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Class 2 and Class 3 Transformers

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UL Standard for Safety for Class 2 and Class 3 Transformers, UL 1585

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The revisions dated February 28, 2001 include a reprinted title page (page1) for this Standard.

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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.

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UL 1585

Standard for Class 2 and Class 3 Transformers

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April 23, 1998

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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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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 which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, 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 Transformers covered by these requirements, herein called Class 2 or Class 3 transformers, are for use with Class 2 or Class 3 circuits, respectively, in accordance with the National Electrical Code, ANSI/NFPA 70. They are intended for connection to essentially sinusoidal supply sources. Permanently connected transformers are rated 600 volts or less, and cord and plug connected transformers are rated 120 volts or less.

1.2 A Class 2 or Class 3 transformer that is inherently limited has an impedance within the transformer that limits the current output to a particular maximum value. It may or may not be provided with a thermostat or other temperature sensitive device to limit its maximum temperature.

1.3 A Class 2 or Class 3 transformer that is not inherently limited does not have an impedance to limit the maximum current output to a specified value. However, the maximum power output is limited by an overcurrent-protective device.

1.4 A Class 2 or Class 3 transformer that includes a separate current-limiting impedance, such as a resistor or a positive temperature coefficient device (PTC), is covered by these requirements.

1.5 A Class 2 transformer has a 30-volt rms maximum secondary potential under any condition of loading or open circuit.

1.6 A Class 2 or Class 3 transformer that includes a resonance regulating circuit is covered by these requirements.

1.7 These requirements do not cover power supplies, toy transformers, direct plug-in transformers, or transformers intended for use in audio-, radio-, or television-type appliances. A transformer provided with a rectifier is considered to be a power supply.

1.8 The requirements in this standard may be modified by requirements in an end product standard if a transformer is intended for use only as a component in other equipment.

1.9 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the 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 does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.9 revised February 28, 2001

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

2.1.1 revised February 28, 2001

2.1.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.1.2 revised February 28, 2001

2.1.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.1.3 revised February 28, 2001

2.1.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.1.4 revised February 28, 2001

2.2 Units of measurement

2.2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2.1 revised February 28, 2001

2.2.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are root-mean-square (rms).

2.3 Undated references

2.3.1 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.

CONSTRUCTION

3 General

3.1 A Class 2 or Class 3 transformer shall have only one secondary winding, which shall be insulated from the primary winding. A winding having intermediate taps is considered to be a single winding.

Exception No. 1: Two or more secondary windings may be considered as a single winding. Interposing insulation between the secondary windings is not required if, when interconnected, the windings are in compliance with the performance requirements for a single-winding construction.

Exception No. 2: An inherently limited transformer marked in accordance with 41.7 may have two secondary windings that, when interconnected, are not in compliance with the performance requirements for a single-secondary winding construction.

Exception No. 3: A transformer intended only for use in other equipment may have multiple secondary windings only where isolation of all circuits can be maintained.

3.2 There shall be no electrical connection between the primary and secondary windings of a transformer or between a primary or secondary circuit and the enclosure.

3.3 A component used to limit the output of a transformer to within the required current or power levels, or otherwise used to maintain its intended performance, shall have permanence and stability so as not to decrease its limiting capabilities. Among the factors taken into consideration when judging the acceptability of a limiting component are the:

- a) Operating temperature;
- b) Electrical stress level;
- c) Transient surges; and
- d) Resistance to moisture.

4 Mechanical Assembly

4.1 A transformer shall be formed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is likely to be subjected. A risk of fire, electric shock, or injury to persons shall not result from a reduction of spacings, loosening or displacement of parts, or other serious defects due to total or partial collapse of the transformer.

4.2 An adhesive used in the assembly of the enclosure shall be investigated as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Methods utilizing fusion techniques, such as solvent cementing, ultrasonic welding, electromagnetic induction, and thermal welding, need not be investigated.

5 Enclosure

5.1 A transformer shall be provided with an enclosure of sheet steel, sheet aluminum, cast aluminum, cast iron, or equivalent metal, or a polymeric material. The enclosure shall contain all uninsulated live parts and primary circuit wiring.

Exception No. 1: The secondary terminals of a Class 2 transformer need not be enclosed.

Exception No. 2: For a transformer mounted on an outlet box cover or intended for mounting in a knockout of an outlet box or cabinet, the primary terminals or leads are considered to be enclosed by the outlet box or cabinet.

Exception No. 3: A Class 3 transformer may be provided with a flexible cord and attachment plug for connection to the source of supply.

Exception No. 4: A transformer may have exposed primary leads when intended for connection to open wiring or concealed knob-and-tube wiring.

Exception No. 5: The enclosure of the end product may serve as the transformer enclosure for a transformer intended for use only in other equipment. However, the primary and secondary wiring of the transformer shall be separated in accordance with the requirements for the end product.

5.1 revised February 28, 2001

5.2 The transformer shall be constructed so that it can be mounted and wired as intended in the field without exposing internal parts such as windings and protective devices to damage. All covers, bases, and similar parts shall be securely fastened in place.

5.3 An enclosure of a transformer that has a flexible cord connected to the primary shall have no opening where a 0.010 inch (0.25 mm) diameter rigid wire, such as a music wire, can be inserted to contact a part at a potential of more than 42.2 volts peak to any other part or to ground. A single bend in the wire is permitted prior to insertion, and a barrier that can be penetrated by the wire is not acceptable as a protective barrier. An indicating circuit connected to the wire probe may be used to determine if contact is made.

Exception: This requirement does not apply to an outlet box that may be provided only to enclose the primary leads or terminals as described in Exception No. 2 to 5.1

5.4 An edge, projection, or corner of an enclosure, opening, or frame of a transformer shall be smooth and not cause a cut-type injury when contacted during intended use or maintenance.

5.5 Among the factors that shall be taken into consideration when evaluating magnesium and nonmetallic materials other than a polymeric material are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture absorption;
- d) Combustibility; and
- e) Resistance to distortion at temperatures to which the material may be subjected under conditions of intended or abnormal use.

5.6 Polymeric materials shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

5.7 A sheet steel enclosure shall be formed from stock having a thickness of not less than 0.026 inch (0.66 mm) when uncoated, or 0.029 inch (0.74 mm) when zinc coated.

Exception: Sheet steel having a thickness of not less than 0.020 inch (0.51 mm) if uncoated, or 0.023 inch (0.58 mm) if zinc coated, may be used for drawn end bells having maximum dimensions of 2-1/4 inches (57.2 mm) on the flat portion and 1-1/2 inches (38.1 mm) at the base of the drawn portion. Figure 5.1 illustrates these portions of an end bell.

5.8 The thickness of a steel sheet is determined by taking five micrometer readings equally spaced across the full width of the sheet as rolled.

5.9 An enclosure of nonferrous sheet metal shall be formed from stock having a thickness of not less than 0.040 inch (1.07 mm).

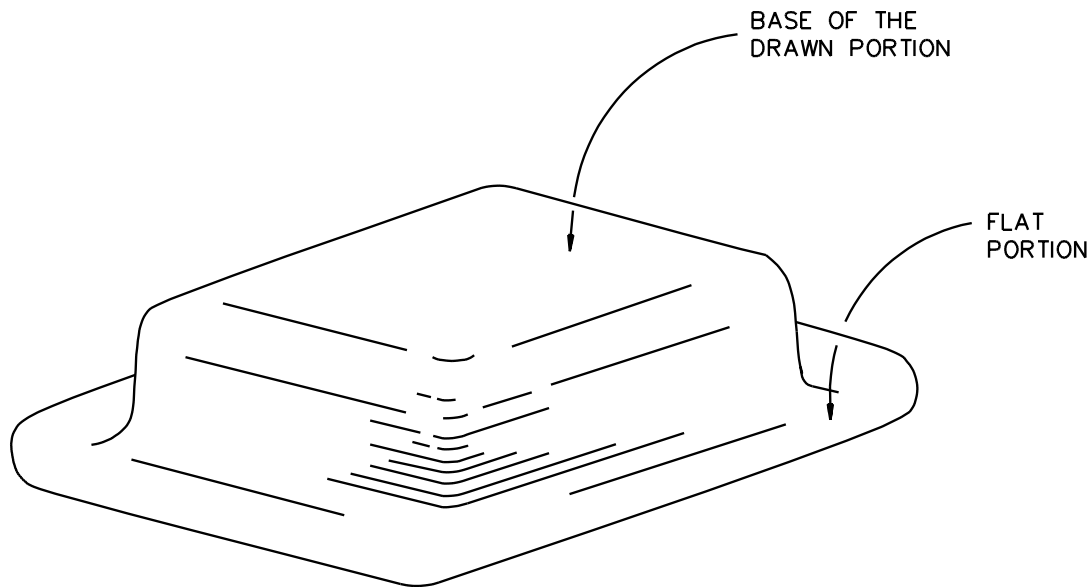
5.10 An enclosure of cast iron or aluminum shall not be less than 1/8 inch (3.2 mm) thick at any point.

Exception: A section 2 square inches (12.9 cm²) or less in area shall not be less than 1/16 inch (1.6 mm) thick, when the sum of the areas of all such sections is less than 50 percent of the total area of the enclosure.

5.11 An enclosure of cast iron shall not be less than 1/4 inch (6.4 mm) thick at tapped holes for conduit.

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Figure 5.1
End bell



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5.12 When threads for the connection of conduit are tapped all the way through a hole in a transformer enclosure, or if a similar construction is used, there shall not be less than 3-1/2 nor more than 5 threads in the metal. The construction shall enable the proper and secure attachment of a standard conduit bushing.

5.13 When threads for the connection of conduit are tapped only part of the way through a hole in the enclosure, there shall not be less than 5 full threads in the metal. There shall be a smooth, well-rounded inlet hole to provide a passage similar to that provided by a standard conduit bushing.

5.14 A transformer intended to be supported by rigid metal conduit shall have conduit hubs with not less than 5 full threads.

5.15 A knockout for the connection of rigid metal conduit to a terminal or wiring compartment of a transformer shall have a diameter in accordance with the requirements in the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

5.16 When a nipple is provided on the primary side for connection to an outlet box, there shall be not less than 3-1/2 threads on the nipple.

6 Corrosion Resistance

6.1 An enclosure of iron or steel, other than stainless steel, shall be corrosion resistant. Galvanizing, plating, varnishing, and painting are among the acceptable means for providing corrosion resistance.

Exception: An interior surface covered by a compound need not be additionally resistant to corrosion.

7 Mounting

7.1 A transformer not intended to be portable shall be provided with a secure mounting means. It shall be constructed so that there will be a spacing through air of not less than 1/4 inch (6.4 mm) between the supporting surface and the enclosure when the device is mounted on a plane surface.

Exception No. 1: A transformer mounted on an outlet box cover or intended for mounting in a knockout of an outlet box or cabinet need not have an air spacing between the supporting surface and the transformer enclosure.

Exception No. 2: A transformer intended for use only in other equipment as described in Exception No. 5 to 5.1 need not be provided with the 1/4 inch spacing.

7.2 A transformer intended to cover an outlet box shall be equipped with a cover that is resistant to corrosion on all surfaces.

7.3 When an outlet box cover is constructed of sheet steel, it shall have a thickness not less than 0.045 inch (1.14 mm) when zinc coated, and 0.042 inch (1.07 mm) when uncoated. When constructed of malleable iron, the cover shall have a wall thickness of not less than 3/32 inch (2.4 mm). When constructed of another type of cast metal, the thickness shall not be less than 1/8 inch (3.2 mm). Covers constructed of sheet aluminum, copper, or brass, shall not be less than 0.058 inch (1.47 mm) thick.

7.4 If the cover mentioned in 7.2 is of nonmetallic material, it shall be strong enough to:

- a) Support a weight three times the weight of the transformer, as described in 37.2.1, without cracking or crazing;
- b) Withstand an impact of 5 foot-pounds (6.8J) applied as described in 37.3.1; and
- c) Comply with the requirements for nonmetallic box covers in the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

7.5 A transformer intended for mounting in place of a knockout in an outlet box, cabinet, or similar area, shall be provided with mounting means that will restrain the transformer from being turned after it is mounted.

7.6 A transformer is considered to comply with the requirement in 7.5 when the mounting means provides restraint against turning when the transformer is mounted in a box or cabinet wall having a minimum uncoated thickness of 0.053 inch (1.35 mm).

8 Wiring Space

8.1 A transformer shall be provided with an enclosure which provides space for the installation of those conductors likely to be used to connect the primary and secondary circuits.

Exception No. 1: The secondary terminals or leads of a Class 2 transformer do not have to be enclosed.

Exception No. 2: The following do not have to be enclosed by the transformer enclosure:

- a) *The primary terminals or leads of a transformer mounted on an outlet box cover;*
- b) *The primary leads of a transformer intended for mounting in a knockout; or*

c) The primary leads of a transformer intended for installation with open wiring or concealed knob-and-tube wiring.

Exception No. 3: Wiring space does not have to be provided for a transformer intended only for use in other equipment as described in Exception No. 5 to 5.1.

8.2 There shall be space provided within a terminal or wiring compartment for a standard conduit bushing to be mounted on rigid metal conduit connected to the compartment.

8.3 A wiring space or compartment intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or similar item that may abrade the insulation on conductors or otherwise damage the wiring.

9 Supply Connections

9.1 The supply connection facilities of a transformer shall consist of insulated wire leads, terminals, or, for a Class 3 transformer, flexible cord with an attachment plug for plugging into a receptacle outlet.

9.1 revised February 28, 2001

10 Primary Wiring Terminals

10.1 For the purpose of these requirements, a wiring terminal is that terminal to which a connection is made in the field when a transformer is installed. A terminal shall be a pressure terminal connector, a wire-binding screw, or a stud.

10.2 When a Class 2 transformer is intended for mounting on an outlet box, wiring terminals that will be inside the box after the transformer is installed shall be located or recessed so that contact between the terminals and wires inside the box will be unlikely after the transformer is installed.

10.3 A wire-binding screw terminal design is one in which the conductor is intended to encircle the terminal screw at least 3/4 of one full turn without overlapping.

10.4 A wire-binding screw shall thread into metal.

10.5 The terminal plate and the wire-binding screw or stud and nut of a primary wiring terminal shall be brass or similar nonferrous metal.

Exception: A No. 10 (4.8 mm) or larger wire-binding screw may be iron or steel if plated. A steel wire-binding screw shall not be plated with copper or brass; however, a cadmium or zinc plating is acceptable.

10.6 A terminal plate for a wire-binding screw shall be not less than 0.030 inch (0.76 mm) thick and shall have not less than two full threads in the metal for the binding screw.

10.7 Wire-binding screws or studs shall be not smaller than No. 6 (3.5 mm) and shall not have more than 32 threads per inch (25.4 mm).

10.8 A wire-binding screw shall be captivated (locked into position) if replacement with a longer screw would create a risk of fire or electric shock.

10.9 Wiring terminals shall be provided with cupped washers, upturned lugs, or equivalent means to retain the wires under the heads of the screws or nuts.

10.10 Terminal studs shall be prevented from turning by means other than friction between mounting surfaces. The acceptability of the use of lock washers to prevent turning of terminals shall be determined by means of an investigation.

10.11 Pressure terminal connectors shall comply with the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A; the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B; or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

10.12 A pressure terminal connector shall be prevented from turning by a restraint such as a shoulder or boss. A lock washer alone is not acceptable for this purpose.

Exception: A means to prevent turning need not be provided when spacings are not less than those specified in Spacings, Section 21, with:

- a) Connectors of opposite polarity turned 30 degrees toward each other or*
- b) A connector turned 30 degrees toward any other opposite polarity live part or dead metal part.*

11 Primary Leads, Including Flexible Cords

11.1 The connection between a primary lead, including a flexible cord, and the winding or other part of the transformer shall be:

- a) Secured by means of a pressure wire connector or
- b) Soldered, welded, or brazed.

A soldered joint shall be made mechanically secure before being soldered.

Exception: Additional mechanical security is not required when a lead is rigidly held in place without the use of solder, or if it will be retained in place by compound or equivalent means.

11.2 A primary field wiring lead of a transformer intended for permanent connection shall have stranded copper conductors not smaller than No. 18 AWG (0.82 mm²).

11.3 Insulation of a primary lead shall be at least 0.030 inch (0.76 mm) thick.

11.4 Thermoplastic insulated wire and flexible cord shall not be used for a transformer lead unless it has been investigated to be acceptable. The investigation is to consider the strain-relief employed, and the effects of the varnishing and compounding operations on the insulation of the lead.

11.5 A transformer lead shall have a voltage and temperature rating appropriate for the application. In a Class 130(B) or higher insulation system, a lead shall be additionally investigated in accordance with the requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

11.6 A primary field wiring lead of a transformer for permanent connection shall extend not less than 6 inches (152 mm) outside the enclosure, and a lead of No. 18 or 16 AWG (0.82 or 1.3 mm²) wire shall extend not more than 12 inches (305 mm) outside the enclosure.

11.7 An insulating bushing or a smooth, well-rounded opening shall be provided where the primary leads pass through the enclosure of a permanently wired transformer.

11.8 A transformer intended for installation with open wiring or concealed knob-and-tube wiring in accordance with Articles 320 and 324 respectively of the National Electrical Code, ANSI/NFPA 70, shall be provided with the following:

- a) A marking in accordance with 41.18;
- b) A spacing of not less than 1/4 inch (6.4 mm) between the conductors;
- c) A spacing of not less than 1/2 inch (12.7 mm) between the conductors and the plane of the transformer support; and
- d) An insulating bushing where the primary leads pass through the enclosure. Either a separate hole for each lead shall be provided in the insulating material or separate bushings shall be provided.

11.8 revised May 24, 1999

11.9 Strain-relief shall be provided so that stress on a flexible cord or a lead intended for connection to field wiring will not be transmitted to the connection inside the transformer. Strain-relief shall be investigated in accordance with the Strain-Relief Test, Section 36.

11.10 A strain-relief means that depends solely on adhesion between the conductor and an asphalt-type compound shall not be used. Epoxy- and polyester-type compounds may be used for strain-relief when the construction complies with the Strain-Relief Test, Section 36.

11.11 Flexible cord, when provided with a Class 3 transformer, shall be:

- a) Not less than 5 feet (1.52 m) nor more than 10 feet (3.05 m) in length;
- b) Connected to an attachment plug rated at 15 amperes; and
- c) A type specified in 11.13.

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11.12 The length of flexible cord is to be measured from the face of the attachment plug to the point where the cord emerges from the transformer enclosure.

11.13 The types of flexible cord for use with a portable Class 3 transformer are indicated in Table 11.1. They are listed from lightest to heaviest, in order, with respect to general serviceability. Where these requirements specify any particular type of flexible cord, all types following it in the table are also acceptable.

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No Text on This Page

Table 11.1
Acceptable types of cord

SP-2	
SP-3	
SPE-2	
SPE-3	
SPT-2	
SPT-3	
SV	SJO, SJOO
SVE	SJT
SVO, SVOO	SJTO, SJTOO
SVT	S
SVTO, SVTOO	SO, SE, SOO
SJ	ST
SJE	STO, STOO

12 Secondary Terminals and Leads

12.1 General

12.1.1 Wiring terminals, quick-connect terminals, or insulated leads shall be provided for secondary circuit connection.

12.1.2 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch wide, quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rise. All tests shall be conducted in accordance with UL 310.

12.1.3 When a quick-connect terminal is provided, the maximum ampere rating of the coil shall be 5 amperes for a terminal tab with a nominal width of 0.125 inch (3.2 mm) or less. The maximum ampere rating of the coil shall be 24 amperes for a terminal tab with a nominal width greater than 0.125 inch.

12.1.4 Terminal plates, wire-binding screws, studs, and nuts shall be constructed as specified for Primary Wiring Terminals, Section 10.

Exception No. 1: The terminal plates may be of plated steel; cupped washers and similar devices are not required.

Exception No. 2: A No. 4 (2.8 mm diameter) wire-binding screw with not more than 40 threads per inch may be used for a secondary terminal of a Class 2 transformer.

12.1.5 The insulation of secondary circuits of a transformer shall be equivalent to that required for the primary circuit of the transformer, or the secondary circuits shall be separated from all wiring of different circuits by routing, clamping, the use of one or more barriers, or equivalent means.

12.1.6 Other than as required in 12.1.5, the type and thickness of insulation is not specified for leads and flexible cord on the load side of required energy-limited components. The leads and flexible cord may be any length.

12.1.7 A fitting having female contacts shall be constructed so that it will not receive the blades of a standard attachment plug as described in the Standard for Attachment Plugs and Receptacles, UL 498. A fitting having male contacts shall be constructed so that the contacts will not touch a live part of a standard attachment-plug receptacle.

12.1.8 Regarding 12.1.7, the output cord or leads of a unit for use as a Class 2 transformer are not required to be terminated in a fitting; however, when a fitting is provided, it shall comply with the requirements in 12.1.7.

12.2 Class 3 transformers

12.2.1 Class 3 secondary terminals and leads shall comply with the requirements for primary terminals and leads in Primary Leads, Including Flexible Cords, Section 11. Class 3 secondary leads that terminate in a fitting shall comply with 12.1.7 in addition to the requirements in Section 11.

13 Bushings

13.1 Other than as specified in 11.7, at a point where a wire of a flexible cord passes or is intended to pass through an opening in a metal wall, barrier, or enclosure, there shall be an insulating bushing or the equivalent secured in place that has a smooth, rounded surface against which the wire or cord may bear. An insulating or metal bushing or the equivalent shall be used with a primary circuit flexible cord.

13.2 A fiber bushing shall have a wall thickness not less than 3/64 inch (1.2 mm) and shall be formed and secured in place so that it will not be affected adversely by conditions of moisture or intended use. A fiber plate not less than 1/32 inch (0.8 mm) thick, with a punched hole, may be used instead of a bushing if the cord or wire is tightly bunched and firmly held in position.

13.3 Bushings of rubber, wood, or hot-molded shellac or tar compositions shall not be used.

14 Internal Wiring

14.1 The internal wiring of a transformer shall be rated for the temperature, voltage, and other conditions of use to which it will be subjected.

14.2 Aluminum conductors, insulated or uninsulated, used for internal interconnections between current-carrying parts, shall be terminated at each end by a method that has been determined to be acceptable for the combination of metals at the connection points.

15 Grounding

15.1 All exposed dead metal parts shall be bonded together and to a grounding means provided for the connection of a grounding conductor of a nonmetallic sheathed cable when a transformer is:

- a) Equipped with a wiring compartment;
- b) Mounted on a nonmetallic outlet box cover; or

- c) Intended for mounting on an outlet box provided with a nonmetallic cover.

The grounding means shall be a grounding screw, a threaded grounding stud, a grounding wire connector, or a grounding wire and shall be identified by the color green or by the designation "G," "GR," "GND," "Ground," or the equivalent. The following symbol may be used for this purpose. ⊕ When used alone, the symbol shall be defined in instructions provided with the transformer.

15.2 When a grounding screw is provided, it shall be No. 8-32 (4.2 mm diameter) or larger and shall have a head that is slotted, hexagonal, or both. When it threads into aluminum, the grounding screw shall be plated steel or stainless steel. When it threads into any other material, the grounding screw shall be plated steel, stainless steel, copper, or copper alloy. A grounding screw shall engage at least two full threads and shall be provided with upturned lugs or the equivalent to hold the conductor under the screw.

15.3 When a threaded grounding stud is provided, it shall be No. 8-32 (4.2 mm diameter) or larger. Studs shall be secured by threading, welding, brazing, or equivalent securement means. When it threads into aluminum, the grounding stud shall be plated steel or stainless steel. When it threads into any other material, the grounding stud shall be plated steel, stainless steel, copper, or copper alloy. A threaded grounding stud shall be provided with a nut and cupped washer with upturned edges or the equivalent to hold the conductor under the nut head.

15.4 When a grounding wire connector is provided, it shall be a pressure wire connector sized to accept a minimum No. 14 AWG (2.1 mm²) copper conductor.

15.5 When a grounding wire is provided, it shall be at least No. 14 AWG (2.1 mm²) and shall be either bare, covered, or insulated solid or stranded copper. When covered or insulated, the covering or insulation shall be green with or without one or more yellow stripes, and no other lead shall be so identified. The grounding wire shall not be less than 6 inches (152 mm) long.

Exception: When the primary leads are smaller than No. 14 AWG, the grounding wire may be no smaller than the primary leads.

15.6 When a transformer is intended for connection to open wiring or concealed knob-and-tube wiring, a grounding means as described in 15.1 shall be provided on the enclosure.

15.7 When a transformer intended for mounting on an outlet box is provided with a metal cover, all exposed dead metal parts shall be bonded to the cover.

15.8 When a transformer is intended for mounting in a knockout, all exposed dead metal parts shall be bonded to the mounting means. If there is no means for maintaining a bonding path between the transformer and the equipment grounding conductor when the transformer is installed in a nonmetallic box, the transformer shall be marked in accordance with 41.19.

15.9 When a Class 3 transformer is cord-connected, all accessible dead metal parts that are likely to be energized by the primary circuit shall be bonded together and to the equipment grounding conductor of the cord. The equipment grounding conductor shall be attached to the grounding blade of a grounding type attachment plug.

Exception: Grounding is not necessary when the transformer enclosure is nonmetallic and there are no accessible metal parts that are likely to be energized by the primary circuit.

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