UL 745-1

Portable Electric Tools

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UL Standard for Safety for Portable Electric Tools, UL 745-1

Second Edition, Dated June 15, 2007

Summary of Topics

This new Second edition of UL 745-1 was issued to clarify the UL effective date statement shown on the Preface page and to make other administrative changes. The technical content of the First edition has reproduced verbatim in this edition; the text of the standard has not been changed.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL and CSA are committed to updating this IEC-based binational standard jointly. However, this Second edition dated June 15, 2007will not be issued by CSA since it addresses UL only administrative changes.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

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

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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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

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

Page	Date
1-132	June 15, 2007

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CAN/CSA-C22.2 No. 745-1
First Edition

Underwriters Laboratories Inc.
UL 745-1
Second Edition

Portable Electric Tools

June 15, 2007

Approved
by
Standards Council
of Canada

Commitment for Amendments

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

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Preface

This is the common CSA and UL Standard for portable electric tools. It is the first edition of CSA Standard C22.2 No. 745-1, *Safety of portable electric tools Part 1: General requirements* and UL 745-1 , *Safety of portable electric tools Part 1: General requirements*. It is written in SI (metric) units.

This Standard was prepared by Canadian Standards Association and Underwriters Laboratories Inc. This common CSA and UL Standard is based on IEC Publication 745-1(1982) *Safety of hand-held motor-operated electric tools Part 1: General requirements*. Where Canadian and US deviations have necessitated the deletion of IEC Publication 745-1 text, the IEC text has been retained but has been over-stricken to indicate it as nonmandatory. Text added to IEC Publication 745-1 as mandatory has been underlined including, where feasible, Tables and Figures.

This Standard contains general requirements and is intended to be used in conjunction with the appropriate particular requirements Standard (if available), which contains Clauses to supplement or modify the corresponding Clauses in the general requirements Standard, to provide the relevant requirements for each type of product.

If the functions of a tool are covered by different particular Standards, the relevant particular requirements Standard is applied to each function separately, so far as is reasonable. If applicable, the influence of one function on the other is taken into account.

This Standard was reviewed by the CSA Subcommittee on Portable Electric Tools 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.

This Standard was processed and reviewed in accordance with the method of development, revision and implementation of UL Standards for safety.

This Standard has been approved by the Standards Council of Canada as a National Standard of Canada.

UL Effective Date

The effective date for UL 745-1 is the date of publication.

When requested by the manufacturer in writing, products may be evaluated to UL 45 until June 1, 2007.

CSA Effective Date

The effective date for CSA will be announced through a *CSA Certification Notice*.

> **Note:** *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 users of the Standard to judge its suitability for their particular purpose.*

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

1 Scope

1.1 This standard applies to ~~hand-held~~ portable electric motor-operated or magnetically-driven tools, intended for indoor or outdoor use, in non-hazardous locations, in accordance with the Canadian Electric Code, Part 1 and the National Electrical Code (NFPA70). It applies to tools rated not more than 440V (not more than 250V for tools employing a universal motor).

~~Hand-held electric motor-operated tools, hereinafter referred to as tools, which can be mounted on a support for use as fixed tools without any alteration of the tool itself, are within the scope of this standard.~~

Tools with an electric heating element incorporated are within the scope of this standard~~, but such tools should also comply with IEC publication 335-1 : Safety of Household and Similar Electric Appliances, Part 1: General Requirements, as far as it reasonably applies~~.

Special requirements for battery-powered tools ~~will be determined in Part 2. Requirements concerning mechanical safety, however, will also apply for these tools~~ are defined in UL 745-3 and C22.2 No. 745-3.

~~Special requirements for exchange type tools (see definition 2.2(16)) are under consideration. Moreover, the requirements of this standard apply where appropriate.~~

For tools intended to be used on board ships or aircraft, additional requirements may be necessary, and in hazardous locations, for example, where explosions are liable to occur, special constructions may be required.

For tools intended to be used in tropical countries, special requirements may be necessary.

This standard applies to accessories and mechanical attachments for use with portable electric tools. These requirements are outlined in Appendix F.

This standard applies to attachments that contain electrical and electronic components. In this case, the attachment shall be evaluated with the tool and a determination must be made as to which clauses apply.

This Standard applies to, but the scope is not limited to: hand tools, such as drills, screwdrivers, nut runners, tappers, hammers, impact wrenches, saws, sanders, polishers, buffers, shears, nibblers, grinders, staplers, valve seat grinders and lappers, cylinder borers, and concrete vibrators; transportable tools, such as diamond core drills, drain cleaners, magnetic drills presses, pipe threaders, and pipe benders.

This standard does not apply to fixed or stationary electric tools, gardening appliances, garage equipment, soldering irons or guns, painting equipment, floor-finishing machines, heat guns, or other equipment covered by individual requirements.

Covered within this standard are Class I, II, and III tools.

1.2 This standard is concerned with safety and takes into account the influence on safety of components necessary to achieve a ~~required~~ degree of radio and television interference suppression.

2 Definitions

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

2.1.1 Where in this standard the expressions ″With the aid of a tool,″ ″Without the aid of a tool,″ and ″requires the use of a tool″ occur, the word ″tool″ means a screwdriver, a coin or any other object which may be used to operate a screw or similar fixing means.

2.2 The following definitions apply for the purpose of this standard:

Rated voltage: denotes the voltage (for three-phase supply, the voltage between phases) assigned to the tool by the manufacturer.

Rated voltage range: denotes the voltage range assigned to the tool by the manufacturer, expressed by its lower and upper limits.

Working voltage: denotes the maximum voltage to which the part under consideration can be subjected when the tool is operating at its rated voltage and under normal conditions of use.

Normal conditions of use include changes of voltage within the tool imposed by likely occurrences such as the operation of a circuit breaker or the failure of a lamp.

When deducing the working voltage, the effect of possible transient voltages on the supply mains is ignored.

Rated input: denotes the input at rated voltage assigned to the tool by the manufacturer.

The term ″input″ refers to input power.

Rated current: denotes the current at rated voltage or at the lower limit of the rated voltage range assigned to the tool by the manufacturer.

If no current is assigned to the tool, the rated current for the purpose of this standard is determined by calculation from the rated input and the rated voltage and/or by measuring the current when the tool is operating at rated voltage under normal load and at normal operating temperature.

Rated frequency: denotes the frequency assigned to the tool by the manufacturer.

Rated frequency range: denotes the frequency range assigned to the tool by tool manufacturer, expressed by its lower and upper limits.

Rated no-load speed: denotes the no-load speed at rated voltage or at the upper limit of the rated voltage range assigned to the tool by the manufacture.

Detachable flexible cable or cord: denotes a flexible cable or cord, for supply or other purposes, intended to be connected to the tool by means of a suitable appliance coupler.

Cord sets are to comply with the applicable standard given in Appendix E ~~covered by IEC Publication 320; Appliance Couplers for Household and Similar General Purposes~~.

Power supply cord: denotes a flexible cable or cord, for supply purposes, fixed to, or assembled with, the tool according to one of the following methods:

type X attachment: which denotes a method of attachment such that the flexible cable or cord can easily be replaced, without the aid of special purpose tools, by a flexible cable or cord not requiring any special preparation;

type M attachment: which denotes a method of attachment such that the flexible cable or cord can easily be replaced, without the aid of special purpose tools, by a special cable or cord with, for example, a molded-on cord guard or crimped terminations;

type Y attachment: which denotes a method of attachment such that the flexible cable or cord can only be replaced with the aid of special purpose tools normally available only to the manufacturer or the manufacturer's ~~his~~ agents;

Type Y attachments may be used either with common flexible cables or cords or with special cables or cords.

type Z attachment: which denotes a method of attachment such that the flexible cable or cord cannot be replaced without breaking or destroying a part of the tool.

Cross-head, slotted-head, torx, socket head, clutch, and roberts tools are not considered special tools. Stiff wire, used to release push-in type terminals, is not precluded by this sub-clause.

Basic insulation: denotes the insulation applied to live parts to provide basic protection against electric shock.

Basic insulation does not necessarily include insulation used exclusively for functional purposes.

Supplementary insulation: denotes an independent insulation applied in addition to the basic insulation, in order to ~~ensure protection against~~ reduce the risk of electric shock in the event of a failure of the basic insulation.

Double insulation: denotes insulation comprising both basic insulation and supplementary insulation.

Reinforced insulation: denotes a single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard.

The term ″insulation system″ does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

Portable Tool: (in this standard abbreviated to ″tool″) denotes a hand-held or transportable tool.

Hand-held tool: ~~(in this standard abbreviated to ″tool″)~~ denotes an electric motor-operated or magnetically-driven machine intended to do mechanical work and so designed that the motor and the machine form an assembly which can easily be brought to the place of operation and which is held by hand or suspended during operation.

Hand-held tools may be provided with a flexible shaft~~, the motor being either fixed or portable~~. Hand-held tools may also have provisions for mounting on a support.

Hand-held tools include also hand-supported tools (such as paving breakers).

Transportable tool: is a tool that is not hand supported during use and which is intended to be taken to the work piece to perform its intended function.

Exchange type tool: denotes a tool which is intended not to be repaired at all, or to be repaired by the manufacturer's service organization only.

Class I tool: denotes a tool in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation in such a way that accessible conductive parts cannot become live in the event of a failure of the basic insulation.

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

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

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

Such a tool may be of one of the following types:

i) a tool having a durable and substantially continuous enclosure of insulating material which envelops all metal parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation; such a tool is called an insulation-encased Class II tool;

ii) a tool having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable; such a tool is called a metal encased Class II appliance;

iii) a tool which is a combination of the types i) and ii).

Class III tool: denotes a tool in which protection against electric shock relies on supply at safety extra-low voltage (SELV) and in which voltages higher than those of SELV are not generated.

~~Tools intended to be operated at safety extra-low voltage and having internal circuits which operate at a voltage other than safety extra-low voltage, are not included in the classification and are subject to additional requirements; these requirements are under consideration.~~

Extra-low voltage: denotes a voltage supplied from a source within the tool and, when the tool is operated at its rated voltage, not exceeding 42 V peak between conductors and between conductors and earth or, for three-phase supply, not exceeding 24 V peak between conductors and neutral, the extra-low voltage circuit being separated from other circuits by basic insulation only.

Safety extra-low voltage: denotes a nominal voltage not exceeding 42 V peak between conductors and between conductors and earth or, for three-phase supply, not exceeding 24 V peak between conductors and neutral, the no-load voltage not exceeding 50 V peak and 29 V peak respectively.

When safety extra-low voltage is obtained from the supply mains, it must be through a safety isolating transformer or a convertor with separate windings.

The voltage limits specified are based on the assumption that the safety isolating transformer is operated at its rated supply voltage.

~~The d.c. value is under consideration.~~

Limitations to voltages lower than 50 V a.c. should be specified in the applicable power unit or transformer standard given in Appendix E ~~particular IEC standards~~, especially when direct contact with live parts is involved.

Separation from the mains by protective impedance is excluded.

Safety isolating transformer: denotes a transformer the input winding of which is electrically separated from the output windings by an insulation at least equivalent to double insulation or reinforced insulation, and which is designed to supply a distribution circuit, a tool or other equipment at safety extra-low voltage.

Normal load: denotes the load to be applied to a tool so that the stress imposed corresponds to that occurring under normal conditions of use, any marking of short-time or intermittent operation being observed and, unless otherwise specified, heating elements, if any, being operated as in normal use.

The normal load is based on the rated voltage or on the upper limit of the rated voltage range.

Rated operating time: denotes the operating time assigned to the tool by the manufacturer.

Continuous operation: denotes operation under normal load for an unlimited period.

Short-time operation: denotes operation under normal load for a specified period, starting from cold, the intervals between each period of operation being sufficient to allow the tool to cool down approximately to room temperature.

Intermittent operation: denotes operation in a series of specified identical cycles, each cycle being composed of a period of operation under normal load followed by a rest period with the tool running idle or switched off.

Non-detachable part: denotes a part which can only be removed with the aid of a tool.

Detachable part: denotes a part which can be removed without the aid of a tool.

Thermal cut-out: denotes a device which, during abnormal operation, limits the temperature of a tool, or parts of it, by automatically opening the circuit or by reducing the current, and which is so constructed that its setting cannot be altered by the user.

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

Creepage distance: denotes the shortest path between two conductive parts, or between a conductive part and the bounding surface of the tool, measured along the surface of the insulating material.

Clearance: denotes the shortest distance between two conductive parts, or between a conductive part and the bounding surface of the tool, measured through air.

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

All-pole disconnection: denotes, for single-phase a.c. tools and for d.c. tools, disconnection of both supply conductors by a single switching action or, for tools to be connected to more than two supply conductors, disconnection of all supply conductors, except the earthed (grounded) conductor, by a

single switching action.

The protective earthing conductor is not a supply conductor.

Accessible part or **Accessible part:** denotes a part or surface which can be touched by means of the standard test finger shown in Figure 1~~, page 122~~. For accessible metal parts, it includes any other metal which is in electrical contact with such parts.

The term **body** includes all accessible metal parts, shafts of handles, knobs, grips and the like and metal foil in contact with all surfaces of insulating material; it does not include inaccessible metal parts.

Watertight tools denotes a tool so constructed that moisture will not enter the tool enclosure under specified test conditions.

Splash-proof tools denotes a tool so constructed or protected that the exposure to a beating rain will not result in the entrance of water into the enclosure under specified test conditions.

A **Type Test** is 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.

Routine Servicing denotes servicing of or replacement of motor brushes or fuses and other service that is recommended in the instruction manual to be performed by the user. It does not include maintenance that the instruction manual recommends be done by authorized service personnel.

Cautionary Markings denote markings required by this standard that are preceded by the signal words CAUTION, WARNING, or DANGER.

Appliance Coupler is a means enabling the connection and disconnection at will of a flexible cable or cord to a tool. It consists of two parts, 1) a connector which is the part integral with the tool, or attached to a flexible cable permanently attached to the tool, and 2) the mating connector which is attached to the power supply cord.

Areas not Protected Against Deposition of Dirt are defined as all points where air drawn through the tool (by the fan) can reach, especially areas where deposits of carbon dust, metal filings, and wood dust occur. The areas of concern are usually around the brush holders and to the rear of the commutator.

3 General requirement

3.1 Tools shall be so designed and constructed that in normal use they function ~~safely so as to cause no danger to persons or surroundings~~ so as to reduce the risk of injury or electric shock ~~even in the event of such careless use as may occur in normal service~~.

~~In general, c~~ Compliance is checked by confirming the tool meets the relevant construction requirements and by carrying out all the relevant tests.

4 General notes on tests

4.1 Tests according to this standard are type tests.

4.2 ~~Unless otherwise specified, the tests are made on a single sample as delivered, which shall withstand all the relevant tests.~~

The recommended sequence of tests is given in Appendix G.

If it is evident from the design of the tool that a particular test is not applicable, this test is not made.

If the tool is designed for different supply voltages, for both a.c. and d.c., for different speeds, etc., ~~more than one sample~~ additional samples may be required.

If the test of Sub-clause 11.6 has to be made, additional samples are required.

If it is necessary to dismantle a Class II tool for the relevant tests, one additional sample is required.

The testing of components may necessitate the submission of additional samples of these components. When the submission of such samples is necessary, they should be submitted together with the tool.

4.3 Unless otherwise specified, ~~the tests are carried out in the order of the clauses of Part I~~ each test may be conducted on a new sample.

Unless otherwise specified, each test is to be conducted only once.

~~If according to Clause 13, the interference levels are to be measured, these measurements will be made immediately after the tests of Clause 8.~~

Before testing is started, the tool is operated at rated voltage or at the lower limit of the rated voltage range in order to verify that it is in working order.

4.4 The tests are carried out with the tool, or any movable part of it, placed in the most unfavorable position which may occur in normal use.

4.5 If the test results are influenced by the temperature of the ambient air, the room temperature is, in general, maintained at 20 ±5°C. If, however, the temperature attained by any part is limited by a temperature sensitive device, or is influenced by the temperature at which a change of state occurs, for example, the temperature of boiling water, the room temperature is, in case of doubt, maintained at 23 ±2°C.

4.6 Tools for a.c. only are tested with a.c. at rated frequency, if marked; those for d.c. only are tested with d.c. and those for a.c./d.c. are tested at the more unfavorable supply.

Tools for a.c. which are not marked with rated frequency or marked with a frequency range of 50 Hz to 60 Hz are tested with either 50 Hz or 60 Hz, whichever is the national frequency.

Tools marked with a rated frequency range other than 50 Hz to 60 Hz are tested at the most unfavorable frequency within the range.

Tools designed for more than one rated voltage are tested at the most unfavorable voltage.

Unless otherwise specified, tools designed for one or more rated voltage ranges are tested at the most unfavorable voltage within the relevant range.

When it is specified, for tools marked with a rated voltage range, that supply voltage is equal to the rated voltage multiplied by a factor, the supply voltage is equal to:

– the upper limit of the rated voltage range multiplied by this factor, if greater than 1.

– the lower limit of the rated voltage range multiplied by this factor, if smaller than 1.

Where reference is made to maximum or minimum rated input, the rated input related to the upper limit or lower limit respectively of the rated voltage range is meant.

When testing tools for d.c. only, the possible influence of polarity on the operation of the tools is taken into consideration.

If the tool is designed for more than one rated voltage or rated voltage range, it may be necessary to make some of the tests at the minimum, the mean and the maximum values of the rated voltage or the rated voltage range in order to establish the most unfavorable voltage.

4.7 Tools for which alternative heating elements or accessories are available are tested in accordance with the relevant section of Part 2, with those elements or accessories which give the most unfavorable results, provided that the elements or accessories used are within the tool manufacturer's specifications.

4.8 If, in normal use, the heating element cannot be operated unless the motor is running, the element is tested with the motor running. If the heating element can be operated without the motor running, the element is tested with or without the motor running, whichever is the more unfavorable. Heating elements incorporated in the tool are connected to a separate supply unless otherwise specified, and tested according to ~~IEC Publication 335-1~~ the standard listed under "Heating Elements" in the Appendix E.

4.9 Unless otherwise specified, tools provided with a regulating device or a similar control~~, other than an electronic speed control,~~ are tested with these controls adjusted to their most unfavorable setting. If the setting can be altered by the user.

If the adjusting means of the control is accessible without the aid of a tool, this sub-clause applies whether the setting can be altered by hand or with the aid of a tool; if the adjusting means is not accessible without the aid of a tool, this sub-clause applies only if the setting can be altered by hand.

Adequate sealing is regarded as preventing alteration of the setting by the user.

4.10 When the conditions of normal load are specified in Part 2, the tool is loaded according to these conditions, irrespective of any marking of short-time or intermittent operation, unless it is evident from the design of the tool that these conditions will not occur in normal use.

When the conditions of normal load are not specified in Part 2, the tool is loaded according to the manufacturer's instructions; in the absence of such instructions, the tool is operated continuously at a load such that rated input is attained.

For accessories performing a function which is within the scope of one of the sections of Part 2, the tests are made in accordance with that section.

For other accessories, the tests are made in accordance with manufacturer's instructions; in the absence of such instructions, the tool is operated continuously at a load such that rated input is attained.

Electronic speed control devices are set for the highest speed.

~~The introduction of tests to be made at other settings is under consideration.~~

4.11 If torque is to be applied, the method of loading is chosen so as to avoid additional stresses, such as those caused by side thrust. Additional loads necessary for the correct operation of the tool are, however, taken into consideration.

4.12 Tools intended to be operated at safety extra-low voltage are tested together with their supply transformer, if this is normally sold with the tool.

4.13 For the purpose of Clauses 8, 15, 23, and 25, parts separated from live parts by double insulation or reinforced insulation are not regarded as likely to become live in the event of an insulation fault; connection of accessible metal parts to an earthing terminal or earthing contact does not remove the necessity for carrying out these tests.

4.14 If Class I tools have accessible conductive parts which are not connected to an earthing terminal and are not separated from live parts by an intermediate metal part which is connected to an earthing terminal, such parts are checked for compliance with the appropriate requirements specified for Class II tools.

4.15 Unless otherwise specified, if Class I or Class II tools have parts operating as safety, extra-low voltage, such parts are checked for compliance with the appropriate requirements specified for Class III tools.

4.16 For tools incorporating electronic circuits, see Appendix B.

4.17 ~~Routine tests are presently under consideration.~~

5 Rating

5.1 The maximum rated voltage is:

250 V for d.c. tools and tools employing universal motors;

440 V for other tools.

50 V for Class III tools~~, the preferred values of the rated voltage are 24 V and 42 V~~.

Compliance is checked by inspection of the marking.

The requirements of this standard are based on the assumption that in normal use the voltage between the supply lines and earth does not exceed ~~254 V~~ 250 V.

6 Classification

Tools are classified:

6.1 According to protection against electric shock:

– Class I tools;

– Class II tools;

– Class III tools.

The class numbers are not intended to reflect the safety level of the tools, but only the means by which the safety is obtained.

6.2 According to degree of protection against moisture:

– ordinary tools;

– splash-proof tools;

– watertight tools.

~~The class numbers are not intended to reflect the safety level of the tools, but only the means by which the safety is obtained.~~

If Class III tools are sold with a separate safety isolating transformer for their supply from the mains, their classification is not altered. Tools that require splashproof or watertight classifications are specified in Clause 20.

7 Marking

7.1 Tools shall be marked with:

– rated voltage(s) or rated voltage range(s), in volts;

– symbol for nature of supply, if applicable;

– rated frequency or rated frequency range, in hertz, unless the tool is designed for d.c. only or for a.c. of both 50 Hz and 60 Hz;

– rated input (if greater than 25 W) in watts or kilowatts, or rated current, in amperes;

– manufacturer's name, trade mark, or identification mark;

The manufacturer's identification may be in a traceable code if the tool is identified by the brand or trademark of a private labeler.

– manufacturer's model or type reference;

– rated operating time, or rated operating time and rated resting time, in hours, minutes or seconds, if applicable;

This marking, if applicable, will be specified in the Part 2 requirements.

– symbol for Class II construction, for Class II tools only;

– rated no-load speed;

Applies only to tools with a rotating output means. A tool provided with more than one speed (by mechanical or electrical means) shall be marked with the no load speed obtainable with the unit in the highest possible speed setting. This does not apply to nut setters, screwdrivers, drain cleaners, belt sanders, band saws, and tools with predominately linear work function motion.

– WARNING – To reduce the risk of injury, user must read and understand instruction manual;

The word "Warning" shall be in capital letters not less than 2.4 mm high, and shall not be separated from the cautionary statement.

The statement shall be verbatim except the term "Operator's manual," or "User guide" may be used for the term "instruction manual."

The word "Warning" shall not be separated from the cautionary statement.

– date of manufacture;

The date of manufacture may be a dating period not exceeding any one month. The date of manufacture may be abbreviated or in established, accepted code, or a code affirmed by the manufacturer. The code shall not require reference to the manufacturer's records to determine when the product was manufactured.

– symbol for degree of protection against moisture, if applicable.

Tools for star-delta connection should be clearly marked with the two rated voltages (e.g. 200Δ /380 Y.)

~~The rated input or current to be marked on the tool is the total maximum input or current that can be on circuit at the same time.~~

If a tool has alternative components which can be selected by a control device, the rated input is that corresponding to the highest loading possible.

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

If the motor of a tool is marked separately, the marking of the tool and that of the motor should be such that there can be no doubt with regard to the rating and manufacturer of the tool itself.

7.1.1 If a nameplate carries a required marking and is on a part that must be removed for normal servicing of the tool, the construction shall be such that the nameplate must be returned to its proper location for the tool to be operable;

7.1.2 A cautionary marking shall be permanent and shall be located on a part permanently attached to the tool or on a part that cannot be removed without impairing the operation or the appearance of the tool.

A fold-over label attached to the power supply cord is acceptable.

7.1.3 Cautionary markings shall be used verbatim as stated. Optional cautionary statements may be added to the markings, as deemed necessary, by the manufacturer. Cautionary statements having the same signal word may be combined into one paragraph under one signal word. The order of statements shall be markings required by Part 1, markings required by the applicable Part 2, and any optional markings.

7.1.4 In cases where danger, warning, and caution appear together, the cautionary markings shall be in the order of severity, i.e., danger, warning, and caution.

7.2 Tools for short-time operation or intermittent operation shall be marked with rated operating time or rated operating time and rated resting time respectively, unless the operating time is limited by the construction of the tool or by the description of normal load given in Part 2.

The marking of short-time operation or intermittent operation shall correspond to normal use.

The marking of intermittent operation shall be such that the rated operating time precedes the rated resting time, both markings being separated by an oblique stroke.

7.3 For tools with heating elements incorporated, the complete marking for heating elements required in ~~IEC Publication 335-1~~ the standard listed under Heating Elements in Appendix E, shall in addition, be given on the marking plate of the tool.

7.4 If the tool can be adjusted to suit different rated voltages or different rated inputs, the voltage or input to which the tool is adjusted shall be easily and clearly discernible.

This requirement does not apply to tools for star-delta connection.

The term "star delta" is the same as "Y delta."

For tools where frequent changes in voltage setting are not required, this requirement is deemed to be met if the rated voltage or the rated input to which the tool is adjusted, can be determined from a wiring diagram fixed to the tool; the wiring diagram may be on the inside of a cover which has to be removed to connect the supply conductors. This diagram may be on a card which is riveted to the cover, or on a paper or similar label secured to the cover by an adhesive, but it must not be on a label loosely attached to the tool.

7.5 For tools marked with more than one rated voltage or rated voltage range, the rated input for each of these voltages or ranges shall be marked, if greater than 25 W.

The upper and lower limits of the rated input shall be marked on the tool so that the relation between input and voltage appears distinctly, unless the difference between the limits of a rated voltage range does not exceed 10 percent of the mean value of the range, in which case the marking for rated input may be related to the mean value of this range.

7.6 When symbols are used, they shall be as follows:

V	.....	volts
A	.....	amperes
Hz	.....	hertz
W	.....	watt
kW	.....	kilowatts
μF	.....	microfarads
l	.....	liters
kg	.....	kilograms
N/cm^2	.....	newtons per square centimeter
Pa	.....	paschals
h	.....	hours
min	.....	minutes
s	.....	seconds
⏦	.....	alternating current
3 ⏦	.....	three-phase alternating current
3N ⏦	.....	three-phase alternating current with neutral
⎓	.....	direct current
n_0	.....	no load speed
⏦ with overline	.....	alternating or direct current
⧈	.....	Class II Construction

Table Continued on Next Page

Table Continued

⚠	.....	splash-proof construction
💧💧	.....	watertight construction
…/min	.....	revolutions or reciprocation per minute

The symbol for nature of supply shall be placed next to the marking for rated voltage.

The dimensions of the symbol for Class II construction shall be such that the length of the sides of the outer square is about twice the length of the sides of the inner square. The length of the sides of the outer square shall not be less than 5 mm, unless the largest dimension of the tool does not exceed 15 cm, in which case the dimensions of the symbol may be reduced, but the length of the sides of the outer square shall not be less than 3 mm.

The symbol for Class II construction shall be so placed that it will be obvious that it is a part of the technical information and is unlikely to be confused with any other marking.

~~A revision of the symbols for the types of construction with regard to protection against moisture is under consideration.~~

7.7 Terminals intended exclusively for the neutral conductor shall be indicated by the letter N.

The ″N″ mark is only required in multi-phase circuits.

Protective e~~E~~arthing terminals shall be indicated by the ⏚ symbol.

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

7.8 Tools to be connected to more than two supply conductors shall be provided with a connection diagram, fixed to the tool, unless the correct mode of connection is obvious.

The correct mode of connection is deemed to be obvious if the terminals for the supply conductors are indicated by arrows pointing towards the terminals. The earthing conductor is not a supply conductor. For tools for star-delta connection, the wiring diagram should show how the windings are to be connected.

The connection diagram may be that referred to in Sub-clause 7.4.

7.9 Unless it is obviously unnecessary, switches shall be marked or placed so as to indicate clearly which part of the tool they control.

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

7.10 A push-button shall be colored red only if it serves to open the circuit to be controlled and has no other function.

This requirement does not apply to push-buttons used for locking the mains switch. This requirement refers to emergency-off switches only and does not preclude the use of red trigger, rocker, toggle, or other switches and controls.

For tools which might ~~cause danger~~ result in a risk of injury when started unexpectedly, the ″off″ position of the mains switch shall be indicated, unless this position is obvious; the indication, if required, shall be the figure 0.

The figure 0 shall not be used for any other indication.

This requirement does not preclude the use of the figure 0 for the minimum setting of a variable speed control, 0 degree, 0 depth of cut, or similar indication.

The position of the moving contacts of the mains switch shall correspond to the indications for the different positions of its operating means.

7.11 Regulating devices and the like, intended to be adjusted during operation shall be provided with an indication for the direction of adjustment to increase or to decrease the value of the characteristic being adjusted.

An indication of + and - is considered to be sufficient.

If figures are used for indicating the different positions, the ″off″ position shall be indicated by the figure 0 and the position for a greater output, input, speed, etc., shall be indicated by a higher figure.

The first requirement does not apply to regulating devices provided with an adjusting means, if its ″fully-on″ position is opposite to its ″off″ position.

The indications for the different positions of the operating means of a control device need not be placed on the device itself.

7.12 Tools provided with electronic regulating devices shall ~~either have a special marking or~~ be accompanied by ~~an instruction sheet giving~~ the necessary instructions for the use of the tool.

7.13 ~~Instruction sheets~~ Cautionary markings shall be written in the official language(s) of the country in which the tool is to be sold. See Appendix H for translations.

Where symbols are used, they shall be those indicated in this standard.

Compliance with the requirements of Sub-clauses 7.1 to 7.13 is checked by inspection.

7.14 Required m~~M~~arking shall be easily visible, legible, and durable.

To comply with this clause a marking shall be etched, molded, die-stamped, paint-stenciled; permanently secured, stamped, or etched metal; or indelibly stamped lettering on pressure-sensitive labels secured by adhesive. Ordinary usage, handling, storage, and the like, of the tool will be considered in determination of the permanence of marking.

Marking specified in Sub-clauses 7.1 to 7.12 shall be on a main part of the tool in such a way that it is clearly discernible when the tool is ready for use.

~~Provisionally, self-adhesive labels glued in recesses in the body of the tool are allowed for ordinary tools.~~

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

Compliance is checked by inspection and, if the label is not in compliance with the standards specified in Appendix E, the following tests: ~~by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.~~

After being subjected to the conditions described below, a pressure sensitive label or a label secured by cement or adhesive is considered to be of a permanent nature if (1) immediately following removal from each test medium and (2) after being exposed to room temperature for 24 hours following removal from each medium:

A. *Each sample demonstrates good adhesion and the edges are not curled.*

B. *The label resists defacement or removal as demonstrated by scraping across the test panel with a flat steel blade, held at right angles to the test panel. The blade is to be 0.8 mm thick and of any convenient width.*

C. *The printing is legible and is not defaced by rubbing with thumb or finger pressure.*

Label Heating Test

Three samples of the label applied to test surfaces as in the intended application are to be placed for 240 hours in an oven maintained at the temperature specified below.

Maximum Temperature During Temperature Test of Surface to Which Applied	*Oven Temperature*
°C	°C
60 or less	*87*
80 or less	*105*
100 or less	*121*
125 or less	*150*
150 or less	*180*
Over 150	*a*

[a] A label that is applied to a surface attaining a temperature greater than 150°C, during the temperature test, is to be heated at a temperature representative of the temperatures attained by the appliance during intended use and abnormal use.

Label Immersion Tests

Six samples of the labels applied to text surfaces as in the intended application are to be placed in a controlled atmosphere maintained at 23.0 ±2.0°C with a 50 ±5 percent relative humidity for 24 hours. Three samples are then to be immersed in water and three samples immersed in IRM 903 (Calumet Oil No. 3) as specified in Tests for Rubber Property – Effect of Liquids ANSI/ASTM D 471 – 1979 at a temperature of 21.0 ±2.0°C for 48 hours in each case.

Label Standard Atmosphere Test

Three samples of the label applied to test surfaces as in the intended application are to be placed for 72 hours in a controlled atmosphere maintained at 23.0 ±2.0°C with a 50±5 percent relative humidity.

After all the tests of this standard, the marking shall be easily legible; it shall not be easily possible to remove marking plates and they shall show no curling.

~~A revision of the test for checking the durability of the marking and requirements for glued-on marking plates is under consideration.~~

8 Protection against electric shock

8.1 Tools shall be so constructed and enclosed that there is adequate protection against accidental contact with live parts and, for Class II tools, with metal parts separated from live parts by basic insulation only, even after removal of detachable parts.

The insulating properties of lacquer, enamel, ordinary paper, cotton, oxide film on metal parts, beads and sealing compound shall not be relied upon to give the required protection against accidental contact with live parts.

The enclosure of the tool shall have no openings other than those necessary for the use and working of the tool, giving access to live parts and, for Class II tools, to parts separated from live parts by basic insulation only.

Unless otherwise specified, parts operating at safety extra-low voltage not exceeding ~~24~~ 42.4 V peak are not considered to be live parts.

Compliance is checked by inspection and by a test with the standard test finger shown in Figure 1~~, page 122~~.

In addition apertures in Class II tools and apertures in Class I tools, other than those in metal parts connected to an earthing terminal or earthing contact, are tested with the test pin shown in Figure 2~~, page 122~~.

After removal of detachable parts, the test finger and the test pin are applied in every possible position, the test finger being applied without appreciable force and the test pin with a force of 10 N.

Apertures preventing the entry of the test finger are further tested by means of a straight unjointed test finger of the same dimensions, which is applied with a force of 50 N; if this finger enters, the test with the finger shown in Figure 1~~, page 122~~, is repeated, except that the force necessary to push the finger through the aperture is exerted. An electrical contact indicator is used to show contact.

It shall not be possible to touch bare live parts or live parts protected by lacquer, enamel, ordinary paper, cotton, oxide film, beads or sealing compound only, with the test finger. For Class II tools it shall not be possible to touch bare live parts with the test pin shown in Figure 2 ~~, page 122~~, or, to touch metal parts, separated from live parts by basic insulation only with the test finger shown in Figure 1.

The standard test finger must be so designed that each of the jointed sections can be turned through an angle of 90° with respect to the axis of the finger in the same direction only.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V.

Ventilation openings shall not be excessively large.

Compliance is checked by inspection and by trying to insert a steel ball, 6 mm in diameter, through the air-intake openings other than those adjacent to the fan.

The ball shall not enter.

This requirement does not imply that live parts must not be visible through ventilation openings.

8.2 Shafts of operating knobs, handles, levers and the like shall not be live.

8.3 For tools other than those of Class III, handles and grasping surfaces ~~or knobs of~~ containing switch operating means, if of metal, shall either be adequately covered by insulating material, or their accessible parts shall be separated from ~~their shafts or fixings~~ other conductive parts of the tool by supplementary insulation and separated from live parts by double or reinforced insulation.

In the case of tools that do not contain the switching means in a handle or grasping surface, the handle or grasping surface primarily used to control the tool are to comply with clause 8.3.

8.3.1 For tools other than those of Class III, switch actuators shall be formed of insulating material or, if of metal, shall be either adequately covered by insulating material or their accessible parts shall be separated from live parts by double or reinforced insulation.

8.3.2 For tools of Class II construction, auxiliary handles and auxiliary grasping surfaces, as recommended in the instruction manual, shall be formed of insulating material or, if of metal, shall be either adequately covered by insulating material or their accessible parts shall be separated from live parts by double insulation and separated from their output shafts by double or reinforced insulation.

Compliance with the requirements of Sub-clauses 8.2, ~~and~~ 8.3, 8.3.1, and 8.3.2 is checked by inspection and by the tests of Clauses 15 and 19.

8.4 For Class II tools, capacitors shall not be connected to accessible metal parts, and their casings, if of metal, shall be separated from accessible metal parts by supplementary insulation.

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

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

Compliance is checked by the following test, which is made ten times.

The tool is operated at rated voltage or at the upper limit of the rated voltage range.

The tool switch if any, is then moved to the "off" position and the tool is disconnected from the supply by means of the plug.

One second after disconnection, the voltage between the pins of the plug is measured with an instrument which does not appreciably affect the value to be measured.

This voltage shall not exceed 34 V.

Capacitors having a rated capacitance not exceeding 0.1 µF are not considered to entail a risk of electric shock.

8.6 Parts providing protection against electric shock shall have adequate mechanical strength and shall not work loose in normal use. It shall not be possible to remove them without the aid of a tool.

Compliance is checked by inspection, by manual test and by the tests of Clauses 16 and 19.

9 Starting

9.1 Motors shall start under all normal voltage conditions which may occur in use.

Centrifugal and other automatic starting switches shall operate reliably and without contact chattering.

Compliance is checked by operating the tool with no load ten times at a voltage equal to 0.85 times rated voltage, regulating devices, if any, being set as in normal use.

Tools provided with a centrifugal or other automatic starting switch are, in addition, operated ten times at a voltage equal to 1.1 times rated voltage. The interval between consecutive starts is made sufficiently long to prevent undue heating.

In all cases, the tool shall function ~~safely and correctly~~.

9.2 Overload protection devices shall not operate under normal starting conditions.

The test of Sub-Clause 9.1 checks compliance with this requirement.

10 Input and current

10.1 The input of the tool at rated voltage and under normal load shall not deviate from the rated input by more than:

Rated input (W)	Deviation
Up to and including 33.3	+10 W
over 33.3 up to and including 150	+30 percent
over 150 up to and including 300	+45 W
over 300	+15 percent

Compliance is checked by measuring the input of the tool operated under normal load at rated voltage or at the mean value of the rated voltage range if the voltage range does not exceed 10 percent of its mean value.

For tools marked with a rated voltage range having limits differing by more than 10 percent of the mean value of the range, the permissible deviations apply for both limits of the range.

10.2 If the tool is marked with rated current, the current taken by the tool under normal load shall not exceed the rated current by more than 15 percent.

Compliance is checked by measuring the current taken by the tool operating under normal load conditions, at rated voltage or at the mean value of the rated voltage range, if the voltage range does not exceed 10 percent of its mean value.

For tools marked with a rated voltage range having limits differing by more than 10 percent of the mean value of the range, the permissible deviations apply for both limits of the range.

11 Heating

11.1 Tools shall not attain excessive temperatures in normal use.

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

11.2 The tool is operated in still air under load, or under the torque load necessary to attain rated input or under the loading conditions as specified in Part 2, whichever causes the higher temperature rise, and at a supply voltage equal to 0.94 times rated voltage, 1.00 times rated voltage or 1.06 times rated voltage, whichever is the most unfavorable.

The torque is kept constant at the value recorded when operating at rated voltage, or at the mean of the rated voltage range, under the most unfavorable of the three loading conditions quoted while the voltage is adjusted to 0.94 or 1.06 times the rated voltage or mean of the rated voltage range.

When applying the torque load necessary to attain rated input, the operating time to be chosen is that specified for normal load.

Heating elements, if any, are operated as indicated in Sub-clauses 4.7 and 4.8 the conditions being as specified in the standards listed under "Heating Elements" in Appendix E ~~Clause II of IEC Publication 335-1~~, when the tool is operated at a voltage equal to 1.06 times rated voltage. When the tool is operated at a voltage equal to 0.94 times rated voltage, the input of heating elements is reduced to 0.90 times rated input.

If it is necessary to make the test at an intermediate voltage, the input of the heating elements is adjusted proportionally.

11.3 Temperature rises of windings are determined by the resistance method unless the windings are non-uniform or it involves severe complications to make the necessary connections for the resistance measurements. In this case, the measurement is made by thermocouples.

Such temperature rises are determined by means of fine-wire thermocouples so chosen and positioned that they have the minimum effect on the temperature of the part under test.

Referee measurements shall be made with 30 AWG type J thermocouple wire.

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

The temperature rise of electrical insulation, other than that of windings, is determined on the surface of the insulation, at places where failure could cause a short circuit, contact between live parts and accessible metal parts, bridging of insulation or reduction of creepage distances or clearances below the values specified in Sub clause 27.1.

11.4 The tool is operated:

– for the rated operating time for tools for short time operation;

– on consecutive cycles of operation, until steady conditions are established, for tools for intermittent operation, the "on" and "off" periods being the rated "on" and "off" periods;

– until steady conditions are established for tools for continuous operation.

11.5 During the test, thermal cut-outs shall not operate. The temperature rises shall not exceed the values shown in the following table except as allowed by Sub-clause 11.6.

Sealing compound, if any, shall not flow out.

Parts	Temperature rise deg C ~~(K)~~
Windings[1], and core laminations in contact therewith, if the winding insulation is:	
– of Class A material [2]	*75(65)*
– of Class E material [2]	*90(80)*
– of Class B material [2]	*95(85)*
– of Class F material [2]	*115*
Ambient of switches and thermostats marked with individual ratings: [3]	
– without T-marking	*30*
– with T-marking	*T–25*
~~*Pins of appliance inlets[9]:*~~	
~~*– for very hot conditions*~~	~~*130*~~
~~*– for hot conditions*~~	~~*95*~~
~~*– for cold conditions*~~	~~*40*~~
Rubber or polyvinyl chloride insulation of internal and external wiring including power supply cords:	
– without T-marking	*50 [4]*
– with T-marking	*T–25 [5]*
Cord sheaths used as supplementary insulation:	
– without T-marking	*35*
– with T-marking	*T–25[5]*
Rubber used for gaskets or other parts, the deterioration of which could ~~affect safety~~ result in risk of injury to persons:	
– when used as supplementary insulation or as reinforced insulation	*40*

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Parts	Temperature rise deg C ~~(K)~~
– in other cases	*50*
Material used as insulation other than for wires and windings [6]:	
– impregnated or varnished textile, paper or press board	*70*
– laminates bonded with:	
• melamine-formaldehyde, phenol-formaldehyde or phenol-furfural resins	*85(175)*
• urea-formaldehyde resin	*65(150)*
– moldings of:	
• phenol-formaldehyde with cellulose fillers	*85(175)*
• phenol-formaldehyde with mineral fillers	*100(200)*
• melamine-formaldehyde	*75(150)*
• urea-formaldehyde	*65(150)*
– polyester with glass-fibre reinforcement	*110*
– silicone rubber	*145*
– polytetrafluoroethylene	*265*
– pure mica and tightly sintered ceramic material, when such products are used as supplementary or reinforced insulation	*400*
– thermoplastic material [7]	*–*
Wood in general [8]	*65*
Outer surfaces of capacitors:	
– with marking of maximum operating temperature (T)	*T–35*
– without marking of maximum operating temperature:	
• small ceramic capacitors for radio and television interference suppression	*50*
• other capacitors	*20*
External enclosure, except handles held in normal use	*60*

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Table Continued

Parts	Temperature rise deg C ~~(K)~~
Handles, knobs, grips and the like which, in normal use, are continuously held:	
– of metal	*30*
– of porcelain or vitreous material	*40*
– of molded material, rubber or wood	*50*
Handles, knobs, grips, and the like which, in normal use, are held for short periods only (e.g. of switches):	
– of metal	*35*
– of porcelain or vitreous material	*45*
– of molded material, rubber or wood	*60*
Parts in contact with oil having a flash-point of t°C	*t–50*

1) To allow for the fact that the temperature of windings of universal motors, relays, solenoids, etc., measured at points accessible to thermocouples is generally below the average, the figures without parentheses apply when the resistance method is used and those within parentheses apply when thermocouples are used. For windings of vibrator coils and a.c. motors, the figures without parentheses apply in both cases.

In case of doubt, the results obtained by means of the resistance method are decisive.

2) The classification ~~is~~ shall be as given in the following examples or in accordance with the Standards in Appendix E ~~IEC Publication 85: Recommendations for the Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to their Thermal Stability in Service:~~

Examples of Class A material are:

– impregnated cotton, silk, artificial silk and paper;

– enamels based on oleo- or polyamide resins.

~~Examples of Class B material are:~~

~~– asbestos, glass fibre, melamine formaldehyde and phenol formaldehyde resins.~~

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Parts	Temperature rise deg C ~~(K)~~
Examples of Class E material are: *– moldings with cellulose fillers, cotton fabric laminates and paper laminates, bonded with melamine-formaldehyde, phenol-formaldehyde or phenol-furfural resins;* *– cross-linked polyester resins, cellulose triacetate film, polyethylene terephthalate films;* *– varnished polyethylene terephthalate textile bonded with oil-modified alkyd resin varnish;* *– enamels based on polyvinyl formal, polyurethane or epoxy resins.* *There is no limit specified for windings insulated with materials other than those of Class A, Class E, Class B or Class F, but they shall withstand the test of Sub-clause 11.6.* *These tests are always made when the temperature rise of windings or core laminations exceeds 75°C ~~(75 K)~~ and where there are doubts with regard to the classification of winding insulation.* *For totally enclosed motors the temperature rise limits for Class A, Class E, and Class B may be increased by 5°C ~~(5 K)~~.* *A totally enclosed motor is a motor so constructed that the circulation of the air between the inside and the outside of the case is prevented, but not necessarily sufficiently enclosed to be called airtight.* *3) T signifies the maximum operating temperature.* *For the purpose of this test, switches and thermal cut-outs marked with individual ratings may be considered as having no marking in this respect, if requested by the tool manufacturer.* *4) This limit applies to cables, cords and wires complying with the relevant ~~IEC~~ standards in Appendix E; for others it may be different.* *5) This limit will become applicable as soon as there are IEC standards for high temperature cables, cords and wires. This limit is the temperature rating of the insulation.* *6) The values in parentheses apply, if the material is used for handles, knobs, grips and the like and is in contact with hot metal.* *7) There is no specific limit for thermoplastic material, which must withstand the tests of Sub-clause28.1 or 28.2, for which purpose the temperature rise must be determined.* *8) The limit is concerned with the deterioration of wood and it does not take into account deterioration of surface finishes.* *If these or other materials are used, they shall not be subjected to temperatures in excess of the thermal capabilities as determined by aging tests made on the materials themselves.*	

The values in the table are based on an ambient temperature not normally exceeding 25°C but occasionally reaching 35°C.

However, the temperature rise values are based on an ambient temperature of 25°C.

In determining the temperature rise of the ambient of a switch or thermostat, the temperature rise resulting from the current through the switch or thermostat is not taken into account, provided it does not influence its ambient temperature.

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

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

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

where:

Δt is the temperature rise in deg C ~~(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 in °C

t_2 is the room temperature at the end of the test in °C

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

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

11.6 If the temperature rise of a winding or core lamination exceeds the value specified in Sub-clause 11.5, three additional samples are subjected to the following tests:

1) The temperature rise of the windings and core laminations is determined by the test of Sub-clause 11.2.

2) The samples are then dismantled as far as is possible without damaging any part. Windings and core laminations are kept for ten days (240 h) in a heating cabinet, the temperature of which is 80 ±1°C in excess of the temperature rise determined according to item 1.

3) After this treatment, the samples are reassembled and no interturn short circuit shall occur. Interturn short circuits may be detected by means of a winding tester.

4) Immediately afterwards, the samples shall withstand the tests of Clause 15.

5) The samples are then subjected to a humidity treatment as specified in Sub-clause 14.4.

After this treatment, they shall again withstand the tests of Sub-Clause ~~15~~ 15.3.

If the three samples pass tests 3 through 5, the tool is considered in compliance with sub-clause 11.5. ~~Tools are considered not to comply with the requirements of Sub-Clause 11.1 if there are more failures than of one sample in one of the tests of Items 3 to 5. If one sample fails in a test, the tests of Items 1 to 5 are repeated an another set of three samples, all of which shall then comply with the repeated tests.~~

Faults which may occur in insulation, which did not show an excessive temperature rise during the test of Item 1 are ignored and are repaired, if necessary, in order to complete the tests of this subclause.

12 Leakage current

12.1 The leakage current in normal use shall not be excessive.

Compliance is checked by measuring, immediately after the test of Sub-clause 11.2, the leakage current which may flow from any pole of the supply to the parts specified, the tool being operated under the conditions specified in Sub-clause 11.2, but at a supply voltage equal to 1.06 times rated voltage.

A measurement is made of the leakage current which may flow from any pole of the supply to accessible metal parts and metal foil with an area not exceeding 20 cm × 10 cm in contact with accessible surfaces of insulating material, connected together; and to metal parts of Class II tools, separated from live parts by basic insulation only.

The measuring circuit is shown:

– For single phase tools ~~with a rated voltage not exceeding 250V~~.

- *if of Class II, Figure 3~~, page 123~~;*
- *if other than Class II, Figure 4~~, page 123~~:*

– for three-phase tools ~~and for single-phase tools with a rated voltage exceeding 250 V~~.

- *if of Class II, Figure ~~5, page 124~~;*

• *if other than Class II, Figure 6~~, page 124~~.*

The resistance of the measuring circuit shall be 1750 ~~2000~~ ±250 ~~100~~ ohms, and is shunted by a capacitor such that the time constant of the circuit is 225 µs ±15 µs if it is suspected that high-frequency currents are being generated, the measuring instrument shall have an accuracy of at least 5 percent for all frequencies within the range of 20 Hz to 5000 Hz, but insensitive to higher frequencies.

For single-phase tools with a rated voltage not exceeding 250 V the leakage current is measured with the selector switch shown in Figures 3 and 4, in each of the positions 1 and 2.

For other tools, the leakage current is measured with the switches a, b, and c, shown in Figures 5 and 6~~, page 124~~, closed: for three-phase tools not suitable for single-phase supply, the measurements are repeated with each of the switches a, b, and c, open in turn, the other two switches being closed: for single-phase tools the measurements are repeated with one of the switches open.

After an operating time as specified in Sub-clause 11.4, the leakage current shall not exceed the following values:

– to accessible metal parts and metal foil.

• *for Class III tools …… 0.5 mA*

• *for Class I tools …… ~~0.75~~ 0.5 mA*

• *for Class II tools……0.25 mA*

– to metal parts of Class II tools separated from live parts by basic insulation only, if the classification according to degree of protection against moisture is:

• *ordinary……~~5.0~~ 3.5 mA*

• other than ordinary……3.5 mA

If the tool incorporates one or more capacitors and is provided with a single-pole switch, the measurements are repeated with the switch in the ″off″ position.

The cut-off frequency of 5,000 Hz may, for example, be obtained by connecting a capacitor of 150 ±7.5 nF in parallel with the resistive components of the measuring circuit. The measuring circuit may be partly or completely incorporated in the measuring instrument. If an instrument of the rectifier type is used, it must rectify linearly from 0.2 mA upwards within the frequency range of 20 Hz to 10,000 Hz, and must be calibrated in r.m.s. values with a current of substantially sine-wave form. If high-frequency voltages are not present, the cut-off frequency of the measuring instrument may exceed 5,000 Hz.

For tools with heating elements incorporated, the total leakage current must be either within the limits specified in the table or within those specified in Appendix E ~~IEC publication 335-1 under Sub-clause 13.2~~, whichever is the greater: the two limits must not be added.

It is recommended that the tool be supplied through an isolating transformer; otherwise, it must be insulated from earth.

The metal foil has the largest area possible on the surface under test, without exceeding the dimensions specified. When its area is smaller than the surface under test, it is moved so as to test all parts of the surface; the heat dissipation of the tool must, however, not be affected by the metal foil.

The test with the switch in the ″off″ position is made to verify that capacitors connected behind a single-pole switch do not cause an excessive current.

13 Tools equipped with radio and television interference suppression

13.1 The incorporation of components necessary to achieve an adequate degree of radio and television interference suppression shall not adversely affect the safety of the tool.

Compliance is checked by the tests of this standard.

~~Attention is drawn to the fact that compliance with the requirements concerning the limits for interference effects generated by the tool, as specified in the C.I.S.P.R. recommendations and when measured in accordance with the relevant C.I.S.P.R. specifications, will in most cases ensure that the tool has the required degree of radio and television interference suppression.~~

14 Moisture resistance

14.1 The enclosure of splash-proof and watertight tools shall provide the degree of protection against moisture in accordance with the classification of the tool.

Compliance is checked by the appropriate treatment specified in Sub-clause 14.2.

Immediately after this treatment, the tool shall withstand the electric strength test specified in Sub-clause 15.3, and inspection shall show that water which may have entered the tool does not impair compliance with this standard; in particular, there shall be no trace of water on insulation for which creepage distances are specified in Sub-clause 27.1.

Tools which are not subject to spillage of liquid in normal use are allowed to stand in normal test-room atmosphere for 24 h before being subjected to the test of Sub-clause 14.4.

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

Sealing rings of glands and other sealing means, if any, are aged in an atmosphere having the composition and pressure of the ambient air by suspending them freely in a heating cabinet ventilated by natural circulation.

They are kept in the cabinet at a temperature of 70 ±2°C for 10 days (240 h).

Immediately afterwards, the samples are taken out of the cabinet and left at room temperature, avoiding direct daylight, for at least 16 h, before being reassembled. The glands and other sealing means are then tightened with a torque equal to two-thirds of the torque applied for the test of Sub-clause 26.1.

The use of an electrically-heated cabinet is recommended. Natural circulation may be provided by holes in the walls of the cabinet.

~~*1) Splash-proof hand-held tools are subjected for 5 min to an artificial rainfall of 3 mm per min, falling vertically from a height of 2000 mm above the top of the tool, the tool being turned continuously through the most unfavorable positions (test apparatus, see Figure 7, page 125).*~~

1) Splash-proof tools are subjected for 2 hours to a water spray equivalent to a beating rain on its top and sides as described below.

The water-spray test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 14. Spray heads are to be constructed in accordance with the details shown in Figure 15. The water pressure for all tests is to be maintained at 5 psi. (35 kPa.) at each spray head. The distance between the center nozzle and the unit is to be approximately 1.5 meters. The spray is to be directed at an angle of 45 degrees to the vertical and in the direction or directions most likely to cause water to enter. The tool is to be positioned as in normal use, as recommended in the operators manual.

2) Watertight tools are immersed for 24 h in water at a temperature of 20 ±5°C the top of the tool being about 50 mm below the water level.

Tools required to be splash-proof or watertight are as specified in Sub-clause 20.17.

14.3 Tools subject to spillage of liquid in normal use shall be so constructed that such spillage does not affect their electrical insulation.

Compliance is checked by the following test.

Tools provided with an appliance inlet are fitted with an appropriate connector and flexible cable or cord; other tools having rewirable cords, are fitted with the lightest permissible type of flexible cable or cord of the smallest cross-sectional area specified in Sub-clause 24.2 and having an overall diameter equal to the mean value of the upper and lower limits specified in the standard listed under Appendix E ~~IEC Publication 227 : Polyvinyl Chloride Insulated Cables of Rated Voltages up to and Including 450/750 V, or IEC Publication 245 : Rubber Insulated Cables of rated Voltages up to and Including 450/750 V,~~ for the relevant type of flexible cable or cord.

The liquid container of the tool is completely filled with water, and a further quantity equal to 15 percent of the capacity of the container is poured in steadily over a period of 1 min.

Immediately a~~A~~fter this treatment the tool shall withstand an electric strength test as specified in Sub-clause 15.3.

The tool is allowed to stand in normal test-room atmosphere for 24 h before being subjected to the test of Sub-clause 14.4.

14.4 Tools shall be ~~proof~~ protected against humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this sub-clause, followed immediately by the tests of Clause 12, (except do not repeat heating test) followed by the tests of Clause 15.

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

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

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity of 93 ±2 percent. The temperature of the air, at all places where samples can be located, is maintained within 1°C ~~(1 K)~~ of any convenient value t between 20°C and 30°C.

Before being placed in the humidity cabinet, the sample is brought to a temperature between t and t + 4°C.

The sample is kept in the cabinet for:

– 2 days (48 h) for ordinary tools

– 7 days (168 h) for splash-proof and watertight tools.

In most cases, the sample may be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity treatment.

A relative humidity between 91 and 95 percent can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water, having a sufficiently large contact surface with the air.

In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air within and, in general, to use a cabinet which is thermally insulated.

After this treatment, the tool shall show no damage within the meaning of this standard.

The electric strength test is made in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature, after reassembly of those parts which may have been removed.

14.5 Tools that utilize pressurized liquid systems shall be constructed using liquid handling components considered not likely to break or, if broken shall not affect the insulation system.

All metal hoses and reinforced pressure tested hoses rated over twice the pressure encountered in normal use are not considered likely to break. Ordinary garden hose connections are considered likely to be mis-assembled by cross-threading or omission of the washer. Pressure vessels are considered not likely to break if it can be shown that they withstand for one hour twice the pressure encountered in normal use. The requirements of this clause may be met by using shields which will direct the fluid away from electrical components in case of a rupture.

Compliance is checked by the following test.

The tool is operated as in normal use and in all operating positions recommended in the instruction manual with the hose, fitting or vessel ruptured for a period of one minute. The leakage current of accessible parts is measured as described in Clause 12. During the test the leakage current shall not exceed:

2 mA for a Class II tool

5 mA for a Class I tool

Following this test, the tool shall meet the test of sub-clause 12.1 after being allowed to dry for 24 hours at room temperature.

14.6 Tools that employ a non-pressurized liquid container shall be so constructed that failure of a hose, fitting, or reservoir, does not affect the electrical insulation.

Compliance is checked by the test of sub-clause 14.5.

15 Insulation resistance and electric strength

15.1 The insulation resistance and electric strength of tools shall be adequate.

Compliance is checked by the tests of Sub-clauses 15.2 and 15.3 which are made on the cold tool not connected to the supply, immediately after the test of Sub-clause 14.4, in the humidity cabinet or in the room in which the sample was brought to the prescribed temperature after reassembly of those parts which may have been removed.

15.2 The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage, heating elements, if any, being disconnected.

The insulation resistance shall be not less than that shown in the following table:

Insulation to be tested resistance	Insulation Resistance (MΩ)
Between live parts and the body	
– for basic insulation	*2*
– for reinforced insulation	*7*
Between metal parts of Class II tools which are separated from live parts by basic insulation only	*2*
Between metal parts of Class II tools which are separated from live parts by basic insulation only and the body	*5*

Immediately after this test, the test of sub-clause 15.3 is to be conducted.

15.3 ~~Immediately after the test of Sub-clause 15.2, t~~The insulation is subjected for 1 min to a voltage of substantial sine-wave form, having a frequency of 50 Hz or 60 Hz. The value of the test voltage and the points of application are shown in the following table:

Points of application of test voltage	Test Voltage (V)		
	Class III tools	Class II tool	Class I tools
1. Between live parts and parts of the body that are separated from live parts by:			
– Basic insulation only	*500*	*–*	*1250*
– Reinforced insulation	*–*	*3750*	*3750*
2. Between live parts of different polarity	*500*	*1250*	*1250*
3. For parts with double insulation, between metal parts separated from live parts by basic insulation only, and:			
– Live parts	*–*	*1250*	*1250*
– The body	*–*	*2500*	*2500*

Table Continued on Next Page

Table Continued

Points of application of test voltage	Test Voltage (V)		
	Class III tools	Class II tool	Class I tools
4. Between metal enclosures or covers lined with insulating material and metal foil in contact with the inner surface of the lining, if the distance between live parts and these metal enclosures or covers, measured through the lining, is less than the appropriate clearance as specified in Sub-clause 27.1	–	*2500*	*1250*
5. Between metal foil in contact with handles, knobs, grips and the like and their shafts, if these shafts can become live in the event of an insulation fault	–	*2500*	*2500*
6. Between the body and either metal foil wrapped around the supply flexible cable or cord inside inlet bushings, cord guards, cord anchorages and the like, or a metal rod of the same diameter as the flexible cable or cord, inserted in its place	–	*2500*	*1250*
Should separate testing of the basic and supplementary insulation not be possible without disassembling or modifying the tool, a separate sample is used which is subjected to the test of Sub-clause 14.4 after disassembly or modification. *The test between live parts of different polarity is only made where the necessary disconnections can be made without damaging the tool.* *The test is not made between the contacts of switches of micro-gap construction, motor-starting switches, relays, thermostats, thermal cut-outs and the like, or on the insulation of capacitors connected between live parts of different polarity.*			

Initially not more than half the prescribed voltage is applied, then it is raised rapidly to the full value.

No flashover or breakdown shall occur during the test.

To distinguish between capacitor leakage and unacceptable performance, a dc potential of 1.414 times the value given in the table above may be substituted for the ac value.

The test equipment for conducting the electric strength test is to have the following features and characteristics:

– A means for indicating the test voltage that is being applied to the tool under test. This may be accomplished by sensing the voltage at the test leads or by an equivalent means.

– An output voltage that (1) has a sinusoidal waveform, (2) has a frequency that is within the range of 40 – 70 Hz, and (3) has a peak value of the waveform that is not less than 1.3 and not more than 1.5 times the root-mean-square value.

– A sensitivity of the test equipment that is such that when a resistor of 120,000 ohms is connected across the output, the test equipment does not indicate unacceptable performance for any output voltage less than the specified test voltage, and the test equipment does indicate (breakdown) unacceptable performance for any output voltage equal to or greater than the specified test value. The resistance of the calibrating resistor is to be adjusted as close to 120,000 as instrumentation accuracy can provide, but never more than 120,000 ohms.

The sensitivity of the test equipment may be increased, a higher value of calibrating resistance may be used, if agreeable to those concerned.

Care is taken that the metal foil is so placed that no flashover occurs at its edges.

The term "body" in item 6 refers to a metal enclosure or a foil covered insulating enclosure. In the latter case the foil should not cover the cord guard.

For Class II tools incorporating both reinforced insulation and double insulation, care is taken that the voltage applied to the reinforced insulation does not overstress the basic insulation or the supplementary insulation.

When testing insulating barriers, the metal foil may be pressed against the insulation by means of a sandbag of such a size that the pressure is about 5 kPa (0.5 N/cm^2). The test may be limited to places where the insulation is likely to be weak, for example where there are sharp metal edges under the insulation.

If practicable, insulating linings are tested separately.

~~The high-voltage transformer used for the test must be so designed that, when the output terminals are short-circuited after the output voltage has been adjusted to the appropriate test voltage, the output current is at least 200 mA.~~

~~The overcurrent relay must not trip when the output current is less than 100 mA.~~

16 Endurance

16.1 Tools shall be so constructed that, in extended normal use, there will be no electrical or mechanical failure that might impair compliance with this standard. The insulation shall not be damaged and contacts and connections shall not work loose as a result of heating, vibration, etc.

Moreover, overload protection devices shall not operate under normal running conditions.

Compliance is checked by the test by Sub-clause 16.2 and, for tools provided with a centrifugal or other starting switch, also by the test of Sub-clause 16.3.

Immediately after these tests, the tool shall withstand an electric strength test as specified in Sub-clause 15.3, the test voltages being, however, reduced to ~~75~~ 50 percent of the specified values. Connections shall not have worked loose, and there shall be no deterioration ~~impairing safety~~ that results in an increased risk of injury to persons in normal use.

16.2 The tool is operated intermittently with no load for 24 h of operation at a voltage equal to 1.1 times rated voltage and then for 24 h at a supply voltage equal to 0.9 times rated voltage.

Each cycle of operation comprises an "on" period of 100 s and an "off" period of 20 s, the "off" periods being included in the specific operating time.

The operating period for tools for short-time or intermittent operation is equal to the operating time, if this is limited by the construction of the tool; otherwise, it is in accordance with the prescriptions given in Part 2, or with the marking, whichever is the more unfavorable.

During the test, the tool is placed in three different positions, the operating time, at each test voltage, being approximately 8 h for each position.

If the temperature rise of any part of the tool exceeds the temperature rise determined during the test of Sub-clause 11.1, forced cooling or rest periods are applied, the rest periods being excluded from the specified operating time.

During these tests, overload protection devices shall not operate.

The tool may be switched on and off by means of a switch other than that incorporated in the tool.

The change of position is made to prevent abnormal accumulation of carbon dust in any particular place. The three positions are, in general, horizontal, vertically up and vertically down.

During this test, replacement of the carbon brushes is allowed and the tool is oiled and greased as in normal use.

Forced cooling, if provided, shall not affect the accumulation of carbon dust.

In general, external temperatures are to be monitored for the purpose of avoiding mechanical failures.

Accessories need not be mounted during this test.

16.3 Tools provided with a centrifugal or other automatic starting switch are started 10,000 times under normal load and at a voltage equal to 0.9 times rated voltage, the operating cycle being that specified in Sub-clause 16.2, forced cooling being applied, if necessary.

17 Abnormal operation

17.1 Tools shall be so designed that the risk of fire, mechanical damage or electric shock as a result of abnormal or careless operation is obviated as far as is practical.

17.2 Compliance is checked by the following test, heating elements, if any, being disconnected.

Tools incorporating series motors are operated at a voltage equal to 1.3 times rated voltage, for 1 min, with no load.

~~*After the test, windings and connections shall not have worked loose and the tool shall be fit for further use.*~~ *During the test the tool shall not exhibit flame through other than existing openings. After the test, the tool shall pass the tests of sub-clauses 8.1 and 12.1.*

Fuses, thermal cut-outs, overcurrent releases or the like, incorporated into the tool, may be used to provide the necessary protection against the risk of fire. If such a device operates within the testing time of 1 min, the test is considered to be complied with.

For tools incorporating induction motors and for magnetically driven tools, tests are under consideration.

17.3 Tools incorporating electronic devices shall be so designed that, in the event of a failure, the speed does not increase to such an extent that this might result in a ~~hazard~~ risk of fire.

Compliance is checked by operating the tool, for 1 min, at a voltage equal to 1.3 times rated voltage, with no load.

This test is then repeated with the electronic device short-circuited and again with the electronic device open circuited.

~~*During these tests, the tool shall show no defects within the meaning of this standard.*~~ *During these tests the tool shall not exhibit flame through other than existing openings. After the tests, the tool shall pass the tests of sub-clause 8.1 and 12.1.*

If the tool incorporates a second device for limiting the speed should the electronic device fail to operate correctly, the test is considered to be withstood if that device operates during the test.

17.4 Switches or other devices for reversing the motor shall withstand the stresses occurring when the direction of rotation is changed under running conditions, if such a change is possible in normal use.

Compliance is checked by the following test.

The tool is operated at a voltage equal to rated voltage or to the upper limit of the rated voltage range, with no load, the device for reversing the direction of rotation being in a position such that the rotor rotates in one direction at full speed. The device is then placed in the position in which the direction of the rotation is reversed, without stopping in an intermediate "off" position.

This sequence of operating is performed 25 times.

During the test, no electrical or mechanical failure of the device and no burning or undue pitting of the contacts shall occur.

~~*After the test, the tool shall show no damage within the meaning of this standard.*~~

17.5 Three ~~T~~tools shall be able to operate under extreme overload conditions without impairing protection against electric shock.

~~A test for compliance is under consideration. Until a test is agreed upon, no test is made.~~

This test is not performed on Class III tools.

Compliance is checked by the following test.

The tool is operated at 100 percent of rated input for 14-1/2 min and followed by operation at no-load for 1/2 min (a mechanical loading device may be driven in a freewheel mode). The load is increased in increments by 10 percent of rated input until the end result. The overload condition must be maintained for a minimum of 30 minutes. Leakage current is monitored between live parts and accessible dead metal parts throughout the entire test per Clause 12.

Reciprocating, impacting, or other mechanism preventing continuous rotary loading is bypassed or disabled.

The tool is to be connected to a power source which maintains rated voltage throughout the test or a variac may be used and the power maintained manually. Class I tools shall be connected through a normal acting fuse equal to the maximum branch circuit protection, as determined by the plug configuration, but not less than 30 amps. Class II tools are to be connected to a branch circuit of high enough capacity to ensure the branch circuit protection will not operate during the test.

For the purpose of this test "no-load" condition means the tool is attached to the loading device without the load applied.

A Class II tool provided with a protective device that can be reset, replaced, repaired, or otherwise modified by the user is to be short-circuited. Such protective devices are to be left in the circuit for Class I tools, and the opening of the device during this test is acceptable.

Class I and Class II tools provided with a one-shot, non-resettable or non-replaceable thermal cutoff, permanently incorporated in the motor, is not short-circuited if the thermal cutoff, upon opening, renders each motor part, it is intended to protect, permanently inoperative and requires that these parts be replaced in order to return the tool to a functional condition. Opening of the device during this test is acceptable.

If agreeable to those concerned, the first cycle may be 100 percent, 110 percent, 120 percent, 130 percent, 140 percent, or 150 percent of rated input.

If the temperature of the enclosure exceeds 90°C during the test, the tool manufacturer may request that the tool be operated at no-load until the enclosure temperature has stabilized. The overload test is then continued for the balance of the 14-1/2 min load cycle, until the end result occurs.

The end result is considered to have occurred if:

(a) the branch circuit fuse opens (Class I only); or

(b) flame appears; or

The flame is to be extinguished immediately.

(c) an open circuit appears; or

(d) the tools stalls and will not operate at rated input; or

If the tool stalls but will run at rated load, reapply the load at the highest level which allows the tool to run until end results are achieved.

(e) a short-circuit develops in the winding which results in a spontaneous increase in current 50% or greater; or

If condition (a), (b), (c) or (d) occurs before the end of the 30 s the test is terminated. However, should none of these end conditions occur, the tool shall be cooled to room temperature. Without adjustment of the load from the value during the 30 s interval, operation of the tool is to be resumed for one period of 30 s, or until condition (a), (b), (c) or (d) occurs, whichever occurs first.

(f) the tool has completed the 200 percent rated load; or

(g) the tool has been operated for 6 hours.

The no-load time to cool the enclosure to a stabile temperature is included in the 6 hours.

At the moment the end result occurs, the neutral conductor is opened and the leakage current monitored until it stabilizes or decreases.

– for Class I tools

If the measured leakage current is less than or equal to 5.0 mA the tool is acceptable.

– for Class II tools

Step A: If the measured leakage current is less than or equal to 0.5 mA, proceed to Step D.

Step B: If the tool does not operate and the measured leakage current exceeding 0.5 mA but is less than 2.0 mA, the tool must be conditioned at 90°C until the temperature is stabilized. If the measured leakage current is greater than 2.0 mA the tool is non-compliant. After the temperature is stabilized at 90°C , the leakage current measurement is then repeated and if the current less than or equal to 0.5 ma proceed to Step D. If not, the tool is non-compliant.

Step C: If the tool still operates, and the measured leakage current exceeding 0.5 mA but is less than 2.0 mA, it is to be operated at rated input until the temperature stabilizes. If the measured leakage current is greater than 2.0 mA the tool is non-compliant. After the temperature is stabilized, the measurement is repeated and if the current is less than or equal to 0.5 mA proceed to step D. If not, the tool is non-compliant.

During the test, there shall be no exposure of live parts as determined by the probe test requirements of Clause 8 and leakage current when measured as specified in Clause 12 is not more than the values indicated.

If the end result occurs in less than 30 min, the test is repeated using a different sample and starting at a lower load value, but not less than 100 percent.

Step D: An electric strength test is performed on Class II tools after the tools are cooled to room temperature. Tools that do not operate after the end results require a 1250 V for 1 min applied between live parts and accessible non-current-carrying metal parts or metal foil specified in Sub-clause 15.3. Tools that operate after the end result requires a 2500 V for one min between live parts and accessible non-current-carrying metal parts or metal foil over a plastic enclosure as specified in Sub-clause 15.3.

18 Mechanical hazards

18.1 Moving parts shall as far as is compatible with the use and working of the tool, be so arranged or enclosed as to provide, in normal use, adequate protection against personal injury.

Protective enclosures, guards and the like shall have adequate mechanical strength. They shall not be removable without the aid of a tool, unless their removal is necessary in normal use, as specified in the relevant Part 2.

Compliance is checked by inspection, by the test of Clause 19, and by a test with a standard test finger similar to that shown in Figure 1~~, page 122~~ but having a circular stop plate with a diameter of 50 mm, instead of the non-circular plate.

It shall not be possible to touch ~~dangerous~~ moving parts that may present a risk of injury to persons through ventilation openings with this test finger.

~~This standard requires only such protection against personal injury as is, in general, required in most countries.~~

Among the factors to be considered in determining the acceptability of an exposed moving part are (1) the degree of exposure, (2) the sharpness of the moving part, (3) the likelihood of unintentional contact therewith, (4) the speed of the moving part, and (5) the likelihood that fingers, arms, feet, or clothing would be endangered by the moving part. These factors are to be considered with respect to the intended operation of the tool and also during setting of any adjustment or replacement of any cutting member.

19 Mechanical strength

19.1 Tools shall have adequate mechanical strength and be so constructed as to withstand such rough handling as may be expected in normal use.

~~*Compliance is checked by applying blows to the sample by means of the spring-operated impact test apparatus shown in Figure 8, page 125.*~~

~~*The apparatus consists of three main parts: the body, the striking element and the spring-loaded release cone.*~~

~~*The body comprises the housing, the striking element guide, the release mechanism and all parts rigidly fixed thereto. The mass of this assembly is 1250 g.*~~

~~*The striking element comprises the hammer head, the hammer shaft and the cocking knob. The mass of this assembly is 250 g.*~~

~~*The hammer head has a hemispherical face of polyamide having a Rockwell hardness of R 100, with a radius of 10 mm; it is fixed to the hammer shaft in such a way that the distance from its tip to the plane of the front of the cone, when the striking element is on the point of release, has approximately the value shown in the table for the compression.*~~

~~*The cone has a mass of 60 g and the cone spring exerts s force of approximately 20 N when the release jaws are on the point of releasing the striking element.*~~

~~*The release mechanism springs are adjusted so that they exert a force just sufficient to keep the release jaws in the engaged position. The force required to release the striking element must not exceed 10 N. The configuration of the hammer shaft, the hammer head and the means for the adjustment of the hammer spring is such that the hammer head passes the plane of impact.*~~

~~*The hammer spring is adjusted so as to cause the hammer to strike with an impact energy as shown in the following table, the spring compression being as shown in that table.*~~

~~Parts to be tested~~ ~~(Nm)~~	~~Impact energy~~ ~~(Nm)~~	~~Compression~~
~~Brush caps~~	~~0.5 ± 0.05~~	~~20.0~~
~~Other parts~~	~~1.0 ± 0.05~~	~~28.3~~

~~The apparatus is cocked by pulling the cocking knob until the release jaws engage with the groove in the hammer shaft.~~

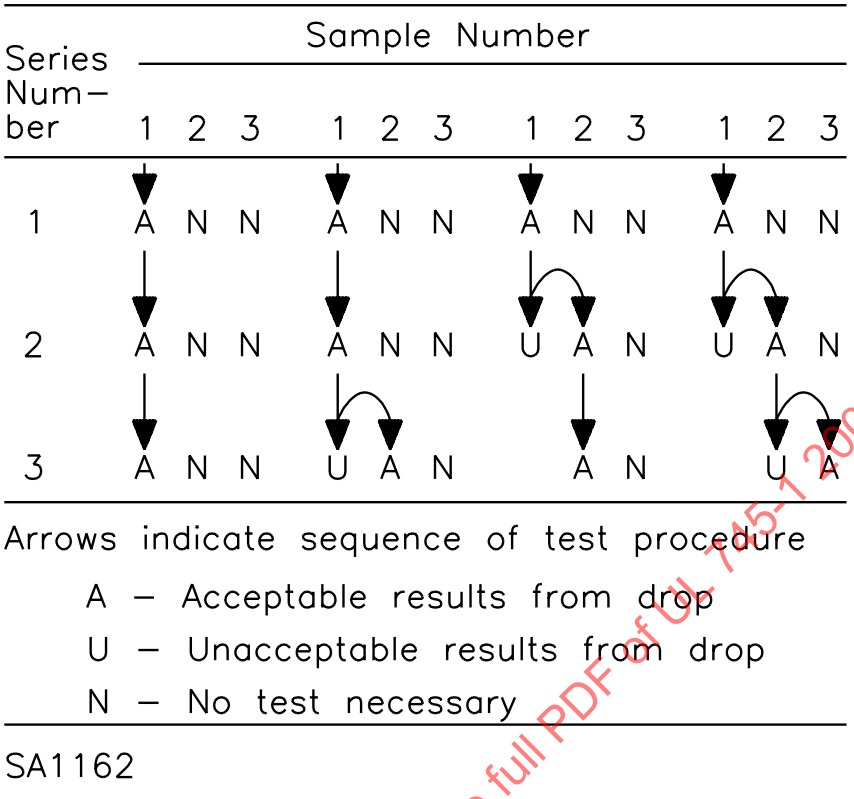
~~The blows are applied by pushing the release cone against the sample in a direction perpendicular to the surface at the point to be tested.~~

~~The pressure is slowly increased so that the cone moves back until it is in contact with the release bars, which then move to operate the release mechanism and allow the hammer to strike.~~

~~The sample as a whole is rigidly supported and three blows are applied to every point of the enclosure that is likely to be weak. If necessary, the blows are applied to every point of the enclosure that is likely to be weak. If necessary, the blows are also applied to handles, levers, knobs, and the like.~~

Compliance is checked by the following tests:

A hand supported tool shall withstand being dropped three times on a concrete surface from a height of 1 m. The sample shall be positioned to vary the point of impact Three samples are to be tested for a total of nine drops. Fewer samples may be used in accordance with the following table:



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Those tools that are not completely hand-supported in use, are to be subjected to the impact that results from the tool being allowed to fall or tip over from its intended operating positions to strike a concrete surface. Those tools that are not completely hand-supported in use, are also to be subjected to a ball impact of 6.8 J on any surface that is exposed to a blow during its intended use. A separate sample may be used.

Those tools intended to rest on the ground or be used on the floor or ground shall be subjected to a ball impact of 6.8 J on any surface that is exposed to a blow during its intended use.

Those tools that are to be subjected to a ball impact of 6.8 J shall be impacted by dropping a steel sphere 51 mm in diameter and weighing 0.53 kg from a vertical height of 1320 mm, or through a pendulum arc having an impact of 6.8 J while the tool is supported against or on a rigid surface that prevents the tool from moving as a result of the impact.

19.1.1 Exposed actuating mechanisms of switches and controls shall have adequate mechanical strength.

Compliance is checked by subjecting one sample to three impacts of 1.4 J.

Following the impact, the sample shall comply with sub-clause 8.1.

The actuating mechanisms shall receive an impact of 1.4 J by means of an impactor as described in sub-clause 19.3.

19.2 ~~The tool is allowed to hit a steel plate, 5 mm thick and mounted on a rigid wall as shown in Figure 9, page 126.~~

~~For tools fitted with a non-detachable flexible cable or cord, the cable is clamped at a point 1000 mm above the center of gravity of the tool.~~

~~Tools provided with an appliance inlet are suspended by a string fastened to the handle.~~

~~The tool is drawn away from the wall, in a plane perpendicular to the wall, the cable or cord, or the string, being substantially straight until its center of gravity is 500 mm above its original position. The tool is then allowed to swing against the steel plate.~~

~~The test is made four times, the tool being turned each time to another position.~~

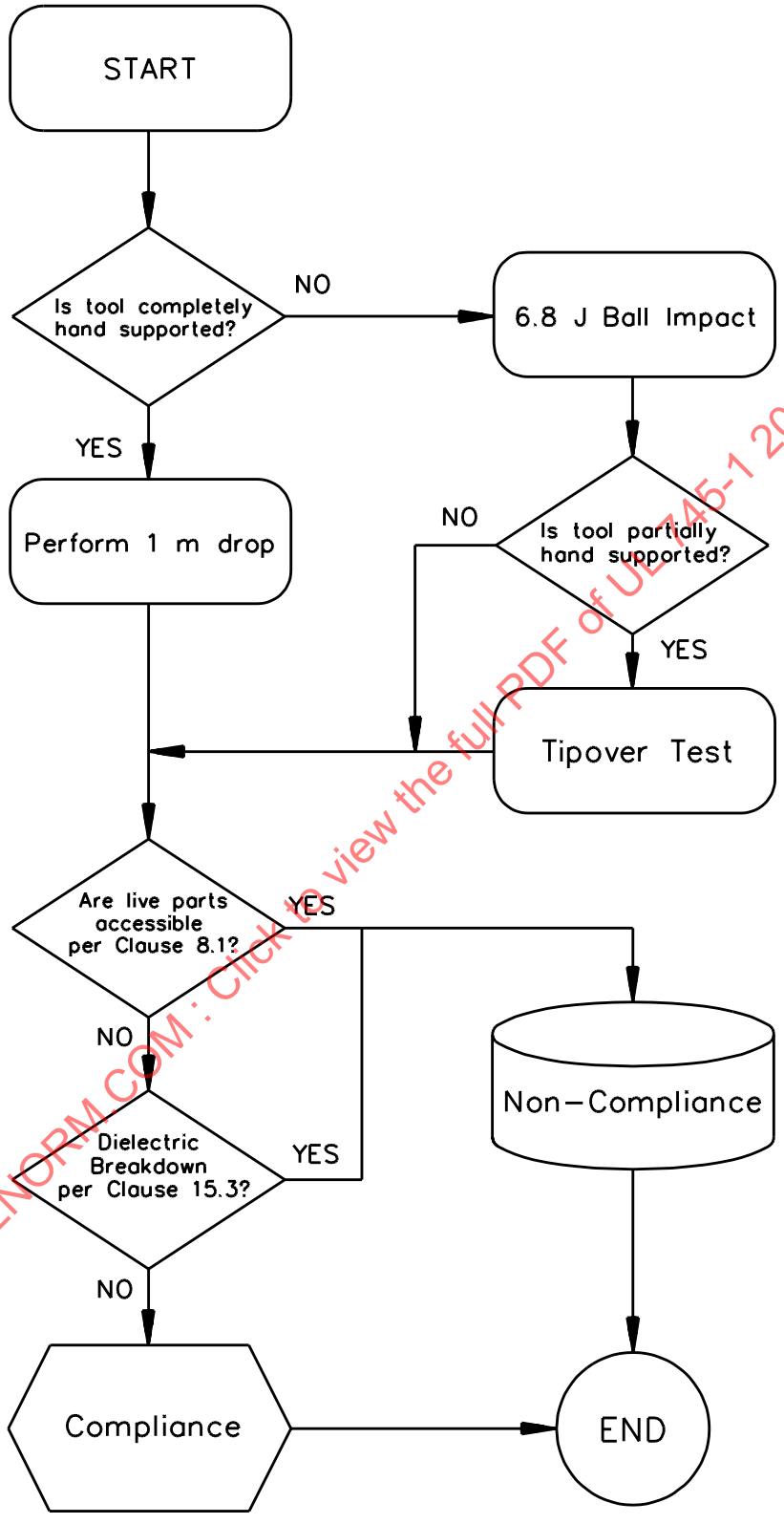
After the tests of Sub-clauses 19.1 ~~and 19.2 the sample shall show no damage within the meaning of this standard; in particular~~, live parts shall not have become accessible so as to cause non-compliance with the requirements of Sub-clauses 8.1, 15.1, 15.2, and 27.1. In case of doubt, supplementary insulation or reinforced insulation is subjected to an electric strength test as in Sub-clause 15.3 but with 75 percent of the values specified.

Damage to the finish, small dents which do not reduce creepage distances and clearances below the values specified in Clause 27, and small chips which do not adversely affect the protection against electric shock or moisture are neglected.

Cracks not visible to the naked eye and surface cracks in fiber-reinforced moldings and the like are ignored.

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

The tests of Clause 19.1 are illustrated in the following flowchart:



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19.3 Exposed brush holders and their caps shall have adequate mechanical strength.

Compliance is checked by inspection and~~, in case of doubt,~~ by removing and replacing the brushes ten times, the torque applied when tightening the cap being as shown in the following table.

Blade width of test screwdriver (mm)	Torque (Nm)
Up to and including 2.8	0.4
over 2.8 up to and including 3.0	0.5
over 3.0 up to and including 4.1	0.6
over 4.1 up to and including 4.7	0.9
over 4.7 up to and including 5.3	1.0
over 5.3 up to and including 6.0	1.25

After this test, the brush holder shall show no damage impairing its further use, the thread, if any, shall not be damaged and the cap shall show no cracks.

The blade width of the test screwdriver must be as large as possible but must not exceed the length of the recess in the cap. If however, the thread diameter is smaller than the length of the access, the blade width must not exceed this said diameter. The torque must not be applied in jerks.

Exposed brush covers or brush caps are also to be tested by withstanding a single impact of 1.4 J applied through the impactor shown in Figure 16 when dropped from a vertical height of 305 mm onto a cover or cap. There shall be no breakage or cracking of the brush cap or brush covers or the insulating barrier supports.

For the purpose of this sub-clause, a crack is defined as a separation of the material that extends through the thickness of the cap. Chipping of the slot is acceptable.

The test sample as a whole is to be rigidly supported so that the impact force of 1.4 J is absorbed by the component under test.

The impacting apparatus consists of a cylindrical solid steel impactor with a total mass of 225 g, with a dimensional shape as shown in Figure 19.3 and a guide tube which guides the impactor. The length, shape and the size of the guide tube shall not restrict the impact force of 1.4 J.

19.4 Insulating material of auxiliary handles and auxiliary grasping surfaces which overlay dead metal as described in Sub-Clause 8.3.2 shall have adequate mechanical strength and shall resist deterioration.

Compliance is checked by the following tests:

The sample is to be impacted as in Sub-Clause 19.1 in such a manner that each auxiliary handle, or area likely to be grasped, shall be impacted. Following the test, the sample shall pass the test of Sub-Clause 15.3, test 5.

For those tools having two auxiliary handles, a single sample may be dropped twice or two different samples may be used.

20 Construction

20.1 Tools which can be adjusted to suit different voltages, or to different speeds, shall be so constructed that accidental changing of the setting is unlikely to occur, if such a change might result in a ~~hazard~~ risk of injury.

Compliance is checked by inspection and by manual test.

20.2 Tools shall be so constructed that accidental changing of the setting of control devices other than the mains switch is unlikely to occur if such a change might result in a risk of injury.

Compliance is checked by manual test.

20.3 It shall not be possible to remove parts which ensure the required degree of protection against moisture without the aid of a tool.

Compliance is checked by manual test.

20.4 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~~ risk of injury.

Compliance is checked by inspection and by manual test.

20.5 Components which may require replacement, such as switches and capacitors shall be suitably fitted so as to facilitate their replacement by an authorized service facility.

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

This requirement is considered to be met if the components form part of an assembly which is itself suitably fitted.

Fixing by means of soldered or crimped connections is only allowed for small resistors, capacitors, inductors and the like, if these components can be suitably fixed by their connecting means. Fixing by means of rivets is not allowed.

Fixing by clamping and fixing by means of suitably shaped casing, such as the provision of a recess which holds the component in position, is allowed.

20.6 Replacement of a flexible cable or cord requiring the displacement of a switch which acts also as a terminal for external conductors shall be possible without subjecting internal wiring to undue stress; after repositioning of the switch and before reassembling the tool, it shall be possible to verify whether the internal wiring is correctly positioned.

Compliance is checked by inspection and by manual test.

20.7 Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation, unless impregnated or chemically rendered non-fibrous.

Insulating material is considered to be impregnated if the interstices between the fibers of the material are substantially filled with a suitable insulant.

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

Driving belts shall not be relied upon to ensure electrical insulation.

Compliance is checked by inspection.

This does not preclude the use of a special non-conductive belt or coupling available only from the tool manufacturer to achieve double insulation. The belt shall comply with the requirements for supplementary insulation.

20.8 Reinforced insulation shall only be used when it is manifestly impracticable to provide separate basic insulation and supplementary insulation.

Compliance is checked by inspection.

Appliance inlets, switches, brush holders and armature coils on shafts are examples where reinforced insulation may be used.

20.9 Insulating barriers of Class II tools, and parts of Class II tools which serve as supplemental insulation or reinforced insulation and which might be omitted during reassembly after routine servicing, shall either:

– be fixed in such a way that they cannot be removed without being seriously damaged; or

– be so designed that they cannot be replaced in an incorrect position, and that, if they are omitted, the tool is rendered inoperable or manifestly incomplete.

Compliance is checked by inspection and by manual test.

Except for exchange-type tools, routine servicing includes replacement of power supply cords, switches and the like.

This requirement is met if the barrier is so fixed that it can only be removed by breaking or cutting.

Fixing by means of rivets is allowed, provided that these rivets need not be removed when replacing the brushes, capacitors, switches, non-detachable flexible cables and cords and the like.

Fixing by means of an adhesive is only allowed if the mechanical strength of the joint is equal to that of the barrier.

An adequate internal lining of insulating material or an adequate internal insulating coating on metal enclosures is considered to be an insulating barrier provided that the coating cannot easily be removed by scraping.

For Class II tools, a sleeve on an insulated internal conductor, other than the core of an external flexible cable or cord, is considered to be an adequate insulating barrier, if it can only be removed breaking or cutting, or if it is clamped at both ends.

20.10 Inside the tool, the sheath (jacket) of a flexible cable or cord shall only be used as supplementary insulation where it is not subject to undue mechanical or thermal stresses.

20.11 Any assembly gap with a width greater than 0.3 mm in supplementary insulation shall not be coincidental with any such gap in basic insulation, neither shall any such gap in reinforced insulation give straight access to live parts.

Compliance is checked by inspection and measurement.

20.12 Class I tools shall be so constructed that, should any wire, screw, nut, washer, spring or similar part become loose or fall out of position, it cannot become so disposed that accessible metal is made live.

Class II tools shall be so constructed that, should any such part become loose or fall out of position, it cannot become so disposed that creepage distances or clearances over supplementary insulation or reinforced insulation are reduced to less than 50% of the values specified in Sub-clause 27.1.

~~Class II tools, other than those of the all-insulated type, shall be provided with insulating barriers between accessible metal and motor parts and other live parts.~~

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

For Class I tools, this requirement can be met by the provision of barriers, or by fixing the parts adequately and by providing sufficiently large creepage distances and clearances.

It is not to be expected that two independent parts will become loose or fall out of position at the same time.

For electrical connections, spring washers (wave, or curved spring washers) are not considered to be adequate for preventing the loosening of the parts.

Wires are considered as likely to become free from terminals or soldered connections, unless they are held in place near to the terminal or termination, independent of the terminal connection or solder.

Short rigid wires are not regarded as liable to come away from a terminal, if they remain in position when the terminal screw is loosened.

20.13 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 tool, to such an extent that creepage distances and clearances are reduced below the values specified in Sub-clause 27.1.

Parts of natural or synthetic rubber used as supplementary insulation in Class II tools shall be resistant to ageing and be so arranged and dimensioned that creepage distances and clearances are not reduced below the values specified in Sub-clause 27.1, even if cracks occur.

Compliance is checked by inspection, by measurement and, for rubber, by the following test.

Parts of rubber are aged in an atmosphere of oxygen under pressure. The samples are suspended freely in an oxygen bomb, the effective capacity of the bomb being at least ten times the volume of the samples. The bomb is filled with commercial oxygen not less than 97 percent pure, to a pressure of 2.1 ±0.07 MPa (210 ±7 N/cm^2).

The samples are kept in the bomb at a temperature of 70 ±1°C, for 4 days (96 h). Immediately afterwards, they are taken out of the bomb and left at room temperature, avoiding direct daylight, for at least 16 h.

After this test, the samples are examined and shall show no cracks visible to the naked eye.

~~In case of doubt with regard to materials other than rubber, special tests may be made.~~

The use of the oxygen bomb presents some danger unless handled with care. All precautions should be taken to avoid the risk of explosion due to sudden oxidation.

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

Compliance is checked by inspection.

Exposure of internal wiring, windings, commutators, slip rings and the like, and of insulation in general, to oil, grease and similar substances is allowed, provided those substances have no deleterious effect on such parts.

The insulating properties of the oil or grease will already have been checked by the test of Sub-clause 15.3.

20.15 It shall not be possible to gain access to brushes without the aid of a tool.

Screw-type brush-caps shall be so designed that, when tightening, two surfaces are clamped together.

Brush-holders which retain the brushes in position by means of a locking device shall be so designed that the locking does not depend upon the brush-spring tension, if loosening of the locking device might make accessible metal parts live.

Screw-type brush-caps which are accessible from the outside of the tool shall be of insulating material or be covered with insulating material of adequate mechanical and electrical strength; they shall not project beyond the surrounding surface of the tool.

Compliance is checked by inspection and by manual test, the properties of the insulating material being verified:

– by the tests of Sub-clauses 19.1 and 19.3 for screw-type brush-caps which are accessible from the outside of the tool:

– by the tests specified for supplementary insulation for Class I tools and Class III tools;

– by the tests specified for reinforced insulation for Class II tools.

20.16 Tools equipped with radio and television interference suppressor shall be so fitted that they are adequately protected by the tool against mechanical damage.

Compliance is checked by inspection and by the test of Sub-clause 19.1.

The suppressor may be either within the enclosure of the tool or in a strong casing firmly fixed by the tool.

Care should be taken, when designing the tool, to allow adequate space for fitting the suppressor.

~~Where, under particularly unfavorable conditions a greater degree of suppression is required than that recommended by C.I.S.P.R., this may necessitate the fitting of additional suppressor. Such additional suppressor may be incorporated in the cable or plug.~~

It is, however, recommended that the possible need for additional suppressor be taken into account when designing the tool by providing adequate space to arrange them in the normal way.

20.17 Tools with water supply shall be either of Class III or shall comply with the applicable tests of Clause 14 ~~designed for use in conjunction with an isolating transformer having a rated output voltage not exceeding 115 V~~.

Compliance is checked by the tests of Sub-Clause 14.3, 14.5, or 14.6, whichever is applicable.

Tools intended to be immersed in a liquid shall be classified Watertight.

Compliance is checked by the test of Sub-Clause 14.1 and 14.2.

Tools having a mass greater than 25kg and commonly used outdoors shall be classified Splashproof.

Compliance is checked by the test of Sub-Clause 14.1 and 14.2.

20.18 Switches shall be so located that accidental operation is unlikely to occur.

Compliance is checked by inspection and by a test during which the tool is placed in any possible position on a horizontal surface.

The edge is not considered part of the horizontal surface.

Inadvertent operation of the switch shall not then occur.

20.19 Tools, other than those provided with a flexible shaft, shall be fitted with a mains switch which can be switched off by the user without releasing his grasp on the tool.

Compliance is checked by inspection and by manual test.

This requirement is considered to be met if the switch has a locking arrangement, such as a locking knob, provided it unlocks automatically upon actuating the trigger or other actuating member. This requirement is considered to be met if the user can control the tool with one hand while switching the tool off with the other hand.

Unless otherwise specified in the relevant Part 2, remote control is not allowed.

20.20 Tools shall be so designed that the protection against electric shock is not affected when screws intended for replacement from the outside during routine servicing are replaced by screws having a greater length.

Compliance is checked by inserting longer screws, without appreciable force, after which creepage distances and clearances between live parts and accessible metal parts shall not have been reduced below the values specified in Sub-clause 27.1.

20.21 A handle, lever, knob, or other control shall be so located that when the accessory or attachment is installed on the intended tool, and when reaching for the control, it is not necessary to traverse an area where the likelihood of injury to persons is present. An area where the likelihood of injury to persons exists, adjacent to the control, shall be so guarded or located that it cannot be entered unintentionally.

Compliance is checked by inspection.

21 Internal wiring

21.1 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, etc., which may cause damage to the insulation of conductors.

Holes in metal through which insulated wires pass shall be provided with bushings or, unless required otherwise in Part 2, shall have smooth well-rounded edges.

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

Compliance is checked by inspection.

A radius of 1.5 mm is considered to be well rounded.

21.2 Internal wiring and electrical connections between different parts of the tool shall be adequately protected or enclosed.

Compliance is checked by inspection.

21.3 Internal wiring shall be either so rigid and so fixed or so insulated that, in normal use, creepage distances and clearances cannot be reduced below the values specified in Sub-clause 27.1.

The insulation, if any, shall be such that it cannot be damaged in normal use.

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

If the insulation of a conductor is not at least electrically equivalent to that of cables and flexible cords complying with ~~IEC Publications 227 or 245~~ applicable standard as shown in Appendix E, that conductor is considered to be a bare conductor. In case of doubt, an electric strength test at 2000 V is made between the conductor and metal foil wrapped round the insulation under conditions specified in ~~IEC Publications 227 or 245~~ applicable standard as shown in Appendix E.

Other tests may be necessary.

For Class I and Class II tools, direct contact between the insulation of wiring with basic insulation only and accessible metal parts shall be effectively prevented except that in Class I tools direct contact between wire insulation and accessible metal parts is permitted when the wire insulation is at least 0.8 mm thick.

Insulating sleeves may be used to prevent such contact, provided that the sleeves withstand the tests specified for supplementary insulation and that the conductors or sleeves are not likely to be lost during routine servicing.

21.4 Conductors identified by the color combination green or green/yellow shall not be connected to terminals other than earthing terminals.

Compliance is checked by inspection.

21.5 Insulated conductors which, in normal use, are subject to a temperature rise exceeding 50°C ~~(50 K)~~ shall have an insulation of heat-resisting material, if compliance with this standard is likely to be impaired by deterioration of the insulation.

Compliance is checked by inspection and, if necessary, by special tests; the temperature rise is determined during the test of Sub-clause 11.1.

21.6 Aluminum wires shall not be used for internal wiring.

~~The introduction of a suitable test to judge whether aluminum wires can be allowed is under consideration.~~

Windings of a motor are not considered to be internal wiring.

22 Components

22.1 Components shall comply with the safety requirements as specified in the relevant ~~IEC~~ Appendix E standards ~~as far as they reasonably apply~~.

If components are rated or marked with their operating characteristics, the conditions under which they are used in the tool shall be in accordance with these ratings or markings (see Note 3 to the table of sub-clause 11.5).

Capacitors connected in series with a motor winding shall be marked with their rated voltage, in volts, and their rated capacitance, in microfarads.

~~Until a standard for thermal cut-outs and overload releases is issued, this standard, as far as is reasonable, together with Appendix A is applicable to these controls.~~

The testing of components which have to comply with other standards is, in general, carried out separately, according to the relevant standard as follows.

It is checked that the marking of components marked with individual ratings suits the conditions which may occur in the tool. The component is then tested in accordance with its marking, the number of samples being that required by the relevant standard. Components not marked with individual ratings are tested under the conditions occurring in the tool, the number of samples being, in general, that required by the relevant standard.

For capacitors connected in series with a motor winding, it is verified that, when the tool is operated at a voltage equal to 1.1 times rated voltage and under minimum load, the voltage across the capacitor is not greater than 1.1 times the rated voltage of the capacitor.

~~Additional tests for electrolytic starting are under consideration.~~

Components incorporated in the tool are subjected to all the tests of this standard as part of the tool.

Compliance with the ~~IEC~~ standards for the applicable component does not necessarily ensure compliance with the requirements of this standard.

22.2 Mains switches shall have adequate breaking capacity, and shall be switches for frequent operation suitable for the application.

Compliance is checked by inspection and by the following test.

Mains switches are tested together with the tool at the upper limit of the rated voltage range of the tool.

The motor is then stalled and the switch is operated 50 times, each "on" period being not more than 0.5 s each "off" period being not less then 10 s.

If, in normal use, an electronic control device switches off the current before opening the main contacts, the number of operations is reduced to five, with the electronic control device short-circuited.

During this test, no sustained arcing or undue burning, pitting or welding of contacts shall occur and there shall be no electrical or mechanical failure.

Mains switches marked with individual ratings are also tested in accordance with ~~IEC Publication 328 : Switches for Appliances~~ the relevant component standard given in Appendix E.

Mains switches not marked with individual ratings are also tested in accordance with ~~IEC Publication 328, the current I_m having the value occurring in the switch when the tool operates under normal load~~ the relevant component standard given in Appendix E.

~~Moreover, the current to be used in the breaking capacity test is six times I_m when closing and three times I_m when opening and the current to be used in the normal operation test is five times I_m when closing and I_m when opening: the power factor is unity in all cases.~~

22.3 Tools shall not be fitted with mains switches of micro-gap construction, nor shall mains switches be fitted in the flexible cable or cord.

This requirement does not apply to micro gap switches complying with the standards given in Appendix E.

22.4 Overload protection devices shall be of the non-self-resetting type.

Compliance with the requirement of Sub-clauses 22.3 and 22.4 is checked by inspection.

22.5 Plugs and appliance inlets for safety extra-low voltage circuits or for frequencies exceeding 60 Hz shall neither be interchangeable with plugs and socket-outlets complying with ~~IEC Publication 83~~ the relevant standard given in Appendix E ~~: Plugs and Socket-outlets for Domestic and Similar General Use. Standards,~~ nor with connectors and appliance inlets complying with ~~IEC Publication 320~~ the relevant standard given in Appendix E.

~~The same requirement will apply to a future unified plug and socket-outlet system which is at present under consideration.~~

22.6 Plugs and connectors on flexible cables or cords, used for an intermediate connection between different parts of a tool, shall not be interchangeable with plugs and socket-outlets complying with ~~IEC Publication 83~~ the relevant standard given in Appendix E or with connectors and appliance inlets complying with ~~IEC Publication 320~~ the relevant standard given in Appendix E, if direct supply of these parts from the mains could cause ~~danger~~ risk of injury to persons or surroundings, or damage to the tool.

Compliance with the requirements of Sub-clauses 22.5 and 22.6 is checked by inspection and by manual test.

22.7 Capacitors shall not be connected between the contacts of thermal cut-outs.

Compliance is checked by inspection.

22.8 Components for basic radio and television interference suppression shall not be incorporated in the plugs.

~~Plugs or power supply cords incorporating interference suppressor for additional radio and television interference suppression, or overload protection devices, shall not impose undue strain on fixed socket-outlets.~~

~~A test is under consideration.~~

22.9 Inductors for radio and television interference suppression inserted in the earthing circuit shall not attain excessive temperatures in normal use and shall withstand short-circuit currents which may occur in the event of an insulation fault.

Compliance is checked by the following tests.

The inductor is loaded for 1 h with a current of 19 A, after which the temperature rise of the inductor and of parts in its vicinity shall not exceed 1.7 times the limits shown in the table of Sub-clause 11.5.

The inductor is then connected to a 250 V a.c. supply source protected by a 10 A fuse and the tool is short-circuited to earth.

After the test, the inductor shall show no damage impairing its further use.

The current of 19 A corresponds with the smaller test current of a 10 A fuse-link.

~~Characteristics of the test fuse and of the test circuit are under consideration.~~

22.10 Appliance couplers shall normally comply with ~~IEC Publication 320~~ the relevant standard given in Appendix E.

~~Where appliance couplers not standardized by IEC are used, the manufacturer shall inform the user in the instructions for use to connect the tool only by means of the appropriate connector specified by the manufacturer.~~

22.11 Alternate magnet wire of the same ANSI grade is considered equivalent; no additional testing is required.

23 Supply connection and external flexible cables and cords

23.1 Type Y and Z attachments shall not be used.

23.2 Ordinary tools shall be provided with either a power supply cord with type X or type M attachment or an appliance inlet.

Splash-proof tools shall be provided with either a power supply cord with type X or type M attachment or, when permitted by Part 2, with an appliance inlet.

Other tools shall be provided with a power supply with type X or type M attachment.

It shall not be easily possible to replace the power supply cord for type M attachment by a cord for type X attachment.

If an appliance inlet is used, it shall be so placed that the connector can be inserted without difficulty.

It shall be so located or enclosed that no live parts or one or more of the pins will be exposed to accidental contact during insertion or removal of a connector.

Compliance is checked by inspection, and by means of the test finger as shown in Figure 1, ~~page 122~~, or, for appliance inlets, by means of the appropriate gauges specified in ~~IEC Publication 320~~ the appropriate standard given in Appendix E.

Flexible cords on tools not intended to be used with liquids shall be (1) less than 0.5 m long, or (2) equal or greater than 1.8 m long.

Flexible cords on tools intended to be used with liquids shall:

– if transportable be less than 0.5 m or greater than 4.0 m;

– if hand-held be greater than 4 m.

A tool intended for use with a detachable power supply cord shall not be provided with terminal pins that will accommodate a standard flatiron or appliance plug.

If a 3-wire grounding type attachment plug or a 2-wire polarized attachment plug is provided, the attachment plug connections shall be as shown in Figure 17.

23.3 Unless otherwise stated in Part 2, the lightest cables which can be used are:

~~– with polyvinyl chloride insulation, a flexible cable with ordinary polyvinyl chloride sheath (227 IEC 53),~~

~~– with rubber insulation, a flexible cable with ordinary rubber sheath (245 IEC 53).~~

– Junior hard service cord in accordance with the National Electrical Code, ANSI/NFPA 70, or Hard Usage cord in accordance with the Canadian Electric Code, Part 1.

Polyvinyl chloride insulated flexible cables or cords, unless specifically rated for the temperature shall, however, not be used for tools having external metal parts, with a temperature rise exceeding 75°C ~~(75 K)~~ and which might be touched in normal use by the cable or cord.

Power supply cords of Class I tools shall be provided with a green/yellow striped or green conductor ~~core~~, which is connected to the internal earthing terminal of the tool and to the earthing contact of the plug~~, if any~~.

~~If provided with a plug, power supply cords of single-phase tools having a rated current not exceeding 16 A shall be provided with a plug complying with IEC Publication 83 or IEC Publication 309 (first edition, 1969): Plugs, Socket-outlets and Couplers for Industrial Purposes.~~ Power supply cords and plugs shall comply with the applicable standards given in Appendix E.

~~If plugs complying with IEC Publication 3W are fitted, the standard sheets to be applied are as follows:~~

~~Class I tools..... Sheet II~~

~~Class I tools..... Sheet [1]~~

~~Class III tools..... Sheet IX~~

[1]1 Pending the introduction into IEC Publication 309 of two-pole plugs, appliance inlets and connectors ~~for cable couplers, plugs to Standard Sheet II are allowed on Class 11 tools. but extension leads supplied for use with such tools must have three cores in case these leads are used for Class I tools.~~

~~The body of the plug shall be of, or covered with, rubber, polyvinyl chloride or material having no less mechanical strength.~~

~~Power supply cords of single-phase tools having a rated current exceeding 16 A but not exceeding 63 A, and of multi-phase tools having a rated current not exceeding 63 A, shall be provided with a plug complying with IEC Publication 309, the standard sheets to be applied being as follows:~~

~~Class I tools..... Sheet II or V according to current~~

~~Class II tools..... Sheet [2]~~

~~Class III tools..... Sheet IX~~

[2]2 Pending the introduction into IEC Publication 309 of suitable plugs, appliance inlets and connectors for ~~cable couplers. without provision for earthing, plugs to Standard Sheet II or V, according to current, are allowed for Class II tools, but extension leads supplied for use with such tools must have an earthing conductor in case these leads are used for Class 1 tools.~~

23.4 The nominal cross-sectional area of flexible cables or cords shall be not less than that shown in the following table:

Rated current of tool	Nominal cross-sectional area	AWG
(A)	(mm^2)	
Up to and including 6	0.75	18
over 6 up to and including 10	1	18
over 10 up to and including ~~16~~ 13	~~1.5~~ 1.25	16
over 13 up to and including 16	1.5	14
over 16 up to and including 25	2.5	12
over 25 up to and including 32	4	10
over 32 up to and including 40	6	8
over 40 up to and including 63	10	4

Compliance with the requirements of Sub-clauses 23.3 and 23.4 is checked by inspection.

23.5 Tools provided with a power supply cord shall have cord anchorages such that the conductors are relieved from strain, including twisting, where they are connected within the tool, and that their covering is protected from abrasion.

For Type X flexible cables or cords, it shall be clear as to how the relief from strain is to be obtained and makeshift methods such as tying the cable or cord into a knot or tying the ends with string shall not be used.

Cord anchorages of power supply cords of Class II tools shall be of insulating material or, if of metal, be insulated from accessible metal parts by insulation complying with the requirements for supplementary insulation.

~~For Class I tools, the conductors of flexible cables or cords shall be so arranged that, when the cord anchorage fails, the earthing conductor is relieved from strain as long as the phase conductors are in contact with their terminals.~~

Cord anchorages of power supply cords of tools other than Class II shall be of insulating material or be provided with an insulating lining, if otherwise an insulation fault on the cable or cord could make accessible metal parts live. This lining shall be fixed to the cord anchorage, unless it is a rubber bushing which forms part of the cord guard specified in Sub-clause 23.6.

Cord anchorages of Type X cords shall be so designed that:

– the cable or cord cannot touch clamping screws of the cord anchorage, if these screws are accessible or electrically connected to accessible metal parts;

– the cable or cord is not clamped by a metal screw which bears directly on the cable or cord;

– the components cannot readily be lost when replacing the cable or cord and at least one part is securely fixed to an integral part of the tool;

– replacement of the flexible cable or cord does not require the use of a tool especially designed for this purpose;

– they are suitable for the different types of flexible cable or cord which may be connected, unless the tool is so designed that only one type of cable or cord can be fitted.

Cord anchorages for Type X cords shall be so designed that replacement of the flexible cable or cord is easily possible.

Cord anchorages may be a part of the mains switch.

Internal s~~S~~crews, if any, which ~~have to be operated when replacing~~ fix the power supply cord, shall not serve to fix any other component unless, when omitted or incorrectly mounted, they render the tool inoperative or manifestly incomplete or unless the parts which are intended to be fastened by them are not detachable during the replacement of the cord.

Glands shall not be used as cord anchorages for power supply cords.

The term "glands" refers to a cord passing through a compression packing of the type generally used to prevent the entry of moisture or dust.

Compliance is checked by inspection and by the following tests.

~~*The tool is fitted with a flexible cable or cord and the conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the normal way, its clamping screws being tightened with two-thirds of the torque specified in Sub-clause 26.1.*~~

~~*The tests are first made with the lightest permissible type of flexible cable or cord of the smallest cross-sectional area specified in Sub-clause 24.2, and then with the next heavier type of flexible cable or cord of the largest cross-sectional area specified, unless the tool is so designed that only one type of cable or cord can be fitted.*~~

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

The cable or cord is then subjected ~~100~~ 10 times to a pull of three times the weight of the tool but not less than 156 or greater than 220 N ~~the value shown in the following table~~. The pulls are applied at a point 250 mm from the cord guard in the most unfavorable direction without jerks, each time for 1 ~~s~~ minute.

~~*Immediately afterwards, the sheathed flexible cables or cords are subjected for 1 min to a torque of the value shown in the following table.*~~

~~Mass of tool (kg)~~	~~Pull (N)~~	~~Torque (Nm)~~
~~Up to and including 1~~	~~30~~	~~0.1~~
~~Over 1 up to and including 4~~	~~60~~	~~0.25~~
~~Over 4~~	~~100~~	~~0.35~~

During the test, the cable or cord shall not be damaged.

After the test, the cable or cord shall not have been longitudinally displaced by more than 2 mm and the conductors shall not have moved over a distance of more than 1 mm in the terminals, nor shall there be appreciable strain at the connection.

For the measurement of the longitudinal displacement, a mark is made on the cable or cord while it is subjected to the pull, at a distance of approximately 20 mm from the cord anchorage before starting the tests.

~~*After the tests, the displacement of the mark on the cable or cord in relation to the cord anchorage is measured while the cable or cord is subjected to the pull.*~~

~~*The cord anchorage is then tightened and loosened ten times, after having fitted the largest flexible cable or cord that can be introduced through the cord guard specified in Sub clause 23.6.*~~

~~*After this test, the cord anchorage shall show no damage within the meaning of this standard.*~~

~~*Creepage distances and clearances shall not be reduced below the values specified in Clause 27.*~~

23.6 Flexible cables or cords of tools shall be protected against excessive bending at the inlet opening of the tool, by means of a cord guard of insulating material. ~~Such guards shall not be integral with a power supply cable or cord for type X attachment.~~

The guards shall be fixed in a reliable manner, and shall be of such a design that they project outside the tool for a distance beyond the inlet opening of at least five times the overall diameter of the cable or cord delivered with the tool.

Compliance is checked by inspection, by measurement and by the following test.

A tool designed for a power supply cord is fitted with a cord guard, the flexible cable or cord being approximately 100 mm longer than the guard.

The tool is so held that the axis of the cord guard, where the cable or cord leaves it, projects upwards at an angle of 45 to the horizontal when the cable or cord is free from stress.

A mass equal to 10 D^2 grams is then attached to the free end of the cable or cord. D being, in millimeters, the overall diameter of the flexible cable or cord delivered with the tool.

If the cord guard is temperature sensitive, the test is made at a temperature of 23 ±2°C.

Immediately after the mass has been attached, the curvature of the cable or cord shall nowhere be less than 1.5 D.

23.7 Cord guards shall have adequate mechanical strength and shall retain these properties throughout extended normal use.

Compliance is checked by the following test.

The part of the tool comprising the cable entry, fitted with the cord guard and the flexible cable or cord for which the tool is designed, is fixed in the oscillating member of an apparatus similar to that shown in Figure 13~~, page 129~~. The sample is so mounted that the axis of oscillation is tangential to the outer surface of the part in which the cord guard is secured, and, when the oscillating member is at the middle of its travel, the axis of the cable or cord where it leaves the cord guard, is vertical.

A weight having a mass equal to that of the tool, but not less than 2 kg or more than 6 kg is attached to the cable or cord.

The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical), the number of flexings being 20,000 and the rate of flexing 60 per minute. After 10,000 flexings, the sample is turned through 90° about the center line of the cord guard.

A flexing is one movement, either backwards or forwards. That is, from vertical to 45° in one direction is the first flex, from there back to vertical is the second flex, from vertical to the opposite 45° is the third flex, from there back to vertical is the fourth flex, continuing until 10000 flexes have occurred.

After the test, the cord guard shall not have worked loose and neither the cord guard nor the flexible cable or cord shall show any damage within the meaning of this standard, except that not more than 10 percent of the number of strands of each conductor may have been broken.

Immediately after this test, the cord anchorage and the terminal screws are loosened, without removing the conductors of the flexible cable or cord. However, if the cord guard is clamped under the cord anchorage, the cord anchorage is not loosened.

The tool is then lifted by the cord guard, without jerks, over a distance of approximately 500 mm in approximately 1 s, and replaced on a support.

The operation is made ten times.

During this test, the cord guard shall not slip out of its location.

23.8 Inlet openings for external wiring shall be so designed that the protective covering of the cable or cord can be introduced without risk of damage.

Inlet openings for flexible cables or cords shall be in insulating material, or be provided with bushings of insulating material, substantially free from ageing effects under conditions of normal use. The openings or bushings shall be so shaped as to prevent damage to the cable or cord.

Inlet bushings shall be reliably fixed and shall not be removable without the aid of a tool.

For Class II tools having inlet openings in metal, the bushings shall neither be of rubber nor form part of the cord guard.

For other tools having inlet openings in metal, a bushing, when used, shall not be of rubber, unless it forms part of the cord guard.

Compliance is checked by inspection and manual test.

Synthetic rubber is not considered to be rubber.

23.9 The space for the power supply cords inside a tool shall be adequate to allow the conductors to be easily introduced and connected, and the covers, if any, fitted without risk of damage to the conductors or their insulation. It shall be possible to check that the conductors are correctly connected and positioned before the cover is fitted.

The removal of covers giving access to terminals for external conductors shall not require the use of a tool specially designed for this purpose.

Class I tools with cords for type X attachment and all Class II tools shall be so designed that the uninsulated end of a conductor, should it become free from its terminal, cannot come into contact with accessible metal parts.

Compliance with the requirements of Sub-clause 23.9 is checked by inspection and by an installation test with cables or flexible cords of the largest cross-sectional area specified in Sub-clause 24.2.

Tools with type X attachment are subjected to the following additional test:

In the case of pillar terminals where the conductors are not separately clamped by a special device at a distance not exceeding 30 mm from the terminal, and in the case of other terminals with screw clamping, the clamping screw or nut is loosened. Without removing the conductor from the conductor space, a force of 2 N is applied to the wire in any direction and adjacent to the terminal, screw or stud. The uninsulated end of the conductor shall not then come into contact with accessible metal parts or any other metal part connected thereto.

For pillar terminals where the conductors arc separately clamped by a special device at a distance not exceeding 30 mm from the terminal, the tool is considered to meet the requirement that the uninsulated end of the conductor shall not come into contact with accessible metal parts.

The special device for clamping the conductors separately may, for example, be a cord anchorage.

24 Terminals for external conductors

24.1 Tools shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.

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

For tools with type X and type M attachments and having a rated input not exceeding 100 W, soldered connections may be used for the connection of external conductors, provided that the conductor is so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided such that creepage distances and clearances between live parts and other metal parts cannot be reduced to less than 50% of the values specified in Sub-clause 27.1 should the conductor break away at the soldered joint.

For the purpose of the requirements for power supply cords:

– it is not to be expected that two independent fixings will become loose at the same time:

– conductors connected by soldering arc not considered to be adequately fixed, unless they are held in place near to the termination, independently of the solder, but ″hooking in″ before soldering is, in general, considered to be a suitable means for maintaining the conductors of a power supply cord in position, provided the hole through which the conductor is passed is not unduly large;

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

Switches having connecting leads (pig tails) arc allowed if the connection point is within the handle or housing and the cord anchorage of the mains supply cable meets the requirements of Sub-clause 23.5.

~~Requirements for resilient connecting means and other terminals without clamping screws or nuts are under consideration.~~

Push-in type terminals are acceptable provided the component complies with the applicable standards given in Appendix E.

24.2 Terminals for type X attachment shall allow the connection of conductors having nominal cross-sectional areas as shown in the following table.

~~Rated current of tool (A)~~	~~Nominal cross-section area (mm) Flexible cables and cords~~
~~Up to and including 6~~	~~0.75 to 1~~
~~Over 6 up to and including 10~~	~~0.75 to 1.5~~
~~Over 10 up to and including 16~~	~~1 to 2.5~~
~~Over 16 up to and including 25~~	~~1.5 to 4~~
~~Over 25 up to and including 32~~	~~2.5 to 6~~
~~Over 32 up to and including 40~~	~~4 to 10~~
~~Over 40 up to and including 63~~	~~6 to 16~~

Rated current equipment	Nominal cross-sectional area			
A	mm^2			AWG
Up to and including 3	0.5	to	0.75	18
Over 3 up to and including 6	0.75	to	1.0	18
Over 6 up to and including 10	1.0	to	1.25	18
Over 10 up to and including 13	1.25	to	1.5	16
Over 13 up to and including 16	1.5	to	2.5	14
Over 16 up to and including 25	2.5	to	4.0	12
Over 25 up to and including 32	4.0	to	6.0	10
Over 32 up to and including 40	6.0	to	10.0	8
Over 40 up to and including 63	10.0	to	16.0	4

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

Compliance with the requirements of Sub-clauses 24.1 and 24.2 is checked by inspection, by measurement and by fitting cables or cords of the smallest and largest cross-sectional areas ~~specified~~ of the appropriate range shown in the table above.

24.3 Terminals and terminations for type M attachment shall be suitable for their purpose.

Compliance is checked by inspection and by applying a pull to the connection of 5 N.

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.4 Terminals shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, internal wiring is not subjected to stress and creepage distances and clearances are not reduced below the values specified in Sub-clause 27.1.

Compliance is checked by inspection and by measurement after fastening and loosening ten times a conductor of the largest cross-sectional area specified in Sub-clause 24.2, the torque applied being equal to two-thirds of the torque specified in Sub-clause 26.1.

Terminals may be prevented from working loose by fixing with two screws, by fixing with one screw in a recess such that there is no appreciable play or by other suitable means.

The requirement for fixation of terminals does not preclude the provision of supply terminals on switches or similar devices in a recess if, after connection of the supply cable and after re-positioning of the switch or similar device in its recess, it can be verified by inspection that these components and the supply cable are, after re-assembly of the tool, in the correct position.

Covering with sealing compound without other means of locking is not considered to be sufficient. Self-hardening resins may, however, be used to lock terminals which are not subject to torsion in normal use.

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.5 Terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without damage to the conductor.

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.6 Terminals of tools having a rated current not exceeding 16 A shall not require special preparation of the conductor in order to effect correct connection, and they shall be so designed or placed that the conductor cannot slip out when the clamping screws or nuts are tightened.

Compliance with the requirements of Sub-clause 24.5 and 24.6 is checked by inspection of the terminals and of the conductors, after the test of Sub-clause 24.4.

The term ″special preparation of the conductor″ covers soldering of the strands, use of cable lugs, formation of eyelets, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate the end.

Conductors are considered to be damaged if they show deep or sharp indentations.

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.7 Terminals of the pillar type shall have dimensions as shown in the following table, except that the length of the thread in the pillar may be reduced, if the mechanical strength is adequate and at least two full threads are in engagement when a conductor of the smallest cross-sectional area specified in Sub-clause 24.2 is tightly clamped.

Rated current of tool (A)	Minimum nominal thread dia. (mm)	Minimum diameter of hole for conductor (mm)	Minimum length of thread in pillar (mm)	Maximum difference between diameter of hole and nominal thread diameter (mm)
Up to and including 6	2.5	2.5	1.8	0.5
Over 6 up to and including 10	3.0	3.0	2.0	0.6
Over 10 up to and including 16	3.5	3.5	2.5	0.6
Over 16 up to and including 25	4.0	4.0	3.0	0.6
Over 25 up to and including 32	4.0	4.5	3.0	1.0
Over 32 up to and including 40	5.0	5.5	4.0	1.3
Over 40 up to and including 63	6.0	7.0	4.0	1.5

The length of the threaded part of the terminal screw shall not be less than the sum of the diameter of the hole for the conductor and the length of the thread in the pillar.

The surface against which the conductor is clamped shall be free from sharp indentations or projections.

Such terminals shall be so designed and located that the end of a conductor introduced into the hole is visible, or can pass beyond the threaded hole for a distance at least equal to half the nominal diameter of the screw, or 2.5 mm, whichever is the greater.

The length of the thread in the pillar is measured to the point where the thread is first broken by the hole or the conductor.

If the thread in the pillar is recessed, the length of headed screws must be increased accordingly.

The part against which the conductor is clamped need not necessarily be in one piece with the part carrying the clamping screw.

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.8 Screw terminals shall have dimensions not less than those shown in the following table, except that the length of the thread in the screw hole or nut and the length of thread on the screw may be reduced, if the mechanical strength is adequate and at least two full threads are in engagement when a conductor of the largest cross-sectional area specified in Sub-clause 24.2 is lightly clamped.

If the required length of thread in a terminal screw hole is obtained by plunging, the edge of the extrusion shall be reasonably smooth and the length of thread shall exceed the specified minimum value by at least 0.5 mm. The length of the extrusion shall be not more than 80 percent of the original thickness of the metal, unless the mechanical strength is adequate with a greater length.

If an intermediate part, such as a pressure plate, is used between the head of the screw and the conductor, the length of thread on the screw shall be increased accordingly, but the diameter of the head of the screw may be reduced by:

1 mm for rated currents not exceeding 16 A;

2 mm for rated currents exceeding 16 A.

Such an intermediate part shall be locked against rotation.

If an intermediate part has more than one screw, screws with the following nominal thread diameter may be used:

3.5 mm for rated currents not exceeding 25 A;

4.0 mm for rated currents exceeding 25 A.

If the thread in the screw hole or nut is recessed, the length of headed screws must be increased accordingly.

Rated current of tool (A)	Nominal thread diameter (mm)	Length of thread on screw (mm)	Length of thread in screw hole or nut (mm)	Nominal difference between diameter of head and shank of screw (mm)	Height of head of screw (mm)
Up to and including 6	2.5	4.0	1.5	2.5	1.5
Over 6 up to and including 10	3.0	4.0	1.5	3.0	1.8
Over 10 up to and including 16	3.5	4.0	1.5	3.5	2.0
Over 16 up to and including 25	4.0	5.5	2.5	4.0	2.4
Over 25 up to and including 32	5.0	7.5	3.0	5.0	3.5
Over 32 up to and including 40	5.0	9.0	3.5	5.0	3.5
Over 40 up to and including 63	6.0	10.5	3.5	6.0	5.0

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.9 Stud terminals shall be provided with washers and shall have dimensions as shown in the following table:

Rated Current of tool (A)	Nominal thread diameter (mm)	Difference between thread and:	
		inner diameter of washers (maximum) (mm)	outer diameter of washers (minimum) (mm)
Up to and including 6	2.5	0.4	3.5
Over 6 up to and including 10	3.0	0.4	4.0
Over 10 up to and including 16	3.5	0.4	4.5
Over 16 up to and including 25	4.0	0.5	5.0
Over 25 up to and including 32	5.0	0.5	5.5

Compliance with the requirements of Sub-clauses 24.7 to 24.9 is checked by inspection, by measurement and, if necessary, by the tests of Sub-clause 24.10. A negative deviation of 0.15 mm is allowed for the nominal thread diameter and for the nominal difference between diameters of head and shank of the screw.

If one or more of the dimensions required in Sub-clauses 24.7 to 24.9 are larger than specified, the other dimensions need not be correspondingly increased, but departures from the specified values must not impair the function of the terminal.

~~A revision of this sub-clause is under consideration.~~

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.10 If the length of thread in the pillar, screw hole or nut, or the length of thread on the screw, is smaller than that shown in the relevant table, or if the length of the extrusion is more than 80% of the original thickness of the metal, the mechanical strength of the terminal is checked by the following tests.

Screws and nuts are subjected to the test of Sub-clause 26.1 but with the torque increased to 1.2 times the torque specified.

After this test, the terminal shall show no damage impairing its further use.

A conductor is then fastened, as specified in Sub-clause 24.4, once more and, while clamped, is subjected for 1 min to an axial pull, applied without jerks, of the value shown in the following table:

Rated current of tool (A)	Pull (N)
Up to and including 6	40
Over 6 up to and including 10	50
Over 10 up to and including 16	50
Over 16 up to and including 25	60
Over 25 up to and including 32	80
Over 32 up to and including 40	90
Over 40 up to and including 63	100

During this test, the conductor shall not move noticeably in the terminal.

~~A revision of this sub-clause is under consideration.~~

Terminals and terminations complying with the standards in Appendix E are considered to be in compliance.

24.11 Where terminals are provided for type X and type M attachments, each terminal shall be located in proximity to its corresponding terminal, or terminals, of different polarity and to the earthing terminal, if any.

Compliance is checked by inspection.

24.12 Terminal devices shall not be accessible without the aid of a tool.

Compliance is checked by inspection and by manual test.

24.13 Terminations shall be so designed that the conductor is retained in position independently of the termination, before soldering or welding, so that it cannot slip out should the soldering or welding break.

Compliance is checked by inspection.

24.14 Terminals and terminations for type X and, when applicable, type M attachment shall be so located or shielded that should a wire of a stranded conductor escape when the conductors are fitted, there is no risk of accidental connection between live parts and accessible metal parts and, for Class II tools, between live parts and metal parts separated from accessible metal 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 manual test and~~ by the following test.

A 8 mm length of insulation is removed from the end of a flexible conductor having a nominal cross-sectional area as specified in Sub-clause 23.4. One wire of the stranded conductor is left free and the other wires are fully inserted into and clamped in the terminals.

The free wire is bent, without tearing the insulation back, in every possible direction, but without making sharp bends round barriers.

The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible or is connected to an accessible metal part or, for Class II tools any metal part which is separated from accessible metal parts by supplementary insulation only.

The free wire of a conductor connected to an earthing terminal shall not touch any live part.

Where the method of connection requires special preparation of the conductor. e.g. soldering, or where a termination is fitted to a type M attachment, e.g. crimping, this preparation is done with one strand left free.

25 Provision for earthing

25.1 Accessible metal parts of Class I tools, which may become live in the event of an insulation fault, shall be permanently and reliably connected to an earthing termination within the tool or to the earthing contact of the appliance inlet.

Earthing terminals and earthing contacts shall not be electrically connected to the neutral terminal, if any.

Class II and Class III tools shall have no provision for earthing.

Compliance is checked by inspection.

If accessible metal parts are screened from live parts by metal parts which are connected to the earthing terminal or to the earthing contact, they are not, for the purpose of this requirement, regarded as likely to become live in the event of an insulation fault.

Accessible metal parts which are separated from live parts by double insulation or by reinforced insulation, are not considered likely to become live in the event of an insulation fault.

Metal parts behind a decorative cover which does not withstand the test of Clause 19 are considered to be accessible metal parts.

25.2 Earthing connections shall not be made using screwless terminals.

The clamping means of earthing terminals shall be adequately locked against accidental loosening and it shall not be possible to loosen them without the aid of a tool.

Compliance is checked by inspection, by manual test and by the test of Clause 24.

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

25.3 All parts of the earthing terminal shall be such that there is no risk of corrosion resulting from contact between these parts and the copper of the earthing conductor, or any other metal that is in contact with these parts.

The body of the earthing terminal shall be of brass or other metal no less resistant to corrosion, unless it is a part of the metal frame or enclosure, ~~when~~ then the screw or nut shall be of brass, plated steel complying with Clause 29, or other metal no less resistant to corrosion.

If the body of the earthing terminal is a part of a frame or enclosure of aluminum alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between copper and aluminum or its alloys.

Compliance is checked by inspection.

The requirement regarding the avoidance of the risk of corrosion does not preclude the use of adequately coated metal screws or nuts.

25.4 For tools with power supply cords or cables, the arrangement of the terminals, or the length of the conductors between the cord anchorage and the terminals, shall be such that the current-carrying conductors become taut before the earthing conductor if the cable or cord slips out of the cord anchorage.

~~*A test for compliance is under consideration.*~~

Compliance is checked by inspection.

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

Compliance is checked by the following test, during which any inductors for interference suppression are left in the earthing circuit.

A current of 1.5 times the rated current but not less than 25 A derived from an a.c. source with a no-load voltage not exceeding 12 V is passed between the earthing terminal or earthing contact, and each of the accessible metal parts in turn.

The voltage drop between the earthing terminal or the earthing contact of the tool, and the accessible metal part is measured, and the resistance calculated from the current and this voltage drop.

In no case shall the resistance exceed 0.1 Ω.

The resistance of the flexible cable or cord is not included in the resistance measurement.

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

26 Screws and connections

26.1 Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use. Screws transmitting contact pressure and screws which are likely to be tightened by the user and have a nominal diameter less than 3 mm shall screw into metal.

Screws shall not be of metal which is soft or liable to creep, such as zinc or pure aluminum.

Screws of insulating material shall have a nominal diameter of at least 3 mm; they shall not be used for any electrical connection.

Screws shall not be of insulating material if their replacement by a metal screw could impair supplementary insulation or reinforced insulation, neither shall screws which may be removed when replacing a power supply cord or undertaking other routine servicing, be of insulating material if their replacement by a metal screw could impair electrical insulation.

Compliance is checked by inspection and, for screws and nuts transmitting contact pressure, or which are likely to be tightened by the user, by the following test.

The screws or nuts are tightened and loosened:

10 times for screws in engagement with a thread of insulating material,

5 times for nuts and other screws.

Screws in engagement with a thread of insulating material are completely removed and reinserted each time.

When testing terminal screws and nuts, a flexible conductor of the largest cross-sectional area specified in Sub-clause 24.2 is placed in the terminal.

The test is made by means of a suitable test screwdriver, spanner or key applying a torque as shown in the following table, the appropriate column being.

– for metal screws without heads if the screw when tightened does not protrude from the hole I

– for other metal screws and for nuts.....II

– for screws of insulating material:

• having a hexagonal head with the dimension across flats exceeding the overall thread diameter; or

• with a cylindrical head and a socket for a key, the socket having a cross-corner dimension exceeding the overall thread diameter; or

• with a head having a slot or cross slots, the length of which exceeds 1.5 times the overall thread diameter II

– for other screws of insulating material..... III

Nominal diameter of screw (mm)	Torque (Nm)		
	I	II	III
Up to and including 2.8	*0.2*	*0.4*	*0.4*
Over 2.8 up to and including 3.0	*0.25*	*0.5*	*0.5*
Over 3.0 up to and including 3.2	*0.3*	*0.6*	*0.6*
Over 3.2 up to and including 3.6	*0.4*	*0.8*	*0.6*
Over 3.6 up to and including 4.1	*0.7*	*1.2*	*0.6*
Over 4.1 up to and including 4.7	*0.8*	*1.8*	*0.9*
Over 4.7 up to and including 5.3	*0.8*	*2.0*	*1.0*
Over 5.3 up to and including 6.0	–	*2.5*	*1.25*

The conductor is moved each time the screw or nut is loosened. Care is to be taken to insure self-threading screws are not cross threaded during the test.

During the test, no damage impairing the further use of the screwed connections shall occur.

Screws or nuts which are likely to be tightened by the user include terminal screws or nuts, screws for fixing covers, if they have to be loosened to open or to remove the cover, screws for fixing handles, knobs, etc.

The shape of the blade of the test screwdriver must suit the head of the screw to be tested. The screws and nut must not be tightened in jerks.

Connectors complying with the standards in Appendix E are considered to be in compliance.

26.2 Screws in engagement with a thread of insulating material shall have a length of engagement of at least 3 mm plus one-third of the nominal screw diameter, or 8 mm, whichever is the shorter.

Correct introduction of the screw into the screw hole or nut shall be ensured.

This requirement does not apply to brush caps.

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

The requirement with regard to correct introduction is met if introduction of the screw in a slanting manner is prevented, for example, by guiding the screw by the part to be fixed, by a recess in the female thread or by the use of a screw with the leading thread removed.

Connectors complying with the standards in Appendix E are considered to be in compliance.

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

Connectors complying with the standards in Appendix E are considered to be in compliance.

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

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

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

Compliance with the requirements of Sub-clauses 26.3 and 26.4 is checked by inspection.

Connectors complying with the standards in Appendix E are considered to be in compliance.

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

Rivets used for current-carrying connections shall be locked against loosening if these connections are subject to torsion in normal use.

Compliance is checked by inspection and by manual test.

Spring washers and the like may provide satisfactory locking.

For rivets, a non-circular shank or an appropriate notch may be sufficient.

Sealing compound which softens on heating provides satisfactory locking only for screw connections not subject to torsion in normal use.

Connectors complying with the standards in Appendix E are considered to be in compliance.

27 Creepage distances, clearances and distances through insulation

27.1 Creepage distances, clearances and distances through insulation shall not be less than the values in millimeters shown in the following table.

	Working Voltage (1)			
Distances	**≤50(2)**	**≤130**	**≤250**	**≤440**
Creepage distances				
Between live parts of different polarity:				
– if protected against deposition of dirt	1.0	1.0	2.0	3.0
– if not protected against deposition of dirt	2.0	2.5	3.0	5.0
Between live parts and other metal parts:				
– over basic insulation protected against deposition of dirt:				
• if of ceramic, pure mica and the like	1.0	1.0	2.0-3.0[3]	–
• if of other material	1.5	2.0	3.0	–
– over basic insulation not protected against deposition of dirt	2.0	2.5	4.0	–
– over reinforced insulation:				
• if protected against deposition of dirt	–	5.0	8.0	–
• if not protected against deposition of dirt	–	8.0	8.0	–
Between metal parts separated by supplementary insulation	–	2.5	4.0	–
Between lacquered or enamelled windings and metal parts separated from live parts:				
– by basic insulation only	1.0	1.5	2.0	–
– by reinforced insulation	–	5.0	6.0	–
Between windings having basic insulation and accessible metal parts of Class II tools (5)	–	2.5	4.0	–
Clearances				
Between live parts of different polarity:				
– if protected against deposition of dirt	1.0	1.0	2.0	3.0
– if not protected against deposition of dirt	2.0	2.5	3.0	4.0
Between live parts and other metal parts:				
– separated by basic insulation:				
• if protected against deposition of dirt	1.0	1.0	2.0-3.0[3]	–
• if not protected against deposition of dirt	1.5	2.0	3.0	–
– separated by reinforced insulation:				
• if protected against deposition of dirt	–	5.0	8.0	–
• if not protected against deposition of dirt	–	5.0	8.0	–
Between metal parts separated by supplementary insulation	–	2.5	4.0	–
Between lacquered or enameled windings and metal parts separated from live parts:				
– by basic insulation only	1.0	1.5	2.0	–
– by reinforced insulation	–	65.0	6.0	–
Between windings having basic insulation and accessible metal parts of Class II tools(5)	–	2.5	4.0	–
Distance through insulation between metal parts (4)				
– separated by supplementary insulation	–	1.0	1.0	–
– separated by reinforced insulation:				
• in general	–	1.5	2.0	–
• between windings and accessible metal	–	1.0	2.0	–

Table Continued on Next Page

Table Continued

	Working Voltage (1)			
Distances	≤50(2)	≤130	≤250	≤440

1) In general, the working voltage for tools is considered to be the rated voltage.

2) The values shown in the table for voltages equal to or smaller than 50 V apply to circuits of Class III type and not, for example, to printed wiring circuits.

3) The first value applies only if the parts are rigid and located by mouldings, or if the design is otherwise such that there is no likelihood of a distance being reduced by distortion or movement of the parts. If this is not the case the second value applies.

4) This distance is not applicable to the insulation of internal wiring and of external flexible cables or cords.

5) Windings are considered to have basic insulation if they are wrapped with tape and then impregnated, or if they are covered with a layer of self-hardening resin, and if, after the test of Sub-clause 14.4, an electric strength test as specified in Sub-clause 15.3 is withstood, the test voltage being applied between the conductors of the winding and metal foil in contact with the surface of the insulation. It is sufficient that the wrapping and impregnation, or the layer of self-hardening resin, cover the windings only at places where it is not possible to obtain the creepage distance or clearance specified for lacquered or enamelled winding.

The requirement concerning the distance through insulation between metal parts does not apply if the insulation is applied in thin sheet foil and consists of at least three layers, provided that, when two layers are in contact, they withstand the electric strength test prescribed for reinforced insulation, the test voltages being applied between the outer surfaces of the two layers.

Compliance is checked by measurement.

The way in which creepage distances and clearances are measured is indicated in Appendix D.

For tools provided with an appliance inlet, the measurements are made with an appropriate connector inserted; for tools with type X attachment, they are made with supply conductors of the largest cross-sectional area specified in Sub-Clause 24.2, and also without conductors; for other tools, they are made on the tools as delivered.

The measurements are made with the belts, if any, in position with the belt tensioning devices in the most unfavorable location and also with the belts removed.

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

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

Distances through slots or openings in external parts of insulating material are measured to metal foil in contact with the accessible surface.

For the purpose of this clause, accessible surfaces of insulating material are treated as though they were covered with a layer of metal foil, the foil being stretched across any openings, but pressed into corners with the test finger of Figure 1, ~~page 122~~.

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

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

– 2 N for bare conductors;

– 30 N for enclosures.

The contribution to the creepage distances of any grooves less than 1 mm is limited to its width. Any air gap less than 1 mm wide is ignored in computing the total clearance.

The clearances required between live parts of different polarity do not apply to the air gap between the contacts of thermal cut-outs, overload protection devices, switches of micro-gap construction and the like. or to the air gap between the current-carrying members of such devices where the clearance varies with the movement of the contacts.

In general, the interior of a tool having a reasonably dust-proof enclosure is deemed to be protected against deposition of dirt, provided the tool does not generate dust in itself; hermetic sealing is not required.

When assessing creepage distances and clearances, the effect of insulating linings of metal enclosures or covers is taken into consideration.

If the insulation on a conductor is not at least electrically equivalent to that of cables and flexible cords, that conductor is considered to be a bare conductor. See also Sub-clause 21.3.

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

For live parts of different polarity separated by basic insulation only, creepage distances and clearances smaller than those specified in the table are allowed, provided the tool does not ~~show any defect within the meaning of this standard~~ exhibit flame or make accessible metal parts live if these creepage distances and clearances are short-circuited consecutively and the creepage distances are over insulating material withstanding the test of Sub-clause 28.3.

Sub-clause 27.1 does not apply to printed wiring boards complying with the applicable standards given in Appendix E.

28 Resistance to heat, fire and tracking

28.1 External parts of insulating material, the deterioration of which might ~~cause the tool to become unsafe~~ increase the risk of fire or shock, shall be sufficiently resistant to heat.

Compliance is checked by subjecting enclosures and other external parts of insulating material to a ball-pressure test by means of the apparatus shown in Figure 10~~, page 126~~.

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

The test is made in a heating cabinet at a temperature of 75 ±2°C or at a temperature which is 40 ±2°C ~~(40 ±2°K)~~ in excess of the temperature rise of the relevant part determined during the test of Clause 11, whichever is the higher.

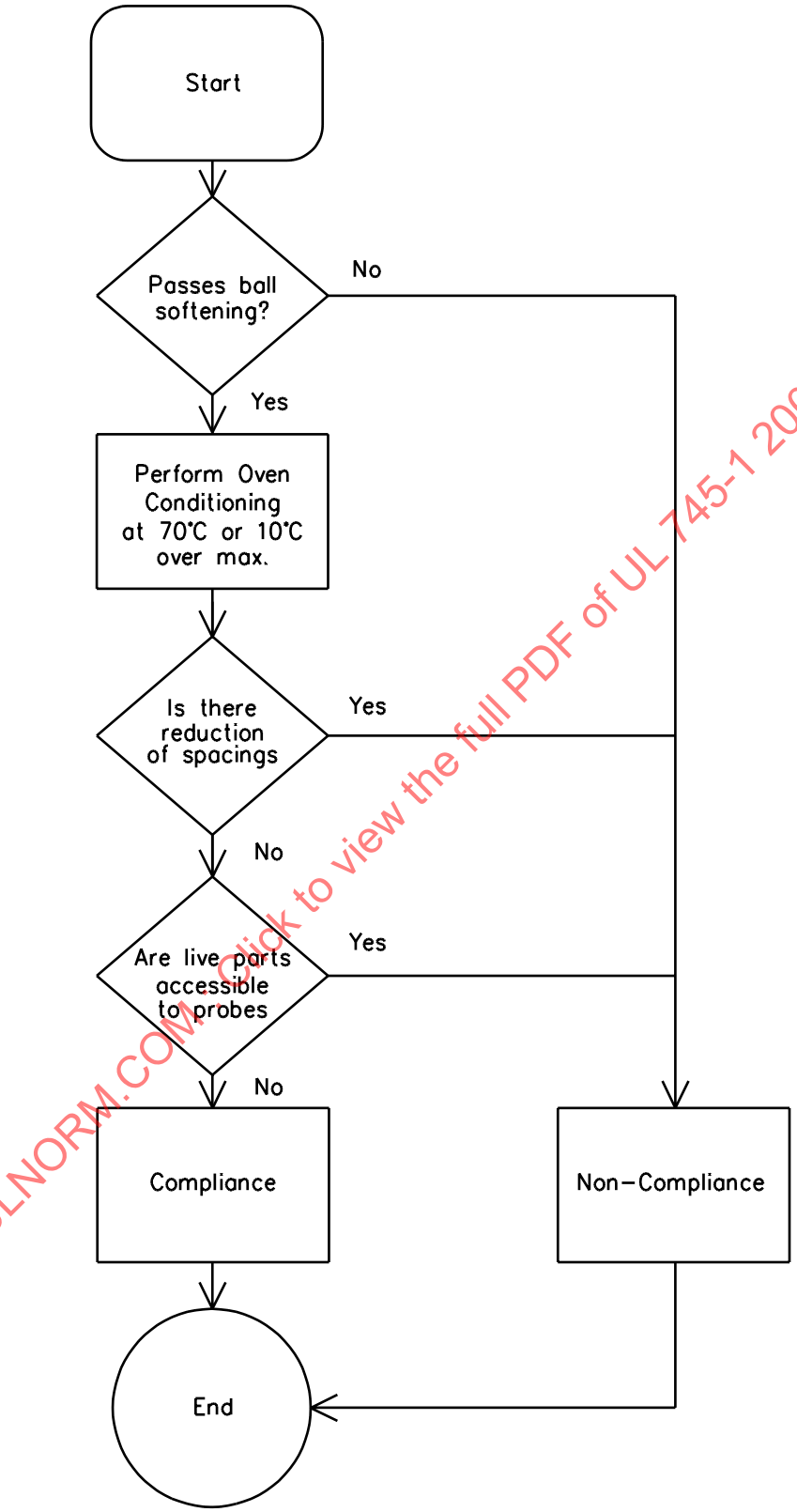
After 1 h, the ball is removed and the diameter of the impression measured. This diameter shall not exceed 2 mm.

The test is not made on parts of ceramic material or materials having an adequate Ball Softening Temperature rating in accordance with the standards given in Appendix E.

28.1.1 External parts of insulation material, the deterioration of which might increase the risk of fire or shock, shall be sufficiently resistant to mold stress.

Compliance is checked by placing one sample tool in an air circulating oven for 7 hours at a temperature 10°C above the maximum attained on the enclosure during the Heating Test of Clause 11 or 70 ±2°C, whichever is higher. Following this conditioning there shall be no reduction of spacings as described in Clause 27 or exposure of live parts or internal wiring as determined by Sub-Clause 8.1.

The tests of Clauses 28.1 and 28.1.1 are illustrated in the following flowchart:



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28.2 ~~Insulating parts retaining live parts in position shall be resistant to abnormal heat and to fire.~~ Insulating parts retaining live parts in position shall (1) comply with the 19 mm flame test given below; or, (2) be rated V; or, (3) be rated HB and possess a Hot Wire Ignition (HWI) rating of 7 sec or greater and an High Ampere Arc Ignition (HAI) rating of 60 arcs or greater. Rated materials are to be in accordance with the standards given in Appendix E.

Compliance is checked by inspection and if necessary by the following test.

~~*A test is made as described in Sub-clause 28.1, but at a temperature of 125 ±2°C or at a temperature which is 40 ±2°C (40 ±2K) in excess of the temperature rise of the relevant part determined during the test of Clause 11, whichever is the higher.*~~

~~*In addition, the insulating parts are subjected to a test made with an electrically heated conical mandrel in an apparatus as shown in Figure 11, page 127.*~~

~~*The mandrel is inserted into a conical hole reamed in the part to be tested in such a way that portions of the conical part of the mandrel of equal length protrude from both sides. The sample is pressed against the mandrel with a force of 12 N. The means by which the force is applied is then locked to prevent any further movement. However, if the sample starts to soften or melt during the test, a force just sufficient to keep the sample in contact with the mandrel is applied in a horizontal direction.*~~

~~*The mandrel is heated to a temperature of 300 C in approximately 3 min and is maintained within 10°C (10K) of this value for 2 min. The temperature is measured by means of a thermocouple inside the mandrel.*~~

~~*During the period of 5 min sparks of about 6 mm in length are produced at the upper surface of the sample where the mandrel protrudes by means of a high-frequency generator, the electrodes of which are moved around the mandrel so as to cover the whole area of the sample near the mandrel.*~~

~~*Neither the sample, nor any gases produced during the heating shall be ignited by the sparks.*~~

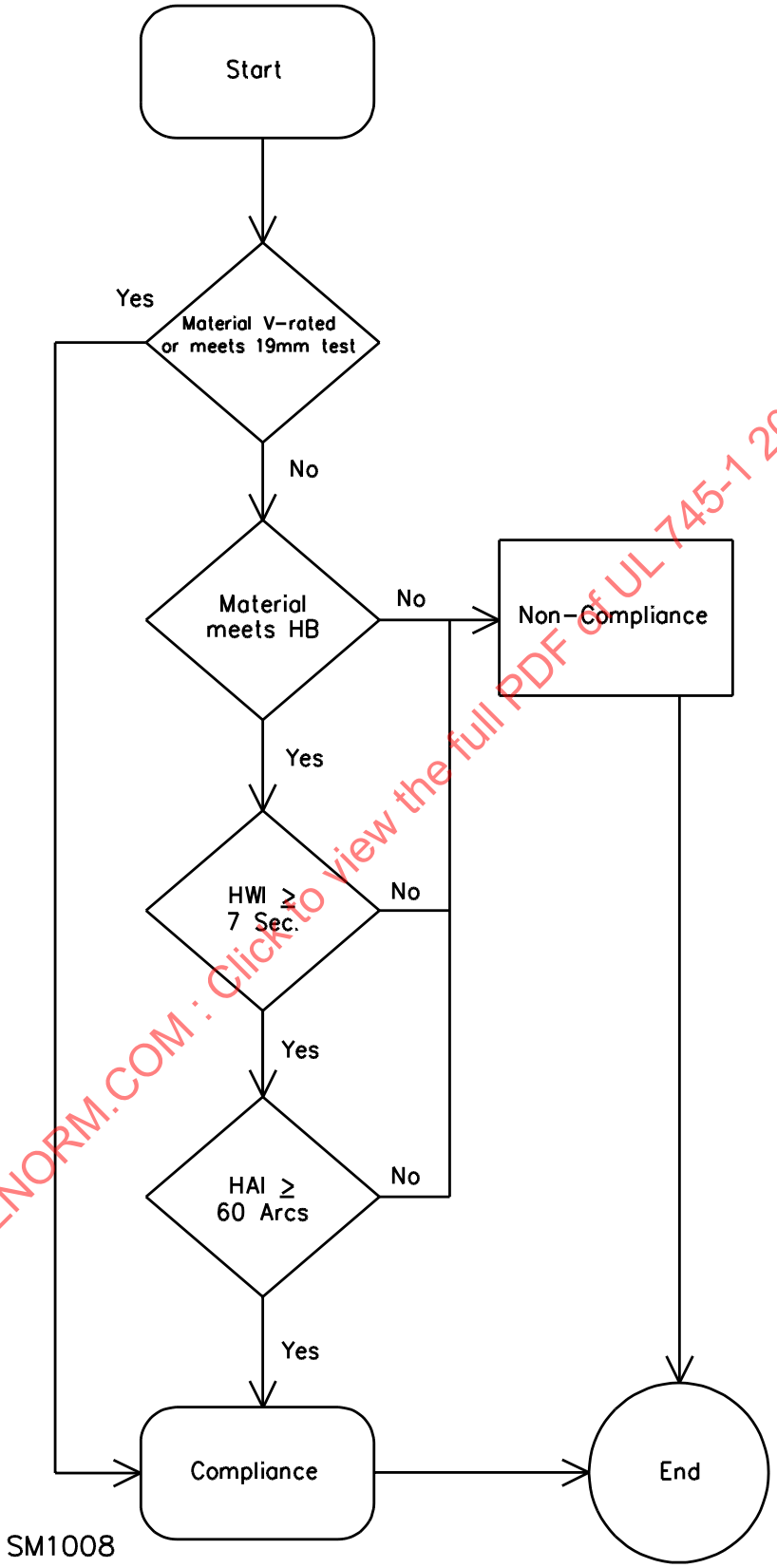
~~The tests are not made on parts of ceramic material, insulating parts of commutators or brush-caps and the like, or on coil formers not used as reinforced insulation.~~

~~A revision of these tests is under consideration.~~

The enclosure is to be supported in its intended operating position in a draft-free location, and non-polymeric parts are to be removed if possible, and all internal mechanisms of the tool are to remain in place. The flame of a Bunsen burner is to be adjusted to have a 19 mm high yellow flame with no blue cone. Two 30-second applications of the tip of the flame are to be applied to the selected section of the enclosure with a 1-minute interval between the flame applications. The enclosure shall not support combustion for more than 1-minute after the two 30-second applications of the flame, nor shall there be a complete destruction of the sample as a result of this test.

Insulating parts retaining live parts refers both to parts directly and part indirectly supporting live parts.

The tests of Clause 28.2 are illustrated in the following flowchart:



28.3 Insulating parts retaining live parts in position and supplementary insulation of metal-encased Class II tools shall be of material resistant to tracking, if they are exposed to excessive deposition of moisture or dirt in normal use.

~~This requirement applies, in general, to splash-proof and watertight tools. and to parts of grinders, sanders, and metal saws, which are exposed to dirt in normal use.~~

For materials other than ceramic, compliance is checked by the standards given in Appendix E, or by the following test:

A flat surface of the part to be tested, if possible at least 15 mm × 15 mm, is placed in the horizontal position.

The sample may be cut from the tool or molded as a separate piece.

Two electrodes of platinum or other sufficiently non-corrodible material, with the dimensions shown in Figure 12~~, page 128~~, are placed on the surface of the sample in the manner shown in this figure, so that the rounded edges are in contact with the sample over their whole length.

The force exerted on the surface by each electrode is about 1 N.

The electrodes are connected to a 50 or 60 Hz supply source having a voltage of 175 V of substantially sine-wave form. The total impedance of the circuit when the electrodes are short-circuited is adjusted by means of a variable resistor, so that the current is equal to 1.0 ±0.1 A with a power factor between 0.9 and 1. An overcurrent relay with a tripping time of at least 0.5 s is included in the circuit.

The surface of the sample is wetted by allowing drops of a solution of ammonium chloride in distilled water to fall centrally between the electrodes. The solution has a volume resistivity of 400 ohm/cm at 25°C, corresponding to a concentration of about 0.1 percent. The drops have a volume of 20^{+5}_{0} mm^3 and fall from a height of 30 mm to 40 mm.

The time interval between one drop and the next is 30 ±5 s.

No flashover or breakdown between electrodes shall occur before a total of 50 drops has fallen.

The test is made at three places on the sample.

Care is taken that the electrodes are clean, correctly shaped and correctly positioned before each test is started.

In case of doubt, the test is repeated, if necessary on a new sample.

The test is not made on insulating parts of commutators or brush-caps.

~~A revision of this test is under consideration.~~

29 Resistance to rusting

29.1 Ferrous parts, the rusting of which might ~~cause the tool to become unsafe~~ increase the risk of injury to persons shall be adequately protected against rusting.

Compliance is checked by the following test.

All grease is removed from the parts to be tested by immersion in ~~carbon tetrachloride or trichloroethane~~ a suitable degreaser for 10 min. The parts are then immersed for 10 min in a 10% solution of ammonium chloride in water at a temperature of 20 ±5°C. Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of 20 ±5°C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of 100 ±5°C, their surfaces shall show no signs of rust.

When using the liquids specified for the test, adequate precautions must be taken to prevent the inhalation of their vapors.

Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

For small helical springs and the like, and for parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are only subjected to the test if there is doubt about the effectiveness of the grease film, and the test is then made without previous removal of the grease.

30 Tests by Manufacturers

30.1 Electric Strength Test

30.1.1 The manufacturer shall determine by routine production-line test that each tool produced will withstand without an indication of unacceptable performance, the application of a potential as given in the following table. The duration of application shall be 1 second.

Points between which potential is to be applied	Test potential, Class I	Class II	Class III
1. Live parts and dead metal parts insulated from each other by basic insulation.	1200	1200	500
2. Accessible dead metal parts or, for a tool with an outer enclosure of insulating material, metal foil wrapped tightly around the enclosure and inaccessible metal parts including metal foil in contact with the insulating barriers provided for spacings involving supplementary or reinforced insulation.		1500	
3. Live parts and accessible dead metal parts or, for a tool with an outer enclosure of insulating material, metal foil wrapped tightly around the enclosure.		3000	
Note A: If necessary because of the inaccessibility of parts, test in accordance with items 1 and 2 may be conducted on sub-assemblies of the tool, and, in this case, the test indicated in item 3 is to be conducted. If the tests in accordance with item 1 and 2 are conducted on the completely assembled tool, the tests indicated in item 3 may be omitted if there is no reinforced insulation.			
Note B: Those parts of the tests described in items 2 and 3 that include application of metal foil to outer enclosures of insulating material may be waived if the manufacturer has an acceptable quality control program. This program is to determine that the insulating material in question is free from cracks and metal inclusions, and that it has the physical and electrical strength required for the application. To determine that the material is free of cracks or metal inclusions, a 100 percent visual inspection is required. Periodic physical-property tests on molded parts shall also be conducted.			

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Table Continued

Points between which potential is to be applied	Test potential Class I	Class II	Class III
Note C: The test of item 3 may be waived for accessible metal parts, such as assembly screws, that are: (1) isolated by an outer enclosure of insulating material that is subject to the control program indicated in Note B and (2) are so located that they are remote from live parts and from inaccessible metal parts separated from live parts by basic insulation only. The remoteness is to include consideration of possible displacement of parts as the result of improper assembly.			

The tool may be in a heated or unheated condition for the test.

The test shall be conducted with the tool complete, fully assembled. It is not intended that the tool be un-wired, modified, or disassembled for the test.

Parts such as snap covers, auxiliary handles, guards, or friction-fit knobs that would interfere with the performance of the test need not be in place.

The test may be performed before final assembly if such a test represents that of the completed tool.

If the tool employs a solid-state component that can be damaged by the test potential, the test on each tool may be conducted before the component is electrically connected. In such a case, additional testing is to be made of a random sampling of each day's production with the circuitry rearranged to reduce the likelihood of damage to any solid-state component but retaining representative dielectric stress of the circuit.

The specified control of the applied voltage, manual or automatic, shall be maintained under conditions of varying line voltage. Higher test potentials may be used if the higher dielectric stress is not likely to adversely affect the insulating systems of the product.

The test equipment is to have the following features and characteristics:

A. A means of indicating the test voltage that is being applied to the tool under test. This may be accomplished by sensing the voltage at the test leads or by an equivalent means.

B. An output voltage that (1) has a sinusoidal waveform, (2) has a frequency that is within the range of 40 – 70 Hz, and (3) has a peak value of the waveform that is not to be less than 1.3 and not more than 1.5 times the root-mean-square value. As an alternative, a DC potential of 1.4 times the RMS value may be used.

C. A means of effectively indicating unacceptable performance. The indication is to be (1) auditory if it can be readily heard above the background noise level, (2) visual if it commands the attention of the operator, or (3) a device that automatically rejects an unacceptable product. If the indication of unacceptable performance is auditory or visual, the indication is to remain active and conspicuous until the test equipment is reset manually.

D. When the test equipment is adjusted to produce the test voltage and a resistance of 120,000 ohms is connected across the output, the test equipment is to indicate an unacceptable performance within 0.5 second. A resistance of more than 120,000 ohms may be used to produce an indication of unacceptable performance, if the manufacturer elects to use a tester having higher sensitivity.

There is not to be any transient voltage applied to the tool under test that results in the instantaneous voltage applied to the product exceeding 120 percent of the peak value of the test voltage that the manufacturer elects to use for this test. This requirement applies for the entire duration of the test, including the time that the voltage is first applied to the product and the time that the voltage is removed from the product.

During the test, a sufficient number of primary switching components shall be in the on position so that all primary circuitry will be stressed. Both sides of the primary circuit of the appliance are to be connected together to one terminal of the test equipment. The second equipment terminal is to be connected to accessible dead metal.

Tools utilizing motors, relays, coils or transformers, having circuitry not subject to excessive secondary build-up in case of indication of unacceptable performance during the test, may be tested with only one side of the primary circuit connected to the dielectric test equipment.

30.2 Grounding Continuity Test

30.2.1 The manufacturer shall determine, by routine production-line test, that each Class I tool produced has continuity between the ground pin of the plug and all accessible dead metal.

A buzzer, light, ohmmeter, or other suitable indication of continuity shall be used for the test.

31 Instructions

31.1 An instruction manual shall be provided with a tool and packaged such that it is obvious when tool is removed from the carton.

General and specific safety instructions required by this standard shall be written in the official language(s) of the country in which the tool is to be sold. See Appendix H for translations.

Instructions shall be legible and contrast with the background.

The instruction manual shall include the name and address, street, city, state, postal code of the manufacturer or private labeler.

This requirement does not preclude supplying the instructions printed on a blister pack backing card, provided the tool can be removed without damaging the instructions.

31.2 The instruction manual shall include the following major categories in the sequence given:

– GENERAL SAFETY RULES

– SPECIFIC SAFETY RULES AND/OR SYMBOLS

– FUNCTIONAL DESCRIPTION

– ASSEMBLY

– OPERATION

– MAINTENANCE

– ACCESSORIES

Equivalent terms for titles of categories a) through g) may be used.

31.2.1 The **GENERAL SAFETY RULES** as presented in 31.3 shall be given verbatim and in the exact same order. Alternatively, an instruction manual found to comply with the ″Marking and instructions″ section of the latest edition of the product standard may be used.

The ″action″ part of the subelement and ″hazard description″ subelement shall be distinguishable from each other by font, highlighting, or other means, consistent with the format set by the **GENERAL AND/OR SPECIFIC SAFETY RULES**.

31.2.2 The **SPECIFIC SAFETY RULES**, taken from Part 2 of this standard for the appropriate tool, shall be given verbatim and in the exact same order.

The ″action″ part of the subelement and ″hazard description″ subelement shall be distinguishable from each other by font, highlighting, or other means, consistent with the format set by the **GENERAL AND/OR SPECIFIC SAFETY RULES**.

The manufacturer shall include in this section of the manual a definition of all symbols used on the tool. Definitions for symbols shown in Clause 7 of this standard shall be used verbatim.

31.2.3 The **FUNCTIONAL DESCRIPTION** category of the instructions, shall describe the essential components or controls of the tool.

31.2.4 The **TOOL ASSEMBLY** category of the instructions shall be provided, if appropriate.

31.2.5 The **OPERATION** category of the instruction shall describe typical operating procedures with the tool.

31.2.6 The **MAINTENANCE** category of the instruction manual shall include instructions and cautionary statements for any user-maintenance operations recommended by the manufacturer.

31.2.7 The **ACCESSORIES** category of the instruction manual shall specify accessories and attachments recommended for use with the tool. The **Accessory** or the **Operation** section of the manual shall include instructions for proper use of such accessories or attachments.

The manufacturer need not specify in the manual all accessories and attachments that may be acceptable for use with the tool. Generic terms such as spade bits, circular saw blades, and the like, may be used to specify accessories. The instruction manual may refer to a manufacturer's catalog to specify a range of accessories.

31.2.8 At the manufacturer's discretion, each mandatory element of **GENERAL SAFETY RULES** and **SPECIFIC SAFETY RULES** of the instructions may be followed by "Supplemental" information provided such information is related to the topic of the element.

The manufacturer may also supply additional elements the **specific** safety rules category of the instructions for the tool. These additional safety rules shall be presented after the mandatory **SPECIFIC SAFETY RULES**. The additional safety rules, whenever appropriate, shall have "action" and "hazard description" subelement. The "action" part of the subelement and "hazard description" subelement shall be distinguishable from each other by font, highlighting, or other means, consistent with the format set by the **GENERAL AND/OR SPECIFIC SAFETY RULES**.

Any of the **SAFETY RULES** may be repeated within the instruction manual at the manufacturer's discretion.

31.3 GENERAL SAFETY RULES

31.3.1 **WARNING! Read and understand all instructions.** Failure to follow all instructions listed below, may result in electric shock, fire and/or serious personal injury.

SAVE THESE INSTRUCTIONS.

31.3.2 **Work Area**

31.3.2.1 **Keep your work area clean and well lit.** Cluttered benches and dark areas invite accidents.

31.3.2.2 **Do not operate power tools in explosive atmospheres, such as in the presence of flammable liquids, gases, or dust.** Power tools create sparks which may ignite the dust or fumes.

31.3.2.3 **Keep bystanders, children, and visitors away while operating a power tool.** Distractions can cause you to lose control.

31.3.3 **Electrical Safety**

31.3.3.1 **Grounded tools must be plugged into an outlet properly installed and grounded in accordance with all codes and ordinances. Never remove the grounding prong or modify the plug in any way. Do not use any adaptor plugs. Check with a qualified electrician if you are in doubt as to whether the outlet is properly grounded.** If the tools should electrically malfunction or break down, grounding provides a low resistance path to carry electricity away from the user.

Applicable only to Class I (grounded) tools.

31.3.3.2 **Double Insulated tools are equipped with a polarized plug (one blade is wider than the other.) This plug will fit in a polarized outlet only one way. If the plug does not fit fully in the outlet, reverse the plug. If it still does not fit, contact a qualified electrician to install a polarized outlet. Do not change the plug in any way.** Double Insulation ⧈ eliminates the need for the three wire grounded power cord and grounded power supply system.

Applicable only to Class II tools.

31.3.3.3 **Avoid body contact with grounded surfaces such as pipes, radiators, ranges and refrigerators.** There is an increased risk of electric shock if your body is grounded.

31.3.3.4 **Don't expose power tools to rain or wet conditions.** Water entering a power tool will increase the risk of electric shock.

This instruction need not be provided for tools classified watertight or splashproof.

31.3.3.5 **Do not abuse the cord. Never use the cord to carry the tools or pull the plug from an outlet. Keep cord away from heat, oil, sharp edges or moving parts. Replace damaged cords immediately.** Damaged cords increase the risk of electric shock.

31.3.3.6 **When operating a power tool outside, use an outdoor extension cord marked "W-A" or "W."** These cords are rated for outdoor use and reduce the risk of electric shock.

31.3.4 **Personal Safety**

31.3.4.1 **Stay alert, watch what you are doing and use common sense when operating a power tool. Do not use tool while tired or under the influence of drugs, alcohol, or medication.** A moment of inattention while operating power tools may result in serious personal injury.

31.3.4.2 **Dress properly. Do not wear loose clothing or jewelry. Contain long hair. Keep your hair, clothing, and gloves away from moving parts.** Loose clothes, jewelry, or long hair can be caught in moving parts.

31.3.4.3 **Avoid accidental starting. Be sure switch is off before plugging in.** Carrying tools with your finger on the switch or plugging in tools that have the switch on invites accidents.

31.3.4.4 **Remove adjusting keys or switches before turning the tool on.** A wrench or a key that is left attached to a rotating part of the tool may result in personal injury.

31.3.4.5 **Do not overreach. Keep proper footing and balance at all times.** Proper footing and balance enables better control of the tool in unexpected situations.

31.3.4.6 **Use safety equipment. Always wear eye protection.** Dust mask, non-skid safety shoes, hard hat, or hearing protection must be used for appropriate conditions.

31.3.5 **Tool Use and Care**

31.3.5.1 **Use clamps or other practical way to secure and support the workpiece to a stable platform.** Holding the work by hand or against your body is unstable and may lead to loss of control.

31.3.5.2 **Do not force tool. Use the correct tool for your application.** The correct tool will do the job better and safer at the rate for which it is designed.

31.3.5.3 **Do not use tool if switch does not turn it on or off.** Any tool that cannot be controlled with the switch is dangerous and must be repaired.

31.3.5.4 **Disconnect the plug from the power source before making any adjustments, changing accessories, or storing the tool.** Such preventive safety measures reduce the risk of starting the tool accidentally.

31.3.5.5 **Store idle tools out of reach of children and other untrained persons.** Tools are dangerous in the hands of untrained users.

31.3.5.6 **Maintain tools with care. Keep cutting tools sharp and clean.** Properly maintained tools, with sharp cutting edges are less likely to bind and are easier to control.

31.3.5.7 **Check for misalignment or binding of moving parts, breakage of parts, and any other condition that may affect the tools operation. If damaged, have the tool serviced before using.** Many accidents are caused by poorly maintained tools.

31.3.5.8 **Use only accessories that are recommended by the manufacturer for your model.** Accessories that may be suitable for one tool, may become hazardous when used on another tool.

31.3.6 **SERVICE**

31.3.6.1 **Tool service must be performed only by qualified repair personnel.** Service or maintenance performed by unqualified personnel could result in a risk of injury.

31.3.6.2 **When servicing a tool, use only identical replacement parts. Follow instructions in the Maintenance section of this manual.** Use of unauthorized parts or failure to follow Maintenance Instructions may create a risk of electric shock or injury.

Appendix A – Thermal cut-outs and overload releases

A1 Thermal cut-outs and overload releases shall operate reliably.

Compliance is checked by confirming the device conforms to referenced standards in Appendix E or by the following tests.

Compliance is checked by subjecting three samples of the device to a test which is made at 1.25 times the current passing through, and 1.1 times the voltage applied to the device when the tool is operated at rated voltage or at the upper limit of the rated voltage range and under normal load.

The test is made with a.c. or d.c., as appropriate, the test with a.c. being made at the power factor determined when the tool is operated under normal load.

The device is caused to operate 15 times.

After the test, the samples shall show no damage impairing their further use.

A2 Thermal cut-outs and overload releases shall be so constructed that their setting is not changed appreciably by heating, vibration, etc., occurring in normal use.

Compliance is checked by inspection during the test of Clause 16.

Appendix B – Electronic circuits

B1 Scope

This appendix applies to circuits comprising an electronic device, an electronic unit or an electronic assembly with components such as resistors, capacitors and inductors, in the tools specified under Clause 1 of this standard. All clauses of this publication apply to electronic circuits except as modified in this Appendix B or in Part 2 for the specific tool.

B2 Definitions

The following definitions apply:

B2.101 **Electronic device:** A part in which conduction is principally by electrons moving through a vacuum, gas or semiconductor.

B2.102 **Electronic unit:** A group of components, at least one of which is an electronic device, in which the components cannot be replaced without damage.

An example of this is an integrated circuit.

B2.103 **Electronic assembly:** A group of components at least one of which is an electronic device, but in which individual parts may be replaced without damage to the assembly.

An example of this is a group of components mounted on a printed circuit board.

B4 General notes on tests

B4.2 Cumulative stress as a result of sequential testing shall be avoided. It may be necessary to replace the affected samples or to use additional samples.

The number of samples should be kept to a minimum by an evaluation of the relevant circuits.

B4.18 Care shall be taken that, except for the test specified in Clause B101, the supply shall be free of such perturbations from external sources as may influence the results of the tests.

B4.101 If an electronic unit is so enclosed that the testing of individual components is impossible, then the entire electronic unit shall be considered as a whole.

It is, however, permitted to take apart electronic units which are not so vacuum sealed, completely encapsulated, moulded-in or potted that the enclosure forms one moulded part with the enclosed components, for the purpose of establishing creepage distances and clearances between live parts and other metal parts as specified in Sub-clause B27.1.

B4.102 If an electronic unit or assembly is tested separately, the conditions of heat dissipation occurring when it is incorporated in the tool are, if necessary, simulated during the tests.

B4.103 All measurements shall be carried out with instruments which do no appreciably affect the values to be measured, and which are not affected by factors such as waveform.

B7 Marking

B7.12 In countries in which the supply could be protected by earth-leakage circuit breakers, Class I tools with electronic circuits where a failure of basic insulation would permit earth-leakage currents with a d.c. component exceeding X mA and exceeding also Y% of the total earth-leakage current, shall be accompanied by an instruction sheet giving the necessary information with regard to the protection of the wiring by fuses or earth-leakage circuit breakers.

The values X and Y depend on the national usage of earth-leakage circuit breakers until international agreements have been reached.

B8 Protection against electric shock

B8.1 For the purpose of this sub-clause, wiring terminals and contacts and connectors are not regarded as live parts if:

either the part is connected to the output terminals of a safety isolating transformer, provided the output voltage of the transformer does not exceed 42.4 V a.c. (peak value) or 42.4 V d.c.

or the current between the part and either pole of the supply source through a non-inductive resistance of 1750 ±250 ~~2000 ± 100~~ Ω does not exceed 0.7 mA (peak value) or 2 mA d.c. and, moreover:

– for voltages between 42.4 V (peak value) and 450 V (peak value) the capacitance does not exceed 0.1 µF.

– for voltages between 450 V (peak value) and 15 kV (peak value) the discharge does not exceed 45 µC.

– for voltages over 15 kV (peak value), the energy of the discharge does not exceed 350 mJ.

Voltages and currents are measured between the relevant part and either pole of the supply source. Discharges are measured immediately after the interruption of the supply.

In the presence of harmonics and of frequencies higher than supply frequencies, the measurement of the a.c. leakage current shall be made with a circuit have an impedance formed by a 1750 ±250 ~~2000 ± 100~~ Ω resistive component, including the resistance of the measuring instrument, shunted by a capacitor of 112 ±6 nF.

~~In some countries, an impedance of 1500 ±75 Ω and 150 ±7.5 nF is used.~~

The introduction of a time-limit for the measurement of the discharge after interruption of the supply is under consideration. For frequencies exceeding 1 kHz, the limit of 0.7 mA (peak value) is multiplied by the value of the frequency in kilohertz, but must not exceed 70 mA (peak value).

The internal resistance of the voltmeter used for the measurements should be at least 50 k Ω.

B15 Insulation resistance and electric strength

B15.1 In order to avoid overstressing of the components of electronic devices, units or assemblies, arranged across insulation which need to be tested according to the main part for dielectric strength and insulation resistance, such tests are not made if the relevant components are not live in the sense of Sub-clause B8.1 of this appendix and if they cannot be disconnected.

Integrated circuits and the like on the secondary side of an isolating transformer are disconnected or removed before the tests are made if they may be damaged or destroyed by capacitive charges or currents.

If, during this test, a flashover or breakdown occurs over an insulation, the tool is not deemed to be unsatisfactory if the relevant insulation shall comply with the requirements of Item 2 of Sub-clause B17.101.

B16 Endurance

Electronic components are tests as part of the tool during the tests of Part 1.

If, during these tests, a sample ceases to function as a result of the failure of an electronic device, electronic unit or any other component which is unlikely to cause any hazardous condition in the sense of Clause B17, that component, electronic device or electronic unit is replaced and the test is continued.

If during these tests the sample develops a fault which produces a malfunction, the test is continued without replacement of the component, electronic device or electronic unit, provided that no hazardous condition in the sense of Clause B17 has been produced.

B17 Abnormal operation

B17.101 Circuits shall be so designed and applied that any fault condition will not render the tool unsafe as regards electric shock, fire hazards, mechanical hazards or ~~dangerous~~ malfunction <u>that may result in personal injury</u>.

Compliance is checked by simulating each of the following conditions mentioned below in turn and one at a time and associated with it those other fault conditions which are an inevitable consequence.

Examination of the tool and its circuit diagrams will generally show the fault conditions which should be simulated.

The fault conditions to be considered are:

1) Short-circuiting of creepage distances and clearances between live parts of different polarities if less than those of Clause B27 where a proper encapsulation has not been used.

2) Short circuit across insulating parts which do not comply with the requirements of Clause B15.

3) Short circuit across or~~, if applicable,~~ open circuiting of electronic devices, electronic units, and components such as resistors, capacitors and inductors~~, not complying with IEC Publication 65: Safety Requirements for Mains Operated Electronic and Related Apparatus for Household and Similar General Use. To check shock risk in all tools, all resistors, capacitors and inductors are open or short-circuited whether or not they comply with IEC Publication 65~~.

~~For mechanical hazards in all tools other than specifically mentioned in Part 2 and for fire risks, if the resistor or capacitor complies with the requirements in IEC Publication 65, it is not required to be short-circuited.~~

The tool is operated at rated voltage or at the most unfavorable voltage of the rated voltage range and under the most unfavorable normal operating conditions as specified in Clause 11. If the operating time specified in Clause 11 consists of more than one operating cycle, the duration of the test shall be equal to one operating cycle, if necessary.

During and after these tests, the tool shall comply with the requirements specified in Sub-clause 17.1.

B27 Creepage distance, clearances and distances through insulation

B27.1 Circuits conductively connected to the supply terminals or to supply contacts shall comply with Part 1.

B27.2 Supplement

Creepage distances and clearances in circuits separated from the supply by an isolating transformer

– for basic insulation between live parts of different polarity

– for the insulation between live parts

- and non-accessible parts in Class II construction, or
- accessible parts in construction according to other classes

– for supplementary insulation

shall not be less than the values shown in the following table.

For reinforced insulation, they shall not be less than twice the values shown in the table.

V (r.m.s.)	Working voltage (peak) v	Minimum clearance (mm)	Minimum creepage distance (mm)
12	Up to and including 17	0.19	0.40
30 and over	over 17 and including 43	0.28	0.55
60 and over	over 43 and including 85	0.38	0.72
130 and over	over 85 and including 184	0.62	1.12
250 and over	over 184 and including 354	1.15	1.95

~~Creepage and clearance distances stated above are under consideration.~~

The distances through insulation shall comply with the following:

– for voltages up to 42.4 V (peak ac or dc) there are no requirements.

– for voltages over 42.4 V (peak a.c. or d.c.) the insulation must comply with the requirements of the voltage test of Clause B15.

B101 ~~Operation under mains-borne perturbation~~

B101.1 ~~Electronic controls and electronic control systems shall not malfunction because of mains-borne perturbations in any way that results in a hazardous situation.~~

~~A test specification is under consideration.~~

Appendix C – Construction of safety isolating transformers

~~Until an IEC standard for safety isolating transformers is available, the following is taken as the minimum requirements for such transformers.~~

The input windings and output windings shall be separated by an insulating barrier, and the construction shall be such that there is no possibility of any connection between these windings, either directly or indirectly, through other metal parts.

In particular, precautions shall be taken to prevent:

– displacement of the input windings or the output windings, or the turns thereof;

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

– wires, screws, washers and the like from bridging any part of the insulation between the input circuit and the output circuits, including the windings, should they loosen or become free.

The input winding and each output winding shall be wound in such a manner that each turn lies adjacent to the next successive turn, in any given layer of the winding.

Examples of constructions which comply with these requirements for windings are:

a) Windings on separate spools of adequate insulating material.

b) Windings on a single spool, with a partition wall, of adequate insulating material, provided that the spool and partition wall are pressed or moulded in one piece, or that pushed-on partition walls have an intermediate sheath or covering over the joint between the spool and the partition wall.

c) Concentric windings on insulation which is applied in thin sheet form on a spool or on the transformer iron core, and between the input winding and each output winding, provided that at least three layers are used, and that, when two layers are placed in contact, they withstand the electric strength test prescribed for reinforced insulation, the test voltage being applied between the outer surfaces of the two layers.

All windings shall have the end turns retained by a positive means. This can be achieved by the use of sheets of insulating material or by the use of a hard baking material which fully penetrates the interstices and effectively seals off the end turns.

It is not to be expected that two independent fixings will become loose at the same time.

Appendix D – Measurement of creepage distances and clearances

The methods of measuring creepage distances and clearances to be used in interpreting the requirements of Sub-clause 27.1 are indicated in Cases 1 to 10 of this appendix. In cases 1 to 10, solid lines are clearance whereas dash lines indicate creepage.

These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made;

1. A groove may have parallel, converging or diverging sides.

2. Any groove having diverging sides, a minimum width exceeding 0.25 mm, a depth exceeding 1.5 mm and a width at the bottom equal to or greater than 1 mm , is regarded as an air gap (see Case 8).

3. Any corner including an angle less than 80 Deg. is assumed to be bridged with an insulating link of 1 mm width (0.25 mm for dirt-free situations) moved into the most unfavorable position (see Case 3).

4. Where the distance across the top of a groove is 1 mm (0.25 mm for dirt-free situations) or more, no creepage distance exists across the air space (see Case 2).

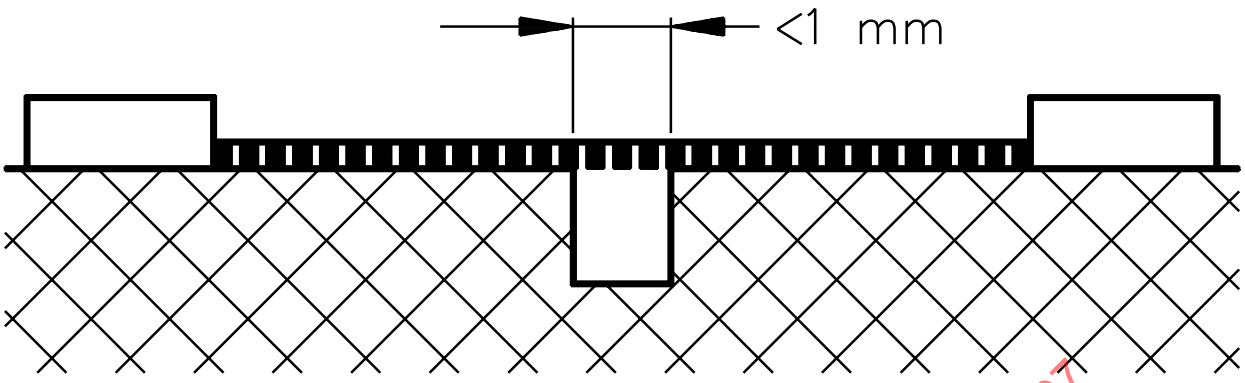
5. A creepage path is assumed not to exist if there is an air gap as defined in Item 2 above exceeding 0.25 mm.

6. Creepage distances and clearances measured between parts moving relative to each other are measured when these parts are in their most unfavorable stationary positions.

7. A computed creepage distance is never less than a measured clearance.

8. Any air gap less than 1 mm wide (0.25 mm for dirt-free situations) is ignored in computing the total clearance.

Case 1

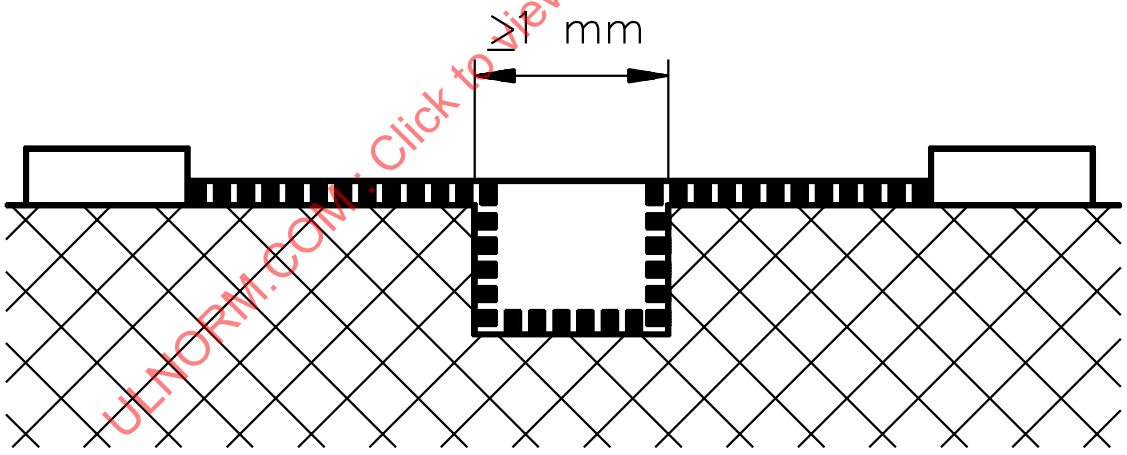


S3409

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

Rule: Creepage distance and clearance are measured directly across the groove as shown.

Case 2

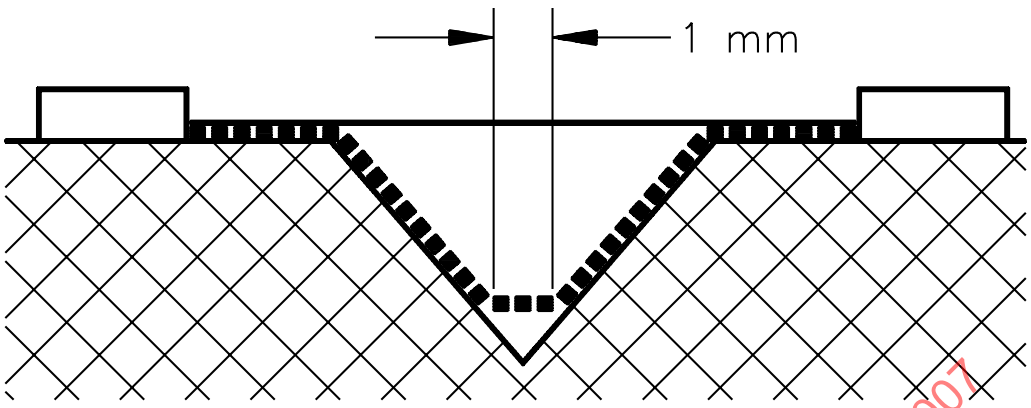


S3410

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 path follows the contour of the groove.

Case 3

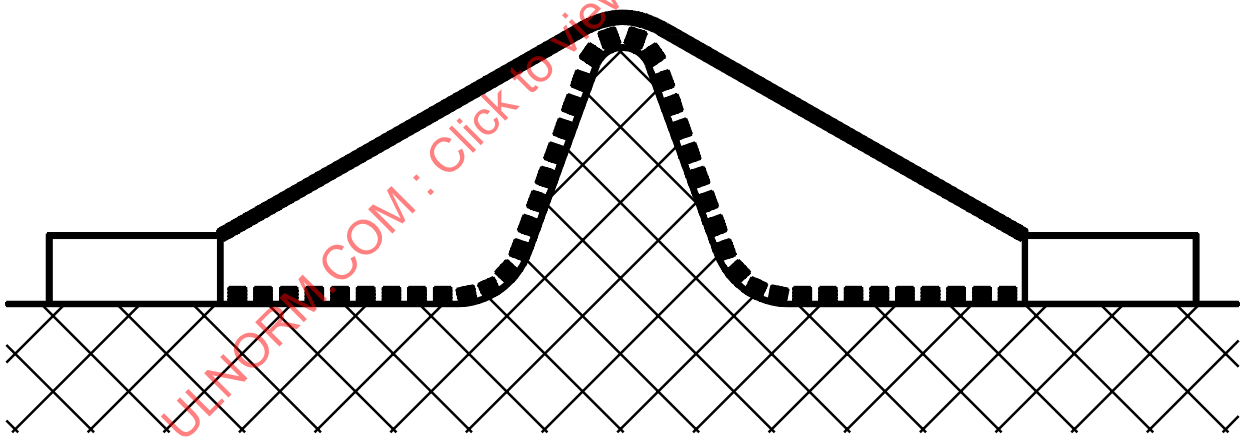


S3411

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

Rule: Clearance is the ″line of sight″ distance. Creepage path follows the contour of the groove but ″short-circuits″ the bottom of the groove by 1 mm (.025 mm for dirt-free situations) link.

Case 4

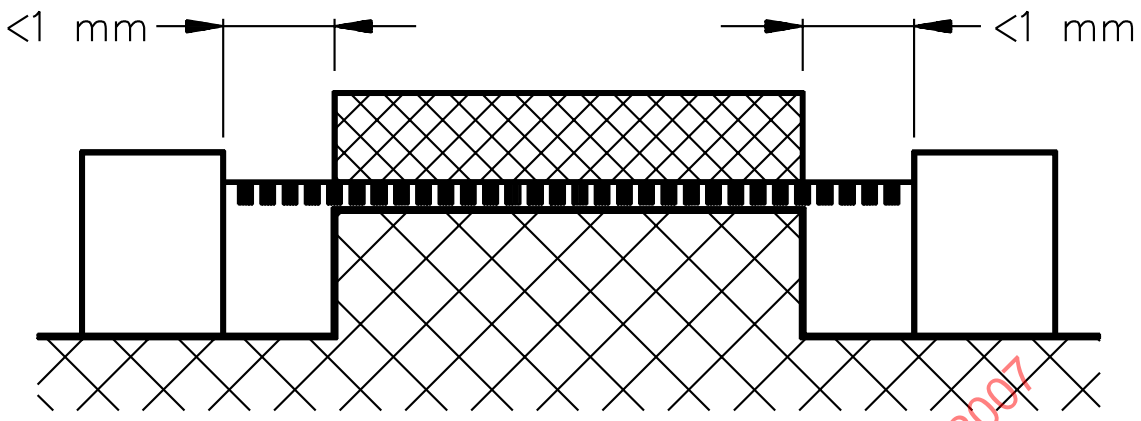


S3412

Condition: Path under consideration includes a rib.

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

Case 5

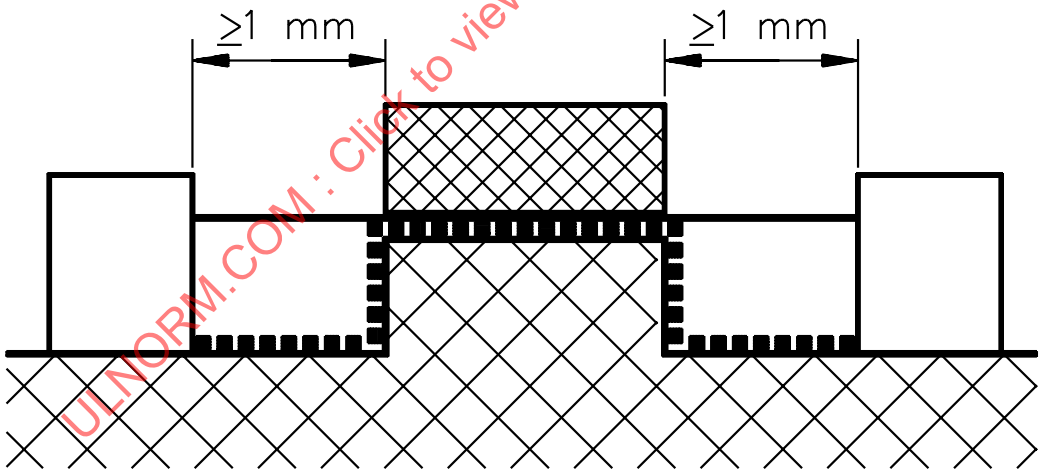


S3413

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 and clearance path is the ″line of sight″ distance shown.

Case 6

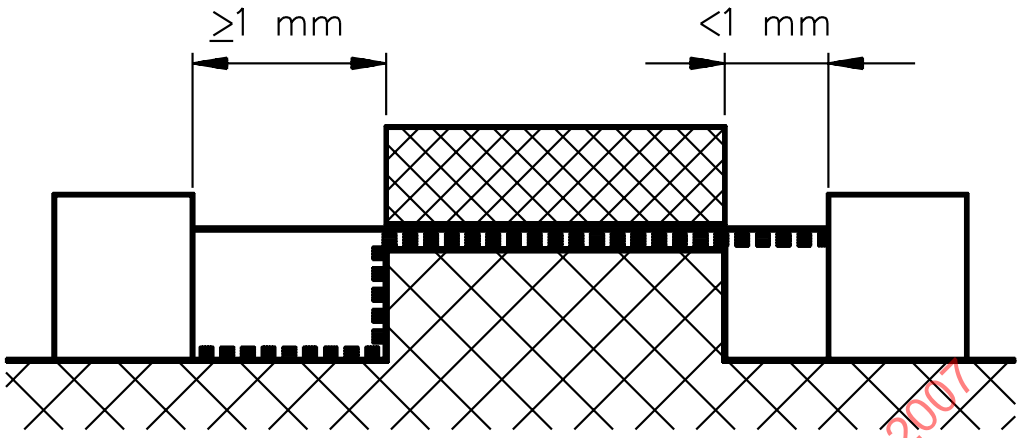


S3414

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

Rule: Clearance is the ″line of sight″ distance. Creepage path follows the contour of the grooves.

Case 7

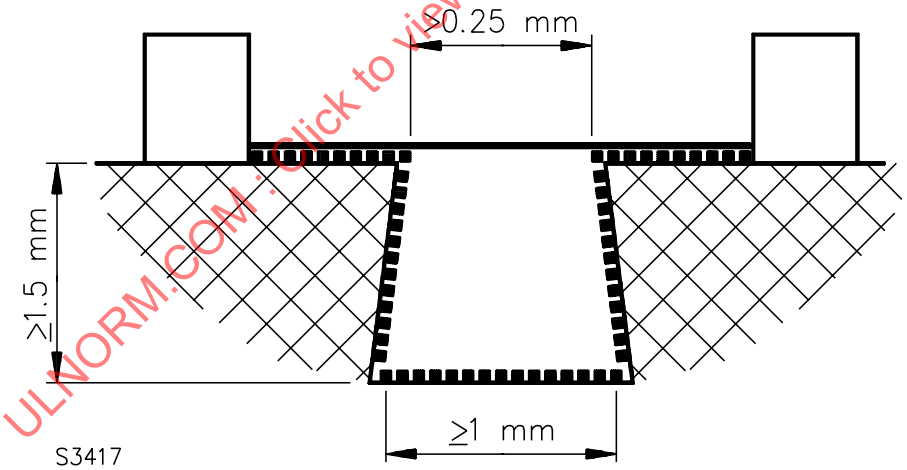


S3415

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

Rule: Clearance and creepage path are as shown.

Case 8



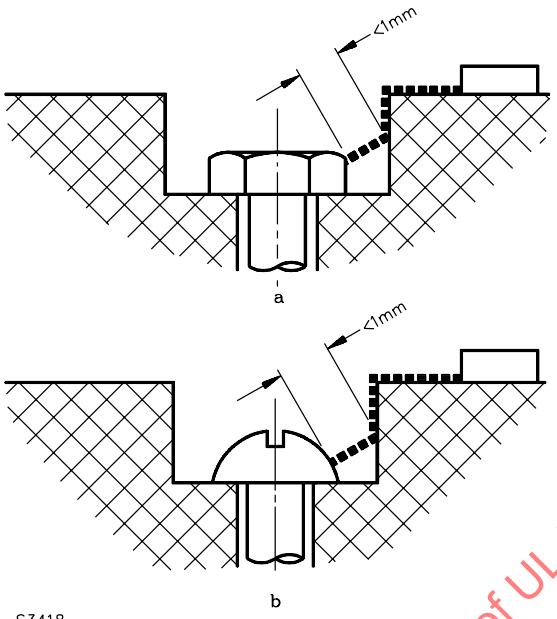
S3417

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.

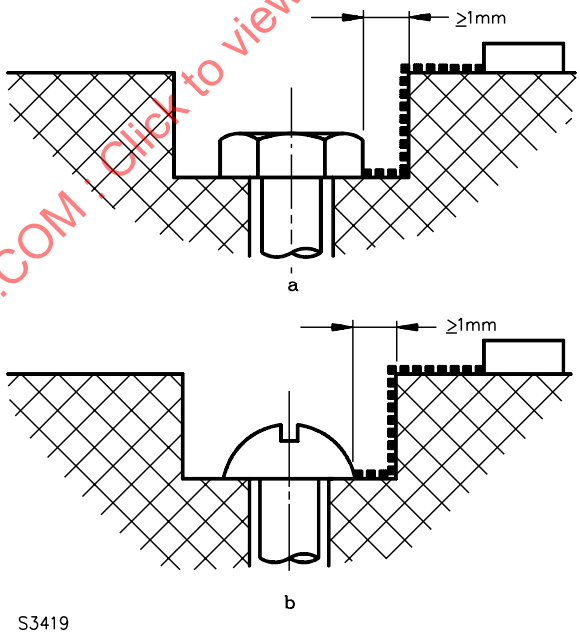
Case 3 applies as well to an internal corner if the angle is less than 80 Deg.

Case 9



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

Case 10



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

Appendix E – Reference standards

A component of a tool need not comply with the standards given in this appendix unless specifically stated in the table below. In cases where a component shall comply with the standard specified in the "Shall Comply With" column, the component shall comply with both the UL and CSA standards given.

Component	Accepted by Tests of this Standard?	Shall Comply With:
Switches	No	UL 1054, C22.2 No.55
Plastics	Yes, or UL 94, UL 746A, UL 746B, UL 746C; C22.2 0.17, or IEC 707	
Terminals & Connectors	Yes, or UL 486, UL 156, UL 310; CSA C22.2 No.153, No.158	
Plugs and Receptacles	No	UL 498; C22.2 No.42
Cord Sets & Power Supply Cord	No	UL 817; C22.2 No.21
Internal Wiring	No	UL 44, UL 83; C22.2 No. 38C22.2 No. 75
Insulating Sleeving and Tubing	No	UL 224, C22.2No. 198.1
Fuses	No	UL 198F, UL 198G, C22.2No. 59.1 C22.2No. 59.2
Electronic Controls	Yes	Not Applicable
Isolating Transformers	Yes	Not Applicable
Thermal Cutouts and Overload	No	UL 1020, C22.2 No.209
Heating Elements	No	UL 1030, C22.2 No.72
Power Supplies for Class III Tools	No	UL 1012 or UL 1310, C22.2 No. 107 or C22.2 No. 223
Sealing Rings and Glands	Yes	Not Applicable
Labels	Yes, or UL 969; CSA C22.2 No. 0.15	
Class B and F Insulation System	No	UL 1446
Grinder Guards	No	ANSI B7.1

The following standards are referenced by this standard, either by specific mention, or used as a basis for development of requirements.

ELECTRICAL CODES

ANSI /NFPA 70
National Electrical Code

CSA C22.1
Canadian Electrical Code (CEC), 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)

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

EXTERNAL FLEXIBLE CABLES AND CORDS

UL 498
Attachment Plugs and Receptacles

UL 817
Cord Sets and Power-Supply Cords

UL 62
Flexible Cord and Fixture Wire

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

C22.2 No. 57-M1985
Appliance Plugs for Heater Cord Sets

FUSES

UL 512
Fuseholders

UL 198G
Fuses for Supplementary Overcurrent Protection

UL 198F
Plug Fuses

C22.2 No. 59.1
Fuses (Both Plug and Cartridge-Enclosed Types)

C22.2 No. 59.2
Supplemental Fuses

GRINDER GUARDS

ANSI B7.1-1988
Use, Care and Protection of Abrasive Wheels

HEATING ELEMENTS

UL 1030
Sheated Heating Elements

C22.2 No. 72
Heater Elements

INSULATING MATERIALS

UL 1446
Systems of Insulating Materials, General

ISOLATION TRANSFORMERS

IEC 742
Isolating Transformers and Safety Isolating Transformers

MARKING AND LABELING SYSTEMS

UL 969
Marking and Labeling

C22.2 No. 0.15
Adhesive Labels

LAMPHOLDERS

C22.2 No. 43-M1984
Lampholders

UL 496
Edison-Based Lampholders

MOTORS

UL 1004
Electric Motors

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

C22.2 No. 100-M1985
Motors and Generators

PLASTICS

UL 94
Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 746A
Polymeric Materials – Short Term Property Evaluations

UL 746B
Polymeric Materials – Long Term Property Evaluations

UL 746C
Polymeric Materials – Use in Electrical Equipment Evaluations

C22.2 No. 0.17
Evaluation of Properties of Polymeric Materials

ASTM Standard, D648-82
Deflection Temperature of Plastics under Flexural Load

IEC 112
D3638-85 CTI

IEC 707,
Flame Tests

PRINTED WIRING BOARDS

UL 796
Printed-Wiring Boards

UL 840
Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment –

RADIO INTERFERENCE SUPPRESSION

C22.2 No. 8-M1986
Electromagnetic Interference (EMI) Filters

UL 1283
Electromagnetic Interference Filters

SWITCHES AND SPEED CONTROLS

UL 1054
Special-Use Switches

UL 508
Industrial Control Equipment

UL 20
General Use Snap Switches

C22.2 No. 55-M1986
Special Use Switches

C22.2 No. 156-M1987
Solid-State Speed Controls

C22.2 No. 14-M1987
Industrial Control Equipment

C22.2 No. 111-M1986,
General Use Switches

THERMAL PROTECTORS

UL 1020
Thermal Cutoffs for Use in Electrical Appliances and Components

C22.2 No. 24-1981
Temperature-Indicating and Regulating Equipment

C22.2 No. 209
Thermal Cutoffs

WIRING MATERIALS

UL 224
Extruded Insulating Tubing

UL 44
Rubber-Insulated Wires and Cables

UL 83
Thermoplastic-Insulated Wires and Cables

UL 510
Insulating Tape

C22.2 No. 198.1-M1986
Extruded Insulating Tubing

MISCELLANEOUS

C22.2 No. 64-1980
Household Cooking and Liquid-Heating Appliances

C22.2 No. 66-1988
Specialty Transformers

CAN3-A165 Series-M85
Concrete Masonry Units

O121-M1978
Douglas Fir Plywood

UL 745-3
Portable Battery-Operated Tools

C22.2 No. 745-3
Portable Battery-Operated Tools

Appendix F – Attachments and accessories

F1 Scope

This Appendix applies to accessories and mechanical attachments that are (1) referred to by catalog number (or equivalent product designation) in the instruction manual accompanying a tool, or (2) packaged with the tool.

F1.101 An accessory or attachment not explicitly covered in this appendix is to be investigated on the basis of compliance with the requirements of this appendix, insofar as they are applicable, and further appropriate examination and tests to determine acceptability for its intended use.

F1.102 These requirements cover carbide-tipped circular saw blades, carbide-tipped planer cutters, wire brushes.

Solid, that is not carbide-tipped, blades, cutters and bits are excluded.

F1.103 A guard or rotating backing pad may either be investigated for use with a specific tool or as an accessory.

F2 Definitions

F2.101 An attachment is a device attached to the housing or other component of the tool and may or may not attach to the spindle. Attachments include tables to convert hand held tools to bench mounted types; for example, a router table.

F2.102 An accessory is a device that is attached only to the spindle of the tool.

F3 General requirements

F3.101 The material of a part, the malfunctions of which might result in the likelihood of injury to persons, shall have properties acceptable for the expected conditions of intended use.

Compliance is checked by inspection.

F4 General notes on test

F4.101 Attachments and accessories shall withstand the appropriate test or tests.

– Without cracking that affects the function of the part so as to increase the risk of injury to persons.

– Without being affected to the extent that a moving part, likely to cause injury to persons, is exposed to unintentional contact.

– Without affecting the mechanical performance of the accessory or tool so as to increase the risk of injury to persons.

F7 Marking

F7.101 An accessory or an attachment, or the package in which it is marketed, shall be marked with a catalog number or equivalent means of identification.

The accessories mentioned in the following table and comparable components need not be marked with catalog numbers or the equivalent.

Accessory or attachment	Tools for which the accessory is recommended by the manufacturer
Drill bit	Drill or Hammers
Screwdriver	Drill or screwdriver
Mounted grinding wheel less than 50.8 mm in diameter	Drill
Rotary file or rasp	Drill
Solid (not carbide-tipped) saw blade	Saw
Sanding disc or belt	Sander
Router bit	Router or trimmer
Polishing pad and buff	Drill
Hole saw	Drill
Chuck	Drill
Socket	Drill
Backing disc and pad	Drill

F7.102 Accessories and attachments that are recommended by the manufacturer for use on a tool, shall be identified. The identification shall appear in at least one of the following locations: (1) on the attachments, (2) on the package housing the attachment, (3) in the instruction book for the basic appliance and (4) in information furnished with the attachments.

Those attachments referenced in the table in F7.101 may be referenced generically for indicated tool types.

F7.103 Carbide-tipped circular saw blades, flexible backing pads, grinding wheels, and wire brushes shall be permanently marked with the maximum speed, "..../min."

A wire brush or backing pad under 38 mm in diameter may include the marking on the package or literature. A grinding wheel less than 102 mm in diameter shall be marked either on the wheel or package.

F7.104 Cautionary markings shall comply with Sub-clauses 7.1.3, 7.13 and 7.14.

F7.105 A cautionary marking shall be permanent and shall be located on a part permanently attached to the accessory or attachment or on a part that cannot be removed without impairing the operation or the appearance of the accessory or attachment. If there is not sufficient room for the marking on the accessory or attachment, the marking may be included on the instructions furnished with the accessory or attachment.

F7.106 A wire brush shall be permanently marked "Wear eye protection."

If there is not sufficient room on the wire brush, the marking shall be in the instructions furnished with the wire brush.

F7.107 If the function of a handle, lever, knob, or other electrical or mechanical control is not obvious, it shall be identified either on the attachment or in instructions furnished with the attachment.

F19 Mechanical strength

F19.101 An accessory or attachment, in combination with the tool, shall be constructed so as to withstand such rough handling as may be expected in normal use.

Compliance is checked by the tests of Sub-clause 19.1 using the complete assembly of tool with accessories and attachments.

F19.102 An accessory shall be resistant to overspeed.

Compliance is checked by rotating the accessory in accordance with the following table. There shall not be breakage, (separation of carbide tips from blade), or other effect that may result in risk of injury to persons.

Rotating Member	Time or Number of Revolutions	Speed of Rotation in Percent of Maximum Rotation Member Speed
Carbide-tipped saw blades	1,000,000 Revolutions	150
Flexible backing pads	1 Hour	120
Wire brushes with shank, all sizes	1 Hour	120
Wire brushes without shank:		
50 to 150 mm	1 Hour	120
>150 to 230 mm	1 Hour	130
>230 mm	1 Hour	150
All other rotating members	1 Hour	150

A wire brush may discharge wires but shall not burst. There shall be no separation of the carbide tips from the saw blade. Flexible backing pads shall not break apart. Accessories listed in the table are exempt from this test.

F20 Construction

F20.101 An edge, projection, or corner of an accessory or attachment shall not be sufficiently sharp to constitute a likelihood of injury to persons in intended use or during operator maintenance.

Compliance is checked by inspection.

This does not apply to an edge that must be sharp to enable the accessory or attachment to perform its intended function.

F20.102 The stability of a bench-top or floor supported attachments shall be such that it will not be overturned readily while in any position that might be encountered during intended use, including positions that might be encountered prior to and after operation.

Compliance is checked by the following test.

The combination of the attachment and a representative tool, mounted in accordance with the manufacturer's instructions, is to be placed, with the motor switched off, on a plane inclined at an angle of 7 degrees to the horizontal. The power-supply cord is to rest on the inclined plane in the most unfavorable position. If, however, the attachment is such that, were it to be tilted to an angle of 7 degrees when standing on a horizontal plane, a part of it not normally in contact with the supporting surface would touch the horizontal plane, the attachment is to be placed on a horizontal support and tilted in the most unfavorable direction through an angle of 7 degrees. The results are considered to be acceptable if the combination does not overturn.

Tests are to be conducted under the most unfavorable conditions, but with the motor unenergized. The attachment is to be placed on the inclined plane with all doors, drawers, and other movable or adjustable parts in the position tending to decrease the stability. If tested on a horizontal plane, the attachment is to be tipped in the direction of least stability. Legs and other supporting means may be blocked to preclude the assembly from sliding. The attachment is to be tested in all possible positions that might typically be encountered while the attachment:

A. Is in a position of being assembled or prepared prior to operation – for example, positioning parts of the attachment prior to adding functional parts;

B. Is in position as if being used to perform one of its intended functions; and

C. Is in a position of being disassembled or cleaned after operation – for example, with applicable functional parts removed.

F20.103 An attachment provided with wheels or casters for mobility shall be retractable or of a locking design, or other means shall be provided to reduce unexpected movement of the tool during operation.

Compliance is checked by inspection.

F31 Instructions

F31.101 An accessory or attachment shall be provided with instructions. The instructions may be packaged with the accessory or attachment or printed on the package provided the accessory or attachment can be removed without damaging the instructions. The instructions shall specifically warn the user of foreseeable potential sources of injury and shall state precautions necessary to guard against those conditions.

F31.102 The instructions shall include the following:

– The type or types of tools with which the attachment is intended to be used.

F31.103 The following statement shall appear either on the packaging of a wire brush or in the instructions provided with the wire brush: ″Allow wire brushes to run at operating speed for at least 1 minute before using wheel. During this time no one is to stand in front of or in line with the brush.″

Appendix G – Sequence of tests

SEQUENCE OF TESTS COMPLIANCE BY INSPECTION:

Standard Reference Section	Sample Number[a] Inspection		1
5	Rating	.....	1
7	Marking	.....	2

Note: Instruction Manual Compliance by Inspection.

COMPLIANCE BY INSPECTION AND/OR MINOR TEST:

Standard Reference Section	Sample Number[a] Inspection & Test		1
8	Protection Against Electric Shock	.....	3
18	Mechanical Hazards	.....	4
20	Construction	.....	5
21	Internal Wiring	.....	6
23	Supply Connections and Flexible Cables and Cords	.....	7[a]
24	Terminals	.....	8
25	Provision for Earthing	.....	9
26	Screws and Connections	.....	10
27	Creepage Distances and Clearance Distances	.....	11

[a] Component parts are required for flex test.

COMPLIANCE BY TEST:

		Sample Number[a]					
Standard reference section	**Test**	**2**	**3**	**4**	**5,6**	**7,8,9**	**10**
9	Starting	1					
10	Input and Current	2					
11	Heating		1				
12	Leakage Current		2				
13	Tools Equipped with Interference Suppression	3					
14	Moisture Resistance			1			
15	Insulation Resistance and Electric Strength			2			
16	Endurance	4					
17	Abnormal Operation – 17.5					1[c]	
	– 17.2, 17.3						1
19	Mechanical Strength			3[b]	1[b]		
22	Components		3				
28	Resistance to Heat	5					
29	Resistance to Rust			4			

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. One sequence need not be completed as a prerequisite to starting of another.

[b] Nine drops required. Sample quantity varies between three and one to complete this test. Each sample shall pass a minimum of three drops.

[c] Three samples shall be tested in accordance with Sub-Clause 17.5.

Appendix H – Translations

H1 Translations

Advisory Note: In Canada there are two official languages; therefore it is necessary to have CAUTION, WARNING, and DANGER markings in both English and French on those products to be sold or used in Canada. Following is a list of acceptable French translations of the markings specified in this Standard.

H1.1 Markings

7. Marquage

AVERTISSEMENT. Afin de réduire le risque de blessures, l'utilisateur doit lire et bien comprendre le mode d'emploi.

Following is a list of acceptable French translations of the instructions specified in this Standard.

H1.2 Instructions

31.3 **RÈGLES DE SÉCURITÉ GÉNÉRALES**

31.3.1 **AVERTISSEMENT ! Vous devez lire et comprendre toutes les instructions.** Le non-respect, même partiel, des instructions ci-après entraîne un risque de choc électrique, d'incendie et/ou de blessures graves.

CONSERVEZ CES INSTRUCTIONS

31.3.2 **Aire de travail**

31.3.2.1 **Veillezà ce que l'aire de travail soit propre et bien éclairée.** Le désordre et le manque de lumière favorisent les accidents.

31.3.2.2 **N'utilisez pas d'outils électriques dans une atmosphère explosive, par exemple en présence de liquides, de gaz ou de poussières inflammables.** Les outils électriques créent des étincelles qui pourraient enflammer les poussières ou les vapeurs.

31.3.2.3 **Tenezà distance les curieux, les enfants et les visiteurs pendant que vous travaillez avec un outil électrique.** Ils pourraient vous distraire et vous faire faire une fausse manoeuvre.

31.3.3 **Sécuritéélectrique**

31.3.3.1 **Les outils mis à la terre doivent être branchés dans une prise de courant correctement installée et mise à la terre conformémentà tous les codes et règlements pertinents. Ne modifiez jamais la fiche de quelque façon que ce soit, par exemple en enlevant la broche de mise à la terre. N'utilisez pas d'adaptateur de fiche. Si vous n'êtes pas certain que la prise de courant est correctement mise à la terre, adressez-vous à un**