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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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

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

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Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

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

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

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

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

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

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

INTRODUCTION

1 Scope

1.1 These requirements cover air-cooled transformers and reactors for general use, and ignition transformers for use with gas burners and oil burners. 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.

Revised 1.1 effective November 1, 2002

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 (other than gas-tube-sign 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 Class 2 and Class 3 Transformers, UL 1585.

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.

Revised 1.3 effective November 1, 2002

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

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 INDUSTRIAL CONTROL TRANSFORMER – A step-down transformer of the open-core and coil-type that may be provided with a fuse or other overcurrent protective device and that generally is used for the operation of solenoids, contactors, and relays as a control function (such as in heating and air conditioning, printing, and general industrial controls).

3.6 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.

3.7 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.

3.8 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.

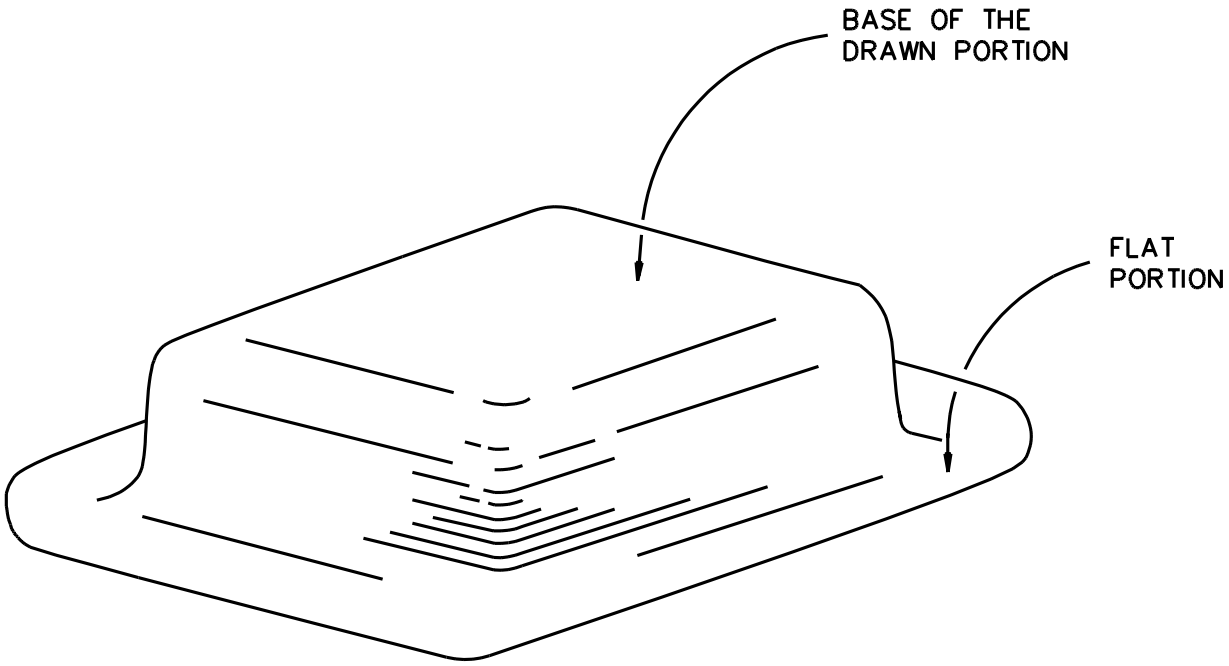
5 Enclosure

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 Rust Resistance Test, Section 37.

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, Section 39.

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 64 – 80) 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.

Revised 8.7 effective November 1, 2002

Table 8.1
Types of cords

C
SP-2, SPE-2
SPT-2
PD
SV, SVE
SVO, SVOO
SVT
SVTO, SVTOO
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 (77°F). 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 No. 24 AWG (0.21 mm^2).

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 No. 30 AWG (0.05 mm^2) 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 thermocouples as specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

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:

Δ *t 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.

GENERAL-PURPOSE TRANSFORMERS AND REACTORS

GENERAL

18 Details

18.1 The requirements in Sections 19 – 43 are considered additional to those specified in Sections 1 – 17, which apply to all types of transformers.

18.2 The requirements in Sections 19 – 43 apply to compound-filled transformers, exposed core transformers, or industrial control transformers.

18.3 The requirements in Sections 19 – 43 do not apply to ventilated transformers; nonventilated transformers other than of the compound-filled or exposed core type; transformers having either primary or secondary ratings, including elevated voltage use, of more than 600 volts nominal; or transformers having overvoltage taps rated greater than 660 volts.

CONSTRUCTION

19 Mechanical Assembly

19.1 A transformer weighing more than 100 pounds (45 kg) shall be provided with a means for lifting by a fork lift, cable, sling, or the equivalent. The lifting means may be provided on the transformer core or frame or the equivalent if the transformer has a removable top cover. The lifting means shall be subjected to the Lifting or Mounting Means Test, Section 32.

Exception: The lifting means test does not apply to a transformer that is intended to be lifted from underneath by a fork lift or other means.

20 Enclosure

20.1 General

20.1.1 A general purpose transformer or reactor shall be provided with an enclosure of moisture-resistant material. The enclosure shall house all uninsulated live parts.

Exception No. 1: Terminals of a transformer intended for mounting on an outlet box need not be additionally enclosed if they will be enclosed within the box when the transformer is mounted.

Exception No. 2: An industrial control transformer as described in 20.1.2 need not be provided with an enclosure that houses all uninsulated live parts.

20.1.2 An industrial control transformer rated 5000 volt-amperes or less that is intended for use in industrial control equipment and is of the unenclosed core and coil construction, shall be insulated between the primary and secondary windings.

20.2 Nonmetallic enclosures

20.2.1 Among the factors that shall be taken into consideration when judging the acceptability of magnesium and nonmetallic material are resistance to:

a) Mechanical damage,

b) Impact,

c) Moisture absorption,

d) Combustion, and

e) Distortion at temperatures to which the material may be subjected under conditions of normal or abnormal use.

20.2.2 A polymeric material shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

20.3 Mounting means

20.3.1 An enclosure shall be provided with means for mounting. The mounting means shall be such that, when the enclosure is mounted on a plane surface, it will make contact with such surface at points of support only. When so mounted, there shall be a spacing through air of not less than 1/4 inch (6.4 mm) between the supporting surface and the enclosure.

Exception No. 1: There need not be a 1/4-inch spacing between the supporting surface and the enclosure if the transformer is intended to be mounted on an outlet box cover.

Exception No. 2: There need not be a 1/4-inch spacing between the supporting surface and the enclosure if the transformer is an industrial control transformer.

20.3.2 An unenclosed core and coil transformer shall be provided with mounting brackets or a mounting plate.

20.3.3 The means of securing a transformer to a wall shall be subjected to the Lifting or Mounting Means Test, Section 32.

20.3.4 A transformer rated 100 volt-amperes or less may be used for mounting on a standard outlet box in place of a cover. The transformer shall include an outlet box cover or similar item that has been determined to be the equivalent. The cover, if sheet steel, shall not be less than 0.045 inch (1.14 mm) thick if zinc coated and 0.042 inch (1.07 mm) thick if uncoated and shall be resistant to corrosion on all surfaces.

20.3.5 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.

20.3.6 A cover that must be removed for the connection of circuit conductors shall not be provided with means for the connection of conduit or armored cable.

20.3.7 The requirement in 20.3.6 does not preclude acceptability of a transformer mounted on an outlet box cover and provided with secondary leads brought out through a flexible conduit connector, if the volt-ampere and secondary voltage ratings are not more than 100 volt-amperes and 30 volts, respectively.

20.4 Enclosures – specific environmental conditions

20.4.1 An enclosure intended for a specific environmental condition and determined to be acceptable for such use, as specified in Table 20.1, shall be marked in accordance with 43.1.6. An enclosure that complies with the requirements for more than one type of enclosure may be marked accordingly with multiple type numbers.

20.4.2 An enclosure shall be subjected to the tests specified in Table 20.1 and shall comply with the construction requirements applicable to an enclosure of the type number or numbers with which it is marked.

Table 20.1
Enclosure types

Type number	Intended use and description	Required tests
Type 1	Indoor use primarily to provide protection against contact with the enclosed equipment and against a limited amount of falling dirt	Corrosion Resistance, Section 6, or Rust Resistance, Section 37
Type 2	Indoor use to provide a degree of protection against limited amounts of falling water and dirt	Corrosion Resistance, Section 6, and Drip, Section 35; or Drip, Section 35, and Rust Resistance, Section 37
Type 3R	Outdoor use to provide a degree of protection against falling rain; undamaged by the formation of ice on the enclosure	Corrosion Resistance, Section 21; Icing, Section 36[a]; and Water Spray, Section 38

[a] The icing test is not required if the transformer has no external cavities that can trap water.

20.4.3 The thickness of a sheet metal enclosure shall comply with the following:

a) Table 20.2 for an enclosure without a supporting frame,

b) The requirements in 20.4.4 and Table 20.2 for an enclosure with a supporting frame, or

c) The requirements in 33.1 for an enclosure with equivalent reinforcement.

Table 20.2
Minimum thickness of sheet metal for enclosures

Maximum dimensions of enclosure				Minimum average thickness of sheet metal							
				Steel[a]				Copper, brass, or aluminum			
				Without supporting frame,		With supporting[b] frame or equivalent reinforcement,[c]		Without supporting frame,		With supporting frame[b] or equivalent reinforcement,[c]	
Length or width, inches	(cm)	Area, inches^2	(cm^2)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
3	7.6	6	38.7	0.020	0.51	0.20	0.51	0.023	0.58	0.023	0.58
8	20.3	30	194	0.026	0.66	0.20	0.51	0.036	0.91	0.029	0.74
12	30.5	90	581	0.032	0.81	0.20	0.51	0.045	1.14	0.029	0.74
18	45.7	135	871	0.042	1.07	0.32	0.81	0.058	1.47	0.045	1.14
24	61	360	2323	0.053	1.35	0.42	1.07	0.075	1.91	0.058	1.47
46	122	1200	7742	0.067	1.70	0.53	1.35	0.095	2.41	0.075	1.91
60	152	1500	9677	0.093	2.36	0.53	1.35	0.122	3.10	0.075	1.91
Over 60	Over 152	Over 1500	Over 9677	0.123	3.12	0.53	1.35	0.153	3.89	0.075	1.91

[a] Other metals may be used if they are tested in accordance with 33.1.

[b] A supporting frame is described in 20.4.4.

[c] As referenced in 20.4.3, thinner metals may be used if they are tested in accordance with 33.1.

20.4.4 With regard to Table 20.2, a supporting frame is a structure of angle or channel or folded rigid piece of sheet metal that is attached to and has essentially the same outside dimensions as the enclosure surface, and that has sufficient torsional rigidity to resist the bending moments that may be transmitted by the enclosure surface when the surface is deflected. Constructions considered to be without supporting frame include:

a) A single sheet with single formed flanges (formed edges);

b) A single sheet that is corrugated or ribbed;

c) An enclosure surface loosely attached to a frame, for example, with spring clips; and

d) An enclosure surface having an unsupported edge.

20.4.5 A watertight connection at a conduit entrance shall be a conduit hub or the equivalent, such as a knockout or fitting, located so that when conduit is connected and the enclosure is mounted in the intended manner the enclosure complies with the tests specified in Table 20.1.

20.4.6 An enclosure marked ″Type 2 Enclosure″ shall have provision for drainage. Provision for the entrance of conduit at the top or side walls shall be a conduit hub or the equivalent as described in 20.4.5.

20.4.7 A bushed hole for open wiring shall not be located in the top or back of the enclosure unless a hood fitting is provided; when a bushed hole is located in a side above live parts, it shall provide for a downward direction of the wire leaving the enclosure.

20.4.8 An enclosure marked ″Type 3R Enclosure″ shall have:

a) A conduit hub or the equivalent as described in 20.4.5 for a watertight connection when the conduit entrances are at a location higher than the lowest live part in compliance with 20.4.5;

b) Provision for drainage; and

c) If a door is used, provision for locking the door.

20.4.9 An enclosure of a transformer that complies with the requirements for a rainproof enclosure, if used with a field-added rainproof hood, may be shipped without the hood when the transformer and hood are marked as described in 43.2.2 – 43.2.4.

20.4.10 The mounting or securing means provided for the hood shall be external to the enclosure.

Exception: Internal means may be provided if constructed so as to reduce the risk of water entering the enclosure.

20.4.11 Hinges and other attachments shall be resistant to corrosion.

20.4.12 Metals shall not be used in such combination as to cause galvanic action that will adversely affect any part of the transformer.

20.4.13 The enclosure of a transformer marked ″Type 3R Enclosure″ shall be constructed to exclude a beating rain.

20.4.14 Unless the enclosure is constructed so that it will obviously exclude a beating rain, a transformer marked ″Type 3R Enclosure″ is to be tested as described in the Water Spray Test, Section 38, to determine if it complies with the requirement in 20.4.13.

20.4.15 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material used to comply with the requirements for a Type 2 or a Type 3R enclosure shall be tested in accordance with the Accelerated Aging of Gaskets Test, Section 40.

21 Corrosion Resistance

21.1 A Type 3R enclosure made of sheet steel (other than stainless steel) having a thickness of 0.120 inch (3.05 mm) or more shall be made corrosion resistant by one of the following coatings:

a) Hot-dipped, mill-galvanized sheet steel complying with the coating designation G60 or A60 in Table I of ASTM A525-1987, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the test method of ASTM A90-1981.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 34.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces after forming. The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests if these are considered necessary.

d) Any one of the means specified in 21.2.

21.2 A Type 3R enclosure made of sheet steel (other than stainless steel) having a thickness of less than 0.120 inch (3.05 mm) shall be made corrosion resistant by one of the following coatings:

a) Hot-dipped, mill-galvanized sheet steel complying with the coating designation G90 in Table I of ASTM A525-1987, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the test method of ASTM A90-1981.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface with a minimum thickness of 0.00054 inch (0.014 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 34. An annealed coating shall also comply with 21.5 and 21.6.

c) A cadmium coating not less than 0.0010 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established by the Metallic Coating Thickness Test, Section 34.

d) A zinc coating complying with the requirements in 21.1 (a) or (b) with one coat of outdoor paint as specified in 21.1(c).

e) A cadmium coating not less than 0.000075 inch (0.0019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.000051 inch (0.0013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established by the Metallic Coating Thickness Test, Section 34, and the paint shall be as specified in 21.1(c).

21.3 With regard to 21.1 and 21.2, other finishes, including paints, special metallic finishes, and combinations of the two may be used when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) complying with 21.1(a) or 21.2(a), as applicable, indicate they provide equivalent protection. Among the factors taken into consideration when judging such coating systems are:

a) Exposure to salt spray,

b) Moist carbon dioxide-sulfur dioxide-air mixtures,

c) Moist hydrogen sulfide-air mixtures,

d) Ultraviolet light, and

e) Water.

21.4 An enclosure made of stainless steel, copper, brass, or aluminum need not be made additionally corrosion resistant.

21.5 An annealed coating on sheet steel that is bent or similarly formed or extruded or rolled at edges of holes after annealing shall additionally be painted in the bent or formed area if the bending or forming process damages the zinc coating.

21.6 If flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered damaged. Simple sheared or cut edges and punched holes are not required to be additionally protected.

22 Current-Carrying Parts

22.1 A current-carrying part shall be of silver, copper, aluminum, alloys of these metals, or the equivalent.

22.2 An aluminum current-carrying part shall be plated at each bolted joint with tin, silver, nickel, or cadmium.

Exception No. 1: An aluminum current-carrying part need not be plated if one or more internal connections are welded and if any connections to the part that are not welded are assembled using a corrosion inhibiting compound.

Exception No. 2: Plating is not necessary when a bus bar is welded to an aluminum pad to which pressure terminal connectors are to be bolted if a corrosion-inhibiting compound is provided along with instructions for its application as specified in 43.3.14.

22.3 Iron and steel shall not be used for a current-carrying part.

22.4 A plated steel screw, nut, and stud may be used to secure a soldering lug, pressure wire connector, or bus bar. A No. 10 or larger plated steel wire-binding screw may be used at a terminal, in connection with a nonferrous terminal plate.

22.5 Copper and brass shall not be used for plating wire binding screws, nuts, and stud terminals. It is not prohibited to use a plating of cadmium, zinc, tin, or silver.

22.6 An uninsulated live part shall be secured so that it is prevented from turning or shifting in position when such motion can result in the reduction of spacings below minimum required values.

22.7 Friction between surfaces shall not be used as means to prevent shifting or turning of a live part.

22.8 A spring washer of a type intended for use with an aluminum bus shall be used at one end of a bolt that secures current-carrying parts together if an aluminum part is included in the joint.

Exception No. 1: A spring washer may be replaced with a split-ring lock washer and flat washer if each aluminum part in the joint has a tensile yield strength of at least 20,000 pounds per square inch (138 MPa).

Exception No. 2: A flat washer, a split-ring lock washer, or a bolt head that complies with 22.10(b) may be used in place of a spring washer if aluminum bolts are used.

Exception No. 3: A spring washer is not required for a type of fastener equivalent to that used for investigating a component wire connector in accordance with the requirements in the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A, or the requirements in the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B.

Exception No. 4: A spring washer is not required at a bolted contact of an aluminum alloy part used in the grounding circuit for an application such as the service grounding electrode, a neutral bonding conductor, or an equipment grounding conductor.

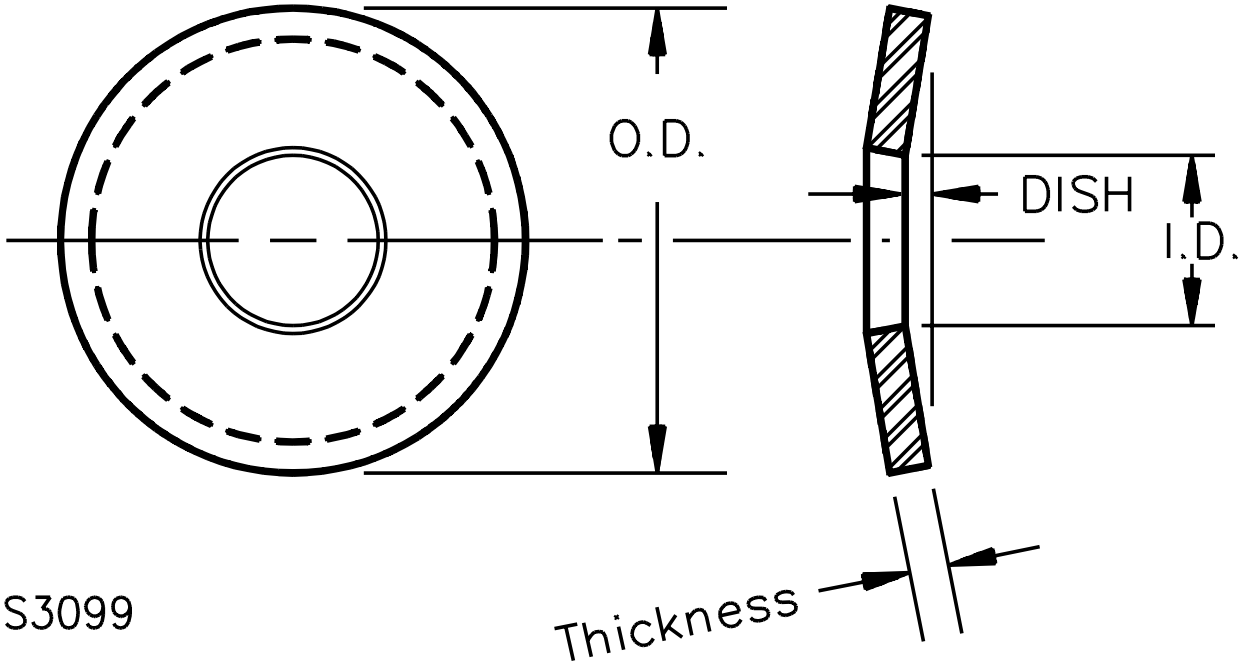
22.9 A spring washer as specified in 22.8 (such as a Belleville washer or the equivalent) and illustrated in Figure 22.1 is a dished washer of stainless or hardened and tempered steel, having:

a) An outer diameter not less than 150 percent of the bolt diameter,

b) A thickness not less than one eighth of the bolt diameter, and

c) A dish not less than 3-1/2 percent of the bolt diameter.

Figure 22.1
Spring washer



22.10 A flat washer as specified in Exception No. 2 to 22.8 shall have:

a) A thickness at least one sixth the diameter of the rivet shank or bolt and

b) An outer diameter at least 150 percent of that of the rivet shank or bolt but not less than the outer diameter of the spring washer.

22.11 Unless investigated for such use, a bolted connection between two bus bars or between a bus bar and another current-carrying part shall not depend on any polymeric insulation material to maintain the clamping force.

23 Connections

23.1 General

23.1.1 A transformer shall have provision for the connection of supply and load conductors, either in the form of busbars, leads, pressure terminal connectors, or terminal pads for pressure terminal connectors.

Exception: Studs or wire binding screws may be used for field connections if the full load current of the terminal is 24 amperes or less and the transformer is marked in accordance with 43.3.7. The studs or wire binding screws may be used for the field connection of No. 10 AWG (5.3 mm^2) or smaller conductors.

23.1.2 An industrial control transformer shall be provided with leads, wire-binding screws, stud terminals, or quick-connect terminals mounted on the coil or on a panel or panels near the top of the transformer, opposite the mounting bracket or plate.

23.1.3 It is assumed that a field-installed conductor will be:

a) Wire sized for 75°C (167°F) ampacity in No. 1/0 AWG (53.5 mm^2) and larger sizes and either 60°C (140°F) or 75°C in No. 1 AWG (42.4 mm^2) and smaller sizes.

Exception: 75°C ampacity wire size is assumed for No. 1 AWG and smaller sizes when the transformer is marked to use 75°C wire as indicated in 43.3.4 (a) or (c).

b) Aluminum wire.

Exception: Copper wire is assumed if the transformer is marked as indicated in 43.3.7.

c) Single conductors (not paralleled) for sizes smaller than No. 1/0 AWG (53.5 mm^2).

d) Installed in multiple conduits if paralleled conductors are involved.

23.1.4 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch (2.8-, 3.2-, 4.7-, 5.2-, or 6.4-mm) wide quick-connect terminal shall comply with the requirements in the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with regard to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rise; all tests shall be conducted in accordance with UL 310.

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

23.2 Leads

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

23.2.2 A transformer lead shall:

a) Be of stranded wire.

b) Not be smaller than No. 14 AWG (2.1 mm^2) copper or No. 12 AWG (3.3 mm^2) aluminum.

Exception: No. 18 AWG (0.82 mm^2) or No. 16 AWG (1.3 mm^2) copper wire may be used as a lead for a transformer if the transformer is provided with a wiring compartment or is intended for mounting on an outlet box.

c) Have a minimum length of 6 inches (152 mm) available for connection.

Exception: A secondary lead of a transformer of the type described in 20.3.7 shall have a minimum length of 18 inches (457 mm) available for connection.

23.2.3 When a transformer is not intended for outlet box mounting and is not provided with a terminal or wiring compartment, the leads shall enter the enclosure either through a nipple or other means for the attachment of rigid metal conduit; or the leads shall enter through separate holes that provide a spacing of not less than 1/4 inch (6.4 mm) between the conductors and not less than 1/2 inch (12.7 mm) between the conductors and the plane of support of the transformer.

23.2.4 Where a lead enters a metal enclosure, the hole shall be provided with insulating material.

23.3 Splice compartment

23.3.1 When a transformer is provided with leads to which field conductors will be spliced, the leads shall be located in a space providing a usable volume in compliance with Table 23.1.

Table 23.1
Field splice compartment size

Minimum coil rating, amperes	Minimum usable volume per coil lead, inches^3	(cm^3)
12	1.25	36.9
20	2.5	41.0
24	3.0	49.2
40	5.0	81.9
70	9.25	152
110	16.7	274
160	30.0	492
250	55.0	901

23.4 Wire-binding screws and studs

23.4.1 The thickness of a terminal plate for a wire-binding screw shall not be less than 0.030 inch (0.76 mm) and there shall not be less than 2 full threads in the metal for the binding screw.

23.4.2 A wire-binding screw or stud shall not be smaller than No. 8 (4.2 mm major diameter) nor shall it have more than 32 threads per inch (1.26 threads per mm).

Exception: A No. 6 (3.5 mm) machine screw may be used where the factory-installed or intended field-installed conductor is not larger than No. 14 AWG (2.1 mm^2).

23.4.3 Wire-binding screws or studs shall be provided with cupped washers, upturned lugs, or the equivalent to retain the wires under the heads of screws or nuts.

23.5 Pressure terminal connectors

23.5.1 When a pressure terminal connector is provided for field connection, it shall be sized to accept a conductor having an ampacity of at least 125 percent of the rated transformer full-load current that will flow through the field connector when the transformer is operating at full kVA at that terminal. For three-phase transformers, the line current is 0.577 of the ratio of the transformer three-phase volt-ampere rating to the line voltage. The size and ampacity of the field-installed conductor shall be determined in accordance with 23.1.3 and Table 23.2.

Exception: The wire connector may be sized for only 100 percent of the rated transformer current if the connector is mounted on a terminal pad as described in 23.1.1 and is replaceable with a connector sized for 125 percent of the rated transformer output.

Table 23.2
Ampacity of insulated conductors

Wire size,		60°C (140°F) Conductor ampacity		75°C (167°F)[a] Conductor ampacity	
AWG	(mm^2)	Copper	Aluminum	Copper	Aluminum
14	2.1	15	–	15	–
12	3.3	20	15	20	15
10	5.3	30	25	30	25
8	8.4	40	30	45	40
6	13.3	55	40	65	50
4	21.2	70	55	85	65
3	26.7	80	65	100	75
2	33.6	95	75	115	90
1	42.4	110	85	130	100
1/0	53.5	–	–	150	120
2/0	67.4	–	–	175	135
3/0	85.0	–	–	200	155
4/0	107.0	–	–	230	180

[a] Conductors with a higher temperature rating may be used but shall be sized on the basis of 75°C (167°F) ampacity as described in 43.3.4.

23.5.2 When a transformer is marked in accordance with 43.3.10, the transformer shall be provided with connectors that are suitable for conductors sized for 250 percent of the rated current of the transformer.

23.5.3 A pressure terminal connector shall be rated to accommodate both aluminum and copper conductors of the sizes indicated in 23.5.1.

Exception: A pressure terminal connector need not be rated to accommodate aluminum wire when the transformer is marked as described in 43.3.7.

23.5.4 With regard to 23.5.3, more than one wire connector may be provided for a single connection point to allow for connection of the various size conductors which may be required to be accommodated. In such case, each connector shall be marked in accordance with 43.3.11.

23.5.5 A pressure terminal connector intended to accommodate copper conductors only shall comply with the requirements in the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A. Pressure terminal connectors intended to accommodate aluminum and copper conductors shall comply with the requirements in the Standard for Wire Connectors for Use With Aluminum Conductors, UL 486B.

23.5.6 The installation of a pressure terminal connector shall not involve the loosening or disassembly of parts other than a cover or other part giving access to the terminal location. The means for securing the terminal connector shall be readily accessible for tightening before and after installation of conductors.

23.6 Wiring compartment

23.6.1 A wiring compartment intended for making field connections shall be free of sharp edges, burrs, fins, or moveable parts, that can damage conductor insulation.

23.6.2 The wiring space shall be large enough to accommodate connections to the transformer as specified in 23.7.1 – 23.7.5. When the transformer is marked for additional uses that require more wiring space, the additional space may be provided by a field-added wiring space extension assembly. Examples of additional uses are:

a) Use of two or more single-phase transformers to make up a multi-phase transformer bank;

b) Connection of a two-winding transformer as an autotransformer;

c) Connection of a transformer for buck or boost use; and

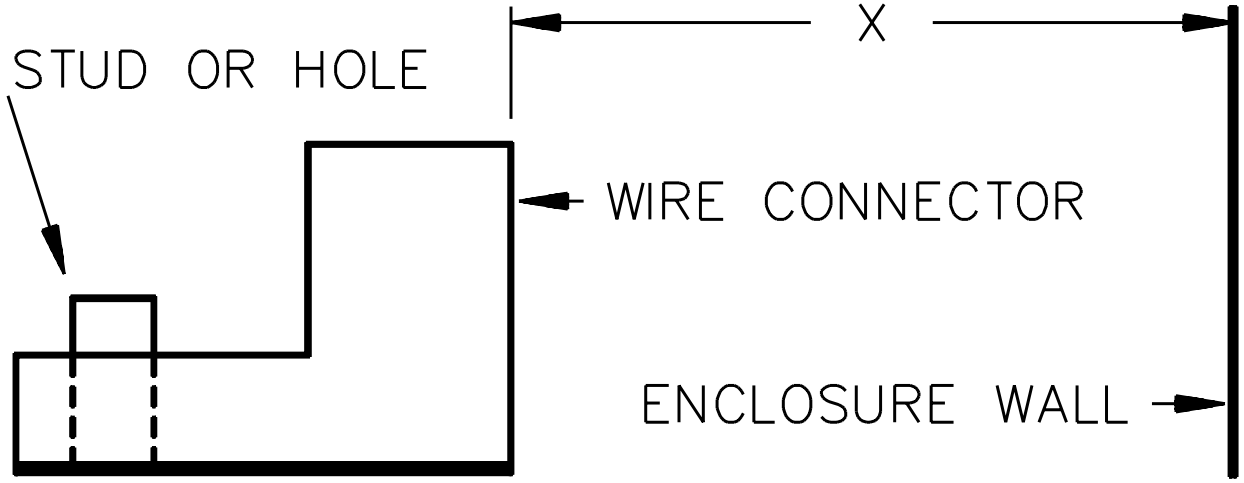
d) Use of aluminum or 250 percent ampacity wire in place of the copper or 125 percent ampacity wire, shown by a marking on the transformer as the intended use.

The wiring space extension assembly shall comply with the requirements for enclosures in Enclosure, Section 20 and shall be marked as specified in 43.3.15 and 43.3.16.

23.7 Wire-bending space

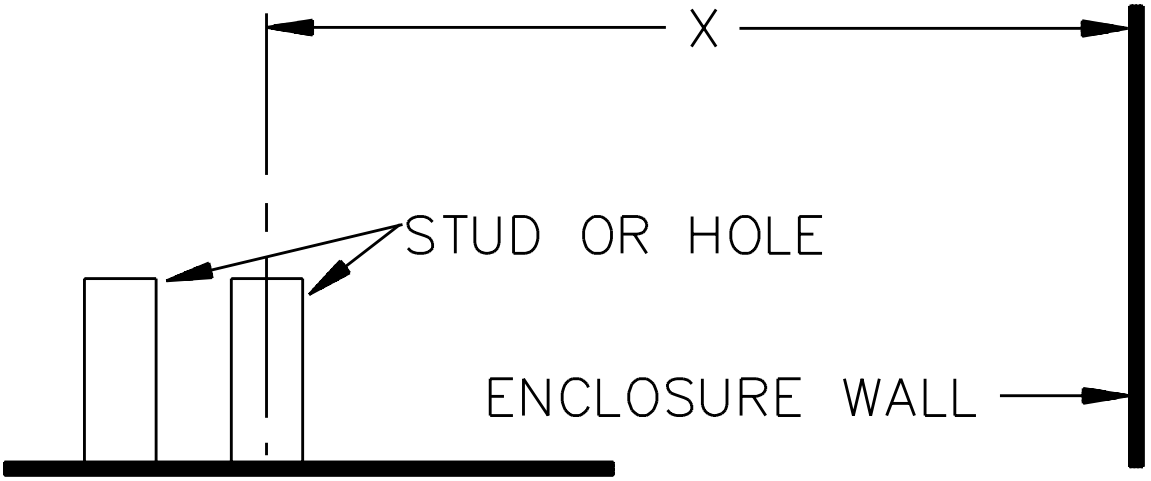
23.7.1 When a transformer is provided with field-wiring terminals with removable wire connectors sized as specified in 23.5.1, the distance between the center of the hole or stud provided for connection of field-installed wire connectors and the wall of the enclosure toward which the wire will be directed when leaving the connector (as illustrated in Figures 23.1 and 23.2) shall not be less than that indicated in Table 23.3. The values for wire-bending space specified in Table 23.3 include the assumed length of the connector as specified in Table 23.4 and Figure 23.3.

Figure 23.1
Terminals provided with non-removable wire connectors



S2902C X=WIRE-BENDING SPACE PER TABLE 23.5

Figure 23.2
Terminals without wire connectors or terminals with removable wire connectors



S2903B X=WIRE-BENDING SPACE PER TABLE 23.3

Table 23.3
Wire-bending space for removable wire connectors

Wire size,		Wire bending space[a]			
		S bend,		90 bend,[b]	
AWG	(mm^2)	inches	(mm)	inches	(mm)
14	2.08	1-3/4	44.5	1-3/4	44.5
12	3.3	1-3/4	44.5	1-3/4	44.5
10	5.3	1-3/4	44.5	1-3/4	44.5
8	8.4	2-1/4	57.2	2-1/4	57.2
6	13.3	2-3/4	69.9	2-1/4	57.2
4	21.2	4	102	3	76.2
3	26.7	4	102	3	76.2
2	33.6	4-1/2	114	3-1/2	88.9
1	42.4	5-3/4	146	4-1/4	108
1/0	53.5	6-3/4	171	4-3/4	121
2/0	67.4	7-1/2	191	5	127
3/0	85.0	7-1/2	191	5-1/2	140
4/0	107	7-3/4	197	5-3/4	146

[a] The assumed length of the connector, as specified in Table 23.4, is included in the wire-bending space values.

[b] The wire-bending space for conductors with an ″S″ shaped bend is to be used unless the transformer is constructed for line and load conductors with a single 90 degree bend and the enclosure is marked as described in 43.3.9.

Table 23.4
Assumed length of wire connector

Wire size,		Length A,[a,b]	
AWG, kcmil	(mm^2)	inches	(mm)
14 – 6	2.1 – 13.3	3/4	19.1
4 – 2	21.2 – 33.6	1	25.4
1 – 1/0	42.4 – 53.5	1-1/4	31.8
2/0 – 3/0	67.4 – 85.0	1-1/2	38.1
4/0 – 250	107 – 127	1-3/4	44.5
300 – 350	152 – 177	2	50.8
400 – 600	203 – 304	2-1/4	57.2
700 – 750	355 – 380	2-1/2	63.5

[a] These dimensions were assumed for the length of wire connectors in determining the wire-bending values for Table 23.3.

[b] As shown in Figure 23.3.

Figure 23.3
Wire connector (typical construction)

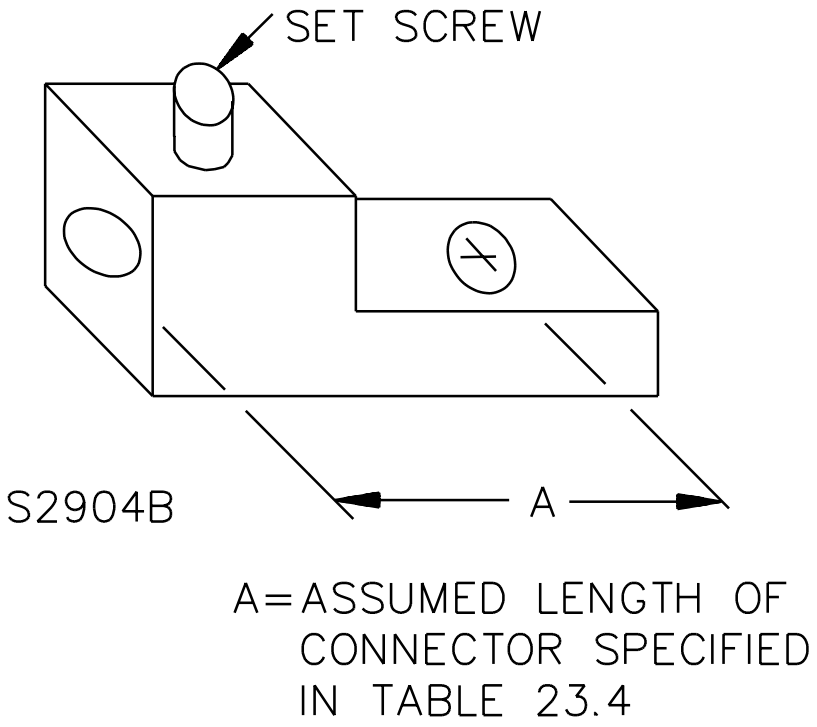


Table 23.5
Wire-bending space for non-removable wire connectors

Wire size,		Wire bending space			
		S bend,		90° bend,[a]	
AWG	(mm^2)	inches	(mm)	inches	(mm)
14	2.08	–	–	–	–
12	3.3	–	–	–	–
10	5.3	–	–	–	–
8	8.4	1-1/2	38.1	1-1/2	38.1
6	13.3	2	50.8	1-1/2	38.1
4	21.2	3	76.2	2	50.8
3	26.7	3	76.2	2	50.8
2	33.6	3-1/2	88.9	2-1/2	63.5
1	42.4	4-1/2	114	3	76.2
1/0	53.5	5-1/2	140	3-1/2	88.9
2/0	67.4	6	152	3-1/2	88.9
3/0	85.0	6-1/2	165	4	102
4/0	107	7	178	4	102

[a] The wire-bending space for conductors with an ″S″ shaped bend is to be used unless the transformer is constructed for line and load conductors with a single 90 degree bend and the enclosure is marked as described in 43.3.9.

23.7.2 When a transformer is provided with field-wiring terminals and non-removable wire connectors, the distance between the end of the wire connectors and the wall of the enclosure toward which the wire will be directed (as illustrated in Figure 23.1) shall not be less than the values indicated in Table 23.5.

23.7.3 With regard to 23.7.1, 23.7.2, 23.7.5, and 24.1, it is to be assumed that aluminum wire of an ampacity in compliance with Table 23.2 for 125 percent of the current rating of the winding and with 60°C (140°F) insulation will be used for the field-installed conductor.

Exception No. 1: Copper wire sized for 125 percent of rating is to be assumed for a transformer marked in accordance with 43.3.7.

Exception No. 2: Wire with 75°C (167°F) rated insulation is to be assumed for a transformer marked for use with 75°C or 90°C (194°F) insulated wire.

23.7.4 When a field-installed conductor is restricted by barriers or other means from being bent as it leaves the connector, the distance is to be measured from the end of the barrier.

23.7.5 The distance between an opening intended for field-wiring terminals or a knockout in a field-wiring compartment and the wall of the enclosure toward which a conductor will be directed upon entering the wiring compartment shall not be less than that indicated in Table 23.3 or 23.5 (in conjunction with the requirements in 23.7.3).

23.7.6 When a transformer is provided with field wiring terminals and two or more primary or secondary windings that can be connected either in series or in parallel, the transformer shall be supplied with jumpers or equivalent means for making field connections. The jumpers or equivalent means shall be packaged with the transformer, and the transformer shall be marked in accordance with 43.3.17.

24 Spacings and Insulation Used in Lieu of Spacings

24.1 The spacings at wiring terminals, between uninsulated live parts of opposite polarity, and between an uninsulated live part and a dead metal part that may be grounded when the transformer is installed shall not be less than those indicated in Table 24.1 for a compound-filled or exposed-core transformer, and not less than those indicated in Table 24.2 for an industrial control transformer. To simulate operating conditions, the spacings at wiring terminals shall be measured with field-installed conductors in place on all terminals. The wire size is to be the smallest size having an ampacity of at least 125 percent of the full-load current of the winding and sized in accordance with the requirements in 23.1.3 and Table 23.2.

Exception: These spacing requirements do not apply when insulation complying with 24.4 is provided.

Table 24.1
Minimum spacings at wiring terminals for compound-filled or exposed-core transformers

Potential involved,[a] volts	Through air, inch	Through air, (mm)	Over surface,[b] inch	Over surface,[b] (mm)
0 – 50	1/8	3.2	1/4	6.4
51 – 250	1/2	12.7	1/2	12.7
251 – 600	1	25.4	1	25.4

[a] The potential involved is to include consideration of voltages obtained in elevated voltage use of winding or windings if the transformer is marked in compliance with 43.3.2.
[b] Gaps less than 0.013 inch (0.33 mm) are to be disregarded (bridged) in determining over surface spacings.

Table 24.2
Minimum spacings at wiring terminals for industrial control transformers

Potential involved,[a] volts	Through air, inch	Through air, (mm)	Over surface,[b] inch	Over surface,[b] (mm)
0 – 50	1/8	3.2	1/4	6.4
51 – 150	1/4	6.4	1/2	6.4
151 – 300	1/4	6.4	3/8	9.5
301 – 600	3/8	9.5	1/2	12.7

[a] The potential involved is to include consideration of voltages obtained in elevated voltage use of winding or windings if the transformer is marked in compliance with 43.3.2.
[b] Gaps less than 0.013 inch (0.33 mm) are to be disregarded (bridged) in determining over surface spacings.

24.2 At points other than wiring terminals, the spacings between:

a) Uninsulated live parts of opposite polarity,

b) An uninsulated live part and a dead metal part, and

c) Different windings

shall not be less than those indicated in Table 24.3.

Exception No. 1: These spacing requirements do not apply between turns of the same winding.

Exception No. 2: If spacings within a transformer coil are reliably maintained by means such as varnishing or impregnation, the spacings may be in accordance with Table 24.4 or 24.5.

Exception No. 3: These spacing requirements do not apply between different windings if the sum of the open circuit voltages of the windings is 30 volts or less.

Exception No. 4: These spacing requirements do not apply if insulation complying with 24.4 is provided.

Table 24.3
Minimum spacings other than at wiring terminals

Potential involved,[a] volts	Through air, inch	Through air, (mm)	Over surface,[b] inch	Over surface,[b] (mm)
0 – 50	1/16	1.6	1/16	1.6
51 – 125	1/8	3.2	1/4	6.4
126 – 250	1/4	6.4	3/8	9.5
251 – 600	3/8	9.5	1/2	12.7

[a] The potential involved is to include consideration of voltages obtained in elevated voltage use of winding or windings if the transformer is marked in accordance with 43.3.2.
[b] Gaps less than 0.013 inch (0.33 mm) are to be disregarded (bridged) in determining over surface spacings.

Table 24.4
Minimum spacings within a transformer coil for transformers rated 250 VA or less

Potential involved,[a] volts	Through air, inch	Through air, (mm)	Over surface,[b] inch	Over surface,[b] (mm)
0 – 250	1/16	1.6	1/16	1.6
251 – 600	1/8	3.2	1/8	3.2

[a] The potential involved is to include consideration of voltages obtained in elevated voltage use of winding or windings if the transformer is marked in accordance with 43.3.2.
[b] Gaps less than 0.013 inch (0.33 mm) are to be disregarded (bridged) in determining over surface spacings.

Table 24.5
Minimum spacings within a transformer coil for transformers rated more than 250 VA

Potential involved,[a] volts	Through air, inch	Through air, (mm)	Over surface,[b] inch	Over surface,[b] (mm)
0 – 50	1/16	1.6	1/16	1.6
51 – 250	1/8	3.2	1/8	3.2
251 – 600	1/4	6.4	1/4	6.4

[a] The potential involved is to include consideration of voltages obtained in elevated voltage use of winding or windings if the transformer is marked in accordance with 43.3.2.
[b] Gaps less than 0.013 inch (0.33 mm) are to be disregarded (bridged) in determining over surface spacings.

24.3 With regard to Exception No. 2 to 24.2, if spacings within a transformer coil are in accordance with Table 24.4 or 24.5, the routine Production Line Dielectric Voltage-Withstand Test, Section 41, is to be conducted.

24.4 Insulating material used in lieu of the spacing requirements specified in 24.1 and 24.2 shall:

a) Be rated for the application,

b) Comply with Table 24.6,

c) Be resistant to moisture,

d) Be securely held in place, and

e) Be of equivalent mechanical strength to electrical grade paper if exposed or otherwise likely to be subjected to mechanical damage.

Exception: Insulating material used in lieu of spacings and located between different windings; between any winding and the core; between any crossover lead and a metallic enclosure; or between any crossover lead and the core may be:

a) Electrical grade paper that has been waxed or otherwise treated to make it resistant to moisture absorption and that has a minimum total thickness of 0.012 inch (0.30 mm), which may consist of more than one layer of paper;

b) A polymeric coil form not less than 0.025 inch (0.64 mm) thick; or

c) Material of any thickness with a minimum dielectric breakdown voltage of 2500 volts applied as described in 29.3.1.

Table 24.6
Insulation provided in lieu of spacings

Insulating material	Minimum thickness of insulating material, inch	(mm)	Minimum portion of specified spacing[a]	Minimum dielectric breakdown voltage[b]	Circuit potential, volts
electrical grade paper	0.028	0.71	–	–	–
electrical grade paper	0.013	0.33	1/2	–	–
electrical grade paper	0.010	0.25	–	–	0 – 50
any	any		1/2	2500	–
any	any		–	5000	–

[a] Spacing required if no insulating material is provided.
[b] Dielectric voltage withstand test is to be conducted in accordance with 29.3.1.

24.5 The coating on magnet wire shall not be relied upon as the sole insulating material specified in 24.4.

24.6 If, during the rated output heating test at rated current, the temperature rise on a coil is above the limit for Class 105 insulation (as specified in Table 28.1), the coil insulation of the transformer provided in accordance with 24.4 shall comply with the requirements in the Standard for Systems of Insulating Materials – General, UL 1446, for the temperature rating involved.

24.7 If a coil does not exceed the temperature rise specified in Table 28.1 for Class 105 insulation, coil insulating materials provided in accordance with 24.4, other than magnet wire insulation, shall have a relative electrical thermal index of 105°C (221°F) or higher. Electrical grade paper is considered to have a minimum relative thermal index of 105°C.

Exception: Insulating materials used as insulation in areas other than between separate windings and between any winding and the core need not have a minimum relative thermal index of 105°C.

24.8 The layer of insulating material between an input winding and an output winding in a flanged, bobbin-wound transformer in which the windings are wound one on top of the other, shall have a continuous minimum 1/32 inch (0.8 mm) bent-up edge against both of the bobbin end flanges.

Exception: Other constructions may be used if they maintain a 1/32 inch overlap between the insulating material and the bobbin between the windings.

PERFORMANCE

25 General

25.1 A representative sample of a transformer shall be subjected to the tests for voltage measurement, impedance, heating, dielectric voltage-withstand, overload, and dielectric voltage-withstand test repeated as described in Sections 26 – 31, in the order given.

25.2 When a transformer has its output rated in volt-amperes, the full-load secondary current is to be determined as follows:

a) For a single phase transformer:

$$Amperes = \frac{volt-amperes}{output\ \ volts}$$

b) For a three phase transformer:

$$Amperes = \frac{volt-amperes}{\sqrt{3}\ \text{x output volts}}$$

25.3 The weight of a transformer shall be determined. When the transformer weighs more than 100 pounds (45 kg), it shall be marked in accordance with 43.1.6.

26 Voltage Measurement Test

26.1 For purposes of comparison with voltages measured as described in 30.1 and 30.2, each secondary open-circuit voltage shall be measured with the primary connected to a rated voltage and frequency supply source.

27 Impedance Test

27.1 The percent impedance of a transformer rated 25 kVA or more shall be determined in accordance with the Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.91-1979. The marked value may be used if it is within ±10 percent of the determined value. The determined value shall be corrected to be the required insulation system temperature rise plus 20°C (68°F) as shown in item 8 of Table 28.1.

28 Heating Test

28.1 With the frame or enclosure grounded, a transformer is to be operated continuously at maximum rated primary voltage, rated frequency, and with the secondary delivering full load secondary current. The test is to be conducted until constant temperatures are attained. The temperature rise on or within a transformer shall not be greater than the values specified in Table 28.1. Additionally, there shall not be damage to any of the transformer materials.

Exception: The temperature rise on or within a transformer may be determined using methods specified in the Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.91-1979.

Table 28.1
Maximum temperature rises

Material or component			°C	(°F)
1. Field-wiring conductors or any surface that may be contacted by field wiring.			35[a]	63[a]
2. Pressure-terminal connectors for field-installed conductors other than as specified in item 3.			50	90
3. Pressure-terminal connectors used in circuits rated 110 amperes or less and marked for use with 75°C (167°F) wire or 90°C (194°F) wire.			65	117
4. Pressure terminals or wire connectors for internal wiring with aluminum conductors unless the conductor has been investigated for higher temperature.			50	90
5. Wire insulation or insulating tubing.			35[b]	63[b]
6. Fiber used as electrical insulation.			65	117
7. Any point on the exterior of the transformer enclosure than as specified in 28.4.			65	117
8. Coil winding by change-of-resistance method specified in 15.4 :				
Insulation system	Ambient	Hot spot[c] differential		
Enclosed transformers[b] :				
Class 105	25	10	70	126
Class 130	25	10	95	171
Class 155	25	15	115	207
Class 180	25	20	135	243
Class 200	25	25	150	270
Class 220	25	30	165	297
Industrial control transformers[d] :				
Class 105	40	10	55	99
Class 130	40	10	80	144
Class 155	40	15	100	180
Class 180	40	20	120	216

[a] The maximum temperature rise for 75°C (167°F) wire is 50°C (90°F) and for 90°C (194°F) wire is 65°C (117°F). See also 43.3.4.

[b] The maximum temperature rise for material that has been investigated and rated for a higher temperature is the temperature rating minus 25°C (45°F).

[c] The assumed difference between the average coil temperature determined by the change-of-resistance method and the hottest point somewhere within the coil.

[d] The maximum temperature rise for material that has been investigated and rated for a higher temperature is the temperature rating minus 40°C (72°F).

28.2 In the performance of the test mentioned in 28.1, the load is to consist of resistance. The load is to be adjusted until full load secondary current flows. After 2 minutes of operation, the load is to be readjusted, if necessary, to restore the current to full load value, but no further adjustment is to be made thereafter. Winding temperature rises (for determining the temperatures on the winding insulation) are to be measured by the resistance method.

28.3 To simulate field conditions for this test, copper conductors sized for 100 percent full load current based on a 75°C (167°F) ampacity are to be utilized for transformer connection.

Exception: Conductors may be sized on a basis of 60°C (140°F) ampacity if the transformer is marked in accordance with 43.3.4 (b) or (d).

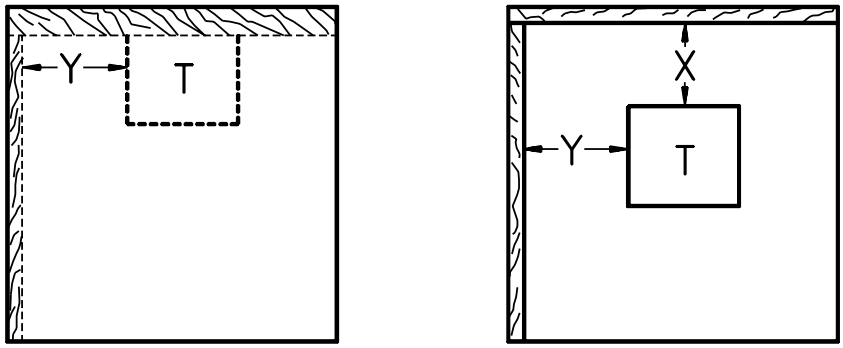
28.4 The temperature rise on the enclosure of a transformer intended for wall mounting shall not be greater than 80°C (144°F) during the heating test if:

a) The temperature test is conducted with the transformer mounted in an alcove as described in 28.5 and Figure 28.1,

b) The temperature rise at any point on the inner surfaces of the alcove is not greater than 65°C (117°F), and

c) The transformer is marked in accordance with 43.3.6.

Figure 28.1
Transformer test set-up



T is the transformer.

X is the minimum spacing between top of transformer enclosure and surface above transformer.

Y is the minimum spacing between hotter end of transformer and adjacent side wall. If the temperature of the right end of the transformer is higher than that of the left end, the side wall is to be to the right instead of to the left as shown.

28.5 The side wall and the top of the test alcove represented in Figure 28.1 are to be of 3/8-inch (9.5-mm) thick fir plywood, and the rear wall (on which the transformer is mounted) is to be of 3/4-inch (19.1-mm) thick plywood. The inner surfaces of the test alcove are to be painted dull black, and the transformer is to be mounted in the intended manner. The horizontal dimensions of the walls and top are to extend beyond the transformer at least 1 foot (305 mm).

29 Dielectric Voltage-Withstand Test

29.1 Applied potential

29.1.1 While hot from the Heating Test, Section 28, a transformer shall be subjected for 1 minute to the application of a potential between each winding and every other winding of the transformer and between each winding and metal of the core or enclosure. The applied potential shall be in accordance with Table 29.1. The terminal ends and taps of the winding under test are to be electrically connected to each other and to one output terminal of the testing transformer. All other terminals and parts (including core and enclosure) are to be connected to the other terminal of the testing transformer. There shall not be dielectric breakdown.

Exception No. 1: For a transformer provided with the marking described in 43.3.2, the applied potential shall be based on the voltage that any part of the winding may obtain when connected as marked. This potential shall be applied between each winding and metal of the core and enclosure and between each winding and every other winding that might not be involved in the connection.

Exception No. 2: When the core and/or coil are insulated so as not to be accessible, connection of the core to the testing transformer is not necessary.

Exception No. 3: A transformer marked as specified in 43.3.18 need not be subjected to the specified applied potential between windings that are intended to be connected in parallel or in series.

Table 29.1
Applied potential

Transformer type or size	Rated voltage of windings, volts	Applied test potential, rms volts
Signaling	25 or less	1050
	26 – 250	1500
250 VA or less	25 or less	1050
	26 – 250	1500
	251 – 600	2500
More than 250 VA	250 or less	2500
	251 – 600	4000

29.1.2 When the transformer has an extended winding, the rated voltage indicated in Table 29.1 is to include the voltage of the extended portion of the winding, even though both terminals of the extended portion are not available for external connection.

29.1.3 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.

29.2 Induced potential

29.2.1 While hot from the Heating Test, Section 28, a transformer shall be subjected to the application of an alternating potential, between the terminals of one winding, of twice the rated voltage of the winding with the ends of all other windings of the transformer open. A two or more winding transformer marked as described in 43.3.2 for autotransformer operation is to be additionally tested in this manner with the transformer connected for such autotransformer operation. A three-phase transformer may be tested with

a single-phase voltage. The specified test voltage is to be successively applied to each winding one at a time. The frequency of the applied potential is to be a minimum of twice the rated frequency of the transformer and is to be applied for 7200 cycles. There shall not be dielectric breakdown.

29.2.2 A transformer marked as specified in 43.3.18 shall also be subjected to the induced potential test with the series/parallel windings connected in series and then in parallel.

29.2.3 The test voltage specified in 29.2.1 is to be started at one-quarter or less of the full value and increased as described in 29.1.3 to full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced in the same manner within 5 seconds to one-quarter of the maximum value or less, and the circuit is to be opened.

29.3 Insulating barriers

29.3.1 With regard to 24.4, the insulating material is to be placed between two opposing electrodes. The electrodes are to be cylindrical brass or stainless steel rods 1/4 inch (6.4 mm) in diameter with edges rounded to a 1/32-inch (0.8-mm) radius. The upper moveable electrode is to weigh 50 ±2 grams to exert sufficient pressure on the specimen to provide electrical contact. The test potential is to be increased to the test value and the maximum test potential is to be maintained for 1 second. There shall not be dielectric breakdown.

30 Overload Test

30.1 A transformer, after being subjected to the test conditions described in 30.2, shall have a stabilized surface or core temperature recorded during the second 50 percent load operation of not more than 5°C (9°F) greater than the stabilized core temperature obtained during the initial 50-percent of load operation. The open-circuit output voltage determined following the final 50 percent load operation shall be within 2 percent of the output voltage measured during the Voltage Measurement Test, Section 26.

30.2 The transformer is to be operated as described in the Heating Test, Section 28, except that the load is to be 50 percent of the rated value, until core or (if encapsulated) surface temperatures become stabilized. The load is to be adjusted until 200 percent of the secondary current flows. After 2 minutes of operation, the load is to be readjusted, if necessary, to restore the current to 200 percent value, but no further adjustment is to be made thereafter. The duration of this overload is to be 1/2 hour. The load is then to be restored to the original 50 percent of rated value and held until the core temperature again stabilizes or until the temperature drops to within 5°C (9°F) of the original 50-percent load-current stabilized temperature, whichever occurs first. This temperature value is to be compared with the original 50-percent load stabilized condition, as specified in 30.1. The secondary load is then to be removed, and with the primary energized the secondary voltage(s) is to be measured and compared with the original output voltage measurements.

Exception: If the core of the transformer is not accessible for direct measurement of temperature, due to the type of construction of the transformer or for such reasons as encapsulation or filling with electrical insulating material, then the surface of the transformer enclosure is to be used. The portion of the enclosure surface used to measure this temperature is to be the hottest spot occurring in the 100-percent load heating test.

31 Dielectric Voltage-Withstand Test Repeated

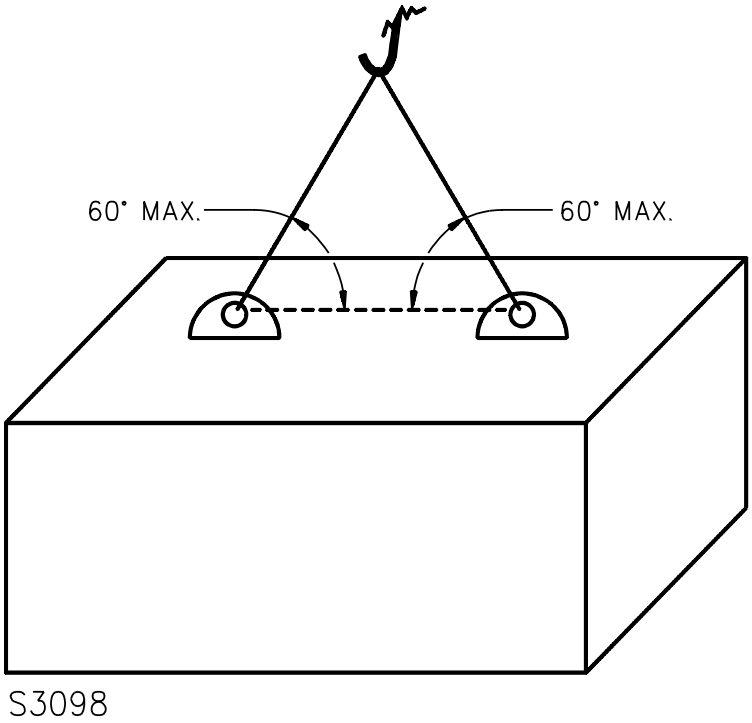
31.1 Following the Overload Test, Section 30, the transformer shall perform as intended in repeated dielectric voltage-withstand tests as described in this section, but with the test potential at 65 percent of the value originally specified.

32 Lifting or Mounting Means Test

32.1 The lifting means specified in 19.1 or the mounting means specified in 20.3.3 and the mounting means of each to the transformer are to be subjected to the direct application of a force (as specified in 32.3) equal to a minimum of four times the weight of the transformer (a force resulting from the weight of the transformer plus a force of three times the weight of the transformer).

32.2 When there is more than one hook, bracket, or hole of a type intended for use with a lifting cable, the test is to be conducted with the cable arranged so that the load will be equally divided and the cable under load will be at an angle of 60 degrees maximum from the horizontal plane. A spreader bar is not to be used with the cable. A typical test set-up is shown in Figure 32.1.

Figure 32.1
Lifting and mounting means test configuration



32.3 The force is to be gradually applied between the hole, hook, or bracket and that part of the transformer to which it is secured (by any convenient means) and is to be maintained for 5 minutes. For convenience in testing, the sample used for this test may consist of only the portion of the enclosure containing the lifting or mounting means and that part of the transformer to which it is secured. There shall not be breakage of the lifting or mounting means.

33 Compression Test

33.1 With regard to 20.4.3 (c), an enclosure shall comply with the compression test described in 33.2.

33.2 An outside force of 100 pounds (444 N) is to be directed toward the inside of the transformer on each of the five surfaces of the assembled transformer enclosure. (The transformer core and coil need not be installed in the enclosure during this test unless the core and coil are necessary to maintain the structural strength of the finished transformer.) The force is to be applied gradually at 90 ±5 degrees to each of the thinner metal surfaces in any area that is most likely to cause the greatest deflection. The force is to be transmitted through a rod having a flat steel face with a 1/2-inch- (12.7-mm-) square contact area at the transformer surface. There shall not be inward deflection greater than 1/2 inch.

34 Metallic Coating Thickness Test

34.1 The method of determining the thickness of the zinc or cadmium coating specified in 21.1 and 21.2 is described in 34.2 – 34.9. The aforementioned applies only if the required thickness is specified.

34.2 The solution to be used for the metallic coating thickness test is to be made from distilled water and is to contain 200 grams per liter of reagent grade chromic acid (CrO_3) and 50 grams per liter of reagent grade concentrated sulfuric acid (H_2 SO_4). (The latter is equivalent to 27 milliliters per liter of reagent grade concentrated sulfuric acid, specific gravity 1.84, containing 96 percent H_2 SO_4.)

34.3 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.05 milliliter each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

34.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which is to be noted and recorded. The test is to be conducted at a room temperature of 21 – 32°C (70 – 90°F).

34.5 Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of solvents. Samples are then to be thoroughly rinsed in water and dried with clean cheesecloth. Care should be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

34.6 The sample to be tested is to be supported from 0.7 to 1 inch (17 to 25 mm) below the orifice so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined about 45 degrees from the horizontal.

34.7 After cleaning, the sample to be tested is to be put in place under the orifice. The stopcock is to be opened and the time in seconds is to be measured with a stop watch until the dropping solution dissolves the protective metal coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

34.8 Each sample of a test lot is to be subjected to the test at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface, at places where the metal coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation are likely to have thin coatings.

34.9 To calculate the thickness of the coating being tested, select from Table 34.1 the thickness factor appropriate for the temperature at which the test was conducted, and multiply by the time in seconds required to expose base metal as noted in 34.7.

Table 34.1
Coating thickness factors

Temperature,		Thickness factors, 0.00001 inch (0.00025 mm) per second	
°F	(°C)	Cadmium platings	Zinc platings
70	21.1	1.331	0.980
71	21.7	1.340	0.990
72	22.2	1.352	1.000
73	22.8	1.362	1.010
74	23.3	1.372	1.015
75	23.9	1.383	1.025
76	24.4	1.395	1.033
77	25.0	1.405	1.042
78	25.6	1.416	1.050
79	26.1	1.427	1.060
80	26.7	1.438	1.070
81	27.2	1.450	1.080
82	27.8	1.460	1.085
83	28.3	1.470	1.095
84	28.9	1.480	1.100
85	29.4	1.490	1.110
86	30.0	1.501	1.120
87	30.6	1.513	1.130
88	31.1	1.524	1.141
89	31.7	1.534	1.150
90	32.2	1.546	1.160

35 Drip Test

35.1 An enclosure marked ″Type 2 Enclosure″ is to be subjected to the test specified in 35.2. There shall not be significant accumulation of water within the enclosure and water shall not enter the enclosure at a level higher than the lowest live part.

Exception: Water may enter the enclosure above a live part if:

a) No water is visible on live parts or insulating material and

b) No wiring is present above live parts within the enclosure space.

35.2 The enclosure is to be mounted beneath a drip pan that produces both splashing and dripping and extends beyond all exposed sides of the enclosure. The bottom of the drip pan is to be equipped with uniformly distributed spouts, one spout for each 20 square inches (129 cm^2) of pan area. Each spout is to drip water at a rate of approximately 20 drops per minute. The enclosure is to be subjected to continuous dripping water for 30 minutes.

36 Icing Test

36.1 An enclosure that is marked ″Type 3R Enclosure″ and has external cavities that can trap water shall be subjected to the test specified in 36.2. The enclosure shall not be damaged after the ice has melted.

36.2 The enclosure is to be mounted in a room that can be cooled to minus 6.7°C (20°F). A metal test bar, 1 inch (25.4 mm) in diameter and 2 feet (610 mm) long, is to be mounted in a horizontal position in a location where it will receive the same water spray as the enclosure being tested. Provision is to be made for spraying the entire enclosure from above with water at an angle of approximately 45 degrees from the vertical. The water is to be at a temperature of 0 – 2.8°C (32 – 37°F). Spraying facilities are to provide 1 – 2 gallons (3.8 – 7.6 l) per hour per square foot (928 cm^2) of spraying area. The room temperature is to be lowered to 35°F (1.7°C). The spray of water is to be started and continued for at least 1 hour, maintaining the room temperature at 0.56 – 2.8°C (33 – 37°F). The room temperature is then to be lowered to minus 6.7 – minus 2.8°C (20 – 27°F) while continuing the water spray. The rate of change in the room temperature is not considered to be critical and is to be whatever is obtainable with the cooling method used. The water spray is to be controlled to cause ice to build up on the bar at a rate of approximately 1/4 inch (6.4 mm) per hour and is to be continued until 3/4 inch (19.1 mm) of ice has formed on the top surface of the bar. The spray is then to be discontinued, but the room temperature is to be maintained at minus 6.7 – minus 2.8°C for 3 hours so that all parts of the enclosure and the ice coating have reached the same temperature.

37 Rust Resistance Test

37.1 At the conclusion of the test specified in 37.2, an enclosure marked ″Type 1 Enclosure″ or ″Type 2 Enclosure″ shall not show signs of rust (other than at those points such as machined and mating surfaces of cast enclosures, sliding surfaces or hinges, and other points where corrosion protection is impractical).

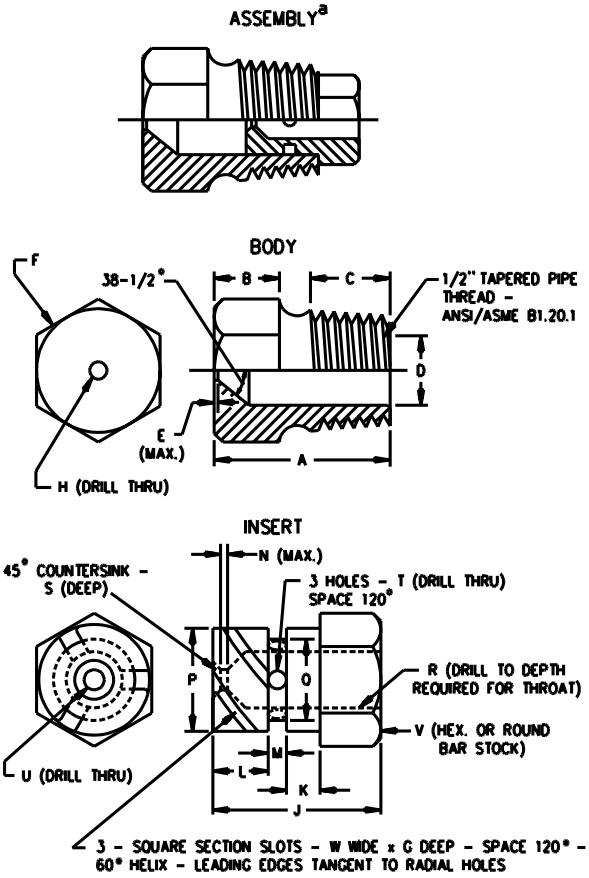
37.2 The enclosure or representative parts of the enclosure are to be subjected to a salt spray (fog) for 24 hours using the test method in Salt Spray (Fog) Testing, ASTM B117-1985, using a 5 percent by weight salt solution. At the end of the test, the specimens are to be removed from the chamber, washed in clean running water not warmer than 37.8°C (100°F) to remove salt deposits from the surface, and dried immediately. Products of corrosion may be removed by light brushing if required to observe corrosion of the underlying surface.

38 Water Spray Test

38.1 To determine compliance with 20.4.14, the enclosure shall be subjected to the water spray test described in 38.2. There shall not be entrance of water above the lowest terminal or other live part within the enclosure.

38.2 The device is to be set up as in normal installation with conduit connections (without pipe compound) if so intended. The device is to be positioned in the focal area of the three spray heads where the greatest quantity of water is likely to enter the device. The water pressure is to be maintained at 5 pounds per square inch (34 kPa) at each spray head. The device is to be exposed to the water spray for 1 hour. Figures 38.1 and 38.2 illustrate the spray head piping and nozzle construction.

Figure 38.1
Water spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

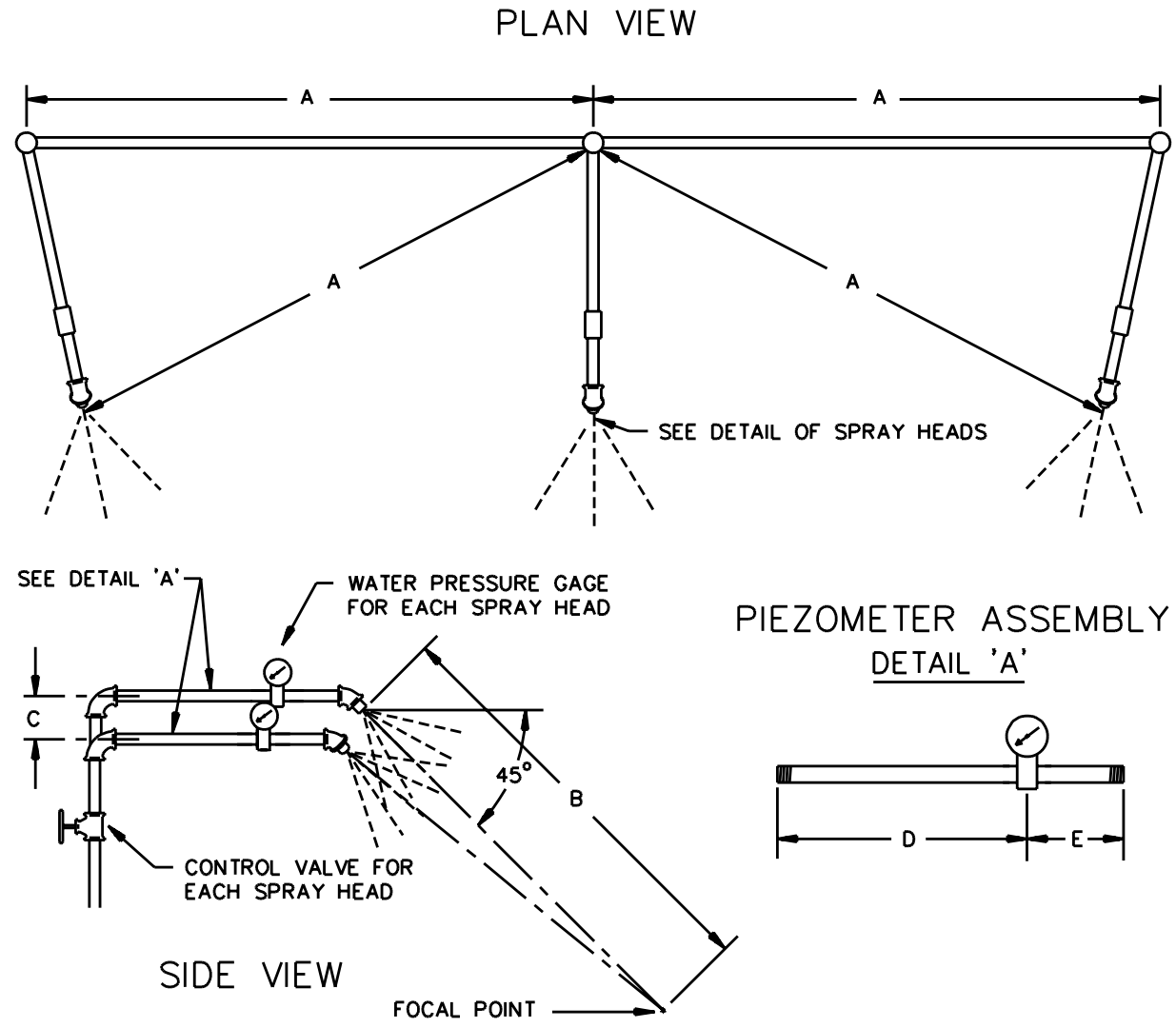
[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

RT100E

Figure 38.2
Water spray head piping



Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101E

39 Strain Relief Test

39.1 In accordance with 8.4, if an epoxy- or polyester-type compound is used as the sole means of strain relief, a force of 10 pounds (45 N) is to be applied to the lead for 1 minute in any direction permitted by the construction. There shall not be indication of stress on the connections inside the transformer.

40 Accelerated Aging of Gaskets Test

40.1 Samples of a gasket as described in 20.4.15 shall be subjected to a uniform temperature at least 10°C (18°F) higher than the maximum temperature of the material measured during the Heating Test, Section 28, but not less than 70°C (158°F) in any case, in circulating air for 168 hours. The aged gasket samples shall have a tensile strength of not less than 60 percent and an elongation of not less than 75 percent of values determined for unaged samples.

MANUFACTURING AND PRODUCTION TEST

41 Production Line Dielectric Voltage-Withstand Test

41.1 In accordance with 24.3, as a routine production line test, a transformer with the spacings described in Exception No. 2 to 24.2 shall be subjected to the application of a potential at a frequency within the range of 40 – 70 hertz. The potential is to be applied:

a) Between each winding and every other winding of the transformer to which it is not conductively connected and

b) Between each winding and metal of the core and the enclosure.

The terminal ends and taps of the winding under test are to be electrically connected to each other and to one output terminal of the testing transformer. All other terminals and parts (including core and enclosure) are to be connected to the other terminal of the testing transformer. There shall not be dielectric breakdown.

Exception No. 1: For a transformer provided with the marking described in 43.3.2, the applied potential between each winding and metal of the core and the enclosure and between each winding and every other winding that might not be involved in the connection is to be based on the maximum voltage any part of the winding may attain when connected as so marked.

Exception No. 2: When the core and the coil are electrically insulated so as not to be accessible, connection of the core to the testing transformer is not necessary.

41.2 The applied potential during the test is to be as specified in Table 29.1. If the test time is to be 1 second instead of 1 minute, the applied potential is to be equal to the required value in Table 29.1 plus an additional 20 percent of the value.

41.3 If the transformer has an extended winding, the ″rated voltage″ specified in Table 29.1 is to include the voltage of the extended portion of the winding, even though both terminals of the extended portion are not available for external connection.

41.4 The transformer may be in a heated or unheated condition during the test.

41.5 The test is to be conducted when the transformer is fully assembled. It is not intended that the unit be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover or a friction fit knob that would interfere with conducting the test need not be in place.

Exception No. 2: The test may be conducted before final assembly if the test represents that for the completed transformer.

41.6 The test equipment is to include a transformer having:

a) An essentially sinusoidal output,

b) A means of indicating the test potential,

c) An audible or visible indicator of dielectric breakdown, and

d) Either a manual-reset device to restore the equipment after dielectric breakdown or an automatic-reject feature activated by any unit not in compliance with the requirements.

41.7 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment is to include a voltmeter in the output circuit to directly indicate the test potential.

41.8 If the output of the test equipment transformer is 500 volt-amperes or more, the test potential may be indicated by:

a) A voltmeter in the primary circuit or in a tertiary winding circuit;

b) A selector switch marked to indicate the test potential; or,

c) In the case of equipment having a single test potential output, a marking in a visible location to indicate the test potential.

When a marking is used without an indicating voltmeter, the equipment is to include a positive means, such as an indicator lamp, to indicate that the manually-reset switch has been reset following a dielectric breakdown.

RATINGS

42 Details

42.1 The electrical ratings of a transformer shall include:

a) The primary voltage, or voltages, and frequency;

b) Number of phases;

c) All secondary voltages; and

d) The secondary capacity in amperes or volt-amperes.

The secondary capacity in amperes and the elevated voltage limit (maximum voltage to ground) of the winding shall be included for a transformer rated for elevated voltage use.

MARKINGS

43 Details

43.1 General

43.1.1 Markings shall be located as shown in Table 43.1. Markings that are specified to be located on a separate instruction sheet may be located on a transformer if either readily visible after installation or visible during installation and beneath a removable cover. Markings that are specified to be located on the transformer so as to be visible during installation and beneath a cover may be located to be readily visible after installation.

Table 43.1
Location of required markings

Marking	Reference in standard	Marking readily visible after installation with cover closed	Marking visible before installation with cover removed	Marking on separate instruction sheet
Identification	43.1.2 – 43.1.4,	X		
	43.1.5			X
Environmental condition enclosures	43.2.1, 43.2.2	X		
	43.2.3[a]	X		X
	43.2.4, 43.2.5		X	
Wiring	43.3.1 – 43.3.4, 43.3.7,			
	43.3.8	X		
	43.3.9 – 43.3.13, 43.3.15		X	
	43.3.5, 43.3.6, 43.3.16	X		
	43.3.14, 43.3.17, 43.3.18			X

[a] The hood identification markings specified in 43.2.3 shall be readily visible on the hood after installation. Instructions for installing the hood may be provided on a separate instruction sheet.

43.1.2 A transformer shall have a plain legible marking that includes:

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. When a code is used, it shall enable the transformer to be identified as being manufactured within a 3-month period.

43.1.3 With regard to Table 28.1, a transformer shall be marked with a temperature class that is less than or equal to the rating of the insulation system used.

43.1.4 An autotransformer shall be marked to indicate that it is such.

43.1.5 A distribution-system transformer shall be provided with a wiring diagram.

43.1.6 A transformer weighing more than 100 pounds (45 kg) shall be marked with its weight in pounds (kg).

43.1.7 A transformer shall be marked with the percent impedance.

Exception: This requirement does not apply to transformers rated less than 25 kVA.

43.2 Environmental condition enclosures

43.2.1 As specified in 20.4.1, a transformer shall be marked with the environmental type number or numbers described in Table 20.1 and with the application for which it has been investigated (such as ″Type 3R Enclosure″). The marking shall be an integral part of the manufacturer's marking containing the manufacturer's name or trademark unless it is an integral part of other required markings.

43.2.2 A transformer that is intended to be rainproof if used with a field-installed hood shall be marked with the following or the equivalent: ″Rainproof-Type 3R Enclosure when provided with hood catalog No. ____. ″

43.2.3 The hood described in 43.2.2 shall be marked with the manufacturer's name and the following or the equivalent: ″Rainproof hood catalog No. ____ for Type ____ transformer. ″ Instructions for installing the hood shall be provided with the hood.

43.2.4 A transformer marked ″Type 3R Enclosure ″ or the equivalent shall be marked to indicate that, after determining its mounting position, any holes drilled during field installation shall be located at the lowest point of the enclosure.

43.2.5 If a hub or a fitting is not provided or installed on a Type 2 or Type 3R enclosure, instructions identifying the proper hub or fitting and the installation instructions shall be provided with the enclosure.

Exception: Instructions are not necessary if knockouts are not provided and the transformer is marked to indicate that connections should be made below the lowest live part.

43.3 Wiring

43.3.1 One of the secondary terminals or leads of an autotransformer intended for operation on a circuit of 150 volts or less to ground shall be identified for the connection of a grounded circuit conductor and shall be directly connected to a similarly identified primary terminal or lead. A terminal for the connection of a grounded conductor shall be identified by means of a metallic-plated coating substantially white in color and shall be readily distinguishable from the other terminals. If wire leads are provided and serve instead of terminals for the transformer, the identified lead shall have a white or natural gray color and shall be readily distinguishable from the other leads.

43.3.2 A transformer intended for elevated voltage use shall be marked to indicate that one or more windings may be operated at an elevated voltage, in either an isolated or autotransformer mode, as appropriate. Such marking shall include the limit of the elevated voltage, the current (ampere) limits for each winding, and reference to the location of additional connection details. This reference shall be worded with the following or the equivalent: ″For additional connections and data, see instruction No.____. ″ The manufacturer shall make additional information available, including typical connection diagrams and methods of relating winding current to total load kVA. Elevated voltage is that situation in which voltages between a winding (including its subordinate parts such as terminals) and other conductive parts of the transformer exceed the voltage of the winding(s).

43.3.3 The voltage rating of each tap from any winding shall be identified. If the tap is not rated for the full kVA rating of the coil, the tap kVA rating shall be indicated.

43.3.4 If, during the temperature test, the temperature on a field-installed conductor or on any part of the wiring compartment that the conductor might contact is more than 60°C (140°F), the transformer shall be marked with one of the statements indicated in (a) – (d) or the equivalent, at or near the points where field connections will be made. The statement to be used, or its equivalent, shall be selected in accordance with Table 43.2.

a) ″For field connections, use wires insulated for a minimum of 75°C. ″

b) ″For field connections, use wires insulated for a minimum of 75°C and sized on the basis of 60°C ampacity. ″

c) ″For field connections, use wires insulated for a minimum of 90°C and sized on the basis of 75°C ampacity. ″

d) ″For field connection, use wires insulated for a minimum of 90°C and sized on the basis of 60°C ampacity. ″

Table 43.2
Wiring compartment marking

Temperature attained during test				Value to be used in marking in 43.3.4	
Higher than		But not higher than			
°C	(°F)	°C	(°F)	°C	(°F)
60	140	75	167	75	167
75	167	90	194	90	194

43.3.5 If the temperature rise on a transformer enclosure is more than 65°C (117°F), the transformer shall be clearly marked to indicate the minimum separations (the distance X and Y in Figure 28.1) between the enclosure and the adjacent surfaces necessary to prevent attainment of temperatures of more than 90°C (194°F) on the adjacent surfaces.

43.3.6 If, during the temperature test, the temperature rise on every component is at least 15°C (27°F) less than the maximum shown in Table 28.1, the transformer may be marked as rated for use in a maximum 40°C (104°F) ambient.

43.3.7 When the pressure terminal connectors, the wire-bending space, or the wiring space of a transformer are not intended for accommodating aluminum wire, the transformer shall be marked, at or adjacent to the terminals, with the following statement or the equivalent: ″Use copper wire only,″ ″CU only.″ This marking may be combined with that specified in 43.3.4.

43.3.8 When the pressure terminal connectors, the wire-bending space, and the wiring space of a transformer are intended for accommodating both copper and aluminum wire, and if the manufacturer intends such use, the transformer shall be marked (independent of any marking of the terminals) with the following statement or the equivalent: ″Use aluminum or copper wire,″ ″AL-CU.″ This marking may be combined with that specified in 43.3.4.

43.3.9 A transformer constructed as described in footnote (b) to Table 23.3 and footnote (a) to Table 23.5 shall be marked by means of a diagram that specifies the method of wiring that shall be used to accomplish the 90 degree bend.

43.3.10 A transformer that is provided with connectors suitable for use with conductors sized at 250 percent of the rated current of the transformer in accordance with 23.5.2 shall be marked: ″Suitable for Use with Wire Sized at 250 Percent of Rated Current. ″

43.3.11 If more than one connector is provided at a single connection point in accordance with 23.5.4, each connector shall be identified as to the wire size or range of wire sizes for which it is intended.

43.3.12 If a wire terminal has been investigated for securing more than one conductor in an opening and is intended for such use, a marking indicating the number of conductors shall be provided. The marking shall be on the wire connector if visible, or in another visible location, such as next to the terminal or on a wiring diagram.

43.3.13 If a pressure terminal connector is provided for a field-installed conductor that requires the use of a special tool for securing the conductor, any necessary instructions for using the tool shall be provided. The instructions shall be included in a readily visible location such as on the connector, on a wiring diagram, or on a tag secured to the connector.

43.3.14 If it is necessary to provide a corrosion-inhibiting compound in accordance with the Exceptions No. 1 and No. 2 to 22.2, instructions for applying the compound shall be provided.

43.3.15 A transformer intended for a connection that requires a wiring space extension assembly as described in 23.6.2 shall be marked with instructions for determining the catalog number of the assembly.

43.3.16 A wiring space extension assembly as described in 23.6.2 shall be marked with its catalog number and with the manufacturer's identification.

43.3.17 A transformer that is provided with jumpers or equivalent means for making field connections in accordance with 23.7.6 shall be marked to identify how the jumpers or equivalent means are to be connected for parallel operation and series operation of the transformer.

43.3.18 A transformer that has two or more windings that are only intended to be connected in a series or parallel configuration and that was not subjected to the applied potential dielectric voltage-withstand test between the series/parallel windings in accordance with Exception No. 3 to 29.1.1 shall:

a) Be marked to identify the windings that are intended to be series or parallel connected and

b) Be marked with the following or the equivalent: ″Windings ____ and ____ are not reliably isolated from each other and should be connected in either a parallel or series configuration. ″ The blanks shall be filled in with the series/parallel winding identifying marking.

GAS-TUBE-SIGN TRANSFORMERS

GENERAL

44 Details

44 deleted effective November 1, 2002

CONSTRUCTION

45 General

45 deleted effective November 1, 2002

46 Enclosure

46 deleted effective November 1, 2002

47 Insulating Materials

47 deleted effective November 1, 2002

48 Connections

48 deleted effective November 1, 2002

49 Spacings

49 deleted effective November 1, 2002

50 Guarding of Live Parts and Grounding

50 deleted effective November 1, 2002

51 Capacitors

51 deleted effective November 1, 2002

PERFORMANCE

52 General

52 deleted effective November 1, 2002

53 Open-Circuit Secondary Voltage Test

53 deleted effective November 1, 2002

54 Input Test

54 deleted effective November 1, 2002

55 Heating Test

55 deleted effective November 1, 2002

56 Short-Circuit Secondary Current Test

56 deleted effective November 1, 2002

57 Dielectric Voltage-Withstand Test

57 deleted effective November 1, 2002

58 Burnout Test

58 deleted effective November 1, 2002

59 Open-Circuit Secondary Operation Test

59 deleted effective November 1, 2002

60 Switch Tests

60 deleted effective November 1, 2002

TEST BY THE MANUFACTURER

61 Production Line Grounding Continuity Test

61 deleted effective November 1, 2002

RATINGS

62 Details

62 deleted effective November 1, 2002

MARKINGS

63 Details

63 deleted effective November 1, 2002

IGNITION TRANSFORMERS

GENERAL

64 Details

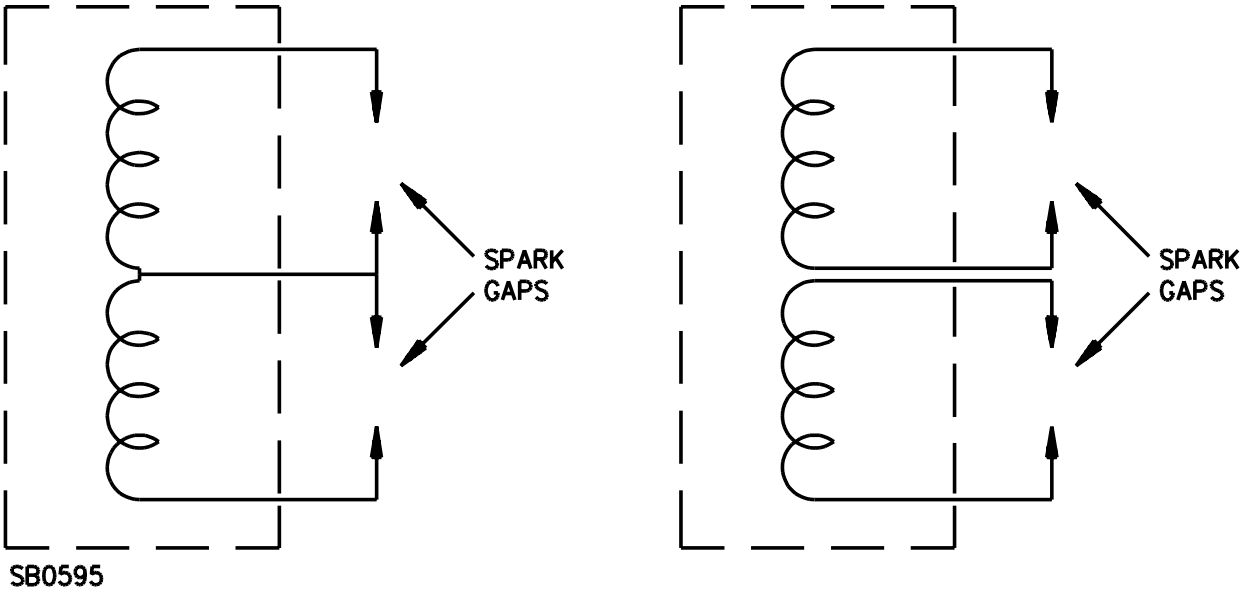
64.1 An ignition transformer is a step-up transformer of the high-secondary-voltage type, intended to provide ignition for an oil or gas burner.

64.2 The requirements for ignition transformers specified in 64.3 – 80.4 shall be considered in addition to those specified in Sections 1 – 17.

64.3 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.

64.4 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 64.1. 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 64.1. A dual-gap transformer is a multiple-gap transformer intended for use with an ignition system using two spark gaps.

Figure 64.1
Schematic diagrams of twin-gap (left) and multiple-gap (right) transformers (secondary circuits only)



CONSTRUCTION

65 General

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

65.2 A transformer intended to be supported by rigid metal conduit shall comply with the requirements in 5.10.

65.3 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.

66 Enclosure

66.1 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.

66.2 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.

66.3 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.

66.4 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.

66.5 The enclosure shall be provided with means for mounting.

66.6 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.

66.7 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 66.1. 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 66.1
Minimum volume per conductor

Conductor size, AWG	Conductor size, (mm^2)	Minimum free space within box for each conductor, $inches^3$	Minimum free space within box for each conductor, (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

66.8 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.

66.9 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 73.6.

67 Primary Connections

67.1 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 No. 18 AWG (0.82 mm^2).

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

67.3 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:

a) Separate holes or a single hole in the enclosure.

b) A conduit hub, a flexible-steel-conduit, armored-cable, or an electrical-metallic-tubing connector.

c) Separate insulating bushings or a single insulating bushing.

d) Separate holes or a single hole in a fiber plate that complies with the requirements in 10.3.

67.4 A lead that enters the transformer by one of the means described in 67.3 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:

a) 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

b) The free end of the lead terminates in an eyelet, a lug, or the like.

67.5 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).

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

67.7 The terminal plate and the wire-binding screw or stud and nut of a primary 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 cadmium or zinc may be used.

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

67.9 A wire-binding screw or stud at a wiring terminal 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).

67.10 Upturned lugs, cupped washers, or equivalent means shall be provided at wiring terminals to retain wires under the heads of screws or under nuts.

67.11 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 (such as by the use of a screw having a square- or hexagonal-shaped head cooperating with a correspondingly shaped recess).

67.12 The requirement in 67.11 applies to the turning of a terminal stud in an insulator in which it may be mounted, as well as to the turning of the insulator with regard to the transformer enclosure. Generally, sealing or insulating compound is not to be used as a means to restrict turning of a fixed terminal part unless the size or shape, or both, of the part surrounded by the compound is such that it is obvious that the terminal will be held in position.

67.13 The use of an unconventional form of wiring terminal, such as one that uses a plug and jack or a spring clip, shall be investigated.

68 Secondary Terminals

68.1 Secondary wiring terminals shall be constructed as specified in 67.6 – 67.13 for primary wiring terminals, but they may be made of iron or steel that is plated for protection against corrosion.

68.2 Wire leads shall not be provided in place of secondary wiring terminals.

69 Spacings

69.1 The spacings between uninsulated live primary parts of opposite polarity and between an uninsulated live primary part and a dead metal part shall not be less than indicated in Table 69.1.

Table 69.1
Minimum spacings involving live primary parts

Transformer primary rating, volts	Spacing through air and over surface between metal parts and dead metal parts,		Spacing between metal parts of opposite polarity			
			Through air,		Over surface,	
	inch	(mm)	inch	(mm)	inch	(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

69.2 The spacings between uninsulated live secondary parts of opposite polarity and between an ungrounded, uninsulated live secondary part and a dead metal part shall not be less than indicated in Table 69.2.

Table 69.2
Minimum spacings involving live secondary parts

Transformer secondary voltage rating, volts	Through air,		Over surface,	
	inch	(mm)	inch	(mm)
0 – 5,000	1/2	12.7	3/4	19.1
5,001 – 10,000	7/8	22.2	1-1/4	31.8
10,001 – 12,000	1-1/8	28.6	1-1/2	38.1
12,001 – 15,000	1-1/2	38.1	2	50.8

69.3 With reference to the requirements specified in 69.1 and 69.2, in a transformer having a grounded secondary winding, the spacing between an ungrounded secondary part and a dead metal part is to be evaluated on the basis of the maximum voltage between that secondary part and ground, with the other ungrounded secondary parts either open-circuited or grounded. No spacing is required between a grounded secondary part and a dead metal part.

69.4 The requirements specified in 69.1 and 69.2 apply to uninsulated parts of a terminal mounted on an insulator.

70 Grounding

70.1 An ignition transformer shall have the enclosure bonded to the core. A transformer of the secondary-grounded type shall have the grounded point of the secondary winding bonded to the core and to the enclosure.

71 Capacitors

71.1 A capacitor supplied as a part of an ignition transformer not provided in the primary circuit shall be investigated.

71.2 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 sheet steel having an uncoated thickness of 0.020 inch (0.51 mm) and shall be treated in a manner to exclude moisture.

71.3 A capacitor shall have a voltage rating of not less than the voltage to which it is subjected during intended operation of the transformer.

PERFORMANCE

72 General

72.1 To determine if an ignition transformer complies with the tests for the open-circuit secondary voltage, input, interchangeability (if of an interchangeable type), heating, dielectric voltage-withstand, and short-circuit operation, a representative sample is to be subjected to the tests described in 72.2 – 78.2, in the order given.

72.2 The enclosure of the transformer is to be grounded during all the tests specified in 72.1.

72.3 A capacitor is not to be disconnected during any of the tests, other than during the Dielectric Voltage-Withstand Test, Section 77.

72.4 A capacitor that becomes short-circuited or breaks down to the enclosure as a result of any of the tests specified in 72.1 is not to be used.

73 Open-Circuit Secondary Voltage Test

73.1 The open-circuit secondary voltage shall not be more than 110 percent of the rated open-circuit secondary voltage and shall in no case be more than 16,000 volts. The peak open-circuit secondary voltage shall not be greater than the value indicated in Table 73.1.

Table 73.1
Maximum peak open-circuit secondary voltage

Rated open-circuit secondary voltage, volts	Maximum peak open-circuit secondary voltage, volts
5,000 or less	7,800
5,001 – 10,000	15,600
10,001 – 15,000	22,600

73.2 The open-circuit secondary voltage of an interchangeable transformer shall not be less than the value indicated in Table 73.2, in accordance with the class of the transformer in question.

Table 73.2
Minimum open-circuit secondary voltage

Class of transformer	Minimum voltage, volts
6	5,700
10	9,200
12	11,000
14	14,000

73.3 To determine if a transformer complies with the requirements in 73.1 and 73.2, maximum rated primary voltage is to be applied to the primary winding and the rms and peak open-circuit secondary voltages are to be measured. The voltage applied to the primary is to have a deviation factor of not more than 1 percent.

73.4 For other than a twin-gap transformer, an ignition transformer having a midpoint-grounded secondary winding shall be such that, with one end of a secondary winding connected to ground, the voltage between ground and the other end of that winding is reduced to such a value that no spark will occur between blunt-nosed electrodes spaced 1/32 inch (0.8 mm) apart with the primary connected to a circuit of rated voltage and frequency.

73.5 When a transformer of the type specified in 73.4 has more than one secondary winding, the performance of each secondary winding shall comply with the requirement in that paragraph while the remaining secondary windings are arcing or open-circuited. If the transformer has more than one primary winding, the performance of each secondary winding shall comply with the requirement in 73.4 when the primary windings, other than that supplying energy to the secondary under test, are opened, one by one, in succession.

73.6 To determine if a transformer complies with the requirement in 66.9, the transformer is to be tested as follows. With the primary winding (or all primary windings, if there are more than one) energized, the voltage of one open-circuited secondary winding is to be measured with each other secondary winding, in turn, short-circuited while the remaining secondary windings are open-circuited. This procedure is to be repeated until the open-circuit secondary voltage of each winding has been measured. Then, for a multiple-primary transformer, the open-circuit voltages of all secondary windings are to be measured while each primary, in turn, is open-circuited while the remaining primary windings remain energized.

74 Input Test

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

74.2 The primary current under conditions of full rated secondary load is to be considered 80 percent of the primary current measured when the secondary terminals are short-circuited.

75 Interchangeability Test

75.1 If a transformer is to be considered interchangeable, the short-circuit secondary current shall not be less than the value indicated in Table 75.1 when the primary is connected to a circuit of minimum rated primary voltage and rated frequency. The spark-gap current shall not be less than the value indicated in the table when the transformer is tested as described in 75.2.

Table 75.1
Minimum short-circuit secondary and spark gap currents

Class of transformer	Secondary short circuit current at minimum rated primary voltage, milliamperes	Electrode gap spacing, inch	(mm)	Secondary spark gap current at 70 percent of minimum rated primary voltage, milliamperes
6	18.7	–	–	–
10	19.5	1/8	3.2	11.5
12	18.0	3/16	4.8	9.4
14	17.5	3/16	4.8	8.7

75.2 In a test to determine if a transformer complies with the requirement specified in 75.1, the primary is to be connected to a circuit of rated frequency and of a voltage equal to 70 percent of minimum rated primary voltage of the transformer. The secondary terminals are to be connected to a set of electrodes, mounted horizontally at diametrically opposite points in a 10-foot (3.0-m) length of 4-inch (102-mm) conduit, with a gap spacing as indicated in Table 75.1. The electrodes are to be of 1/16 inch (1.6 mm) diameter steel rod with blunt points, porcelain-insulated, and adjustable. The electrodes are to be mounted near one end of the conduit and a power blower is to be at the other end to establish an air velocity of 50 feet (15.2 m) per second in the tube as measured by a differential Pitot tube mounted so that its orifice is spaced 3 inches (76.2 mm) from the arc gap, or by equivalent measuring means. The orifice is to be placed between the spark gap and the open end of the conduit. The spark-gap current is to be measured by means of an ammeter.

75.3 In the case of a multiple-gap transformer, the additional procedure to be followed in the performance of the tests described in 75.2 is as follows. A separate blower tube (and associated equipment) as described in 75.2, is to be used for each secondary winding. The primary windings are to be energized individually and in succession. When a primary is energized, the performance of the secondary winding associated with that primary is to comply with the requirements specified in 75.1. The test is then to be repeated with all primary windings energized concurrently and each secondary winding under this condition is also to comply with the requirements specified in 75.1.

76 Heating Test

76.1 A Class 6 interchangeable transformer and a noninterchangeable transformer having a secondary voltage rating of 6000 volts or less and not specifically intended for operation in an air blast, is to be operated continuously for 24 hours at maximum rated primary voltage and rated frequency, when delivering secondary current to a spark-gap load as described in 76.2. Following the test:

a) The temperature on or within the transformer shall not be such as to adversely affect any of the material used in its construction;

b) There shall not be mechanical or electrical malfunction of the device;

c) There shall not be emission of flame or molten material; and

d) The temperature rise at any point on the enclosure shall not be greater than 65°C (117°F).

76.2 In a test to determine if a transformer complies with the requirement specified in 76.1, the secondary load is to consist of a spark gap adjusted to give maximum continuous arcing. The electrodes of the spark gap are to consist of 1/16-inch (1.6-mm) diameter steel rods having blunt points that are porcelain-insulated and adjustable. In the case of a twin-gap and a multiple-gap transformer, a spark gap is to be connected to represent each spark gap that normally would be connected to the transformer in service and all spark gaps are to arc simultaneously. The enclosure of the transformer is to be solidly grounded during the test.

76.3 A Class 10, 12, or 14 interchangeable transformer, a noninterchangeable transformer having a secondary voltage rating of more than 6000 volts, and a noninterchangeable transformer having a secondary voltage rating of 6000 volts or less and specifically intended for operation in an air blast shall be operated continuously for 48 hours at maximum rated primary voltage and frequency, when delivering secondary current to a spark gap in an air blast as described in 76.2. Following the test:

a) The temperature on or within the transformer shall not be such as to adversely affect the materials used in its construction;

b) There shall not be mechanical or electrical malfunction of the device;

c) There shall not be emission of flame or molten material; and

d) The temperature rise at any point on the enclosure shall not be greater than 65°C (117°F).

76.4 For a noninterchangeable transformer, the electrode spacing for the test described in 76.3 is to be 1/8 inch (3.2 mm) if the secondary voltage rating of the transformer is less than 12,000 volts and 3/16 inch (4.8 mm) if the rating is 12,000 volts or more. In the case of a twin-gap transformer, both sets of electrodes are to be mounted in the same air-blast tube. For a multiple-gap transformer, each set of electrodes is to be mounted in a separate tube. If the transformer has more than one primary winding, all primaries are to be energized continuously during the test. The enclosure of the transformer is to be solidly grounded during the test.

76.5 The insulation on a lead is to be considered adversely affected if, during the tests described in 76.1 – 76.4, the insulation attains a temperature rise higher than that indicated in Table 55.1.

77 Dielectric Voltage-Withstand Test

77.1 An ignition transformer with an ungrounded secondary while hot from the Heating Test, Section 76, 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 the primary and secondary windings; and

c) A value of 150 percent of the maximum rated primary voltage applied across 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 winding and then the other, in turn, connected to the common connection of the primary winding and the enclosure.

There shall not be dielectric breakdown.

77.2 An ignition transformer with a grounded secondary, while hot from the Heating Test, Section 76, 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; and

b) A value of 150 percent of maximum rated primary voltage applied to the primary winding, with one end of the primary winding solidly connected to the enclosure.

There shall not be dielectric breakdown.

77.3 Each secondary winding of a multiple-gap transformer is also to be subjected to the tests described in 77.1 and 77.2. If its secondary windings are ungrounded, a multiple-gap transformer is to be subjected for one minute to the application of 125 percent of rated secondary voltage between each pair of secondary windings. There shall not be dielectric breakdown.

77.4 A capacitor that is supplied as a part of a transformer for use in the primary circuit and that can be readily disconnected from the transformer is to be subjected for one minute to the application of an alternating potential of 1000 volts plus twice its rated voltage between the capacitor enclosure and the plates. There shall not be dielectric breakdown.

77.5 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 frequency of the test potential is to be the rated frequency of the transformer under test.

Exception: For the test described in 77.1 (c) and 77.2 (b), a higher frequency may be used if agreeable to those concerned if magnetic saturation effects result in excessive heating of the transformer being tested.

78 Short-Circuit Operation Test

78.1 When operated continuously until constant temperatures are attained with the secondary terminals short-circuited, an ignition transformer shall:

a) Not emit flame or molten material from the enclosure,

b) Not have any normally ungrounded point or any winding become grounded as a result of the test, and

c) Comply with the requirements in 78.2.

The applied primary voltage during the test is to be the maximum rated primary voltage of the transformer.

78.2 When retested after the conclusion of the short-circuit test, an interchangeable transformer shall comply with the requirements in 73.2 and 75.1. When retested after the conclusion of the short-circuit test, a noninterchangeable transformer shall comply with the requirements in 74.1 and 74.2. With maximum rated voltage at rated frequency applied to the primary, the open-circuit secondary voltage shall not be less than 95 percent of the value measured in the tests described in 73.1.

Exception: The requirements do not apply if the primary winding, the secondary winding, or both windings become open-circuited as a result of the short-circuit test.

RATINGS

79 Details

79.1 The electrical ratings of an ignition transformer shall include the primary voltage, frequency, current or volt-amperes, and all open-circuit secondary voltages.

79.2 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, since it is specified in 80.1 that the marking shall include the words ″mid-point grounded ″ or the equivalent.

79.3 The primary-voltage rating of an ignition transformer shall not be more than 600 volts, and the open-circuit secondary voltage rating shall not be more than 15,000 volts.

MARKINGS

80 Details

80.1 A transformer shall have a plain, legible marking, readily visible after the transformer has been installed as intended, that includes:

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 would 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.

80.2 An ignition transformer complying with the requirements of the interchangeability program shall be identified as such.

80.3 A transformer intended for use with a twin-gap ignition system shall be marked as such.

80.4 A transformer intended for use with a multiple-gap ignition system shall be marked as such. The marking shall state the number of secondary circuits for which the transformer is intended, and the marking shall indicate which pair of terminals is associated with each secondary winding, unless such identification is obvious.

APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard − UL Standard Designation

Attachment Plugs and Receptacles – UL 498
Cord Sets and Power-Supply Cords – UL 817
Electrode Receptacles for Gas-Tube Signs – UL 879
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Fuses, Plug – UL 198F
Gas-Tube-Sign and Ignition Cable – UL 814
Organic Coatings for Steel Enclosures for Outdoor-Use Electrical Equipment – UL 1332
Outlet Boxes, Fittings for Conduit and – UL 514B
Outlet Boxes, Flush-Device Boxes, and Covers, Nonmetallic – UL 514C
Outlet Boxes, Metallic – UL 514A
Signs, Electric – UL 48
Switches, General-Use, Snap – UL 20
Switches, Special-Use – UL 1054
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510
Temperature-Indicating and -Regulating Equipment – UL 873
Terminal Blocks – UL 1059
Thermal Cutoffs for Use in Electrical Appliances and Components – UL 1020
Tubing, Extruded Insulating – UL 224
Wire Connectors and Soldering Lugs for Use with Copper Conductors – UL 486A
Wire Connectors for Use with Aluminum Conductors – UL 486B
Wires and Cables, Rubber-Insulated – UL 44
Wires and Cables, Thermoplastic-Insulated – UL 83

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Superseded requirements for the Standard for Specialty Transformers

UL 506, Twelfth Edition

The requirements shown are the current requirements that have been superseded by requirements in this edition. The numbers in parentheses refer to the new requirements with future effective dates that have superseded these requirements. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

1.1 These requirements cover air-cooled transformers and reactors for general use; ignition transformers for use with gas burners and oil burners; and gas-tube-sign transformers for use with inert-gas tubes. 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.

1.3 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 Class 2 and Class 3 Transformers, UL 1585.

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.

8.7 The types of flexible cord that may be used with a gas-tube-sign transformer (Sections 44 – 63) or an ignition transformer (Sections 64 – 80) are indicated in Table 8.1 and are given 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.

44 Details

44.1 A gas-tube-sign transformer is a step-up transformer of the high secondary voltage type intended to supply very low current to electrodes of glass tubes containing an inert gas, such as neon, helium, and the like (electric-discharge tubes). It may be of the weatherproof, outdoor non-weatherproof, or indoor type. The requirements in 44.2 – 63.2 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.

44.2 A reactor supplied as a part of a gas-tube-sign transformer shall comply with the requirements in Sections 45 – 63.

44.3 The requirements for a gas-tube-sign transformer in Sections 45 – 63 are to be considered in addition to those specified in Sections 1 – 17.

45 General

45.1 There shall not be electrical connection between primary and secondary windings of a gas-tube-sign transformer.

45.2 The requirements in Sections 45 – 63 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 multisecondary-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.

45.3 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.

46 Enclosure

46.1 General

46.1.1 A gas-tube-sign 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 46.1.2.

46.1.2 The following leads or terminals shall be enclosed:

a) Primary and secondary terminals of a weather-proof 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.

46.1.3 Regarding 46.1.2(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.

46.1.4 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 50.6, 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.

46.1.5 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.

46.1.6 The enclosure shall be provided with means for mounting.

46.1.7 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.

46.1.8 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.

46.1.9 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.

46.1.10 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.

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

46.1.12 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.

46.2 Weatherproof enclosures

46.2.1 The enclosure of a weatherproof transformer shall comply with the requirements in 20.4.3 – 20.4.14 and Corrosion Resistance, Section 21.

47 Insulating Materials

47.1 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.

48 Connections

48.1 Primary terminals and leads

48.1.1 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 1/2 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 1/2 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 48.1.8.

48.1.2 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 48.1.1(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.

48.1.3 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).

48.1.4 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.

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

48.1.6 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 No. 14 AWG (2.1 mm^2).

48.1.7 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 No. 14 AWG (2.1 mm^2).

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 No. 18 AWG (0.82 mm^2) if it does not use the construction described 48.1.1(a).

48.1.8 A three-conductor flexible cord, not lighter than Type C and not smaller than No. 18 AWG (0.82 mm^2) may be used for the power supply connection of a portable indoor-type transformer. A Type SPT-3 cord may be used in the Nos. 18 – 16 AWG (0.82 – 1.3 mm^2) sizes.

48.1.9 The flexible cord specified in 48.1.8 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.

Exception: An open core-and-coil transformer and a transformer intended for use inside a portable sign enclosure need not be provided with an attachment plug.

48.1.10 A flexible cord shall comply with the requirements in 48.1.4 and 48.1.5. 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.

48.1.11 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.

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

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

48.1.14 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.

48.1.15 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.

48.1.16 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.

48.1.17 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).

48.1.18 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.

48.1.19 The requirement in 48.1.18 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.

48.1.20 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.

48.1.21 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.

48.1.22 The barrier specified in 48.1.21 shall comply with the requirements in 48.2.8.

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

a) The spacings specified in Table 49.3 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.

48.1.23 A clamp or similar device used as described in 48.1.21 for securing the flexible cord shall have smooth, well-rounded edges to reduce the risk of damage to the insulation of the conductors.

48.2 Secondary terminals and leads

48.2.1 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.

48.2.2 A secondary lead shall be of stranded Type GTO cable. The lead shall not be less than No. 14 AWG (2.1 mm^2), except that it may not be less than No. 18 AWG (0.82 mm^2) for a transformer intended for a show window display or a small portable sign 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 gas-tube-sign transformer may have other than gas-tube-sign cable for secondary leads but such leads shall not be less than No. 20 AWG (0.52 mm^2) 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.

48.2.3 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).

48.2.4 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.

48.2.5 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.

48.2.6 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).

48.2.7 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.

48.2.8 A barrier provided to reduce the risk of contact between parts as described in 48.2.7 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 48.1 and in 48.2.13.

48.2.9 A cap of insulating material provided over an otherwise uninsulated secondary terminal to reduce the risk of contact between secondary parts as specified in 48.2.7 shall be tight-fitting and capable of being secured to the terminal. The cap shall be of one of the materials indicated in Table 48.1. 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.

48.2.10 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.

Table 48.1
Thickness and determination of use of insulating materials

Material	Minimum Thickness				For use in weatherproof and outdoor nonweatherproof transformers	For use in indoor transformers
	Cap		Barrier,			
	inch	(mm)	inch	(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 49.3 for the spacings between primary and secondary parts, and if there is not likelihood of contact between the barrirer 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.

48.2.11 Regarding 48.2.9, after installation of the transformer, a compartment is considered tightly closed if it does not have uncovered openings, a gas-tube-sign 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.

48.2.12 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.

48.2.13 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 48.1.21 and 48.2.7 shall comply with Table 48.1.

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.

48.2.14 An opening intended for the entrance of an electric- discharge-tube electrode into the enclosure of an indoor-type transformer having a secondary voltage rating of more than 7500 volts shall be provided with an insulating bushing or with an electrode receptacle. An insulating bushing shall provide a spacing between the tubing and the dead metal parts of the transformer of not less than 1/4 inch (6.4 mm), measured with the tubing in place and contacting the bushing.

48.2.15 If the secondary-voltage rating of an indoor-type transformer is 7500 volts or less, an opening as specified in 48.2.14 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.

48.2.16 Electric-discharge-tube supports furnished as parts of a transformer shall provide a means for mounting the tubing and shall be securely attached to the transformer. If the rated secondary voltage of the transformer is more than 7500 volts, these supports shall be of porcelain, glass, or similar combustion-resistant, absorption-resistant, insulating material, and shall provide a spacing of not less than 1/4 inch (6.4 mm) between the tubing and dead metal parts of the transformer.

48.2.17 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.

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

48.2.19 An electric-discharge-tube receptacle provided as a part of a transformer shall be of a required type and shall be secured to restrict turning.

48.2.20 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.

49 Spacings

49.1 Spacing requirements do not apply to parts completely covered by compound. The spacings specified in 49.2 – 49.12 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 49.2 – 49.12 may be required unless the parts involved are mounted so that it is unlikely that any reduction in these minimum spacings would occur.

49.2 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 49.1.

Table 49.1
Minimum spacings at primary wiring terminals

Transformer primary rating, volts	Spacing through air and over surface between live parts and dead metal parts,		Spacing between live parts of opposite polarity			
			Through air,		Over surface,	
	inch	(mm)	inch	(mm)	inches	(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

49.3 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 49.2 will be provided.

Table 49.2
Minimum spacings involving uninsulated live parts

Transformer primary rating, volts	Spacing through air and over surface between live parts and dead metal parts,		Spacing between live parts of opposite polarity			
			Through air,		Over surface,	
	inch	(mm)	inch	(mm)	inches	(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

49.4 The spacings in an open core-and-coil type of transformer shall be such that an air space of 1/2 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.

49.5 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 49.3.

49.6 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.

49.7 If the secondary winding is ungrounded, the spacings between the parts specified in Table 49.3 are to be evaluated on the basis of the rated secondary voltage of the transformer.

49.8 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.

49.9 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.″

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

49.11 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.

49.12 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 49.4.

Exception: This requirement does not apply if the compartment is tightly closed as described in 48.2.11.

Table 49.3
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,		Over surface,		Through air,		Over surface,		Through air,		Over surface,		Through air,		Over surface,	
	in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)	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
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 48.2.7 – 48.2.11, 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.

Table 49.4
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

50 Guarding of Live Parts and Grounding

50.1 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.

50.2 If it is intended that a conductor from an electrode of an electric-discharge tube will be connected to the grounded point of a secondary winding, a secondary lead or terminal shall be provided for such connection. If a terminal is provided, it shall be connected to the grounded point of the winding by a continuous metallic conductor. The conductor, including any part of the enclosure comprising a part of the conductor, shall be free of joints, unless such joints are bolted, welded, soldered, or equivalently secured. A pressed-together joint may be used if determined to be equivalent by investigation.

50.3 Regarding 50.1 and 50.2, 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.

50.4 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.

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

50.6 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.

50.7 The requirement in 50.6 applies to an outdoor, non-weatherproof transformer if such a transformer is to be additionally used as an indoor-type transformer.

50.8 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.

50.9 An indoor transformer intended to have the gas tube replaceable without opening the enclosure shall be constructed so that no live parts or live connections would be exposed to unintentional contact when tubes are being replaced. Pigtail leads shall not be used, but center contacts of electrode receptacles are not to be considered as being exposed to unintentional contact.

50.10 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.

51 Capacitors

51.1 A capacitor supplied as a part of a gas-tube-sign transformer, when not used in the primary circuit, shall be investigated.

51.2 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.

51.3 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.

52 General

52.1 To determine if a gas-tube-sign 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 53 – 58, in the order given.

52.2 The enclosure is to be grounded during all the tests specified in 52.1. 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.

53 Open-Circuit Secondary Voltage Test

53.1 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.

53.2 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 53.1, corresponding to the maximum rated voltage between any two secondary terminals or leads.

Table 53.1
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

53.3 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 53.2, corresponding to the rated secondary voltage of the transformer.

Table 53.2
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

53.4 To determine if a transformer complies with the requirements in 53.1 – 53.3, 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.

54 Input Test

54.1 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.

54.2 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.

Exception: For a high-power-factor type of transformer, full-load primary current is to be considered to be 100 percent of the primary current measured with the secondary connected to a tube load that draws 80 ±2-1/2 percent of the measured short-circuit secondary current. The tube load is to consist of 12 mm red neon tubing in which the gas is at a pressure of 9 mm of mercury.

54.3 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.

54.4 Regarding 54.3, 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 54.2.

55 Heating Test

55.1 A gas-tube-sign 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 (117°F);

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 (117°F) if Class 105 insulation is used and not more than 90°C (162°F) if Class 130 insulation is used.

55.2 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.

55.3 The insulation on a lead is to be considered adversely affected if, during the heating test described in 55.1 and 55.2, it attains a temperature rise of more than that indicated in Table 55.1.

Table 55.1
Maximum rise in lead temperature

Lead types	Maximum rise, °C	(°F)
T, TF, TFF, and TW	35	63
FFH-2, RH, and RFH-2	50	90

56 Short-Circuit Secondary Current Test

56.1 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 gas-tube-sign transformer shall not be more than 110 percent of the rated value.

56.2 A measurement to determine if a transformer complies with the requirement in 56.1 may be made during the short-circuit test.

57 Dielectric Voltage-Withstand Test

57.1 A gas-tube-sign transformer with an ungrounded secondary, while hot from the heating test described in the Heating Test, Section 55, 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.

57.2 A gas-tube-sign transformer with a grounded secondary, while hot from the Heating Test, Section 55, 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.

57.3 A capacitor that is supplied as a part of a gas-tube-sign 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.

57.4 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 gas-tube-sign transformer.

Exception: The test described in 57.1(c) and 57.2(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.

58 Burnout Test

58.1 A gas-tube-sign 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.

58.2 In the burnout test, an open core-and-coil transformer is to be tested as described in 55.2 and shall comply with the requirement in 55.2.

58.3 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 55, reveal whether the transformer complies with the requirement specified in 58.1.

59 Open-Circuit Secondary Operation Test

59.1 A gas-tube-sign 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.

60 Switch Tests

60.1 General

60.1.1 A switch provided with a gas-tube-sign transformer is to be subjected to the overload and endurance tests described in 60.2.1 – 60.3.2.

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.

60.2 Overload

60.2.1 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.

60.2.2 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.

60.3 Endurance

60.3.1 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 gas-tube 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 60.2.2 with the same criteria for acceptance.

60.3.2 Snap switches and other wiring devices are to be disconnected during the Dielectric Voltage-Withstand Test, Section 57, 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.

61 Production Line Grounding Continuity Test

61.1 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.

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

61.3 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 61.1.

62 Details

62.1 The electrical ratings of a gas-tube-sign transformer shall include the primary voltage, frequency, and current or volt-amperes, and all secondary open-circuit voltages and the secondary short-circuit current.

62.2 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 63.1 that the marking include the words ″mid-point grounded ″ or the equivalent).

62.3 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.

63 Details

63.1 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.

63.2 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. ″