UL 1097

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Double Insulation Systems for Use in Electrical Equipment

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety
for
Double Insulation Systems for Use in Electrical Equipment, UL 1097

Fourth Edition, Dated September 23, 1997

Revisions: This Standard contains revisions through and including April 14, 1998.

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The revisions dated April 14, 1998 include a reprinted title page (page 1) for this Standard.

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

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that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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

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

Page	Date
tr1 – tr4	April 14, 1998
1	September 23, 1997 (Reprinted April 14, 1998)
2 – 4	September 23, 1997
5, 6, 6A, 6B	April 14, 1998
7 – 15	September 23, 1997
16, 16A, 16B	April 14, 1998
17 – 24	September 23, 1997

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UL 1097

Standard for

Double Insulation Systems for Use in Electrical Equipment

First Edition – November, 1978
Second Edition – April, 1983
Third Edition – June, 1993

Fourth Edition

September 23, 1997

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated September 23, 1997. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Approved as ANSI/UL 1097-1993, October 7, 1993
Approved as ANSI/UL 1097-1997, September 22, 1997

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.

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CONTENTS

FOREWORD

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

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

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

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

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

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

INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated equipment marked "Double Insulation" or "Double Insulated" to be used in accordance with the National Electrical Code, NFPA 70.

1.2 Equipment marked "Double Insulation" or "Double Insulated" shall comply with the applicable requirements in this standard and the standard covering the particular type of equipment – the end-product standard. In cases where the end-product standard contains requirements for double insulation, that standard takes precedence.

1.3 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involve a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.3 revised April 14, 1998

2 General

2.1 Units of measurement

2.1.1 When a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

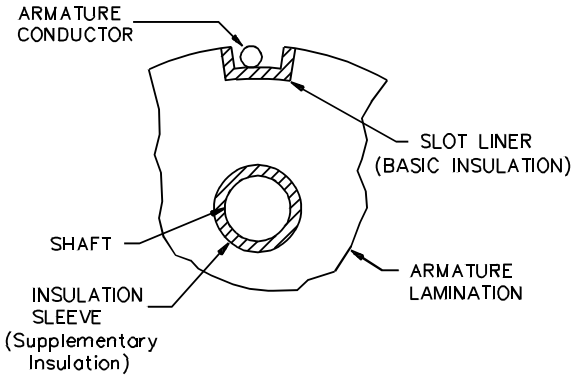
3.2 ACCESSIBLE PART OR SURFACE – A part or surface subject to contact by persons under any condition of operation or user function. In a determination of whether a live or dead part or surface is accessible to such contact, the criteria specified in the product standard are to be applied.

3.3 BASIC INSULATION (FORMERLY FUNCTIONAL INSULATION) – 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.

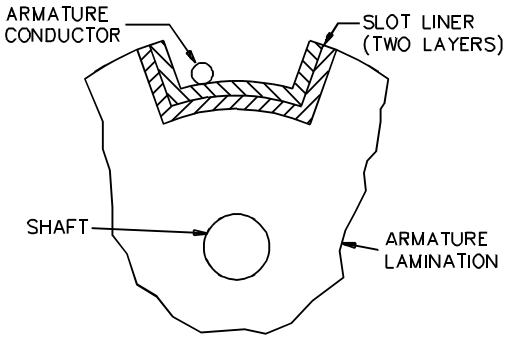
3.4 DEAD METAL PART – A metal or other electrically conductive part, accessible or inaccessible, that is not conductively connected to a live part.

3.5 DOUBLE INSULATION – An insulation system comprised of basic (formerly functional) insulation and supplementary insulation, with the two insulations physically separated and arranged so that they are not simultaneously subjected to the same deteriorating influences (temperature, contaminants, and the like) to the same degree. See Figure 3.1.

Figure 3.1
Examples illustrating 3.5



A -- CONSIDERED TO CONSTITUTE DOUBLE INSULATION



B -- NOT CONSIDERED TO CONSTITUTE DOUBLE INSULATION. CONSTRUCTION TO BE INVESTIGATED AS REINFORCED INSULATION.

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Figure 3.1 revised April 14, 1998

3.6 LIVE PART – A part that is conductively connected either to the power-supply circuit, or a secondary circuit that operates at more than 42.4 V peak with reference to ground or accessible metal, and in which the available current measured through a 1500-ohm resistor shunted with a 0.15-FF capacitor connected from the part to ground or to any other accessible part exceeds 0.25 mA.

3.7 REINFORCED INSULATION – An improved basic (formerly functional) insulation with such mechanical and electrical qualities that it, in itself, provides the same degree of protection against electric shock as double insulation. It may consist of one or more layers of insulating material. Its acceptance in place of double insulation is described in 4.1 and Reinforced Insulation, Section 5.

3.8 SUPPLEMENTARY (PROTECTING) INSULATION – An independent insulation provided in addition to the basic (formerly functional) insulation to protect against electric shock in case of mechanical rupture or electrical breakdown of the basic insulation. An enclosure of insulating material may form a part or the whole of the supplementary insulation.

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CONSTRUCTION

4 General

4.1 The equipment shall be constructed so that double insulation is interposed between all live parts and each of the following:

a) All accessible surfaces of the equipment.

b) All inaccessible dead parts and surfaces that are conductively connected to accessible dead parts or surfaces or both.

Exception No. 1: A construction that provides increased through-air and over-surface spacings between live parts and accessible dead parts and surfaces specified in the end-product standard (refer to Table 11.1) is acceptable in place of double insulation. This construction may be used only where it is impractical to provide double insulation.

Exception No. 2: A construction using Reinforced Insulation, Section 5, is acceptable in place of double insulation. This construction may be used only where it is impractical to provide double insulation.

4.2 The thickness and the resistance to deterioration with aging of insulation employed as supplementary insulation shall not be less than that required for the same material employed as basic insulation. A greater thickness of supplementary insulation is required if severe environmental or use conditions are likely.

4.3 The insulation qualities and resistance to deterioration with aging of materials employed as reinforced insulation shall not be less than the combination of basic and supplementary insulation.

4.4 The equipment shall be constructed so that the added protection provided by the supplementary or reinforced insulation is not reduced by the normal use and reasonable abuse (see Resistance to Impact Tests, Section 16, and Abnormal Operation Test, Section 19) to which the equipment is likely to be subjected.

4.5 The equipment shall be constructed so that the following parts are not accessible:

a) A live part.

b) A dead part that is insulated from live parts by basic insulation only, unless it is Reinforced Insulation, Section 5.

c) Basic insulation itself, unless it is Reinforced Insulation, Section 5.

4.6 The equipment shall be constructed so that all parts – straps, screws, nuts, washers, springs, and the like – are secured so that they are not likely to become loosened or displaced if such loosening or displacement reduces the spacings to values below those specified in Table 11.1.

4.7 Parts secured by two independent fastenings or by means of screws or nuts provided with lock washers are to be regarded as not likely to become loose, provided that these fastening means are not required to be removed during routine servicing.

Exception: Where loosening or displacement of the part causes malfunctioning of the equipment and does not result in an accessible live part.

4.8 Leakage, rupture, or overfilling of a reservoir, pipe, tube, or the like for storing or conducting water or other fluid associated with the equipment shall not render either basic, reinforced, or supplementary insulation ineffective or result in deterioration of the insulation.

5 Reinforced Insulation

5.1 General

5.1.1 Reinforced insulation can be accepted in place of double insulation in the locations described in 5.2.1.1 – 5.7.1.

5.2 Brushcaps and brush holders

5.2.1 General

5.2.1.1 Reinforced insulation can be accepted in an accessible brushcap or brush holder if the construction complies with each of the following:

a) The brushcap or brush holder shall be recessed so that, when it is mounted normally, its top is inside the plane of the opening in the surrounding portion of the enclosure of the equipment.

b) The brushcap or brush holder shall be entirely of insulating material.

c) The brushcap or brush holder shall acceptably withstand the impact test described in 16.2.

5.2.2 Brush holders in enclosures of insulating material

5.2.2.1 Reinforced insulation is acceptable in place of double insulation at a brush holder assembly that is supported in the insulating-material housing of the equipment. The total insulation thickness shall not be less than 3/16 inch (4.8 mm) provided that any path between parts of the enclosure is broken by barriers or the like so that there is no direct path from the outside to live parts of the brush holder assembly.

5.2.3 Brush holders in enclosures of conductive material

5.2.3.1 Reinforced insulation is acceptable in place of double insulation at a brush holder assembly that has its own enclosure of insulating material if the construction complies with both of the following:

a) All live parts of the brush holder assembly shall be enclosed in the enclosure of insulating material.

Exception: The wiring terminals and the brush itself need not comply with this requirement.

b) The enclosure of the brush holder assembly shall be separated from accessible dead metal parts by any one or more of the following constructions:

1) Mica not thinner than 0.005 inch (0.13 mm).

2) Other inorganic insulation having electrical properties at least equivalent to those of mica.

3) Acceptable organic insulating material not less than 1/16 inch (1.6 mm) thick.

5.3 Commutator and end turns of the armature winding

5.3.1 Reinforced insulation is acceptable between the commutator segments and the shaft, the end turns and the shaft, and in both locations if the insulation consists of one or more of the following:

a) Sheet mica that is not less than 0.005 inch (0.13 mm) thick.

b) Other inorganic insulation having electrical properties at least equivalent to those of mica. If such insulation is used under the commutator segments, the thickness of the insulation shall not be less than 0.080 inch (2.0 mm). If such insulation is used under the end turns, the thickness of the insulation shall not be less than 0.040 inch (1.02 mm) or the length of the air gap, whichever is larger.

c) Acceptable organic insulating material provided that the armature complies with the armature-investigation tests described in the Investigation of Armature Employing Reinforced Insulation Test, Section 20.

5.3.2 If any of the constructions described in 5.3.1(b) is used, the armature laminations shall be insulated from the shaft by either of the following:

a) Sheet mica that is not less than 0.005 inch (0.13 mm) thick.

b) Other inorganic insulation having electrical properties at least equivalent to those of mica. The insulation shall have a thickness not less than 0.040 inch (1.0 mm) or the length of the air gap, whichever is larger.

5.4 Switches

5.4.1 General

5.4.1.1 Reinforced insulation is acceptable in place of double insulation at a switch in equipment with double insulation if the switch has its own enclosure of insulating material and if the following conditions are met:

a) A dead metal part that extends outside of the switch enclosure shall not enter the arc chamber.

b) The plunger, toggle, or the like that contacts live parts inside the switch shall be entirely of insulating material.

c) With the exposed external parts of the plunger, toggle, or the like removed, a live part inside the switch enclosure shall not be accessible, and a live part inside the switch shall not be contacted by a metal actuating arm, cam, or the like.

d) All live parts of the switch other than terminals shall be completely enclosed in the switch enclosure.

e) The construction shall comply with 5.4.2.1 or 5.4.3.1.

5.4.2 Switches in equipment enclosures of conductive material

5.4.2.1 If a switch is located in equipment that has a conductive enclosure, reinforced insulation is acceptable in place of double insulation (see also 5.4.1.1) provided that both of the following conditions are met:

a) That portion of a switch or switch enclosure that contains arcing parts, and may therefore be subjected to arcing, shall be separated from exposed dead metal of the equipment by means of not less than 0.005-inch (0.13 mm) thick mica or by other insulation having at least the equivalent electrical properties.

b) Any metal in contact with the switch enclosure shall be insulated from the accessible dead metal of the equipment by supplementary insulation.

5.4.3 Switches in equipment enclosures of insulating material

5.4.3.1 If a switch is located in equipment that has an enclosure of insulating material, reinforced insulation is acceptable in place of double insulation provided that metal mounting screws or rivets by which the switch is secured to accessible dead metal of the equipment do not pass through the body of the switch enclosure. (See also 5.4.1.1.) The mounting means may pass through tabs, ears, or other projections from the switch body, including a piece of insulating material secured to the switch.

5.5 Power-supply cord

5.5.1 Reinforced insulation is acceptable in place of double insulation at points inside the equipment where the power-supply cord contacts supplementary insulation.

5.5.2 Inside the equipment, a nonjacketed power-supply cord (see 6.2) or the insulated individual conductors of a jacketed supply cord may be insulated from an accessible dead metal part by supplementary insulation in any one of the following forms:

a) An insulating liner.

b) A coating of insulating material.

c) A sleeve around the cord, if the sleeve is loose-fitting and is secured to the enclosure.

5.5.3 If the nonjacketed flexible cord in a power-supply cord or one or more of the insulated individual conductors of a jacketed flexible cord in a power-supply cord contacts supplementary insulation inside the equipment, the cord insulation or the individual insulation and the supplementary insulation shall be such that they are not affected to the same degree by deteriorating influences such as heat, contaminants, and the like. The flexible cord jacket itself may serve as the supplementary insulation for the insulated individual conductors provided that the conditions of use of the equipment are not likely to stress or degrade the physical properties of the jacket.

5.6 Internal wiring

5.6.1 Reinforced insulation is acceptable in place of double insulation at points inside of the equipment where the insulated wiring – including insulated splices – contacts supplementary insulation.

5.6.2 Internal wiring that has basic insulation – including an insulated splice – shall be spaced 1/32 inch (0.8 mm) from an accessible dead metal part.

5.6.3 If internal wiring that has basic insulation – including an insulated splice – contacts an enclosure of insulating material, the insulation on the wire and the enclosure of the insulating material shall be such that they are not affected to the same degree by deteriorating influences such as heat and contaminants.

5.6.4 Insulating tubing may be accepted as supplementary insulation between internal wiring that has basic insulation – including an insulated splice – and accessible dead metal parts, if all of the following conditions are met.

a) The tubing shall be loose-fitting on the conductors.

b) The tubing shall be fixed in position so as to prevent relative movement between the tubing and the metal.

c) The length of the leads shall prevent any tension during assembly or repair.

d) The tubing shall not contact sharp bends, projections, corners, or the like, nor shall it be subjected to tension or compression.

e) The wiring shall not be subject to flexing.

f) The materials of the tubing and the insulation on the wire shall be such that they are not affected to the same degree by deteriorating influences such as heat and contaminants.

g) The tubing shall be of a thickness that is acceptable for the application.

5.7 Other locations

5.7.1 Reinforced insulation is acceptable in place of double insulation anywhere in the equipment if the reinforced insulation consists of one or more layers with a total thickness of not less than 3/16 inch (5 mm). In a multilayer assembly, contact between adjacent layers is acceptable.

6 Flexible Cord

6.1 A power-supply cord shall not include a grounding conductor.

6.2 A power-supply cord shall be a jacketed type.

Exception: Nonjacketed flexible cords may be investigated for use as a power-supply cord for specific equipment when the equipment standard does not require a jacketed cord.

6.3 Inside the equipment, a nonjacketed flexible cord or the insulated individual conductors of a jacketed flexible cord shall not contact an accessible dead metal part.

7 Strain Relief

7.1 If an accessible metal strain-relief clamp is employed, it shall be provided with supplementary insulation located between the clamp and the flexible cord.

8 Bushings

8.1 A bushing of insulating material shall be provided at each point at which a flexible cord passes through a dead metal part. A bushing of rubber, neoprene, polyvinyl chloride, or similar material is not acceptable for this application.

9 Capacitors

9.1 The dielectric in a capacitor shall not be depended upon as supplementary (protecting) insulation.

10 Transformers

10.1 If a secondary circuit of an isolating transformer is conductively connected to an accessible metal part or terminal or outlet for connection of circuits external to the equipment, the secondary circuit shall be considered to be accessible dead metal. The primary of the transformer shall be isolated from the secondary circuit by means of insulation that complies with the requirements described in Overload Tests on Isolating Transformers, Section 17.

11 Spacings

11.1 Spacings shall be in accordance with Table 11.1 except that larger spacings may be required at points at which carbon dust or other conductive contaminants exist or might accumulate.

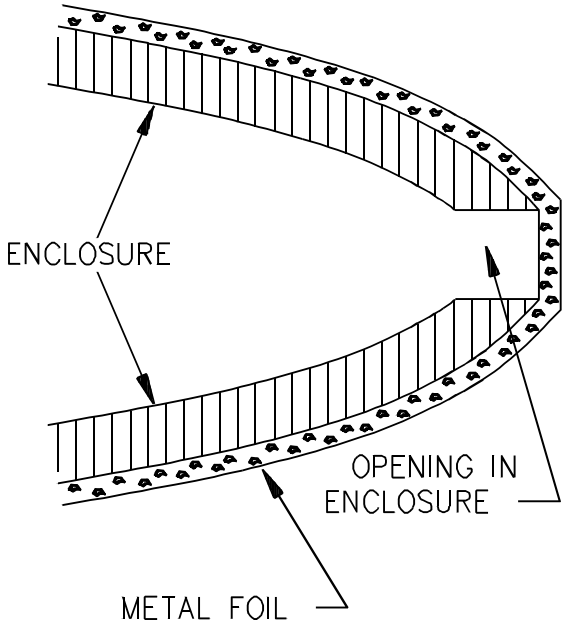
11.2 The spacing specified as the minimum acceptable in item 1 of Table 11.1 does not apply to the inherent spacings of a component (such as a snap switch) of equipment. The acceptability of spacings on a component is based on the requirements for that component.

Table 11.1
Minimum spacings

Parts between which spacings are measured	Minimum acceptable spacings
1. Uninsulated live parts and dead metal parts that are separated by basic insulation only, other than reinforced insulation	Not less than the through-air and over-surface spacings required in the end-product standard
2. Accessible dead metal parts[a] and dead metal parts separated from uninsulated live parts by basic insulation only (this ordinarily is a spacing resulting from supplementary insulation)	Not less than the through-air and over-surface spacings required in the end-product standard
3. Uninsulated live parts and dead metal parts[a] separated by double insulation or by reinforced insulation, where acceptable, except as indicated in item 4	Not less than twice the through-air and over-surface spacings required in the end-product standard between uninsulated live parts and dead metal parts that are separated by basic insulation
4. Uninsulated live parts and accessible dead metal parts[a] at a commutator or other location in which foreign materials can build up	5/16 inch (8.0 mm) over surface
5. Uninsulated live parts, including enameled wire wound in the form of a coil and reliably held in place, and the interior surface of insulating material that serves as supplementary insulation	1/32 inch (0.8 mm)
6. Outer surface of a wrapped coil and the interior surface of insulation material that serves as supplementary insulation	1/32 inch (0.8 mm)

[a] If the outer surface of the enclosure consists wholly or partially of insulating material, the spacings applied to accessible dead metal also apply to metal foil wrapped tightly around and in intimate contact with the enclosure. The foil is to be drawn tightly across any opening in the enclosure to form a flat plane across such opening. See Figure 11.1.

Figure 11.1
Method of covering enclosure with foil for measurement and tests



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12 Internal Wiring

12.1 Internal wiring shall be located or restrained so that breakage or loosening of the wire at a termination and subsequent displacement cannot reduce the spacings to values below those specified in Table 11.1.

Exception: Where breakage or loosening of the wire at a termination and subsequent displacement causes malfunctioning of the appliance and does not result in a live part being made accessible.

12.2 Compliance with 12.1 can be accomplished by any one or more of the following means:

a) The use of barriers.

b) Relative placement of parts.

c) Physical restraint of the conductor in addition to that resulting from its normal electrical connections.

d) Other equivalent means.

12.3 The requirement in 12.1 requires that a brush holder be constructed so that, upon removal of the cap, the spring cannot touch accessible dead metal.

12.4 The connection of a lead to a switch or other component likely to require replacement and the connection of a lead to a conductor of the power-supply cord shall be made so that, if the component or power-supply cord is to be replaced, it shall not be necessary to do any of the following:

a) Cut a conductor.

b) Disconnect a soldered and taped splice between two conductors.

c) Disconnect a soldered joint between a lead and a bus bar, strap, or terminal.

12.5 A supplementary part, such as an insulating barrier liner, that is necessary to maintain the level of insulation shall be secured to the equipment so that it remains in place when the power-supply cord or a component, such as a switch, is being replaced.

Exception: A supplementary part need not be fixed to the equipment if its design precludes its being left out after servicing of the equipment.

PERFORMANCE

13 Leakage Current Test

13.1 The equipment shall be subjected to the leakage current test described in the end-product standard. If the end-product standard does not specify a leakage current test for double insulated equipment, the test method described in 13.2 – 13.9 may be used in its entirety or modified as appropriate for the specific type of end product.

13.2 For a product rated for a nominal 120/240-volt (120 volts or less to ground) or less supply, the leakage current of the equipment when tested in accordance with 13.3 – 13.9 shall not be more than:

a) 0.25 mA for accessible dead metal parts,

b) 0.5 mA for inaccessible dead metal parts, and

c) 0.5 mA between accessible and inaccessible dead metal parts.

13.3 Equipment having parts, such as the commutator-and-brush assembly of a universal motor, that are likely to produce conductive dust is to be conditioned as described in 13.4 before being tested for leakage current. Equipment that is not likely to produce conductive dust is to be tested without the conditioning described in 13.4.

13.4 If the equipment has parts likely to produce conductive dust, it is to be operated at no load for 100 hours, or until any motor brushes wear out if the latter condition occurs at less than 100 and at more than 25 hours of operation. If the brushes wear out at less than 25 hours of operation, they are to be replaced and operation is to be continued until the appliance has operated for a total of 25 hours. Operation is to be continuous unless the motor is not for such operation.

13.5 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed from any dead metal parts, accessible and inaccessible, of the equipment to other dead metal parts of the equipment or to ground.

13.6 All accessible and inaccessible dead metal parts are to be tested for leakage currents. The leakage currents are to be measured to the grounded supply conductor individually as well as collectively and from one part to another.

Exception: If inaccessible dead metal parts such as an armature of a motor move during normal operation, measurements involving the moving parts are to be made with switch S1, (see Figure 13.1) open.

13.7 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil with an area of 10 by 20 centimeters in contact with the surface. Where the surface is smaller than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the equipment.

13.8 The measurement circuit for leakage current is to be as shown in Figure 13.1. The measuring instrument is defined in (a) – (d). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all of the features of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 FF.

b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of current through the resistor.

c) Over a frequency range 0 – 100 kHz, the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistance shunted by a 0.15-µF capacitor to 1500 ohms. At an indication of 0.25 or 0.5 mA, the measurement is to have an error of not more than 5 percent at 60 Hz.

d) Unless the meter is being used to measure leakage from one part of the equipment to another, the meter is to be connected between the dead metal parts and the earth-grounded supply conductor.

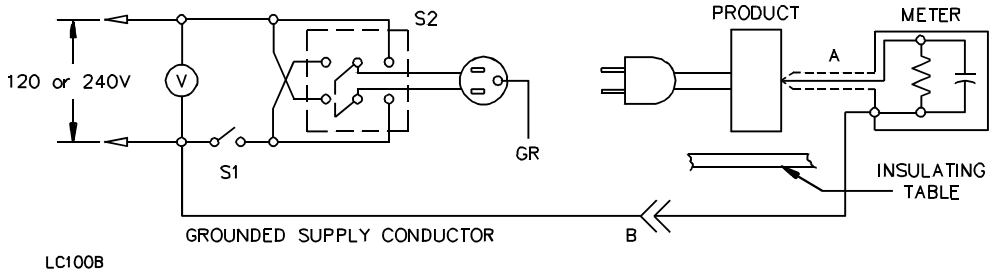
13.9 The supply voltage is to be adjusted to 120, 208, or 240 V. The test sequence, with reference to the measuring circuit (Figure 13.1), is to be as follows:

a) With switch S1 open, the equipment is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the equipment switching devices in all of their intended operating positions.

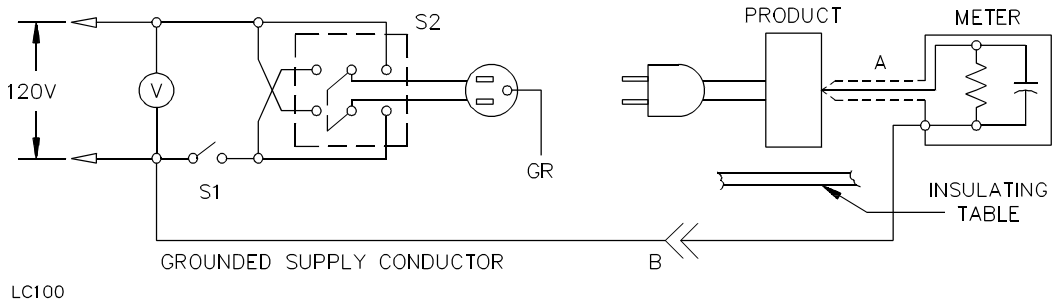
b) Switch S1 is then to be closed energizing the equipment and, within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the equipment switching devices in all of their normal operating positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal-temperature test in the end-product standard.

Figure 13.1
Leakage-current measurement circuit



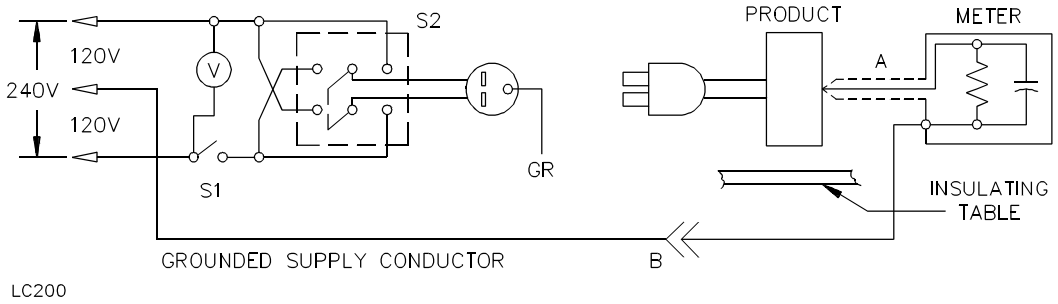
Product intended for connection to a 120- or 240-V power supply.



Product intended for connection to a 120-V power supply.

(Continued)

Figure 13.1 (Cont'd)



Product intended for connection to a 3-wire, grounded-neutral power supply, as illustrated above. Represents 240- or 208-V supply.

Notes:

A – Probe with a shielded lead.

B – Separated and used as a clip when measuring currents from one part of a product to another.

Figure 13.1 revised April 14, 1998

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14 Dielectric Voltage-Withstand Tests

14.1 The equipment shall withstand for 1 minute without breakdown the application of a 60 Hz essentially sinusoidal potential in accordance with Table 14.1.

Table 14.1
Points of application and voltages for dielectric voltage-withstand test

Points between which potential is to be applied	Test potential in volts
1. Live parts and inaccessible dead metal parts	Voltage prescribed for dielectric voltage-withstand test in the end-product standard
2. Inaccessible dead metal parts and accessible dead metal parts – or for equipment with an outer enclosure of insulating material, metal foil wrapped tightly around the enclosure – see Figure 11.1	2000 V plus twice the rated voltage of the equipment
3. Accessible dead metal parts, or the foil mentioned in item 2, and metal foil in contact with the inner surfaces of insulating barriers provided to accomplish compliance with 12.1	2000 V plus twice the rated voltage of the equipment
4. Accessible dead metal parts and:	
a. Metal foil wrapped around the power-supply cord inside the inlet bushings, cord guards, strain-relief clamps, and the like or	2000 V plus twice the rated voltage of the equipment
b. A metal rod of the same cross-sectional dimensions as the cord and inserted in its place	2000 V plus twice the rated voltage of the equipment
5. Live parts and accessible dead metal parts, or the foil mentioned in item 2	3500 V plus twice the rated voltage of the equipment

15 Insulation Resistance Test

15.1 After conditioning as described in 15.4, the equipment shall have an insulation resistance not less than the following:

a) Between live parts and accessible dead metal parts – 7 megohms.

b) Between live parts and inaccessible dead metal parts – 2 megohms.

c) Between inaccessible dead metal parts and accessible dead metal parts – 5 megohms.

15.2 For equipment having an outer enclosure consisting wholly or partly of insulating material, the term "accessible dead metal parts" used in 15.1 signifies metal foil tightly wrapped around the exterior of the enclosure.

15.3 If the equipment has parts that might produce conductive dust, the insulation-resistance test is to be made on the sample used for the leakage-current test.

15.4 In preparation for the test, the sample is to be conditioned at 32.0 ±2.0EC (91.4 ±3.6EF) for 4 hours and then placed in an enclosure for 48 hours at 20.0 – 30.0EC (68.0 – 86.0EF) and a relative humidity of 88 ±2 percent. The specified relative humidity can be obtained by placing a supply of a saturated solution of potassium sulphate inside a tightly closed compartment.

15.5 The measurements of insulation resistance are to be made with the equipment still in the conditioning chamber.

15.6 In determinations of insulation resistance, a direct potential of 500 V is to be employed, and the value of insulation resistance is to be determined 1 minute after application of the test potential. An acceptable megohmmeter can be used for conducting the insulation-resistance test, or other similar means can be employed. The sample is not to be energized during this test.

15.7 Following the insulation-resistance test, and while still humidity-conditioned, the sample shall be subjected to the Dielectric Voltage-Withstand Tests, Section 14.

16 Resistance to Impact Tests

16.1 The equipment shall withstand the impact tests applicable to the end-product standard without resulting in any of the following:

a) Reduction of spacings below the minimum acceptable values.

b) Making accessible to contact live parts and dead metal parts that are insulated from live parts by only basic insulation.

c) Breakage, cracking, rupture, or the like, that have an adverse effect on the insulation.

d) Producing any other condition that increases the risk of electric shock from the equipment. The equipment is to comply with the dielectric voltage-withstand requirements applicable to the equipment after being subjected to the impact.

16.2 An accessible brush holder or brushcap shall withstand an impact energy of 1 pound-force•feet (1.36 J) without cracking and without exposing live parts.

16.3 The impact is to be applied by the hemispherical end of a solid, smooth, steel cylinder having a C-scale Rockwell hardness of 65 ±5, a diameter of 0.25 inch (6.4 mm), a length to produce a weight of 0.22 ±0.01 pound (0.100 ±0.004 kg), and a velocity to produce a kinetic energy of 1 pound-force•feet (1.36 J) at the time of impact. The cylinder is to fall freely or is to be suspended by cords and fall as a pendulum through the distance required to cause it to strike the surface with the specified impact energy. The point of impact and the center of gravity of the cylinder are to be in a line parallel to the direction of travel at the time of impact.

16.4 If an accessible metal switch handle, knob, operating button, or the like has an insulating cover to provide either supplementary or reinforced insulation, the insulating material shall withstand an impact of 5 pounds-force•feet (6.78 J) as specified in 16.6 without cracking or breaking the insulating material – or the inner layer of insulation if there is more than one layer – or dislodging the handle from its normal position.

16.5 An accessible switch handle, knob, operating button, or the like consisting entirely of insulating material shall withstand an impact of 5 pounds-force•feet (6.78 J) as specified in 16.6 without dislodging the handle from its normal position.

Exception: The requirement in 16.5 does not apply if, with the handle dislodged or broken by the impact, live parts or normally inaccessible dead metal parts are not accessible.

16.6 For the impact test in 16.4 and 16.5, a smooth steel sphere 2 inches (50.8 mm) in diameter and weighing 1.18 pounds (0.535 kg) is to be used. The sphere is to fall freely or is to be suspended by a cord and fall as a pendulum through the distance required to cause it to strike the surface with the specified impact.

17 Overload Tests on Isolating Transformers

17.1 An isolating transformer that has:

a) A secondary circuit conductively connected to an accessible metal part or

b) A terminal or outlet for connection of circuits external to the equipment (see Transformers, Section 10)

shall not experience a temperature rise greater than indicated in Table 17.1 under any condition of overload, including short circuit of any secondary winding or a portion of a tapped secondary winding. There shall not be any damage to the transformer, such as excessive deterioration of the insulation, that results in a risk of fire or electric shock.

17.2 To determine that there is compliance with 17.1, a transformer with inherent temperature-limiting characteristics is to be operated continuously with the secondary winding or sections of a tapped winding short-circuited and the primary winding connected to a supply circuit in accordance with the end-product standard. Temperature is to be determined by the resistance method.

17.3 If a transformer has more than one secondary winding, or a tapped secondary winding, separate tests are to be performed for each winding or each section of a tapped winding with the other windings unloaded – or loaded as intended, if the equipment is constructed so that an overload on one winding cannot be obtained without the loading of the other – unless it can be determined that a test on one of the windings produces the most unfavorable result.

17.4 If a transformer is not inherently temperature-limited but is used with devices that operate to prevent overheating, the test is to be made with the secondary winding loaded to result in the maximum current input to the transformer without causing the protective device to open, and also with the secondary winding short-circuited.

17.5 For transformers with thermal cutouts or overcurrent devices, temperatures are to be measured by means of thermocouples consisting of wires not larger than No. 30 AWG (0.05 mm^2) placed on the surfaces of coils of all windings. A thermocouple for measuring a coil temperature is to be applied to the conductor metal or it is to be separated from the metal material by, at most, the integral conductor insulation.

17.6 To determine whether a transformer with an automatic-reset protector complies with the average-temperature-rise requirement in Table 17.1, the transformer is to be energized for 360 hours (15 days) with the secondary winding short-circuited. The transformer is to be at room temperature at the beginning of the test.

17.7 The average temperature is to be determined as follows. The curve or graph of temperature plotted against time is to be obtained for the second hour and also for the 360th hour. During each of these periods, the average temperature is to be determined by taking the arithmetic mean of the maximum temperatures, and of the minimum temperatures.

Table 17.1
Acceptable rises in temperature for isolation transformers

Type of protection	Maximum acceptable rise		Average acceptable rise	
	Class 105 insulation	Class 130 insulation	Class 105 insulation	Class 130 insulation
Impedance (see 17.2)	135EC (243EF)	160EC (188EF)	–	–
Thermal cut-out				
Automatic reset				
1. During first hour of operation	175EC (315EF)	200EC (360EF)	–	–
2. After first hour of operation	150EC (270EF)	175EC (315EF)	125EC (205EF)	150EC (270EF)
Fusible and nonresettable				
1. Before opening during first hour of operation	175EC (315EF)	200EC (360EF)	–	–
2. Opening after first hour of operation	150EC (270EF)	175EC (315EF)	–	–
Manual reset				
1. During first hour of operation, or during the 10 cycles of operation mentioned in 17.8, whichever is the shorter interval	175EC (315EF)	200EC (360EF)	–	–
2. After first hour of operation, if the 10 cycles mentioned in 17.8 require more than 1 hour for completion	150EC (270EF)	175EC (315EF)	–	–

17.8 To determine whether a manual-reset protector operates at a temperature that is acceptable under secondary short-circuit conditions, it is to be operated for 10 cycles, with the protector being reclosed as quickly as possible after it has opened the circuit. The test is to be started with the transformer at room temperature.

17.9 Following the tests described in 17.1 – 17.8, the transformer shall withstand for 1 minute without breakdown a 60 Hz essentially sinusoidal potential as indicated in item 1 of Table 14.1.

17.10 All values for temperature rises in Table 17.1 are based on an assumed ambient temperature of 25EC (77EF). Tests may be conducted at any ambient temperature within the range of 10 – 40EC (50 – 104EF).

18 Overload Test on Motors

18.1 Operation of a motor under conditions of extreme overload shall not affect the insulation to the extent that the insulation does not comply with 18.8 or that live parts are exposed.

18.2 To determine whether a motor complies with 18.1, three previously untested samples are to be operated as described in 18.3 or 18.4, whichever applies.

18.3 If the motor can be subjected to a running overload as used in the equipment, each of three samples of the motor is to be subjected to operation at no load for 1/2 hour, immediately followed by operation at rated load or the load imposed by the equipment if the motor has no marked rating for 1/2 hour. Immediately following this, the load is to be increased in steps of 10 percent of the rated current for each of four successive 1-hour periods, followed by two 1/2-hour periods, followed by eight 1/4-hour periods, followed by such additional periods of five minutes each as prove necessary to achieve breakdown of the basic insulation.

18.4 If the motor cannot readily be subjected to running overload as used in the equipment, the first sample is to be subjected to an overvoltage that breaks down the basic insulation in 2 – 4 hours, the second is to be subjected to such overvoltage as causes breakdown of the basic insulation in 4 – 6 hours, and the third is to be subjected to such overvoltage as causes breakdown of the basic insulation in 6 – 8 hours.

18.5 With reference to 18.3 and 18.4, breakdown of the basic insulation is considered to have occurred when flame appears, the winding burns open, or a short circuit develops in the winding that results in a spontaneous increase in current to 50 percent or more of the last adjusted value.

18.6 If breakdown of the basic insulation occurs as a short-circuit in the winding, operation is to be continued for 30 seconds after the short-circuit occurs, unless flame or burnout occurs earlier. If flame or burnout occurs, operation is to be terminated immediately. If neither flame nor burnout occurs during the 30-second interval, the motor is then to be given time to cool to room temperature. Without adjustment of the current from the value during the 30-second interval, operation of the motor is to be resumed until flame or burnout occurs or until 30 seconds elapse, whichever occurs first. This procedure is to be repeated three more times, giving the motor time to cool to room temperature at the conclusion of each 30-second interval, making a total of five 30-second periods of operation after the period in which breakdown of the basic insulation was first noted. However, the procedure is to be terminated finally at any time that flame appears, burnout occurs, or the motor stalls under essentially no-load conditions.

18.7 During the running-overload operation, any protective device provided with the motor is to be short-circuited, and the branch-circuit protection is to be of high enough capacity to withstand the test currents without opening the circuit. The objective of the test is to determine the integrity of the motor insulation and not the effectiveness of a protective device.

18.8 Following the operation described in 18.3 or 18.4 (whichever applies), the motor shall be given time to cool to room temperature and shall withstand for 1 minute, without breakdown, the application between live parts and accessible dead metal parts – or the foil as mentioned in note a to Table 11.1 – and between all inaccessible dead metal parts and accessible dead metal parts – or the foil mentioned in note a to Table 11.1 – of a 60 Hz potential of 1000 V plus twice the rated voltage.

19 Abnormal Operation Test

19.1 Operation of the equipment under any of the abnormal conditions described in the end-product standard shall not affect the insulation to the extent that it does not comply with 19.2 or that it exposes live parts.

19.2 Following the operation mentioned in 19.1, the equipment shall be given time to cool to room temperature and shall withstand for 1 minute without breakdown the application, between live parts and accessible dead metal parts – or the foil as described in 15.2 – of the potential specified in Table 14.1.

20 Investigation of Armature Employing Reinforced Insulation Test

20.1 If a construction as described in 5.3.1(c) is employed, each of three samples of the armature, after each of the three conditioning procedures described in 20.2, 20.3, and 20.5, shall withstand for 1 minute without breakdown the application of a 60 Hz sinusoidal potential of 1000 V plus twice rated voltage between the armature winding and dead metal.

20.2 The three samples mentioned in 20.1 are first to be kept in an oven for 500 hours at a temperature that is 20EC (36EF) higher than the temperature of the armature winding measured under conditions of normal use.

20.3 One armature sample is then to be caused to carry the locked-rotor current of the motor, another is to be caused to carry half of such locked-rotor current, and the third is to be caused to carry one-fourth of that locked-rotor current. The specified current is to flow in each sample for 4 hours unless breakdown of the basic insulation, as defined in 18.5, occurs before the end of that interval. If breakdown of the basic insulation of a given sample does not occur before the end of the 4-hour period, the test is to be continued as long as is necessary to accomplish that result, with the current during each additional hour being increased by 50 percent of the initial value.

20.4 If breakdown of the basic insulation occurs as a short circuit in the winding, the current flow is to continue for 30 seconds after the short circuit occurs, unless flame or burnout occurs earlier. If flame or burnout occurs, operation is to be terminated immediately. If neither flame nor burnout occurs during the 30-second interval, the armature is then to be given time to cool to room temperature. The current flow is then to be resumed without readjustment until flame or burnout occurs or until 30 seconds elapse, whichever occurs first. This procedure is to be repeated three more times, giving the armature time to cool to room temperature in each instance, making a total of five 30-second periods of current flow after the period in which breakdown of the basic insulation was first noted, except that the procedure is to be finally terminated any time flame appears or burnout occurs. If flame occurs, it is to be extinguished immediately.

20.5 Each sample is then to be rotated at its normal no-load speed for 1 minute by any convenient external means.

21 Moisture Resistance Test

21.1 Equipment that is intended for outdoor use or subject to contact with water or spillage of liquid in intended use is to be subjected to rain, splash, or spillage tests as described in the end-product standard.

21.2 Following the tests mentioned in 21.1, the equipment:

a) Shall comply with the requirement in 13.2 in a repeat leakage-current test.

b) Shall withstand for 1 minute without breakdown the application of a 60 Hz essentially sinusoidal potential between live parts and accessible dead metal parts – or the foil mentioned in item 2 of Table 14.1. The value of the potential shall be the value indicated in item 2 of Table 14.1.

MANUFACTURING AND PRODUCTION TESTS

22 Production-Line Dielectric Voltage-Withstand Test

22.1 The manufacturer shall determine by a routine production-line test that each product that is marked "double-insulated" or "double insulation" withstands for 1 second without breakdown the application of the test potentials indicated in Table 22.1.

Table 22.1
Production line dielectric voltage-withstand test potentials

Points between which potential is to be applied	Test potential in volts	
	RMS	Peak
1. Live parts and dead metal parts insulated from one another by basic insulation	1000	1414
2. Inaccessible dead metal parts and accessible dead metal parts insulated from one another by supplementary (protecting) insulation	1500	2122
3. Live parts and accessible dead metal parts	2500	3536

NOTES

1 If necessary because of the inaccessibility of parts, tests in accordance with items 1 and 2 may be conducted by subassemblies of the equipment, and, in this case, the test indicated in item 3 is to be conducted. If the tests in accordance with items 1 and 2 are conducted on the completely assembled equipment, the tests indicated in item 3 may be omitted if there is no reinforced insulation.

2 Those parts of the test described in items 2 and 3 that include application of metal foil to outer enclosures of insulation 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.

MARKINGS

23 General

23.1 Equipment that complies with this standard shall be permanently marked with the words "Double Insulation – When servicing, use only identical replacement parts." The words "Double Insulated" may be used instead of "Double Insulation" in the marking.

23.2 The double-insulation symbol – a square within a square – may be used in addition to but not in place of the words "Double Insulation."

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