts concerned.

For example:
Suppose x = 2 mm, then computed voltage = 2 × 69 = 138.
Suppose y = 1 mm, then computed voltage = 1 × 138 = 138.

The sum of these voltages is 276 and thus the example complies with the requirements for a working voltage of 250 V.

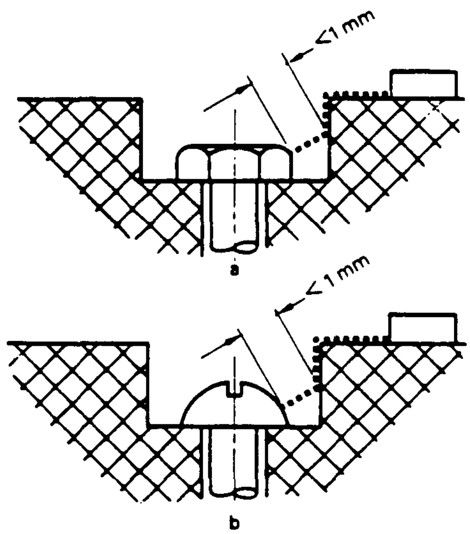


Condition: Path under consideration includes a diverging-sided groove equal to or greater than 1.5 mm deep and greater than 0.25 mm wide at the narrowest part and equal to or greater than 1 mm at the bottom.
Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove.

Note: Figure F3 also applies to the internal corners if they are less than 80°.

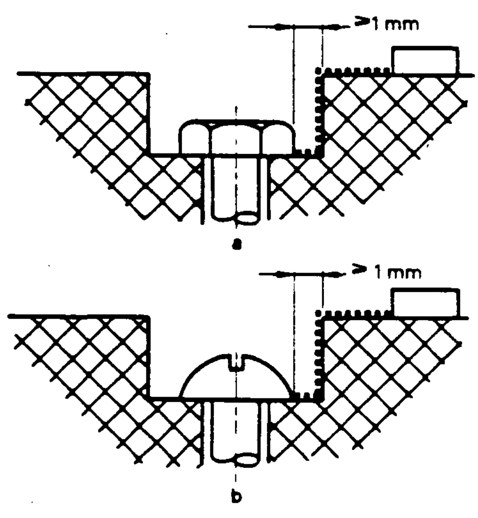
Figure F9

.... Creepage distance
__________ Clearance



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

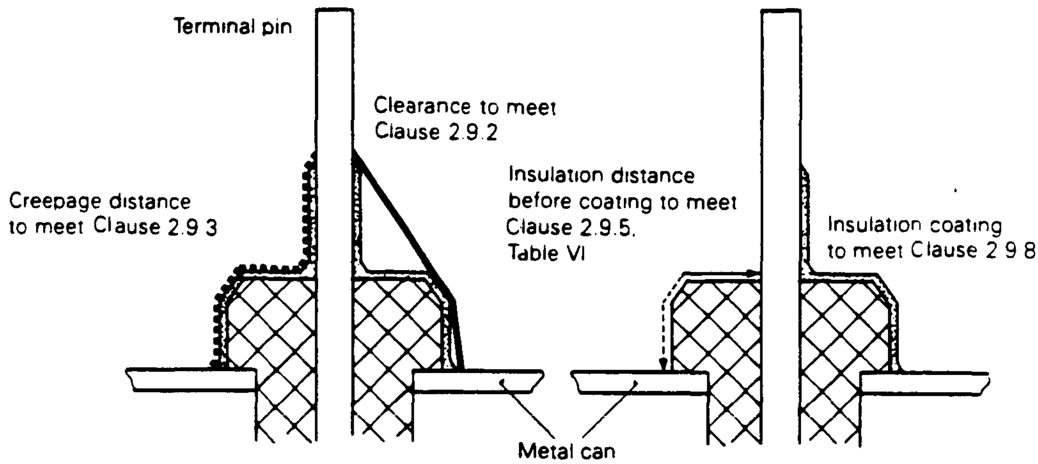
Figure F10



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

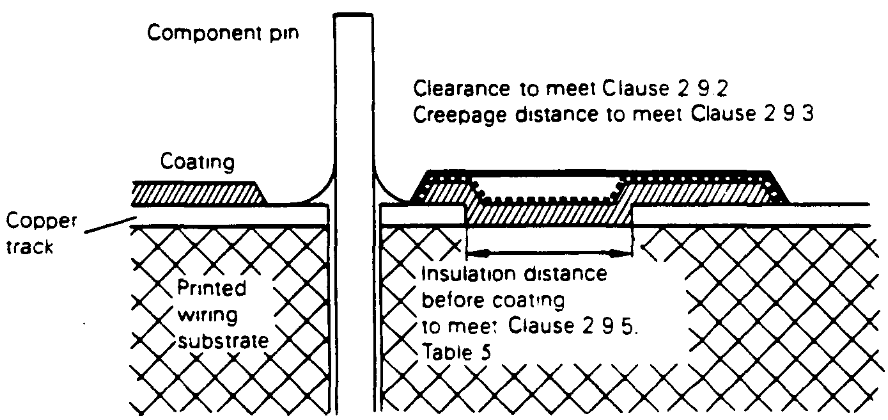
Figure F11

.... Creepage distance



Example of use of coating to increase creepage and clearance around terminal.

Figure F12



Example of use of coating over printed wiring.

Figure F13

.... Creepage distance
____________ Clearance

Appendix G
Earth Leakage Current for Power Supplies Intended to be Connected Directly to IT Power Systems

G1.

This Appendix provisionally covers the requirements for power supplies to be connected directly to IT power systems. Power supplies which meet these requirements will also meet the requirements, specified in Clause 5.2, for connection to TT or TN power systems. Power supplies which are not intended to be connected to IT power systems should be tested according to Clause 5.2, not this Appendix.

Note: On an IT power system, the current which flows through the power supply safety earth conductor when it is correctly connected may be higher than for TT or TN power systems. 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 power supply safety earth conductor.

G2.

Power supplies shall not have earth leakage currents in excess of the values in Table G1 when measured as defined in Clauses G3 or G4.

Table G1
Maximum Earth Leakage Current for Power Supplies Connected to IT Power Systems

Class	*Type of equipment*	*Maximum leakage current (mA)*
II	*All*	*0.25*
I	*Hand-held*	*0.75*
I	*Movable (other than hand-held)*	*3.5*
I	*Stationary, pluggable type A*	*3.5*
I	*Stationary, permanently connected or pluggable type B*	*3.5*
	– not complying with Clause G5	*3.5*
	– complying with Clause G5	*5 % of input current*

Systems of interconnected power supplies with individual connections to primary power shall have each power supply tested separately. Systems of interconnected power supplies with one common connection to primary power shall be treated as a single power supply.

Power supplies designed for multiple (redundant) sources of primary power shall be tested with only one source of primary power connected.

Where, from a study of the circuit diagrams of Class I permanently connected power supplies or pluggable power supplies Type B, it is clear that the earth leakage current will exceed 3.5 mA but will not exceed 5% of input current, the tests need not be made.

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 power supply shall be mounted on an insulating stand, not earthed, and appropriate safety precautions shall be taken in view of the possibility of the body of the power supply being at a hazardous voltage.

For Class II power supplies, the test shall be made to conductive parts, and to metal foil with an area not exceeding 10 cm x 20 cm *on accessible nonconductive parts. The metal foil shall have the largest possible part of its area on the surface under test, without exceeding the dimensions specified. If its area is smaller than the surface under test, it shall be moved so as to test all parts of the surface. Precautions shall be taken to avoid the metal foil affecting the heat dissipation of the power supply.*

Note: Where it is inconvenient to test power supplies at the most unfavourable supply voltage (see Clause 1.4.5), it is acceptable to test at any available voltage within the rated voltage range or within the tolerance of rated voltage, and then calculate the results.

G3. Single-Phase Equipment

G3.1

Single-phase equipment intended for operation between one phase conductor and neutral shall be tested using the circuit of Figure G1 with the selector switch in each of the positions 1, 2, and 3.

G3.2

For each position of the selector switch, any switches within the power supply controlling primary power and likely to be operated in normal use shall be opened and closed in all possible combinations.

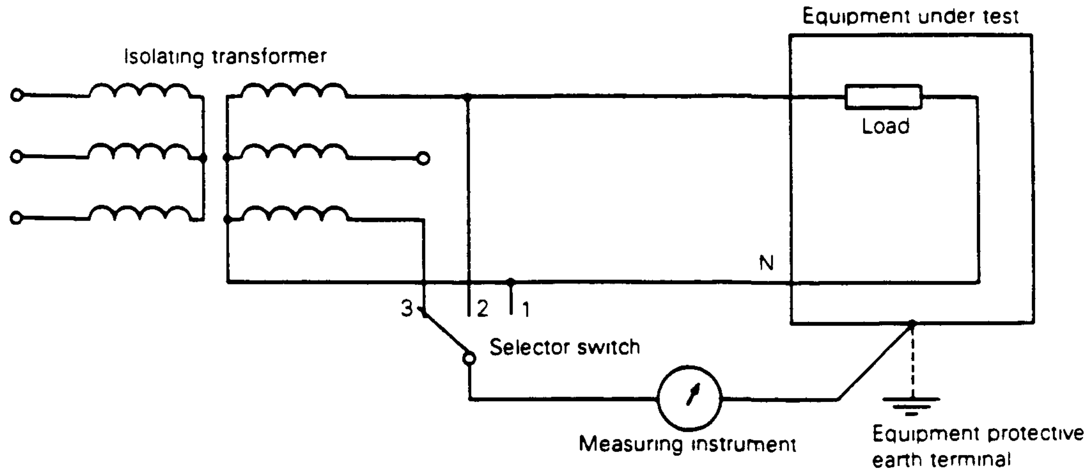


Figure G1
Test Circuit for Earth Leakage Current on
Single-Phase Power Supplies for Connection to IT Power Systems

None of the current values shall exceed the relevant limit specified in Table G1.

G4. Three-Phase Power Supplies

G4.1

Three-phase power supplies and power supplies intended for operation between two phase conductors shall be tested under the following conditions, using the circuit of Figure G2 with the selector switch in each of the positions 1, 2, 3, and 4.

G4.2

For each position of the selector switch, any switches within the power supply controlling primary power and likely to be operated in normal use shall be opened and closed in all possible combinations.

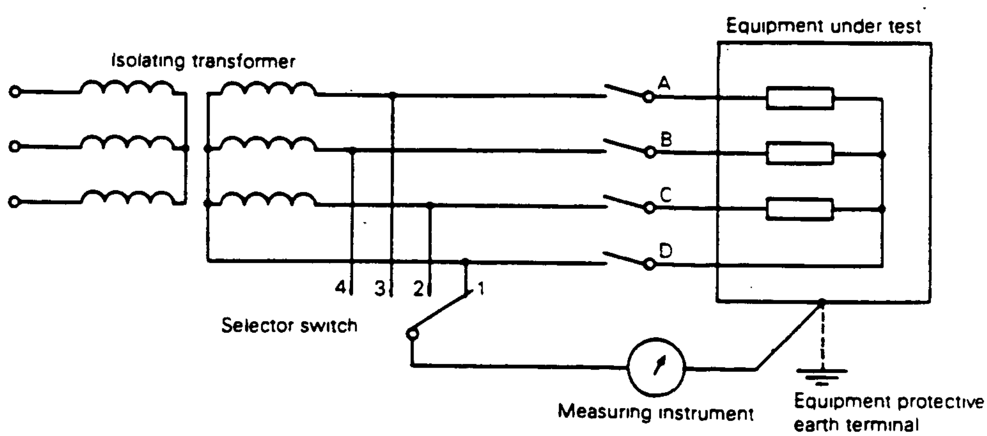


Figure G2
Test for Earth Leakage Current on Three-Phase Power Supplies
for Connection to IT Power Systems

G4.3

Test as in Clause G4.2 and in addition disconnect one at a time any components used for EMI suppression 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 Clause G4.2 shall be repeated.

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

None of the current values shall exceed the relevant limit specified in Table G1.

G5. Power Supply with Earth Leakage Current Exceeding 3.5 mA

A Class I stationary power supply that is permanently connected or that is pluggable Type B, with an earth leakage current exceeding 3.5 mA, shall be subject to the following conditions:

(a) leakage current shall not exceed 5% of the input current per phase. Where the load is unbalanced, the largest of the three phase currents shall be used for this calculation. Where necessary, the tests in Clauses 5.2.3 and 5.2.4 shall be used but with a measuring instrument of negligible impedance;

(b) the cross-sectional area of the internal protective earthing conductor shall be not less than 1.0 mm^2 in the path of high leakage current;

(c) a label bearing the following warning, or similar wording, shall be affixed adjacent to the equipment primary power connection:

HIGH LEAKAGE CURRENT
Earth connection essential before connecting supply

and

COURANT DE FUITE ÉLEVÉ
Raccordement à la terre indispensable avant le raccordement au réseau

or equivalent.

Appendix K
Table of Electrochemical Potentials

Note. – 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, austonitic stainless steel	Ni on steel	Silver	Rh on Ag on Cu, silver/gold alloy	Carbon	Gold, platinum
Magnesium, magnesium alloy	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
Zinc, zinc 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
80 tin/20 Zn on steel, Zn on iron or steel			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
Aluminium				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
Cd on steel					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
Al/Mg alloy						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
Mild steel							0	0.1	0.15	0.2	0.25	0.35	0.45	0.3	0.55	0.7	0.75	0.8	0.85
Duralumin								0	0.05	0.1	0.15	0.25	0.35	0.4	0.45	0.6	0.65	0.7	0.75
Lead									0	0.05	0.1	0.2	0.3	0.35	0.4	0.55	0.6	0.66	0.7
Cr on steel, soft solder										0	0.05	0.15	0.25	0.3	0.35	0.5	0.55	0.6	0.65
Cr on Ni on steel, tin on steel 12% Cr stainless steel											0	0.1	0.2	0.25	0.3	0.45	0.5	0.55	0.6
High Cr stainless steel												0	0.1	0.15	0.2	0.35	0.4	0.45	0.5
Copper, copper alloys													0	0.05	0.1	0.25	0.3	0.35	0.4
Silver solder, austonitic stainless steel														0	0.05	0.2	0.25	0.3	0.35
Ni on steel															0	0.15	0.2	0.25	0.3
Silver																0	0.05	0.1	0.15
Rh on Ag on Cu, silver/gold																	0	0.05	0.1
Carbon																		0	0.05
Gold, platinum																			0

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

Appendix Z
High-Voltage Components and Assemblies

Z1.

The requirements of this Appendix are derived from IEC Publication 65, Clause 14.4.

Note: Where components are part of a range of values it is usually not necessary to test every value within that range. If this range of values consists of several technologically homogeneous subranges, the sample should be representative of each of these subranges. Moreover, it is recommended, where possible, to make use of the concept of structurally similar components.

Z2.

Components operating at peak-to-peak voltages exceeding 4 kV and spark gaps provided to protect against overvoltages in excess of 4 kV under fault conditions shall not give rise to danger of fire to the surroundings of the apparatus, or to any other hazard within the sense of this Standard.

Compliance is checked:

(a) for separate components, by tests of Clauses Z3, Z4, or Z5;

(b) for components incorporated in the power supply, by the test of Clause Z6.

The latter test may also be used where there is doubt of the validity of the results of the tests of Clauses Z3, Z4, or Z5, or, for components not satisfying these tests, when the avoidance of a fire hazard is claimed to be inherent in the method of mounting the components.

Z3. High-Voltage Transformers and Multipliers

Three specimens of the transformer with one or more high-voltage windings or high-voltage multipliers are subjected to the treatment specified under Item (a), followed by the test specified under Item (b).

No failure is allowed.

(a) Preconditioning

For transformers, a power of 10 W *(dc or ac at the frequency of the supply mains) is initially supplied to the high-voltage winding. This power is sustained for* 2 min, *after which it is increased by successive steps of* 10 W *at* 2 min *intervals to* 40 W.

The treatment lasts for 8 min, *or is terminated as soon as interruption of the winding or appreciable splitting of the protective covering occurs.*

The input voltage is adjusted so that the short-circuit current is initially 25 ± 5 mA dc. *This is maintained for* 30 min *or terminated as soon as any interruption of the circuit or appreciable splitting of the protective covering occurs.*

Each specimen is allowed to cool to room temperature and is then placed for 2 h *in an oven having a temperature of* 100 ± 2°C.

Note: Certain transformers are so designed that this preconditioning cannot be carried out. In such cases, only the test of Item (b) of this Clause is applied; in case of doubt, the test of Clause Z6 is also performed.

Where the design of a high-voltage multiplier is such that a short-circuit current of 25 mA cannot be obtained, a preconditioning current is used, which represents the maximum attainable current, determined either by the design of the multiplier or by its conditions of use in a particular apparatus.

(b) Flame Test

The specimen is removed and immediately positioned 20 cm *above a piece of white pine board which is covered with wrapping tissue. Attempts are then made to ignite the high-voltage winding or the multiplier in still air by means of a butane gas flame* 12 ± 2 mm *long from a burner consisting of a tube having a bore of* 0.5 ± 0.1 mm.

The gas flame is applied for 10 s. *If a self-sustaining flame does not last for more than* 30 s, *the gas flame is applied again for* 1 min *at the same point or at any other point. If again, a* *self-sustaining flame does not last for more than* 30 s, *the gas flame is applied again for* 2 min *at the same point or any other point.*

During any of these attempts, a self-sustaining flame shall go out within 30 s, *no burning of the wrapping tissue shall occur and the board shall not scorch.*

Z4. Associated Parts

The gas flame test, as described in Item (b) of Clause Z3, is applied to any insulating part supporting or enclosing a conductive part, whose clearance from a bare conductor at a voltage exceeding 4 kV *is less than D, where D expressed in millimetres is equal to the voltage expressed in kilovolts, with a minimum of* 10 mm.

This test also applies to spark gaps referred to in this Appendix.

Z5. Fusing and Interrupting Devices

Cables subjected to a voltage exceeding 4 kV *under normal operating conditions or under fault conditions are tested with a flame as specified in Item (b) of Clause Z3. The test is made on three specimens taken from each type of cable as used in the apparatus, eg, with additional metal screening and sleeves.*

The specimens are not preheated and the burner is supported so that its axis is at an angle of 45° *to the vertical. The specimen is held at an angle of* 45° *to the vertical, its axis being in a vertical plane perpendicular to the vertical plane containing the axis of the burner.*

The flame shall be applied to each specimen once only, for 10 s, 1 min, *and* 2 min *respectively.*

During this test, any burning of the insulating materials shall be steady and shall not spread appreciably and any flame shall be self-extinguished within 30 s *after removal of the gas flame.*

Z6. Components Tested in the Power Supply

Components operating at a voltage exceeding 4 kV, mounted in an apparatus for which they are designed, are subjected to the following tests.

Z6.1

Resistance to heat is checked under normal operating conditions, the ambient temperature however being between 35°C *and* 40°C.

For a power supply to be used under tropical conditions, the ambient temperature is between 45°C *and* 50°C.

The duration of the test is 4 h.

Note: The test room or cabinet, with the power supply in it, is brought to the temperature mentioned and maintained at that temperature during the test.

After the test, the apparatus shall show no damage within the meaning of this Standard.

At the temperature attained during the test, sealing impregnating compounds shall not become fluid to such a degree that protection against electric shock hazard becomes insufficient.

Note: Components failing during this test due to the ambient temperature being over 35°C or 45°C respectively, may be replaced insofar as their failure does not affect safety.

If a component is very sensitive to heat, it is advisable to carry out the test at a temperature as near as possible to 35°C or 45°C respectively.

If the premature operation of a temperature-limiting device would prevent the test from being carried out, this device is rendered inoperative.

Z6.2

Immediately after the test of Clause Z6.1, the apparatus is placed on a piece of white pine board covered with wrapping tissue paper. With the apparatus in operation, the flame described in Item (b) of Clause Z3 is applied to the high-voltage components (see Clause Z3) and associated parts (see Clause Z4) as follows:

The gas flame is applied for 1 min. *If a self-sustaining flame does not last for more than* 30 s, *the gas flame is applied again for* 1 min *at the same point or at any other point of the same* *component or part. If again, a self-sustaining flame does not last for more than* 30 s, *the gas flame is applied again for* 2 min *at the same point or at any other point of the same component or part.*

If any flame does not last for more than 30 s *after the removal of the gas flame, the component meets the requirement.*

If during any of the above applications of the gas flame, a flame persists for more than 30 s, *any cover is replaced and the top and sides of the apparatus are covered with cotton cheesecloth, while the component is still burning.*

After the flames have been extinguished, the cheesecloth and wrapping tissue shall show no burning or charring.

Note: Bleached cotton cheesecloth running 26 to 28 m^2/kg and having a count of 32 x 28, or any similar material may be used, provided the spacing of the threads is such that free circulation of air is not impeded.

Wrapping tissue, as specified in ISO Standard 4046, may be used where the paper is described: "Thin, soft, relatively tough paper generally intended for packaging delicate articles, its substance being between 12 and 25".

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