UL 1876

STANDARD FOR SAFETY

Isolating Signal and Feedback Transformers for Use in Electronic Equipment

UL Standard for Safety for Isolating Signal and Feedback Transformers for Use in Electronic Equipment, UL 1876

Fourth Edition, Dated June 25, 2015

Summary of Topics

This revision of UL 1876 is being issued to reaffirm approval as an American National Standard. No changes in requirements are involved.

The revisions are substantially in accordance with Proposal(s) on this subject dated July 17, 2015.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

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Standard for Isolating Signal and Feedback Transformers for Use in Electronic Equipment

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This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through September 16, 2015.

The most recent designation of ANSI/UL 1876 as an American National Standard (ANSI) occurred on September 14, 2015. ANSI approval for a standard does not include the Cover Page, Transmittal Pages and Title Page. Any other portions of this ANSI/UL standard that were not processed in accordance with ANSI/UL requirements are noted at the beginning of the impacted sections.

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.

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INTRODUCTION

1 Scope

1.1 These requirements apply to isolating signal and feedback transformers intended to be used in electronic equipment where only audio, video, and other signal waveforms are transformed. These transformers are intended to provide isolation from circuits that are either conductively connected to a branch circuit supply or connected to secondary circuits involving voltages that are considered to present a risk of electric shock by the nature of their use in an end-product.

1.2 These requirements do not apply to transformers and motor-transformers that are connected to a supply circuit to power a secondary circuit.

2 Components

2.1 Except as indicated in 2.2, 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.

2.2 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.

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

2.4 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.

3 Units of Measurement

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

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

4 Undated References

4.1 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.

5 Glossary

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

5.2 ENCAPSULATION COMPOUND – A material, generally of the polymeric type, that is at least 1/32 inch (0.8 mm) thick and that encapsulates the transformer by being molded around the coil windings where the transformer is not provided with any other housing material.

5.3 HAZARDOUS CIRCUIT– A circuit in an appliance that either is conductively connected to a branch circuit or involves a risk of electric shock.

5.4 HAZARDOUS CIRCUIT WINDING – A winding of an isolating signal transformer that is intended to be connected to a hazardous circuit.

5.5 HOUSING – A partial or complete enclosure, generally of polymeric material or metal, that is around the outside of all or part of the transformer (such as end bells) but is not in contact with current-carrying parts.

5.6 IMPREGNATION COMPOUND – A material, generally of the polymeric type and commonly in the form of varnish, that is absorbed by insulating materials such as electrical grade paper and that provides a coating of less than 1/32 inch (0.8 mm) thick over all transformer parts.

5.7 ISOLATED CIRCUIT – A circuit that is not conductively connected to the supply circuit.

5.8 ISOLATED WINDING – A winding of an isolating signal transformer that is intended to be connected to a nonhazardous circuit.

5.9 POTTING COMPOUND– A material, generally of the polymeric type, that seals the transformer by filling the space between the coil windings and the housing. Potting material differs from impregnation material in that impregnation material is not intended to completely fill the space between the coil windings and the housing.

5.10 TRANSFORMER FAMILY – A series of transformer models which have identical insulating materials provided between each winding. The number of windings may vary for different models in a family, but the models must either all be suitable for securement to a live chassis or not suitable for securement to a live chassis.

5.11 WINDING – A coil of wire including the start, finish, and crossover leads up to the point where insulated leads or terminals are connected.

CONSTRUCTION

6 Housing

6.1 A material provided as a housing around all or part of a transformer shall comply with 6.2 if of metal and 6.3 if of polymeric material.

6.2 Sheet metal provided around all or a portion of the current-carrying parts of a transformer shall be at least 0.010 inch (0.25 mm) thick if formed of steel and 0.020 inch (0.51 mm) thick if formed of aluminum or copper alloy.

Exception: A metal housing is not required to be of a specific minimum thickness if spacings are maintained by a potting compound complying with 6.3.

6.3 A polymeric material provided to encapsulate, pot, or house a transformer shall be rated V-2 or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A polymeric material less than 1/16 inch (1.6 mm) thick need not be rated V-2 or better if the material is rated V-2 or better for a thickness of 1/16 inch.

7 Resistance to Corrosion

7.1 All ferrous parts shall be provided with a means for corrosion resistance.

8 Mechanical Assembly

8.1 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. The risk of fire, electric shock, and injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or the like shall not be increased when the component is subjected to such likely abuse.

8.2 An adhesive used in the assembly of an enclosure shall be investigated as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Methods utilizing fusion techniques, such as solvent bonding, ultrasonic welding, electromagnetic induction, and thermal welding, need not be investigated.

9 Impregnation

9.1 A transformer shall be impregnated unless it is either potted or encapsulated, or the absorptive insulating materials such as fiber, paper, and the like are individually impregnated, treated, or the like.

10 Leads

10.1 Insulation

10.1.1 The insulation on lead wires, sleeving, and tubing shall be rated for the voltage involved and shall be flame rated VW-1.

10.1.2 Insulating tape used on lead wires shall be rated flame-retardant and rated for the voltage involved.

10.2 Connections between leads

10.2.1 Connections shall be soldered, welded, or otherwise positively secured. A soldered connection shall be made mechanically secure before soldering.

10.3 Strain relief

10.3.1 Strain relief shall be provided so that stress on each individual lead is not transmitted to connections as determined by the Strain Relief Test, Section 17.

10.3.2 Strain relief that depends solely on potting compound or encapsulation material shall be constructed such that mechanical securement is provided by the routing of lead wires, such as right angle turns in the leads as they pass through the material or compound, or by a knot in the leads.

10.4 Protection of wiring

10.4.1 The edges of an opening through which wires pass shall be free of burrs, fins, and other defects that tend to damage the conductor insulation and, if sheet metal, shall be rolled or covered by a bushing complying with 10.4.2.

10.4.2 A bushing that is relied upon for protection of wiring shall be:

a) Secured in place by mechanical means other than friction alone;

b) Made of material other than natural rubber; and

c) Of a construction that does not cause wire damage.

11 Terminal Support

11.1 A polymeric material that directly supports terminals and is not provided as layers of coil insulation shall be:

a) Rated for temperatures of at least 105°C (221°F) and have a flammability rating of V-2 or better for the minimum material thickness provided or 1/16 inch (1.6 mm), whichever is greater.

b) Suitable for direct support of live parts with respect to hot-wire ignition, high-current-arc resistance to ignition, volume resistivity, and dielectric strength in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: A polymeric material that supports only the isolated winding terminals need not comply with (b).

Exception No. 2: A polymeric material subjected to the following need not to comply with the volume resistivity and dielectric strength requirements specified in (b).

a) An additional dielectric voltage-withstand test conducted between adjacent hazardous circuit terminals on the transformer following the method and complying with the requirements described in the Transformer Dielectric Voltage-Withstand Test, Section 16; and

b) Insulation resistance between adjacent hazardous circuit terminals with windings disconnected, in addition to those described in the Insulation Resistance Test, Section 18, that is found to be greater than 10 megohms;

12 Transformer Insulation

12.1 Insulation (excluding the magnet wire coating) between the parts specified below shall comply with 12.4 and with either the generic insulation material types and thicknesses specified in 12.5 or with the Insulating Materials Equivalence Test, Section 20

a) Hazardous circuit windings and dead-metal parts;

b) Hazardous windings and isolated windings;

c) Points of opposite polarity in the hazardous windings;

d) Isolated windings and dead-metal parts;

e) Hazardous connections and adjacent windings; and

f) Hazardous windings and isolated winding connections;

.

Exception No. 1: A transformer intended to be conductively secured to a hazardous live chassis (in the end-use electronic equipment) need not comply with (a).

Exception No. 2: A transformer intended for installation in electronic equipment where dead-metal parts of the transformer are to be reliably spaced away from hazardous live chassis parts or where chassis parts of the electronic equipment are not conductively connected to a branch circuit supply or other hazardous source, need not comply with (d).

12.2 The insulation between the isolated and hazardous circuit windings in a flanged bobbin-wound transformer having the hazardous circuit winding wound over the isolated winding, or the isolated winding wound over the hazardous circuit winding as shown in Figure 12.1, shall be as specified in (a) – (c) below, or of an equivalent construction.

a) The insulation shall be made of formed, molded, or extruded material having continuous bent-up edges tightly fitted against the outer bobbin end-flanges. The height of the outer winding shall not be less than 1/32 inch (0.8 mm) or twice the diameter of the outer coil wire, whichever is less, above the top layer of the outer winding as shown in Figure 12.1.

b) The insulation shall extend from end-flange to end-flange of the bobbin and with the sides of the isolated winding offset a minimum of 1/8 inch from the sides of the hazardous circuit winding by a spacer or a built-in step in the bobbin end-flange as shown in Figure 12.2.

c) The winding insulation shall extend from end-flange to end-flange of the bobbin and be overlapped by a tape which extends up and over the top edge of the bobbin end-flange by at least 1/8 inch, overlaps the winding insulation and bobbin end-flange by at least 1/8 inch, and complies with 12.5 or 12.6 as shown in Figure 12.3.

Figure 12.1
Bobbin wound transformer with inner bobbin

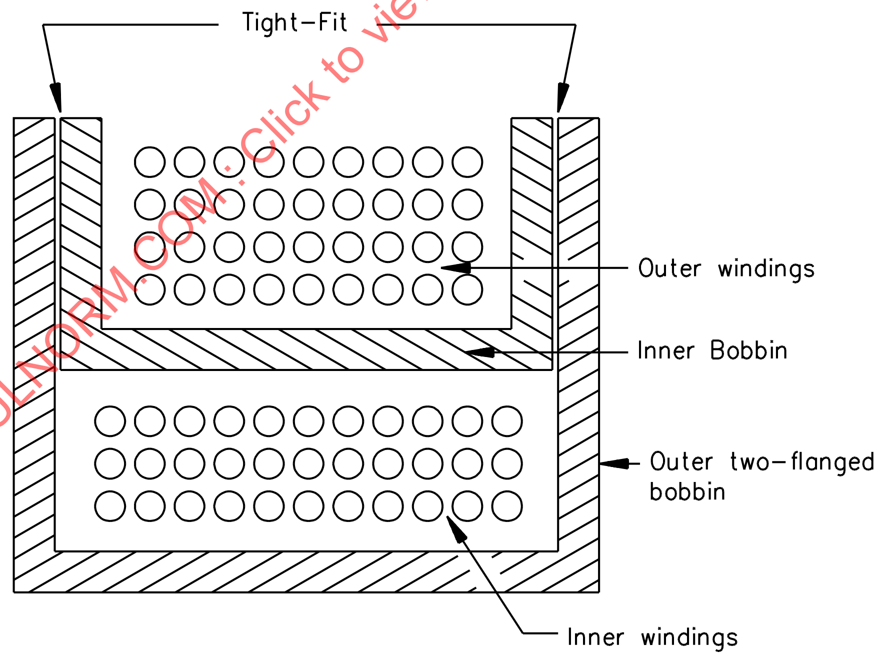

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Figure 12.2
Bobbin wound transformer with offset coils

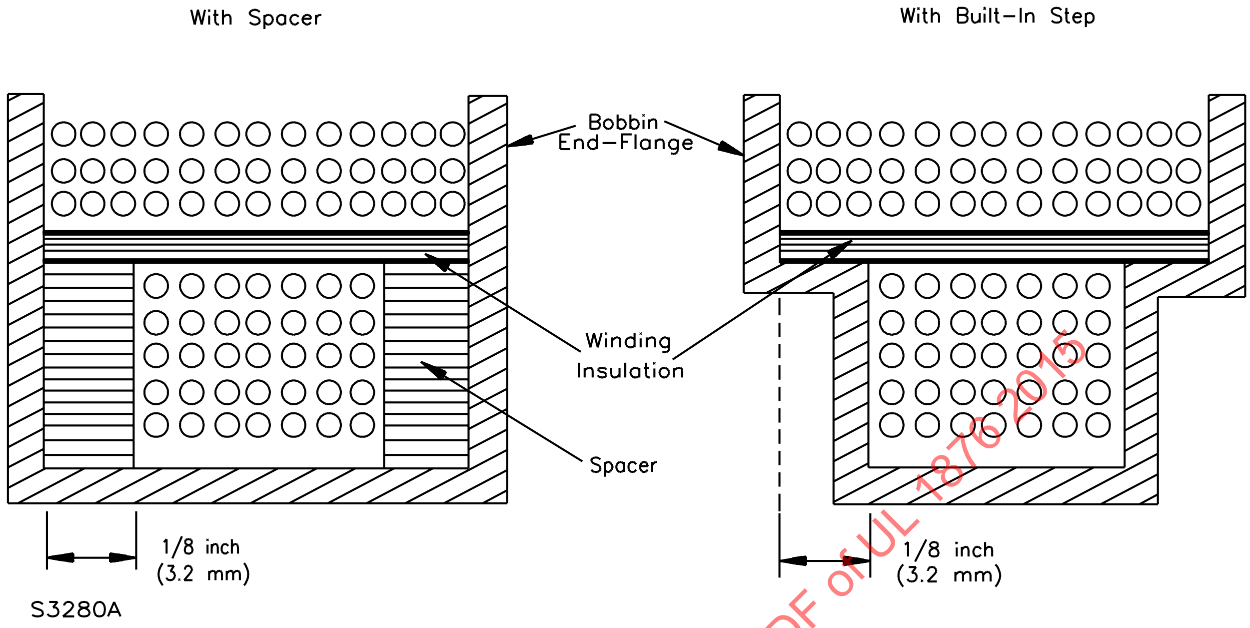
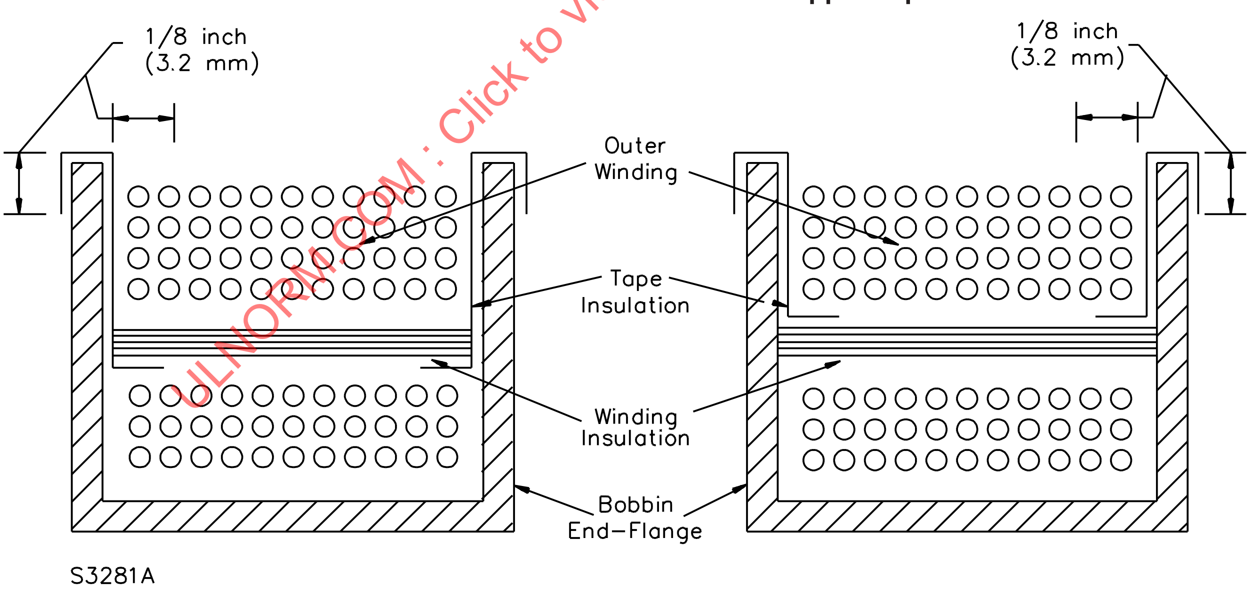


Figure 12.3
Bobbin wound transformer with overlapped tape



12.3 Each flange of a flanged bobbin-wound transformer shall not be less than 1/32 inch (0.8 mm) or twice the diameter of the outer coil wire, whichever is less, above the top layer of the outer winding as shown in Figure 12.1.

12.4 A polymeric material in direct contact with uninsulated current-carrying parts (such as a coil form bobbin) shall be temperature and flame rated in accordance with the terminal support requirements of 11.1(a).

12.5 The insulation between the transformer parts specified in 12.1 shall be either:

a) A minimum 0.025 inch (0.64 mm) thick if of a molded polymeric material such as a coil form or a bobbin; or

b) Of the generic material types specified in Table 12.1 where the layer(s) of each generic material is of a minimum thickness such that all layers collectively are greater than or equal to the minimum thickness required (T):

$$T \leq A_1(EF_1) + A_2(EF_2) + A_3(EF_3)...$$

in which:

A_1, A_2, A_3. . . is the total thickness of each generic material type, inches (mm);

EF_1, EF_2, EF_3. . . is the equivalency factor specified in Table 12.1 for the generic material type corresponding to A_1, A_2, A_3...;

T is the constant 0.012 inch (0.30 mm) for insulation between points identified in 12.1 (a) – (d) or 0.023 inch (0.58 mm) for insulation between points identified in 12.1 (e) and (d).

Exception: Transformer insulation constructions that comply with the insulation systems requirements of 12.6 may be of other material types and thicknesses.

Table 12.1
Equivalency factors for insulation materials

Generic material	Equivalency factor, (EF)
Electrical grade paper, fiber, or pressboard	1
Impregnated rag paper	1.3
Acetate sheet	1.5
Polyvinyl chloride (PVC)	1.3
Silicone rubber (SIR)	0.5
Impregnated glass or acetate cloth	1.2
Polyester	2
Fluorinated ethylene propylene (FEP)	3
Aramid paper	2
Polyimide (PI)	6

12.6 For transformers with insulation other than as specified in 12.5, the insulation between the transformer parts specified in 12.1 shall be of at least 2 layers and shall comply with the Insulating Materials Equivalence Test, Section 20. Complete transformer samples shall also comply with the Insulating System Tests, Section 21.

13 Spacings

13.1 Spacings between hazardous winding terminals of opposite polarity and between hazardous winding terminals and isolated winding terminals shall not be less than 1/8 inch (3.2 mm).

14 Double Protection

14.1 A transformer intended to provide double protection shall comply with the requirements in 14.2 and 14.3.

14.2 Insulated lead wires shall have either:

a) Two separate layers of insulation having a total thickness of not less than 0.026 inch (0.66 mm), neither layer of which is less than 0.007 inch (0.18 mm) thick; or

b) A single layer of insulation not less than 0.027 inch (0.69 mm) thick.

14.3 A transformer provided with double protection shall comply with the Transformer Dielectric Voltage-Withstand Test, Section 16, with an applied potential of 3500 volts.

PERFORMANCE

15 General

15.1 Each transformer construction shall comply with the test requirements described in Sections 16 – 19. Constructions built in accordance with 12.6 shall be tested as described in Insulating Materials Equivalence Test, Section 20, and the Insulating System Tests, Section 21.

Exception: For a transformer family as defined in 5.10, the specified number of transformers with the smallest core volume, a medium core volume and with the maximum number of isolated windings, and the largest core volume shall comply with the tests described in Sections 16 – 21.

16 Transformer Dielectric Voltage-Withstand Test

16.1 A transformer shall withstand for 1 minute without indication of dielectric breakdown the application of a 40 – 70 hertz essentially sinusoidal potential between:

a) Hazardous circuit winding(s) (including terminals and leads) and any dead-metal part(s);

b) Isolated winding(s) (including terminals and leads) and any dead-metal part(s); and

c) Hazardous circuit winding(s) (including terminals and leads) and the isolated winding(s).

Exception No. 1: A transformer intended to be conductively secured to a hazardous live chassis (in the end-use electronic equipment) need not comply with (a).

Exception No. 2: A transformer intended for installation in electronic equipment where dead-metal parts of the transformer are to be reliably spaced away from hazardous live chassis parts or where chassis parts of the electronic equipment are not conductively connected to a branch circuit supply or other hazardous source need not comply with (b).

16.2 With respect to 16.1, the potential is to be 2875 volts or, if the transformer is intended to comply with the requirements for Double Protection, Section 14, the potential is to be 3500 volts.

16.3 The transformer is to be in an unheated condition before the test. During the test, the transformer is to be located in an area with an ambient temperature of 15 – 30°C (59 – 86°F).

Exception: A transformer tested in accordance with 21.3.1 need not comply with this requirement.

16.4 The applied voltage is to be measured directly across the points of application with a voltmeter having an input impedance of at least 2 megohms.

16.5 The test equipment is not to create transient voltages such that the instantaneous voltage applied to the product exceeds 105 percent of the peak value of the specified test voltage. The applied potential is to be increased at a uniform rate in approximately 5 seconds, from zero to the specified test potential, and maintained at the test potential for 1 minute. Manual or automatic control of the rate of rise may be used.

16.6 The test equipment is to produce an output voltage that has an essentially sinusoidal waveform, a frequency that is within the range of 40 – 70 hertz, and a peak value of the waveform that is not less than 1.3 and not more than 1.5 times the rms value.

16.7 When the test equipment is adjusted to produce the specified voltage and a resistance of 120,000 ohms is connected across the output, the test equipment is to indicate dielectric breakdown.

16.8 When it is intended that the potential or duration, or both, used for the production-line test specified in 22.1 is to be higher than that shown by Curve A in Figure 22.1, three samples of the transformer are to be subjected to the continuous application of the potential that the manufacturer intends to use for a time duration that is 100 times the intended time for the production-line test. There is to be no indication of electrical breakdown during the test.

17 Strain Relief Test

17.1 A force equal to the weight of the transformer but not less than 3 pounds-force (lbf) (13.4 N) and not greater than 10 lbf (44.5 N), applied to a lead for 1 minute in any direction provided by the construction, shall not result in displacement of the electrical connection at the transformer. This test is to be conducted at an ambient temperature of 15 – 30°C (59 – 86°F).

18 Insulation Resistance Test

18.1 One sample of a transformer is to be conditioned for 24 hours in air having a relative humidity of 85 ±5 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). Immediately after conditioning, the transformer insulation resistance is to be measured using test equipment having a direct-current open-circuit output voltage of 500 volts.

18.2 The insulation resistance shall not be less than 10 megohms when measured between:

a) Hazardous circuit winding(s) (including terminals and leads) and any dead-metal part(s);

b) Isolating winding(s) (including terminals and leads) and any dead-metal part(s); and

c) Hazardous circuit winding(s) (including terminals or leads) and the isolated winding(s).

Exception No. 1: A transformer intended to be conductively secured to a hazardous live chassis (in the end-use electronic equipment) need not comply with (a).

Exception No. 2: A transformer intended for installation in electronic equipment where dead-metal parts of the transformer are to be reliably spaced away from hazardous live chassis parts or where chassis parts of the electronic equipment are not conductively connected to a branch circuit supply or other hazardous source need not comply with (b).

19 Thermoplastic Bobbin Temperature Stability Test

19.1 Each of three samples of a transformer using a thermoplastic bobbin shall, after 7 hours of conditioning in an air-circulating oven and while still in a heated condition, comply with the Transformer Dielectric Voltage-Withstand Test, Section 16. The oven temperature is to be 115°C (239°F).

20 Insulating Materials Equivalence Test

20.1 Each insulating material used in the transformer as specified in 12.1 shall comply with 12.5. Alternatively, if at least two layers of insulation in a given use are part of the construction, compliance may be determined by subjecting these insulating materials to the equivalence test described in 20.2 – 20.4 if complete samples of the transformers are also subjected to the Insulating System Tests, Section 21.

20.2 Two samples of each type or combination of insulating material used in the transformer construction are to be tested with any one layer of insulation removed. Each sample of material layer is to be placed on a smooth steel plate and subjected to a force of 4-1/2 pounds-force (20.0 N) exerted by a winding simulator while undergoing thermal conditioning. The winding simulator is to consist of two 20 AWG (0.52 mm^2) solid aluminum or tin plated steel wires secured to a 1-1/8 inch by 1/2 inch by 1/4 inch (28.6 mm by 12.7 mm by 6.4 mm) aluminum block in a parallel configuration, spaced 1/4 inch apart as shown in Figure 20.1. The ball-pressure apparatus shown in Figure 20.2 is to be used to apply the force to the center of the flat side of the winding simulator. The test samples are to be of sufficient size so that when the dielectric test described in 20.4 is conducted, electrical discharge does not occur around the edges of the insulating material. When the insulating material is provided with adhesive on one side only, one set of sample layers are to be placed with the adhesive side up and the other set of sample layers with the adhesive side down. The samples are to be conditioned at a temperature of 105°C (221°F) for seven hours.

Figure 20.1
Winding simulator

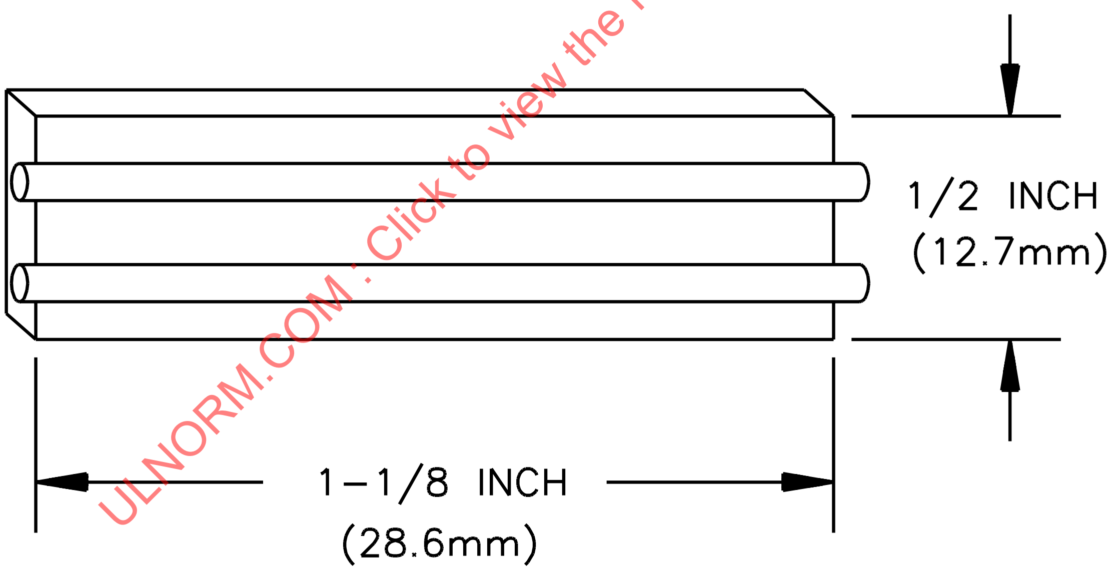


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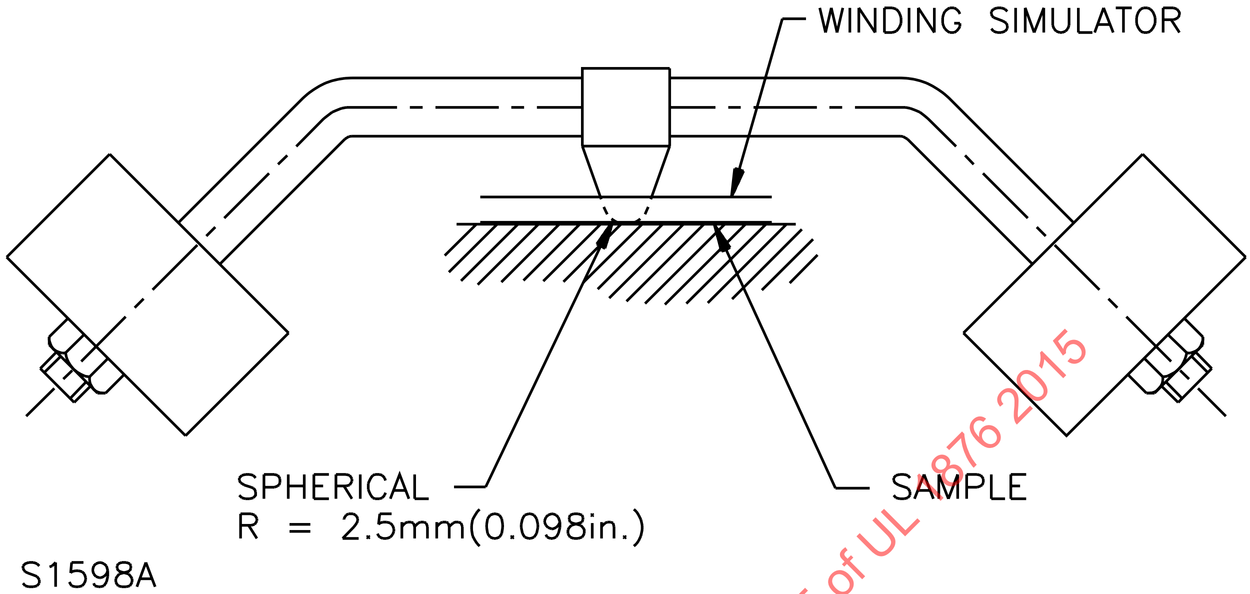
Figure 20.2
Ball-pressure apparatus



20.3 The conditioned samples are to be removed from the oven and immediately subjected to the test described in 20.4.

20.4 Each set of conditioned insulating materials shall withstand for 1 minute an essentially sinusoidal dielectric potential of 2875 volts, with a frequency between 40 and 70 hertz, between the lower steel plate and the winding simulator with the ball-pressure apparatus in place. The applied test potential is to be increased from zero to 2875 volts at a uniform rate of approximately 500 volts per second.

21 Insulating System Tests

21.1 General

21.1.1 The samples of the transformer specified in 21.3.1 shall comply with the requirements specified in 21.4.1, and, after being conditioned in accordance with 21.2.1 and 21.2.2 are to be subjected to the Transformer Dielectric Voltage-Withstand Test, Section 16, and to the voltage surge test specified in 21.4.1 – 21.4.3.

21.2 Conditioning

21.2.1 Ten ″as-received″ samples of the transformer are to be thermally conditioned in an air-circulating oven at 170°C (338°F) for 300 hours. The samples are then to be removed from the oven and allowed to cool to room temperature before being subjected to the Transformer Dielectric Voltage-Withstand Test, Section 16.

21.2.2 Ten ″as-received″ samples are to be subjected to humidity conditioning for at least 10 hours in a chamber maintained at 50 ±5 percent relative humidity at a temperature of 14.0 ±2.0°C (57.2 ±3.6°F). Following the above conditioning, the samples are to be conditioned for another 48 hours at 88 ±2 percent relative humidity at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F).

21.3 Dielectric voltage-withstand

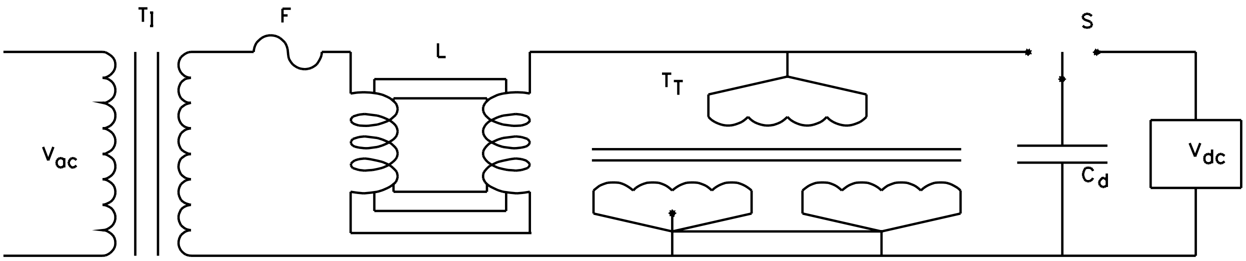
21.3.1 The ten samples that were subjected to the humidity conditioning described in 21.2.2 are to be immediately subjected to the Transformer Dielectric Voltage-Withstand Test, Section 16.

21.4 Voltage surge

21.4.1 Immediately following the dielectric withstand test, each of the ten samples that were humidity conditioned and each of the ten samples that were thermally conditioned are to be placed on a tissue-paper-covered softwood surface, covered with a single layer of cheesecloth, and then subjected to four discharges (applied from the supply circuit windings to the isolated circuit windings) with an interval of 5 seconds between discharges. The voltage surge shall not result in either the cheesecloth or tissue-paper glowing or flaming or failure of insulation between the supply circuit and the isolated windings as determined by conducting the Transformer Dielectric Voltage-Withstand Test, Section 16.

21.4.2 The circuit for performing the voltage-surge test is illustrated in Figure 21.1.

Figure 21.1
Circuit for voltage surge



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V_{ac} – 120 volt, 60 hertz, 30 amperes voltage source.

T_I – Optional isolation transformer for pulse blocking, 120 volts, 3 kilovolt-amperes, minimum. Isolation must be provided to prevent the pulse from entering the supply source and breaking down wiring, switches, receptacles, or the like.

F – Plug fuse rated 30 amperes, 125 volts.

L – Choke consisting of two coils of 16 AWG (1.3 mm^2) solid film-coated copper wire wound on insulating tubes placed on an approximately 3-1/4 by 3-1/2 by 5/8 inch (82.6 mm by 88.9 mm by 15.9 mm) ferrite core. Each coil is to consist of approximately 7-1/2 feet (2.29 m) of wire wound into 30 turns. The two coils are to be connected in circuitry such that the magnetic flux is aiding, thereby producing an effective inductance and resistance of each coil of approximately 3 millihenries and 0.03 ohms, respectively.

T_T – Transformer under test.

S – High-voltage switch.

C_d – Dump capacitor having a capacitance value of 0.01 microfarad.

V_{dc} – 10-kilovolt direct-current source of supply.