



UL 506

STANDARD FOR SAFETY

Specialty Transformers

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UL Standard for Safety for Specialty Transformers, UL 506

Fourteenth Edition, Dated June 2, 2017

Summary of Topics

This revision of ANSI/UL 506 dated January 28, 2022 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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.

The requirements are substantially in accordance with Proposal(s) on this subject dated December 3, 2021.

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June 2, 2017

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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 <https://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover ignition transformers for use with gas burners and oil burners and specialty step-up transformers used in applications such as insect electrocuting. Transformers incorporating overcurrent or over-temperature protective devices, transient voltage surge protectors, or power factor correction capacitors are also covered by these requirements. These transformers are intended to be used in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements do not cover liquid-immersed transformers, variable voltage autotransformers, transformers having a nominal primary rating of more than 600 volts, transformers having overvoltage taps rated over 660 volts, cord and plug connected transformers, garden light transformers, voltage regulators, swimming pool and spa transformers, or other special types of transformers covered in requirements for other electrical devices or appliances.

1.3 These requirements do not cover:

- a) Autotransformers used in industrial control equipment, which are evaluated in accordance with the Standard for Industrial Control Equipment, UL 508.
- b) Class 2 or Class 3 transformers, which are evaluated in accordance with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.
- c) Toy transformers, which are evaluated in accordance with the Standard for Toy Transformers, UL 697.
- d) Transformers for use with radio- and television-type appliances, which are evaluated in accordance with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411.
- e) Transformers for use with high intensity discharge lamps, which are evaluated in accordance with the Standard for High-Intensity-Discharge Lamp Ballasts, UL 1029.
- f) Transformers for use with fluorescent lamps, which are evaluated in accordance with the Standard for Fluorescent-Lamp Ballasts, UL 935.
- g) Ventilated transformers for general use or non-ventilated transformers for general use (other than compound filled or exposed core types), which are evaluated in accordance with the Standard for Dry-Type General Purpose and Power Transformers, UL 1561.
- h) Dry-type distribution transformers rated over 600 volts, which are evaluated in accordance with the Standard for Transformers, Distribution, Dry-Type – Over 600 Volts, UL 1562.
- i) Transformers incorporating rectifying or waveshaping circuitry evaluated in accordance with the Standard for Power Units Other Than Class 2, UL 1012.
- j) Transformers of the direct plug-in type evaluated in accordance with the Standard for Class 2 Power Units, UL 1310.
- k) Transformers for use with electric discharge and neon tubing, which are evaluated in accordance with the Standard for Neon Transformers and Power Supplies, UL 2161.
- l) General purpose and industrial control transformers evaluated in accordance with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

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 generally used in the products covered by this standard.

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.

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

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.

2.2 Units of measurement

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

2.2.2 Unless otherwise indicated, 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.

3 Glossary

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

3.2 COMPOUND-FILLED TRANSFORMER – A transformer in which the windings are enclosed with an insulating fluid that becomes solid, or remains plastic, at intended operating temperatures.

3.3 ENCAPSULATED COIL – A coil that is enclosed with an insulating fluid that becomes solid.

3.4 EXPOSED CORE TRANSFORMER – A transformer with exposed core lamination.

3.5 NONVENTILATED DRY-TYPE TRANSFORMER – A dry-type transformer other than of the compound-filled or exposed core-type that is constructed so as to provide no intentional circulation of ambient air through the transformer and is intended to operate at normal ambient room air pressure.

3.6 VENTILATED DRY-TYPE TRANSFORMER – A dry-type transformer that is constructed so that ambient air may circulate through the enclosure to cool the transformer core and windings.

3.7 WINDING – A continuous conductor made up of a number of turns magnetically coupled to a magnetic core, to which a voltage is either applied or induced. Two or more such conductors that are permanently factory connected together to form intermediate voltage taps, current taps, or the like are considered to be a single winding. The winding can consist of single or parallel-wound conductors.

ALL TRANSFORMERS

CONSTRUCTION

4 Mechanical Assembly

4.1 A transformer shall be formed and assembled so that it will have 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 defect due to total or partial collapse of the transformer.

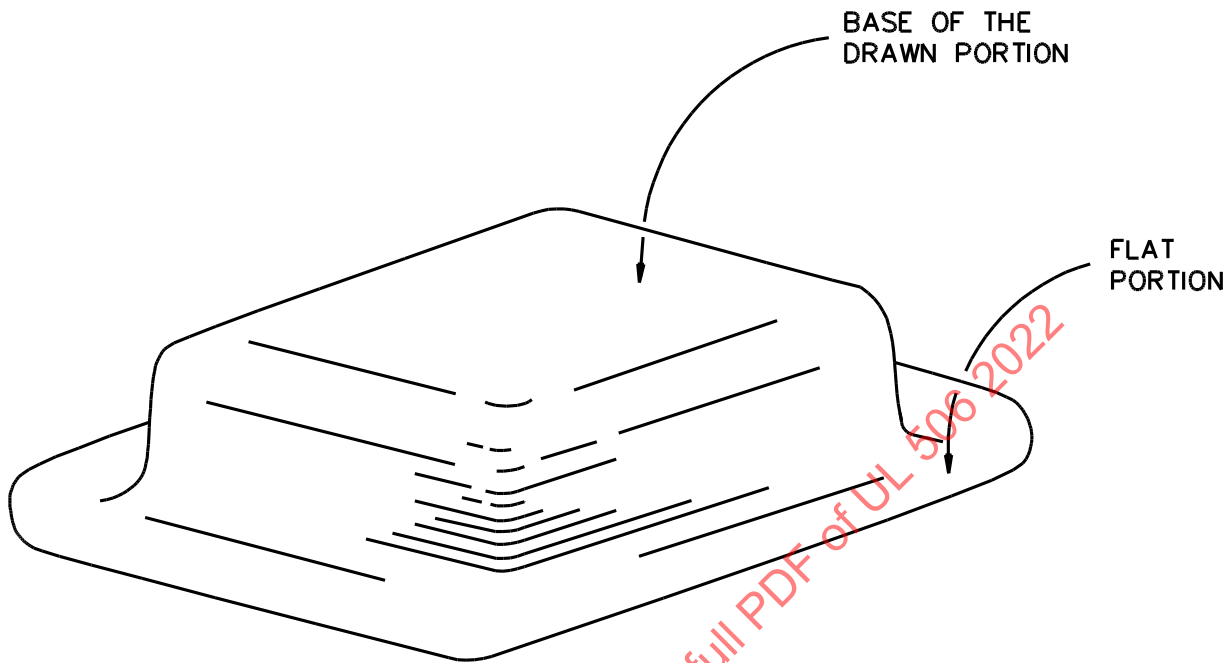
5 Enclosure

5.1 In addition to the overall enclosure, the requirements in [5.2](#) – [5.15](#) apply to those portions of an enclosure surrounding a terminal or wiring compartment.

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

Exception: Sheet steel having a thickness of not less than 0.020 inch (0.51 mm) if uncoated or not less than 0.023 inch (0.58 mm) if zinc coated may be used for drawn end bells having a maximum width or length 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.

Figure 5.1
End bell



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5.3 A sheet aluminum enclosure shall be formed from stock having a thickness of not less than 0.040 inch (1.02 mm).

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

5.5 The thickness of an enclosure of nonferrous sheet metal shall provide strength and rigidity not less than that of an enclosure of sheet steel as described in [5.2](#).

5.6 A cast iron enclosure shall not be less than 1/8 inch (3.2 mm) thick at any point and of greater thickness at reinforcing ribs and edges of doors or covers.

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

5.8 If threads for the connection of conduit are tapped all the way through a hole in a transformer enclosure, or if an equivalent construction is used, there shall not be less than 3-1/2 or more than 5 threads in the metal. The construction shall enable the secure attachment of a standard conduit bushing.

5.9 If 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 equivalent to that provided by a standard conduit bushing.

5.10 A transformer intended to be supported by rigid metal conduit shall have conduit hubs with not less than 5 full threads or other equivalent supporting means of such strength that these parts would comply with the requirements specified in the Pullout, Bending, and Twisting Tests, Section [16](#).

5.11 A knockout for the connection of conduit to a wiring compartment of a transformer shall be constructed in accordance with [Table 5.1](#).

Table 5.1
Dimensions of conduit bushings and diameter of knockouts and widths of flat surrounding surfaces

Trade size of conduit, inches	Bushings				Knockout diameter				Minimum width of flat surrounding surface,	
	Overall diameter,		Height,		Minimum,		Maximum,			
	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inch	(mm)
1/2	1	(25.4)	3/8	(9.5)	0.859	(21.82)	0.906	(23.01)	0.13	(3.4)
3/4	1-15/64	(31.4)	27/64	(10.7)	1.094	(27.79)	1.141	(29.98)	0.16	(4.1)
1	1-19/32	(40.5)	33/64	(13.1)	1.359	(34.52)	1.406	(35.71)	0.20	(5.0)
1-1/4	1-15/16	(49)	9/16	(14.3)	1.719	(43.66)	1.766	(44.86)	0.27	(7.0)
1-1/2	2-13/64	(56)	19/32	(15.1)	1.969	(50.01)	2.016	(51.21)	0.31	(7.8)
2	2-45/64	(68.7)	5/8	(15.9)	2.453	(62.31)	2.50	(63.50)	0.36	(9.2)
2-1/2	3-7/32	(81.8)	3/4	(19.1)	2.953	(75.01)	3.00	(76.20)	0.30	(7.8)
3	3-7/8	(98.4)	13/16	(20.6)	3.578	(90.88)	3.625	(92.08)	0.33	(8.3)
3-1/2	4-7/16	(113)	15/16	(23.8)	4.094	(103)	4.156	(105)	0.34	(8.6)
4	4-31/32	(126)	1	(25.4)	4.609	(117)	4.672	(118)	0.38	(9.7)
5	6-7/32	(158)	1-3/16	(30.2)	5.688	(144)	5.750	(146)	0.48	(12).2
6	7-7/32	(183)	1-1/4	(31.8)	6.781	(172)	6.844	(173)	0.56	(14.2)

5.12 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.

5.13 Wires within an enclosure, compartment, raceway, or the like shall be located or guarded to reduce the risk of contact with any sharp edge, burr, fin, or moving part, that may cause damage to the conductor insulation.

5.14 Wiring space or other compartments provided for field wiring shall be free of any sharp edge, burr, fin, moving part, or sharp point of a sheet metal screw that may cause damage to the conductor insulation or cause a cut-type injury.

5.15 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, or handle of a device shall be smooth and rounded and not sharp to cause a cut-type injury when contacted during intended use or maintenance.

6 Corrosion Resistance

6.1 The internal and external surfaces of an enclosure of iron or steel, other than stainless steel, shall be corrosion resistant. Examples of corrosion resistance means that comply with these requirements are galvanizing, plating, and enameling.

Exception No. 1: An interior surface covered by compound need not be additionally resistant to corrosion.

Exception No. 2: A Type 1 or Type 2 enclosure need not be additionally resistant to corrosion if it complies with the rust resistance test described in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

7 Wiring Terminals

7.1 For these requirements, wiring terminals are those to which connections are made in the field when a transformer is installed.

7.2 When a 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 these terminals and wires would be unlikely after the transformer is installed.

8 Leads – Including Flexible Cords

8.1 The connection between a lead, including a flexible cord, and the winding or other part of the transformer shall be soldered, welded, or otherwise securely connected within the enclosure. A soldered joint shall be made mechanically secure before being soldered.

8.2 When a lead is rigidly held in place without the use of solder or if it is intended to be retained in place by compound or other means so as not to be subjected to appreciable motion, additional mechanical security shall not be required.

8.3 Strain relief shall be provided so that stress on a lead, including a flexible cord, will not be transmitted to the connection inside the transformer.

8.4 A strain relief means shall not depend solely on adhesion between the conductor and an asphalt-type compound. When epoxy- and polyester-type compounds are used for strain relief, the construction shall comply with the Strain Relief Test in the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

8.5 The surface of an insulated lead intended for the connection of an equipment grounding conductor shall be green with or without one or more yellow stripes. No other lead shall be so identified.

8.6 Thermoplastic-insulated wire and flexible cord shall not be used for a transformer lead unless it has been investigated and determined to be acceptable for the application. The investigation is to normally include a consideration of the strain relief means used, as well as the effects of the varnishing and compounding operations of the insulation of the lead.

8.7 The types of flexible cord that may be used with an ignition transformer (Sections [38](#) – [54](#)) are indicated in [Table 8.1](#) from the lightest to the heaviest. Where these requirements specify any particular type of flexible cord, all of the heavier types following it in the table may also be used.

Table 8.1
Types of cords

C
SP-2, SPE-2
SPT-2
PD
SV, SVE
SVO, SVOO
SVT
SVTO, SVTOO

Table 8.1 Continued on Next Page

Table 8.1 Continued

SJ, SJE
SJO, SJOO
SJT
SJTO, SJTOO
S
SO, SOO
ST
STO, STOO

9 Internal Wiring

9.1 The internal wiring of a transformer shall be rated for the temperature and voltage to which it will be subjected.

9.2 A splice or connection shall be mechanically secure and shall provide electrical contact.

9.3 A splice shall be provided with insulation equivalent to that on the wires involved if necessary to maintain permanence of spacing between the splice and uninsulated live parts.

9.4 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.

10 Bushings for Low Voltage Wiring – Nominal 600 Volts or Less

10.1 A bushing used in a transformer intended for outdoor use shall be of:

- a) Porcelain,
- b) Cold-molded or phenolic composition,
- c) Fiber that has been treated to render it resistant to moisture, or
- d) Other equivalent insulating material.

10.2 An untreated fiber bushing shall only be used in a transformer intended for indoor use.

10.3 A fiber bushing shall have a wall thickness of not less than 3/64 inch (1.2 mm) and shall be formed and secured in place so that it would not be adversely affected 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 when the cord or wire is rigidly held in position.

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

10.5 A cord- or wire-entry hole in an enclosure, a partition, or bushing shall be smooth, well-rounded, and without burrs or fins that might damage the conductor insulation.

10.6 A bushing shall be securely held in place.

10.7 An insulating bushing is not required at a point where a low-voltage wire or cord passes through:

- a) A hole in an interior metal wall or barrier,
- b) A hole in insulating material,
- c) A conduit nipple or hub, or
- d) An armored cable connector or the equivalent.

An insulating bushing is not required where a Type SV or heavier flexible cord enters the enclosure of a transformer.

11 Insulating Material for Mounting Low-Voltage Live Parts – Nominal 600 Volts or Less

11.1 Material for the mounting of low voltage live parts shall be glass, porcelain, phenolic or cold-molded composition, or equivalent insulating material. Untreated fiber, rubber, wood, and hot-molded shellac or tar compositions shall not be used.

Exception: This requirement does not apply to material used for separators, spacers, coil supports, and similar parts within a transformer enclosure.

12 Coil Insulation

12.1 Coils shall be constructed to provide insulation between the various windings and between the windings and the core and the enclosure.

12.2 Coil insulation, unless inherently moisture-resistant, shall be treated to render it resistant to moisture.

12.3 Film-coated wire is not required to be additionally treated to reduce moisture absorption.

13 Wiring Devices

13.1 A switch or other wiring device shall be mounted so that it will not turn with regard to the mounting surface.

PERFORMANCE

14 General

14.1 Unless otherwise specified, all tests are to be conducted at the supply voltages specified in [Table 14.1](#).

Exception: When a transformer is provided with one or more primary voltage winding taps, the lowest rated full capacity tap is to be used. The test voltage applied to this tap is to be the rated tap voltage. When the voltage is expressed as a range, the highest voltage of the range is to be used.

Table 14.1
Values of test voltages

Rated primary voltage	Test voltage
Less than 110	Rated voltage ^a
110 – 120	120
Over 120 and less than 220	Rated voltage ^a
220 – 240	240
Over 240 and less than 254	Rated voltage ^a
254 – 277	277
Over 277 and less than 440	Rated voltage ^a
440 – 480	480
Over 480 and less than 550	Rated voltage ^a
550 – 600	600
Over 600 – 660	Rated voltage ^a

^a If the rated voltage is expressed as a range, the maximum voltage of the range is to be used.

15 Temperature Test

15.1 Requirements relating to heating are based on an ambient air temperature of 25°C. A temperature test may be conducted at any ambient air temperature; however, the variation from 25°C shall be added to or subtracted from the observed temperature reading.

15.2 Other than in those cases where it is specifically stated that temperature determinations are to be made by the change-of-resistance method, temperatures are to be measured by means of thermocouples. A thermocouple-measured temperature is to be considered constant if three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test (but at not less than 5-minute intervals), indicate no change. The junction of the thermocouple is to be secured in contact with the point on the surface at which the temperature is to be measured. The thermocouple is to consist of wires not larger than 24 AWG (0.21 mm²).

Exception No. 1: Where the thermocouple is used to measure temperatures of electrically live points, electrical insulation having a maximum thickness of 0.028 inch (0.71 mm) may be located between the thermocouple and the live points.

Exception No. 2: The coil temperature is to be determined by the change-of-resistance method.

Exception No. 3: The ambient temperature may be determined by a thermometer.

15.3 When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is standard practice to use thermocouples consisting of 30 AWG (0.05 mm²) iron and constantan wires and a potentiometer-type indicating instrument. Such equipment is to be used whenever referee temperature measurements are necessary. The thermocouple wire is to comply with the requirements for Special Tolerances thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

15.4 The temperature rise of a copper or aluminum winding is to be determined by the change-of-resistance method using the following formula (windings are to be at room temperature at the start of the test):

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise,

R is the resistance of the coil at the end of the test,

r is the resistance of the coil at the beginning of the test,

k is 234.5 for copper and 225.0 for aluminum,

t_1 is the room temperature in degrees C at the beginning of the test, and

t_2 is the room temperature in degrees C at the end of the test.

16 Pullout, Bending, and Twisting Tests

16.1 Conduit and fixture connections of a transformer constructed for support by rigid metal conduit shall be subjected to:

- a) A pull of 200 pounds-force (890 N),
- b) A bending moment of 600 pound-inches (67.8 N·m), and
- c) A torque of 600 pound-inches,

Each shall be applied in turn for 5 minutes. The connections shall not be pulled apart following this test.

16.2 When the pullout test is conducted, the transformer is to be supported by rigid metal conduit in the intended manner. The transformer is then to be caused to support a weight of 200 pounds (90 kg) or, if a fixture stud or similar fitting is provided, the weight is to be supported from rigid metal conduit or the equivalent threaded onto this fitting so that the stud and the conduit connection are tested simultaneously.

16.3 When the bending and twisting tests are conducted, the transformer is to be rigidly supported by means other than the conduit fittings. In the bending test, the force is to be applied to the conduit at right angles to its axis. The lever arm is to be measured from the inner end of the threaded section, in a conduit-hub- or stud-type connection, to the point of application of the bending force.

16.4 In the torsion test, the torque is to be applied to the conduit in a direction tending to tighten the connection and the lever arm is to be measured from the center of the conduit.

MARKINGS

17 Details

17.1 If a manufacturer produces transformers of a particular type (for example, ignition transformers) at more than one factory, each finished transformer shall have a distinctive marking, which may be in code, by which it may be identified as the product of a particular factory.

SPECIALTY STEP-UP TRANSFORMERS

GENERAL

18 Details

18.1 A specialty step-up transformer is a step-up transformer intended to supply very low current for applications such as insect electrocuting. Typically, the secondary voltage would range between 5000 and 15,000 V. It may be of the weatherproof, outdoor non-weatherproof, or indoor type. The requirements in [18.2](#) – [37.2](#) do not contemplate use of the transformer in an application in which it is mounted in a confined space inside a wall, ceiling, and the like, as in some indoor illuminating systems.

18.2 A reactor supplied as a part of a specialty step-up transformer shall comply with the requirements in Sections [19](#) – [37](#).

18.3 The requirements for a specialty step-up transformer in Sections [19](#) – [37](#) are to be considered in addition to those specified in Sections [1](#) – [17](#).

CONSTRUCTION

19 General

19.1 There shall not be electrical connection between primary and secondary windings of a specialty step-up transformer.

19.2 The requirements in Sections [19](#) – [37](#) cover a transformer having a single secondary winding that may be tapped and that may consist of two or more electrically interconnected coils. They do not cover a multisecundary-winding transformer in which the secondary windings are not electrically interconnected – such a transformer is to be determined for use only on the basis of an investigation.

19.3 A compound shall not be depended upon to prevent shifting of the core-and-coil assembly inside the enclosure if such shifting might result in reduction of spacings or in stress on internal connections.

20 Enclosure

20.1 A specialty step-up transformer of other than the open core-and-coil type shall be provided with an enclosure of metal or of material having equivalent properties. The enclosure shall house all live parts (insulated and uninsulated).

Exception: The primary and secondary terminals or leads need not be enclosed in a transformer of a type other than as described in [20.2](#).

20.2 The following leads or terminals shall be enclosed:

- a) Primary and secondary terminals of a weatherproof transformer.
- b) Primary terminals of a transformer having receptacles, bushings, or openings for the insertion of tubing electrodes.
- c) Secondary terminals or leads of a portable transformer intended exclusively to rest on a horizontal surface, such as a counter, shelf, table, and the like.

20.3 Regarding [20.2\(c\)](#), a portable transformer is not to be considered as intended exclusively for support by a counter, shelf, and the like, if the transformer is constructed so that it can be supported by

suspension mounting and if the arms, brackets, chains, or similar accessories necessary for such mounting are available.

20.4 A compound that covers high-voltage parts (including windings) may be exposed when a cover is removed for wiring or servicing the transformer. With some restrictions for indoor-type transformers as noted in 24.6, a transformer may be accessible even though the construction is such that uninsulated secondary parts would be exposed when a cover is removed for wiring or servicing.

20.5 A surface of iron or steel, other than stainless-steel parts, shall be corrosion resistant. Such surfaces may be protected by galvanizing, plating, or enameling.

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

20.6 The enclosure shall be provided with means for mounting.

20.7 A transformer that is supplied with a flexible cord and an attachment plug and is intended for portable use may be provided with means for attachment to hanging brackets, chains, and the like even though such means could be used for mounting the transformer permanently and rigidly.

20.8 The cover of an enclosure shall be provided with means (such as screws) for firmly securing it in place. Friction alone is not to be used. A cover that must be removed to permit the connection of circuit conductors shall not be provided with means for the connection of conduit.

20.9 A construction involving the use of sheet metal screws for securing the assembly of a transformer to a portion of the enclosure shall be investigated to determine its acceptability.

20.10 A switch shall not be mounted on a removable part of an enclosure unless the switch can be readily replaced without damage to such part.

20.11 A switch provided on an outdoor transformer shall be investigated.

20.12 A gasket used with a wiring terminal or with a bushing for a secondary lead shall be of a material that does not decompose readily, if the malfunction of the gasket would be likely to result in a risk of fire or electric shock, such as a loose connection or a reduction of spacings below the minimum requirement.

21 Insulating Materials

21.1 Material for the mounting of high-voltage (more than 600 volts) live parts shall be porcelain, glass, or insulating material that has been determined to be the equivalent.

22 Connections

22.1 Primary terminals and leads

22.1.1 If a transformer is not provided with a terminal or wiring compartment, the leads shall enter the transformer enclosure, if of metal, by one of the following means:

- a) Through separate holes in insulating material or through separate insulating bushings. For a weatherproof transformer, there shall be a spacing of not less than 2 inches (50.8 mm) between leads and a spacing of not less than 0.5 inch (12.7 mm) between each lead and the surface on which the transformer is mounted. For a transformer other than a weatherproof transformer, the corresponding minimum spacing requirements are 1 inch (25.4 mm) and 0.5 inch, respectively.

- b) Through a conduit nipple or through an armored-cable or metal-conduit (rigid or flexible) connector.
- c) Through a single hole without a fitting, if the transformer is intended for use inside another enclosure.
- d) By a flexible cord, as specified in [22.1.8](#).

22.1.2 If the transformer is not provided with a terminal or wiring compartment, the length of a lead outside the transformer enclosure shall not be less than 10 inches (254 mm) if the lead enters the enclosure by the means described in [22.1.1\(a\)](#) and if the transformer is of the weatherproof type; otherwise, the length of the lead shall not be less than 6 inches (152 mm). The lead of an open core-and-coil transformer shall not be less than 6 inches in length.

22.1.3 If a transformer is provided with a terminal or wiring compartment, the free length of each lead inside the wiring compartment shall not be less than 6 inches (152 mm).

22.1.4 A lead shall be rated for the temperature to which it is likely to be subjected and shall have a voltage rating of not less than the maximum rated primary voltage of the transformer.

22.1.5 A lead shall have an ampacity of not less than the primary current rating of the transformer.

22.1.6 A lead of a transformer intended for use outdoors shall be of Type RH, of other acceptable wire having 1/32 inch (0.8 mm) or more rubber insulation plus an impregnated braid, or of wire determined to be the equivalent. The lead shall not be smaller than 14 AWG (2.1 mm²).

22.1.7 A lead of a transformer not intended for use outdoors shall be of Type RH wire, or of other wire determined to be acceptable for use, and shall not be smaller than 14 AWG (2.1 mm²).

Exception: A transformer not intended for use outdoors may be provided with leads of Type FFH-2 or RHF-2, or of wire determined to be the equivalent, and not smaller than 18 AWG (0.82 mm²) if it does not use the construction described in [22.1.1\(a\)](#).

22.1.8 A three-conductor flexible cord, not lighter than Type C and not smaller than 18 AWG (0.82 mm²) may be used for the power supply connection of a portable indoor-type transformer. A Type SPT-3 cord may be used in the 18 – 16 AWG (0.82 – 1.3 mm²) sizes.

22.1.9 The flexible cord specified in [22.1.8](#) shall have one conductor finished to show a continuous green color, with or without one or more yellow stripes, to serve as the equipment grounding conductor. A three-blade attachment plug of the grounding type shall be provided on the supply end of the cord.

22.1.10 A flexible cord shall comply with the requirements in [22.1.4](#) and [22.1.5](#). If a knot in a lead or a flexible cord serves as the strain relief, the surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, fins, and the like that might cause abrasion of the insulation on the conductors.

22.1.11 If the insulation on an individual conductor of a flexible cord is less than 1/32 inch (0.8 mm) thick, additional insulation may be required on the individual conductors after they have been separated inside the transformer enclosure.

22.1.12 A transformer equipped with flexible cord and an attachment plug may also be provided with knockouts for the connection of rigid metal conduit.

22.1.13 The setscrew form of wiring terminal shall not be used.

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

Exception: A No. 10 (4.8 mm) or larger wire-binding screw may be of iron or steel if plated. Copper or brass shall not be used for plating of a steel wire-binding screw, but a plating of cadmium or zinc may be used.

22.1.15 A terminal plate or a wiring terminal shall not be less than 0.030 inch (0.76 mm) thick and shall have not less than two full threads in the metal for the binding screws.

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

22.1.17 A wire-binding screw or stud shall not be smaller than No. 6 (3.5 mm) and shall have not more than 32 threads per inch (1.26 threads per mm).

22.1.18 A wiring terminal shall be securely and rigidly mounted and shall be restricted from turning or shifting in position by means other than friction between surfaces.

22.1.19 The requirement in [22.1.18](#) applies to the turning of a terminal stud in an insulator in which it is mounted, as well as to the turning of the insulator with regard to the transformer enclosure. Sealing or insulating compound is generally not to be used as a means to restrict turning of fixed terminal parts unless the size or shape or both of the part which is surrounded with compound is such that it is obvious that the terminal will be held in position.

22.1.20 A lock washer shall not be used as the sole means to restrict turning at a terminal in which twisting motion is involved when a conductor is being connected. The use of a more positive means is required – for example, the use of a square- or hexagonal-head screw with a similarly shaped recess in the insulating material in which the screw is mounted.

22.1.21 A barrier shall be provided in a wiring compartment that encloses primary wiring terminals (primary leads to which connection will be made in the field) or a power supply cord to reduce the risk of contact between all primary parts and all secondary parts, including primary and secondary leads that will be installed or to which connection will be made in the field.

Exception: A barrier is not required between a power supply cord and factory-installed secondary leads in a compartment if:

- a) The construction is such that no connection will be made to the secondary leads in the field and*
- b) The flexible cord is secured by a clamp or the equivalent so as to restrict displacement that would reduce the spacings between the cord and the secondary leads to values less than those required.*

22.1.22 The barrier specified in [22.1.21](#) shall comply with the requirements in [22.2.8](#).

Exception: The barrier may be of fiber or similar material if:

- a) The spacings specified in [Table 23.3](#) between primary and secondary parts (uninsulated and insulated) are provided between secondary parts and the barrier and*
- b) The secondary is not provided with wiring terminals or with leads to which connection is to be made in the field.*

22.1.23 A clamp or similar device used as described in [22.1.21](#) for securing the flexible cord shall have smooth, well-rounded edges to reduce the risk of damage to the insulation of the conductors.

22.2 Secondary terminals and leads

22.2.1 Secondary wiring terminals shall be constructed as specified for primary wiring terminals; however, they may be made of iron or steel if plated as a means of corrosion resistance.

22.2.2 A secondary lead shall be of stranded Type GTO cable. The lead shall not be less than 14 AWG (2.1 mm²), except that it may not be less than 18 AWG (0.82 mm²) for a transformer intended for a portable device where the lead is:

- a) Permanently attached within the transformer enclosure and
- b) Not longer than 8 feet (2.44 m).

For a transformer not having an end-point-grounded secondary winding, the voltage rating of the cable used for a lead, including a grounded lead, shall not be less than the maximum rated voltage between any two secondary leads (a grounded secondary terminal is to be considered a lead for the purpose of this requirement). The voltage rating of the cable used for a secondary lead, including a grounded lead, of a transformer having an end-point-grounded secondary winding shall not be less than twice the secondary voltage rating of the transformer.

Exception: An open core-and-coil specialty step-up transformer may have other than high voltage cable for secondary leads but such leads shall not be less than 20 AWG (0.52 mm²) in size and shall not be more than 6 inches (152 mm) in length. Leads other than stranded Type GTO cable are to be treated as bare conductors.

22.2.3 At a point where a secondary lead, other than a grounded lead or stranded Type GTO cable, passes through a metal partition, including the wall of the enclosure, there shall be an insulating bushing (separate leads may pass through individual holes in the same piece of insulating material).

22.2.4 For leads other than stranded Type GTO cable, bushings of glazed porcelain or steatite may be used for secondary leads. Bushings of unglazed porcelain may be used in an indoor-type transformer provided with an outlet box or connection compartment. Bushings of phenolic composition shall not be used if the voltage involved is more than 1000 volts. Bushings of rubber or fiber shall not be used in any case for secondary leads.

22.2.5 If a transformer using secondary leads is not provided with an outlet box, connection compartment, or the like for the secondary leads, each lead shall extend not less than 6 inches (152 mm) outside the enclosure.

Exception: For weatherproof transformers, each lead shall not extend less than 10 inches (254 mm) outside the enclosure.

22.2.6 If a transformer using secondary leads is provided with an outlet box, connection compartment, or the like for the secondary leads, the free length of each lead inside the box or compartment shall not be less than 6 inches (152 mm).

22.2.7 In a wiring compartment that encloses secondary wiring terminals or secondary leads to which connection is intended to be made in the field, a barrier shall be provided to reduce the risk of contact between all secondary parts and all primary parts, including primary and secondary leads that are intended to be installed or to which connection is intended to be made in the field. In such a compartment, a barrier or an insulating cap shall be provided to reduce the risk of contact between a secondary lead that

is intended to be installed, or to which connection is intended to be made, in the field and an uninsulated live secondary part of opposite polarity.

22.2.8 A barrier provided to reduce the risk of contact between parts as described in [22.2.7](#) shall be firmly secured in place and:

- a) If of metal, shall have strength and rigidity not less than that of a steel sheet having an uncoated thickness of 0.026 inch (0.66 mm) and shall be bonded to the transformer enclosure.
- b) If of insulating material, shall comply with the requirements in [Table 22.1](#) and in [22.2.13](#).

Table 22.1
Thickness and determination of use of insulating materials

Material	Minimum thickness				For use in weatherproof and outdoor non-weatherproof transformers	For use in indoor transformers
	Cap,		Barrier,			
	in	(mm)	in	(mm)		
Fiber	1/8	(3.2)	1/32	(0.8)	No	See footnote a
Phenolic composition	1/8	(3.2)	1/32	(0.8)	No	See footnote b
Cold molded composition	1/8	(3.2)	1/32	(0.8)	No	Yes ^c
Porcelain:						
Glazed	1/8	(3.2)	1/8	(3.2)	Yes	Yes
Unglazed	1/8	(3.2)	1/8	(3.2)	Only as tubes on insulated wires	Yes ^c
Mica	1/8	(3.2)	1/32	(0.8)	Yes	Yes
Glass	1/8	(3.2)	1/8	(3.2)	Yes ^d	Yes ^d

^a May be used only if the spacings to the barrier or liner from secondary parts (insulated and uninsulated) comply with those specified in [Table 23.3](#) for the spacings between primary and secondary parts, and if there is not likelihood of contact between the barrier or liner and a secondary lead that will be installed or to which connection will be made in the field.

^b May be used only if the spacing (over surface or through air) to the barrier or liner from an insulated secondary part is not less than 1/4 inch (6.4 mm) and if the spacing (over surface or through air) to the barrier or liner from an uninsulated secondary part is not less than 1/4 inch (6.4 mm), 3/8 inch (9.6 mm), or 1/2 inch (12.7 mm) for secondary potentials of 0 – 5,000, 5,001 – 10,000, 10,001 – 15,000 volts, respectively; and if there is no likelihood of contact between the barrier or liner and a secondary lead that will be installed or to which connection will be made in the field.

^c May be used only if not in contact with secondary parts (insulated or uninsulated) and if inaccessible to contact by a secondary lead that is to be installed or to which connection will be made in the field.

^d If glass tubing is used, it shall be of double thickness – approximately 0.1 inch (2.5 mm) thick – and shall be securely fastened in place.

22.2.9 A cap of insulating material provided over an otherwise uninsulated secondary terminal to reduce the risk of contact between secondary parts as specified in [22.2.7](#) shall be tight-fitting and capable of being secured to the terminal. The cap shall be of one of the materials indicated in [Table 22.1](#). The cap shall be such that, when in place, the spacing between the uninsulated live parts of the terminal and the exterior surface of the cap, at the crevice where the cap abuts the other insulated parts of the terminal, would not be less than 1/8 inch (3.2 mm) measured through the crevice.

22.2.10 The wiring compartment that encloses secondary wiring terminals or secondary leads to which connection is intended to be made in the field shall be tightly closed when the transformer is installed as intended.

22.2.11 Regarding [22.2.9](#), after installation of the transformer, a compartment is considered tightly closed if it does not have uncovered openings, a specialty step-up electrode receptacle (of other than the skeleton type), a close-fitting cable bushing, or a rigid-metal-conduit, armored-cable, or flexible-steel-

conduit fitting (including an integral conduit hub). A compartment that has an opening intended for the insertion of a tubing electrode and that is not provided with a receptacle or an opening with a skeleton-type receptacle, is not considered tightly closed.

22.2.12 If the wall of a primary wiring compartment consists of fiber (treated or untreated), phenolic or cold-molded composition, unglazed porcelain, paper, or wood, and if the back of the wall is in contact with compound, no secondary live part (insulated or uninsulated) shall be in contact with the wall before the compound is poured.

22.2.13 An insulating liner, barrier, or cap used where spacings would otherwise be insufficient or used to reduce the risk of contact between the parts specified in [22.1.21](#) and [22.2.7](#) shall comply with [Table 22.1](#).

Exception: The required thickness of the barrier may be greater than the value indicated in the table if the barrier is likely to be subjected to mechanical abuse.

22.2.14 If the secondary-voltage rating of an indoor-type transformer is 7500 volts or less, an opening as specified in [22.2.14](#) shall be provided with an insulating bushing or an electrode receptacle determined to be acceptable for the application; or the opening shall be investigated for the application.

22.2.15 Insulating sleeves provided with the secondary leads of a transformer to enclose splices to other high-voltage wiring or connections to tubing electrodes shall be investigated.

22.2.16 An ordinary glass tube, taped in place, shall not be used as an insulating sleeve.

22.2.17 If a transformer is not provided with secondary leads and if it is not intended that the tubing electrodes be inside the transformer enclosure, the enclosure of the electrodes shall be investigated.

23 Spacings

23.1 Spacing requirements do not apply to parts completely covered by compound. The spacings specified in [23.2](#) – [23.12](#) do not apply to the inherent spacings of a component part of the transformer, such as a snap switch, for which spacing requirements are specified elsewhere than in this standard. Spacings larger than those specified in [23.2](#) – [23.12](#) may be required unless the parts involved are mounted so that it is unlikely that any reduction in these minimum spacings would occur.

23.2 At the primary wiring terminals of a weatherproof or outdoor non-weatherproof transformer, the spacings between uninsulated live parts of opposite polarity and the spacings between an uninsulated live part and a dead metal part shall not be less than those indicated in [Table 23.1](#).

Table 23.1
Minimum spacings at primary wiring terminals

Transformer primary rating, volts	Spacing through air and over surface between live parts and dead metal parts, in (mm)		Spacing between live parts of opposite polarity			
			Through air, in (mm)		Over surface, in (mm)	
0 – 125	1/2	(12.7)	1/2	(12.7)	3/4	(19.1)
126 – 250	1/2	(12.7)	3/4	(19.1)	1-1/4	(31.8)
251 – 600	1	(25.4)	1	(25.4)	2	(50.8)

23.3 Uninsulated primary live parts within any transformer or capacitor enclosure, uninsulated terminals of an open capacitor provided with an open core-and-coil transformer, and primary wiring terminals of an indoor-type transformer shall be located so that spacings not less than those indicated in [Table 23.2](#) will be provided.

Table 23.2
Minimum spacings involving uninsulated live parts

Transformer primary rating, volts	Spacing through air and over surface between live parts and dead metal parts, in (mm)	Spacing between live parts of opposite polarity			
		Through air, in (mm)		Over surface, in (mm)	
0 – 125	1/2 (12.7)	1/8 (3.2)		1/4 (6.4)	
126 – 250	1/2 (12.7)	1/4 (6.4)		3/8 (9.5)	
251 – 600	1 (25.4)	3/8 (9.5)		1/2 (12.7)	

23.4 The spacings in an open core-and-coil type of transformer shall be such that an air space of 0.5 inch (12.7 mm) would be provided between any coil winding or unenclosed capacitor and the surface on which the transformer may be mounted, unless the winding and the unenclosed capacitor are protected by sheet steel having an uncoated thickness of not less than 0.026 inch (0.66 mm) so that the transformer or its performance would not be adversely affected in any way by denting or deformation of the enclosure in which it may be mounted.

23.5 The spacings between secondary live parts of opposite polarity, between secondary live parts and primary live parts, and between secondary live and dead metal parts shall not be less than those indicated in [Table 23.3](#).

Table 23.3
Minimum spacings involving live secondary parts

Parts involved	0 – 5000 volts		5001 – 10,000 volts		10,001 – 12,000 volts		12,001 – 15,000 volts	
	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)
Uninsulated secondary and uninsulated secondary of opposite polarity, or primary (insulated or uninsulated)	1 (25.4)	1 (19.1)	1-1/2 (38.1)	1-1/2 (38.1)	2 (50.8)	2 (50.8)	2 (50.8)	2 (50.8)
Uninsulated secondary and insulated secondary of opposite polarity	3/4 (19.1)	3/4 (25.4)	1-1/8 (28.6)	1-1/8 (28.6)	1-1/2 (38.1)	1-1/2 (38.1)	1-1/2 (38.1)	1-1/2 (38.1)

Table 23.3 Continued on Next Page

Table 23.3 Continued

Parts involved	0 – 5000 volts		5001 – 10,000 volts		10,001 – 12,000 volts		12,001 – 15,000 volts	
	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)	Through air, in (mm)	Over surface, in (mm)
Uninsulated secondary and metal which is or may be grounded	1/2 (12.7)	3/4 ^a (19.1 ^a)	7/8 (22.2)	1-1/4 (31.8)	1-1/8 (28.6)	1-1/2 (38.1)	1-1/2 (38.1)	2 (50.8)
Insulated secondary and insulated secondary of opposite polarity, or primary (insulated or uninsulated)	1/2 (12.7)	1/2 (12.7)	3/4 (19.1)	3/4 (19.1)	1 (25.4)	1 (25.4)	1 (25.4)	1 (25.4)
Insulated secondary and metal which is or may be grounded	1/4 (6.4)	1/4 (6.4)	3/8 (9.5)	3/8 (9.5)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)

NOTE – In a wiring compartment complying with the requirements in [22.2.7](#) – [22.2.11](#), the minimum spacing requirements do not apply to the spacings between primary and secondary parts; and in such a compartment, no minimum spacing is required between an uninsulated secondary part and an insulated secondary part of opposite polarity; between insulated secondary parts of opposite polarity; and between an insulated secondary part and grounded metal.

^a This spacing shall not be less than 1/2 inch (12.7 mm) in an open core-and-coil transformer.

23.6 If a transformer has a grounded secondary winding, the spacings from an ungrounded secondary part to a primary part, and from an ungrounded secondary part to a dead metal part are to be evaluated on the basis of the voltage to ground from the secondary part in question. The spacings between secondary parts of opposite polarity are to be evaluated on the basis of the secondary voltage between the parts involved.

23.7 If the secondary winding is ungrounded, the spacings between the parts specified in [Table 23.3](#) are to be evaluated on the basis of the rated secondary voltage of the transformer.

23.8 A spacing is not required between a grounded secondary part and a dead metal part, and between a grounded secondary part and an insulated primary part. Grounded secondary parts are to be considered on the same basis as dead metal parts in evaluating spacings.

23.9 To be considered "insulated" with regard to spacing requirements, a secondary part shall be provided with an insulating covering having insulating properties not less than those of standard Type GTO cable intended for use at the voltage to which the insulation would be subjected. A secondary part not so insulated shall be considered uninsulated. The mounting of an uninsulated secondary or primary part on an insulator or in a bushing is not considered to be "insulated."

23.10 Spacing measurements are to be made with all leads furnished as part of the transformer in place.

23.11 If a secondary terminal is provided with an insulating cap, the spacings to the live parts of the terminal are to be measured through the crevice where the surface of the cap abuts that of the remainder of the insulator.

23.12 In a secondary wiring compartment of an indoor transformer, the spacing between an uninsulated live secondary part and grounded metal, measured along a secondary lead and over the surface of the lead insulation, shall not be less than that indicated in [Table 23.4](#).

Exception: This requirement does not apply if the compartment is tightly closed as described in [22.2.11](#).

Table 23.4
Minimum spacings in secondary wiring compartments of indoor transformers

Rating of cable used for secondary lead, volts	Spacing,	
	inches	(mm)
5,000	1-1/2	(38.1)
10,000	2	(50.8)
15,000	2-1/2	(63.5)

24 Guarding of Live Parts and Grounding

24.1 An enclosed transformer shall have its enclosure bonded to the core. A transformer of the grounded-secondary type shall have the grounded point of the secondary winding bonded to the core and to the enclosure, if any.

24.2 Regarding [24.1](#), solder alone shall not be used for making a connection. Solder may be used if the conductor has been made mechanically secure before soldering, is held rigidly in place without the use of solder, or is retained in place by compound or equivalent means so as not to be subjected to stress. A lock washer or the equivalent shall be used together with any bolt or screw used at a connection in a bonding conductor.

24.3 The grounding conductor of the flexible cord of a portable transformer shall be bonded to the core, to the enclosure, and also to the grounding blade of a three-blade attachment plug or equivalent device. A soldered connection to the grounding conductor of a flexible cord shall be mechanically secure before being soldered.

24.4 A bolt and lock washer may be used to secure the grounding conductor of the cord to the enclosure.

24.5 Unless a high-voltage (more than 600 volts) part of an indoor transformer is insulated by some means, such as insulating caps over the terminals, it shall be rendered inaccessible to other than qualified persons by providing the transformer cover or door with an interlock switch that, on opening the cover or door, disconnects the primary circuit. Alternatively, the cover or door shall be fastened so that the use of other than ordinary tools will be necessary to open the enclosure.

24.6 The requirement in [24.5](#) applies to an outdoor, non-weatherproof transformer if such a transformer is to be additionally used as an indoor-type transformer.

24.7 An uninsulated high-voltage part within a transformer enclosure is to be considered as having been rendered inaccessible if not less than two screws fastening each removable section are soldered to the enclosure, ground off, or otherwise treated so that they cannot be removed with ordinary tools such as

pliers or a screwdriver. Other means for accomplishing the same result may be used if investigated and determined to be equivalent.

24.8 A transformer shall have provision for grounding all dead metal parts. A transformer having an outlet box or a wiring or terminal compartment to which rigid metal conduit or armored cable may be connected, and a transformer having mounting means that would provide a bond between all dead metal parts and a sign enclosure, need not have additional means for grounding.

25 Capacitors

25.1 A capacitor supplied as a part of a specialty step-up transformer, when not used in the primary circuit, shall be investigated.

25.2 A capacitor shall be rated for the temperature to which it is subjected during operation of the transformer and shall have a voltage rating not less than the voltage to which it is subjected during intended operation.

25.3 A capacitor shall be sealed in compound within the transformer enclosure; or it shall be enclosed in metal having strength and rigidity not less than that of a steel sheet having an uncoated thickness of 0.020 inch (0.51 mm) and shall be treated in a manner to exclude moisture.

Exception: A capacitor may be unenclosed if it is mounted on an open core-and-coil transformer and complies with the requirements for such use.

PERFORMANCE

26 General

26.1 To determine if a specialty step-up transformer complies with the tests for open-circuit secondary voltage, input, heating, short-circuit secondary current, dielectric voltage-withstand, burnout, and open-circuit secondary operation, a representative sample is to be subjected to the tests described in Sections [27](#) – [32](#), in the order given.

26.2 The enclosure is to be grounded during all the tests specified in [26.1](#). A capacitor is not to be disconnected during any of the tests except the dielectric voltage-withstand test. During the tests, a capacitor shall not breakdown or become short-circuited to the enclosure.

27 Open-Circuit Secondary Voltage Test

27.1 The open-circuit secondary voltage of a transformer shall not be more than 110 percent of the rated value. If the secondary winding is tapped, the open-circuit secondary voltage of a section of the winding shall not be more than 115 percent of the rated value for that section, and the open-circuit secondary voltage of the entire secondary winding shall not be more than 110 percent of the rated voltage for the entire winding. The open-circuit secondary voltage between any two ungrounded secondary terminals (or leads) shall not be more than 16,000 volts. The open-circuit voltage between a grounded secondary terminal (or lead) and any ungrounded secondary terminal (or lead) shall not be more than 8000 volts.

27.2 For other than a transformer having an end-grounded secondary winding, the open-circuit secondary peak voltage shall not be higher than indicated in [Table 27.1](#), corresponding to the maximum rated voltage between any two secondary terminals or leads.

Table 27.1
Maximum open-circuit peak secondary voltage (not end grounded)

Transformer secondary rating, volts	Maximum secondary peak voltage, volts
5,000 or less	7,800
5,001 – 10,000	15,600
10,001 – 15,000	22,600.

27.3 The open-circuit secondary peak voltage of a transformer having an end-grounded secondary winding shall not be higher than the value indicated in [Table 27.2](#), corresponding to the rated secondary voltage of the transformer.

Table 27.2
Maximum open-circuit peak secondary voltage (end grounded)

Transformer secondary rating, volts	Maximum secondary peak voltage, volts
2,500 or less	3,900
2,501 – 5,000	7,800
5,001 – 7,500	11,300

27.4 To determine if a transformer complies with the requirements in [27.1](#) – [27.3](#), maximum rated primary voltage is to be applied to the primary terminals and the peak open-circuit secondary voltages are to be measured with meters. The voltage applied to the primary is to have a deviation factor of not more than 1 percent.

28 Input Test

28.1 The primary current input shall not be more than 105 percent of the primary current rating when the transformer is connected to a circuit of rated primary voltage and rated frequency and when the secondary is carrying full load.

28.2 The primary current under conditions of secondary full load is to be considered 80 percent of the primary current measured with the secondary short-circuited.

28.3 A transformer marked to indicate that it is power-factor corrected shall have a power factor within 10 percent of unity. If the actual power factor is indicated, the power factor shall not be less than 90 percent of the marked value.

28.4 Regarding [28.3](#), the power factor is to be determined from the ratio of the measured input in watts and in volt-amperes under the conditions described in [28.2](#).

29 Heating Test

29.1 A specialty step-up transformer is to be operated continuously with the secondary terminals short-circuited. Following the test:

- a) The temperature on or within the transformer shall not adversely affect any of the materials used in its construction;

- b) The temperature rise at any point on the enclosure of an enclosed-type transformer shall not be greater than 65°C;
- c) There shall not be emission of flame or molten material from the enclosure; and
- d) The temperature rise at any point on the exterior of a coil of an open core-and-coil transformer shall not be greater than 65°C if Class 105 insulation is used and not more than 90°C if Class 130 insulation is used.

29.2 An open core-and-coil transformer is to be tested in an enclosure of sheet steel having an uncoated thickness of not less than 0.026 inch (0.66 mm) and having inside dimensions of 6 by 6 by 12 inches (152 by 152 by 304 mm). There shall not be flame or molten material emitted from inside or outside this enclosure.

29.3 The insulation on a lead is to be considered adversely affected if, during the heating test described in [29.1](#) and [29.2](#), it attains a temperature rise of more than that indicated in [Table 29.1](#).

Table 29.1
Maximum rise in lead temperature

Lead types	Maximum rise, °C
T, TF, TFF, and TW	35
FFH-2, RH, and RFH-2	50

30 Short-Circuit Secondary Current Test

30.1 When the secondary winding is short-circuited and when the primary winding is connected to a circuit of maximum rated voltage and rated frequency, the secondary current of a specialty step-up transformer shall not be more than 110 percent of the rated value.

30.2 A measurement to determine if a transformer complies with the requirement in [30.1](#) may be made during the short-circuit test.

31 Dielectric Voltage-Withstand Test

31.1 A specialty step-up transformer with an ungrounded secondary, while hot from the heating test described in the Heating Test, Section [29](#), is, in each case, to be subjected for 1 minute to the application of an essentially sinusoidal potential, at rated frequency, as follows:

- a) A value of 1000 volts plus twice the maximum rated primary voltage, applied between the primary winding and the core or enclosure;
- b) A value of 125 percent of the maximum rated secondary voltage applied between primary and secondary windings; and
- c) A value of 150 percent of the maximum rated primary voltage applied to the ends of the primary winding, with one end of the primary winding solidly connected to the enclosure. This test is to be conducted first with one end of the secondary and then the other, in turn, connected to the enclosure.

There shall not be dielectric breakdown.

31.2 A specialty step-up transformer with a grounded secondary, while hot from the Heating Test, Section 29, is, in each case, to be subjected for 1 minute to the application of an essentially sinusoidal potential, at rated frequency, as follows:

- a) A value of 1000 volts plus twice the maximum rated primary voltage, applied between the primary winding and the core or enclosure;
- b) A value of 150 percent of the maximum rated primary voltage applied to the ends of the primary winding, with one end of the primary winding solidly connected to the enclosure; and
- c) If the transformer is constructed so that the primary winding and each half of the secondary winding are wound on separate legs of the core, with the magnetic paths in parallel, the test described in (b) is to be repeated with first one secondary terminal and then the other, in turn, connected to the enclosure, even though the midpoint of the secondary is connected to the enclosure internally.

There shall not be dielectric breakdown.

31.3 A capacitor that is supplied as a part of a specialty step-up transformer for use in the primary circuit and that can be disconnected readily from the transformer shall be subjected for 1 minute to the application of an essentially sinusoidal potential of 1000 volts plus twice its intended operating voltage, between the capacitor enclosure and the live parts of the capacitor. There shall not be dielectric breakdown.

31.4 The test potential is to be supplied from a 500-volt-ampere or larger capacity testing transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter. The tests are to be conducted at the rated frequency of the specialty step-up transformer.

Exception: The test described in 31.1(c) and 31.2 (b) and (c) may be conducted at a higher frequency if agreeable to all concerned, if the exciting current at rated frequency is such as to cause excessive heating of the primary winding.

32 Burnout Test

32.1 A specialty step-up transformer is to be operated continuously until constant temperatures are attained, with the secondary winding short-circuited or with any combination of short-circuiting or grounding of the secondary winding that results in maximum heating. There shall not be emission of flame or molten material from the enclosure.

32.2 In the burnout test, an open core-and-coil transformer is to be tested as described in 29.2 and shall comply with the requirement in 29.2.

32.3 For a transformer with an ungrounded secondary winding and for a transformer with an end-grounded secondary winding, the performance of a separate burnout test is not necessary since the results of the Heating Test, Section 29, reveal whether the transformer complies with the requirement specified in 32.1.

33 Open-Circuit Secondary Operation Test

33.1 A specialty step-up transformer is to be operated continuously for 24 hours at maximum rated primary voltage and rated frequency, with the secondary open-circuited. There shall not be malfunction of the insulation.

34 Switch Tests

34.1 General

34.1.1 A switch provided with a specialty step-up transformer is to be subjected to the overload and endurance tests described in [34.2.1](#) – [34.3.2](#).

Exception: A switch having a current rating not less than twice that of the transformer primary and a voltage rating not less than that of the transformer primary need not be subjected to the tests.

34.2 Overload

34.2.1 Three samples of each switch are to be subjected to an overload test consisting of 50 cycles of operation at 10-second intervals, opening and closing the primary circuit of the transformer. During the test, the transformer primary is to be connected to a supply circuit of maximum rated primary voltage and rated frequency and the secondary terminals are to be short-circuited. There shall not be undue burning or pitting of the contacts or other damage.

34.2.2 The switches are to be mounted in the transformer enclosure in the intended manner during the test, and the enclosure is to be grounded through a 15-ampere fuse that would not open as a result of the test.

34.3 Endurance

34.3.1 After the overload test, the same three samples of each switch are to be subjected to an endurance test consisting of 1000 cycles of operation at 1-second intervals with the primary of the transformer connected to a supply circuit of maximum rated primary voltage and rated frequency. The secondary of the transformer is to be connected to a load of such magnitude as to result in an input of rated primary current; or the secondary terminals are to be short-circuited. The switches are to be tested under the conditions described in [34.2.2](#) with the same criteria for acceptance.

34.3.2 Snap switches and other wiring devices are to be disconnected during the Dielectric Voltage-Withstand Test, Section [31](#), and are to be subjected to a separate dielectric voltage-withstand test. A wiring device is to be subjected for 1 minute to the application of an essentially sinusoidal potential of 1000 volts between all live and dead metal parts. There shall be no dielectric breakdown.

TEST BY THE MANUFACTURER

35 Production Line Grounding Continuity Test

35.1 As a routine production-line test, each transformer that has a power supply cord having a grounding conductor shall be tested for grounding continuity between the grounding blade of the attachment plug and the accessible dead metal parts of the transformer that are likely to become energized.

35.2 Only a single test need be conducted if the accessible metal selected is conductively connected to all other accessible metal.

35.3 Any indicating device (an ohm-meter, a battery-and-buzzer combination, or the like) may be used to determine compliance with the grounding continuity requirement specified in [35.1](#).

RATINGS

36 Details

36.1 The electrical ratings of a specialty step-up transformer shall include the primary voltage, frequency, and current or volt-amperes, and all secondary open-circuit voltages and the secondary short-circuit current.

36.2 If a grounded point of the secondary winding is at mid-potential with respect to the ends of that winding, it is not necessary to include in the rating the values of the voltage from each end of the secondary winding to the grounded point (in view of the requirement in [37.1](#) that the marking include the words "mid-point grounded " or the equivalent).

36.3 The nominal primary voltage rating shall not be more than 600 volts. The open-circuit secondary voltage rating of:

- a) An open core-and-coil transformer shall not be more than 5000 volts;
- b) An enclosed-type transformer that has the secondary grounded at one end shall not be more than 7500 volts; and
- c) An enclosed-type transformer, the secondary of which is not grounded or is grounded at the center point, shall not be more than 15,000 volts.

The volt-ampere rating shall not be more than 4500 volt-amperes.

MARKINGS

37 Details

37.1 A transformer shall have a plain, legible marking that is readily visible after the transformer has been installed as intended with the following:

- a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified;
- b) The catalog number or the equivalent;
- c) The electrical rating; and
- d) The date of manufacture which may be abbreviated or in an established or otherwise traceable code or a code affirmed by the manufacturer, that will enable the transformer to be identified as being manufactured within a three-month period.

If any point of the secondary winding is grounded, the marking shall indicate specifically which point is grounded.

37.2 A weatherproof transformer shall be marked with the word "Weatherproof" or the designation "WP". A transformer not investigated for use outdoors, other than an open core-and-coil transformer, and a transformer provided with a power supply cord shall be marked with the following or equivalent marking: "For indoor use only."

IGNITION TRANSFORMERS

GENERAL

38 Details

38.1 An ignition transformer is a step-up transformer of the high-secondary-voltage type, intended to provide ignition for an oil or gas burner.

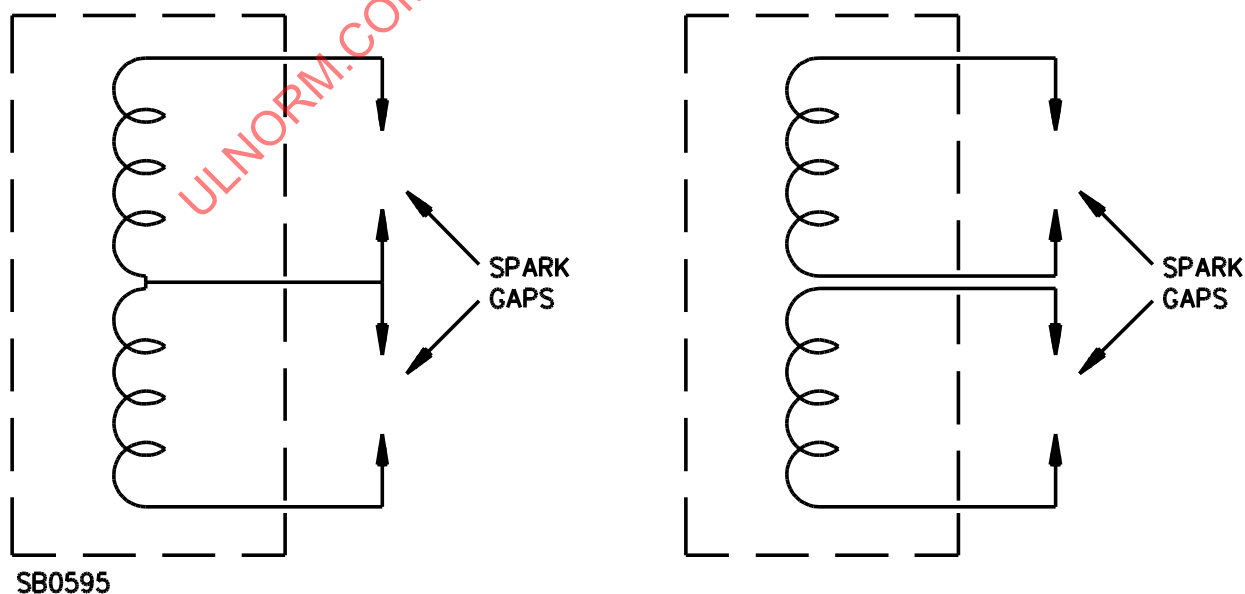
38.2 The requirements for ignition transformers specified in [38.3](#) – [54.4](#) shall be considered in addition to those specified in Sections [1](#) – [17](#).

38.3 An interchangeable ignition transformer, identified as a Class 6, 10, 12, or 14 transformer, is electrically interchangeable with any other transformer of the same class and having a similar form of secondary grounding on gas- or oil-burning equipment that has been investigated and determined to be acceptable. Noninterchangeable ignition transformers may be used only on oil or gas burners with which they have been tested. A Class 6 interchangeable transformer is one having a secondary voltage rating of 6000 volts; the corresponding ratings for Class 10, 12, and 14 transformers are 10,000, 12,000, and 14,000 volts, respectively. A transformer having a secondary voltage rating of 15,000 volts may be tested as a Class 14 transformer.

38.4 A twin-gap transformer is one that is intended for use with an ignition system using two spark gaps that are electrically interconnected as indicated in [Figure 38.1](#). A twin-gap transformer shall not be used under the interchangeability program. A multiple-gap transformer is one intended for use with an ignition system using more than one spark gap, with each spark gap being electrically independent of the others as indicated in [Figure 38.1](#). A dual-gap transformer is a multiple-gap transformer intended for use with an ignition system using two spark gaps.

Figure 38.1

Schematic diagrams of twin-gap (left) and multiple-gap (right) transformers (secondary circuits only)



CONSTRUCTION

39 General

39.1 There shall not be electrical connection between primary and secondary windings of an ignition transformer.

39.2 A transformer intended to be supported by rigid metal conduit shall comply with the requirements in [5.10](#).

39.3 Compound shall not be depended upon to reduce shifting of the core-and-coil assembly inside the enclosure if such shifting might result in reduction of spacings or in stress on internal connections.

40 Enclosure

40.1 An ignition transformer shall be provided with an enclosure of metal to enclose all live parts.

Exception: Primary and secondary terminals and primary leads (including a flexible cord) need not be enclosed if the transformer is intended to be mounted in oil- or gas-burning equipment so that these parts will be enclosed.

40.2 A surface of iron or steel, other than stainless-steel, shall be resistant to corrosion. Galvanizing, plating, and enameling may be used for corrosion resistance.

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

40.3 Unless the transformer is intended for installation in such a manner that the wiring will be enclosed inside other equipment, means shall be provided for the connection of rigid metal conduit for the primary wiring.

40.4 The enclosure of a transformer of the compound-filled type shall not be provided with ventilating louvers. An enclosure provided with louvers shall be investigated with regard to mechanical strength, rigidity, and the accessibility of live parts.

40.5 The enclosure shall be provided with means for mounting.

40.6 The cover of an enclosure shall be provided with means (such as screws) for firmly securing it in place. Friction alone shall not be used. A cover that must be removed to permit connection of circuit conductors shall not be provided with means for the connection of conduit.

Exception: An ignition transformer with primary leads for field connection may be provided with a knockout in the cover for connection of a flexible wiring method.

40.7 On oil- or gas-fired equipment, a compartment in which field-installation connections are to be made shall have a volume as determined in [Table 40.1](#). A conductor passing through the compartment is to be counted as one conductor and each conductor terminating therein is also to be counted as one conductor.

Table 40.1
Minimum volume per conductor

Conductor size,		Minimum free space within box for each conductor,	
AWG	(mm ²)	inches ³	(cm ³)
16 or smaller	1.3	1-1/2	25
14	2.1	2	33
12	3.3	2-1/4	37
10	5.3	2-1/2	41
28	8.4	3	49

40.8 Material for the mounting of high-voltage (more than 600 volts) live parts shall be porcelain, glass, or insulation material that has been determined to be equivalent.

40.9 The construction of a multiple-gap transformer shall be such that the open-circuit voltage of each secondary winding would not be affected by a fault in any other secondary and, in the case of a multiple-primary transformer, by an open-circuit in any primary winding other than that supplying energy to the secondary in question. See [47.6](#).

41 Primary Connections

41.1 A primary lead shall be of Type RFH-2, FFH-2, or RH wire, or of insulated wire that has been determined to be equivalent. The lead shall be of an ampacity corresponding to the primary rating and shall not be smaller than 18 AWG (0.82 mm²).

41.2 A length of Type SJ or heavier flexible cord may be used for connection of the transformer primary to the power supply.

41.3 If the transformer is provided with primary leads but does not have a primary outlet box or wiring compartment, the leads shall enter the enclosure through one of the following:

- Separate holes or a single hole in the enclosure.
- A conduit hub, a flexible-steel-conduit, armored-cable, or an electrical-metallic-tubing connector.
- Separate insulating bushings or a single insulating bushing.
- Separate holes or a single hole in a fiber plate that complies with the requirements in [10.3](#).

41.4 A lead that enters the transformer by one of the means described in [41.3](#) shall not be less than 6 inches (152 mm) in length, measured outside the transformer.

Exception: The length of a lead may be less than 6 inches if:

- The transformer is intended for use in a specific application for which it can be shown that the 6-inch lead length is unnecessary; and*
- The free end of the lead terminates in an eyelet, a lug, or the like.*

41.5 If a transformer is provided with an outlet box or wiring compartment in which primary connections are to be made, the free length of each lead inside the outlet box shall not be less than 6 inches (152 mm).

41.6 The setscrew form of wiring terminal shall not be used.