UL 5085-3

STANDARD FOR SAFETY

Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers

UL Standard for Safety for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3

First Edition, Dated April 17, 2006

Summary of Topics

This revision of ANSI/UL 5085-3 dated January 28, 2022 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

As noted in the Commitment for Amendments statement located on the back side of the title page, UL and CSA are committed to updating this harmonized standard jointly. However, the revision pages dated January 28, 2022 will not be jointly issued by UL and CSA as these revision pages only address UL ANSI approval dates.

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

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

No Text on This Page

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CSA C22.2 No. 66.3-06
First Edition

Underwriters Laboratories Inc.
UL 5085-3
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Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers

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ANSI/UL 5085-3-2012 (R2022)

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as “CSA Group”) and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

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This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include “Proposal for change” in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the First Edition including revisions through January 28, 2022. The most recent designation of ANSI/UL 5085-3 as a Reaffirmed American National Standard (ANS) occurred on January 26, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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Annex D (Normative)

Preface

This is the harmonized CSA Group and UL standard for low voltage transformers. It is the first edition of CSA C22.2 No. 66.3 and the first edition of UL 5085-3. This harmonized standard has been jointly revised on November 30, 2012. For this purpose, CSA Group and UL are issuing revision pages dated November 30, 2012.

This harmonized standard was prepared by a Technical Harmonization Committee comprised of members from CSA Group, Underwriters Laboratories Inc. (UL), and representatives of the low voltage transformer manufacturing industry. The efforts and support of the members of the Technical Harmonization Committee are gratefully acknowledged.

This Standard is considered suitable for use for conformity assessment within the stated scope of the Standard.

This standard was reviewed by the CSA Subcommittee on C22.2 No. 66, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

***Note:** Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.*

Level of harmonization

This standard uses the IEC format but is not based on, nor is it to be considered equivalent to, an IEC standard. This standard is published as an equivalent standard for CSA Group and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for Differences from IEC

The Technical Harmonization Committee identified the following IEC Standard within the scope of this standard: IEC 61558-1 (1998-07), Safety of power transformers, power supply units, and similar - Part 1: General requirements.

The THC determined that the safe use of transformers and reactors is critically dependent on the electrical system in which they are intended to be installed. Significant investigation is required to assess safety and system compatibility issues that may lead to harmonization of traditional North American transformers and reactors with those presently addressed in the known IEC standards. The THC agreed such future investigation might be facilitated by completion of harmonization of North American standards for transformers and reactors.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one literal interpretation has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

Parts

The Standard for Low Voltage Transformers is divided into the following parts:

Part Number	Standard Title	Standard Number
1	General Requirements	CSA C22.2 No. 66.1/UL 5085-1
2	General Purpose Transformers	CSA C22.2 No. 66.2/UL 5085-2
3	Class 2 and Class 3 Transformers	CSA C22.2 No. 66.3/UL 5085-3

NOTES –

1. Part 1 covers the general requirements for transformer characteristics, marking, construction, and tests. Additional specific requirements are provided in the subsequent parts.

2. Part 2 and Part 3 supplement requirements and/or modify the corresponding clauses in Part 1 and should be applied together with Part 1. The numbered clauses in Part 2 and Part 3 correspond to the numbered clauses in Part 1.

PART 3: CLASS 2 AND CLASS 3 TRANSFORMERS

1 Scope

1.1 As noted in Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, or CSA C22.2 No. 66.1, Low Voltage Transformers – Part 1: General Requirements, the requirements in Part 3 cover Class 2 transformers for use with Class 2 circuits in accordance with the National Electrical Code, ANSI/NFPA 70, or the Canadian Electrical Code, Part I, CSA C22.1. They are intended for connection to essentially sinusoidal supply sources.

***Advisory Note**: For transformers intended for use in the United States, these requirements also cover Class 3 transformers for use with Class 3 circuits in accordance with the National Electrical Code, ANSI/NFPA 70, unless otherwise specified in this standard. See Annex D for Class 3 requirements.*

1.3 In addition to the items specified in Clause 1.3 of Part 1, the requirements of Part 3 do not cover:

a) Power supplies (a transformer provided with a rectifier is considered a power supply);

b) Toy transformers;

c) Cord and plug connected transformers other than Class 3;

d) Direct plug-in transformers;

e) Transformers intended for use in audio, radio, or television type appliances; or

f) Other special types of transformers covered in requirements for other electrical devices or appliances.

***Advisory Note:** The requirements of Part 3 do not cover transformers intended for use in the United States having a nominal primary rating of more than 600 V and transformers having overvoltage taps rated over 660 V.*

1.7 This part is intended to be used in conjunction with Part 1. The numbering of the clauses in Part 3 corresponds to the numbered clauses in Part 1. The requirements in Part 1 apply unless modified by Part 3.

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

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

4 Construction

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

Note 1: Two or more secondary windings may be considered as a single winding and interposing insulation between the secondary windings is not required if the windings, when interconnected, are in compliance with the performance requirements for a single-winding construction.

Note 2: An inherently limiting type transformer marked in accordance with Clause 17.4.2 may have two secondary windings that, when interconnected, do not comply with the performance requirements for a single-secondary winding construction.

Note 3: A transformer intended only for use in other equipment may have multiple secondary windings only where isolation of all circuits can be maintained, or where the interconnection of the secondary windings is such that they comply with the performance requirements for an isolated single-secondary winding construction.

4.3 There shall not be electrical connection between the primary and secondary windings of a transformer, or between a primary or secondary circuit and the enclosure.

4.4 A component used to limit the output of a transformer to a value within the required current, power, or safety levels shall be permanent and stable in order to maintain its limiting capabilities. The following factors are to be considered when evaluating a limiting component:

a) Effect of operating temperature;

b) Electrical stress level;

c) Effect of transient surges; and

d) Resistance to moisture.

6 Enclosure

6.1 General

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

The secondary leads or terminals of a Class 2 transformer do not have to be enclosed.

The enclosure of the end product may serve as the transformer enclosure for a transformer intended for use only in other equipment. However, the primary and secondary wiring of the transformer shall be separated in accordance with the requirements for the end product.

Note 1: For a transformer mounted on an outlet box cover or intended for mounting in a knockout of an outlet box or cabinet, the primary terminals or leads are considered enclosed by the outlet box or cabinet.

Note 2: A transformer may have exposed primary leads if intended for connection to open wiring or concealed knob-and-tube wiring.

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

The secondary leads or terminals of a Class 2 transformer do not have to be enclosed.

The enclosure of the end product may serve as the transformer enclosure for a transformer intended for use only in other equipment. However, the primary and secondary wiring of the transformer shall be separated in accordance with the requirements for the end product.

Note 1: For a transformer mounted on an outlet box cover or intended for mounting in a knockout of an outlet box or cabinet, the primary terminals or leads are considered enclosed by the outlet box or cabinet.

Note 2: A transformer may have exposed primary leads if intended for connection to open wiring or concealed knob-and-tube wiring.

8 Connections

8.2 Wiring terminals

8.2.3 Primary wiring terminals

8.2.3.1 Unless otherwise specified, the requirements for wire binding screws and studs and pressure terminal connectors shall comply with Clauses 8.3 and 8.4 of Part 1.

8.2.4 Secondary terminals

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

8.2.4.2 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch wide quick-connect terminal shall comply with the requirements for the Standard for Electrical Quick-Connect Terminals, UL 310, or CSA C22.2 No. 153, Quick-Connect Terminals.

8.2.4.3 Terminal plates, wire binding screws, studs, and nuts shall be constructed as specified for Primary wiring terminals in Clause 8.2.3.

Note 1: Plated steel terminal plates are acceptable for use; cupped washers or similar devices are not required.

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

8.5 Leads

8.5.9.1 Primary leads

8.5.9.1.1 A primary field wiring lead of a transformer shall have stranded copper conductors not smaller than 18 AWG (0.82 mm^2). Leads on component type transformers shall have an ampacity suitable for the transformer rating but shall not be less than 22 AWG (0.35 mm^2).

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

8.5.9.1.3 A primary field wiring lead of a transformer shall extend not less than 152 mm (6 in) outside the enclosure, and a lead of 18 or 16 AWG (0.82 or 1.3 mm^2) wire shall extend not more than 305 mm (12 in) outside the enclosure.

8.5.9.1.4 A transformer with open wiring or concealed knob-and-tube wiring shall be provided with the following:

a) A marking in accordance with Clause 17.4.10 or 17.4.11;

b) A spacing of not less than 6.4 mm (0.25 in) between the conductors;

c) A spacing of not less than 12.7 mm (0.5 in) between the conductors and the plane of the transformer support; and

d) An insulating bushing where the primary leads pass through the enclosure. Either a separate hole for each lead shall be provided in the insulating material or separate bushings shall be provided.

Note: In Canada, the Canadian Electrical Code, Part I, no longer permits concealed knob-and-tube wiring.

8.5.9.2 Secondary leads

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

8.5.9.2.2 Other than as required in Clause 8.5.9.2.1, the insulation type and thickness shall not be specified for leads and flexible cord on the load side of required energy-limited components. The leads and flexible cord may be any length.

11 Spacings and Insulation

11.2 Insulating material for mounting of low voltage live parts

11.2.3 With regard to the requirement in Clause 11.2.1 of Part 1, vulcanized fiber may be used for mounting of the low voltage terminals of a Class 2 transformer, or for material used for separators, spacers, coil supports, and similar parts within a transformer enclosure.

11.3 Coil insulation

11.3.1 In addition to the requirements in Clause 11.3.1 of Part 1, a coil shall be provided with insulation between the primary crossover lead and adjacent windings.

Note 1: Interposing insulation between two or more secondary windings is not required if the windings, when interconnected, are in compliance with the performance requirements for a single-winding construction.

Note 2: Insulation between the various windings, between the windings and the core, between the windings and the enclosure, and between the primary crossover lead and adjacent windings is not required if the spacings specified in Spacings in Clause 11.5 are provided.

11.4 Insulation in lieu of spacings

11.4.1 When the primary is wound with 30 AWG (0.05 mm^2) or smaller wire, primary over primary crossover insulation may be omitted in view of the inherent protection provided by fusing of the wire.

11.5 Spacings

11.5.1 At primary wiring terminals, the spacing through air or over surface between uninsulated live parts of opposite polarity, and between an uninsulated live part and a dead metal part that may be grounded, shall not be less than:

a) 12.7 mm (0.5 in) when the primary voltage rating is 300 V or less and

b) 25.4 mm (1 in) when the primary voltage rating exceeds 300 V.

11.5.2 At points other than primary wiring terminals, the spacings between uninsulated live parts of opposite polarity, and between an uninsulated live part and a dead metal part shall not be less than those shown in Table 6 of Part 1.

Note 1: Spacings at a point in the secondary circuit may be less than those specified in Table 6 of Part 1 when the transformer is marked " Class 2" and the transformer complies with the requirements in Clauses 27 – 29, and Clause 32 – 34 with a short-circuit introduced at the point of reduced spacing.

Note 2: Spacings between the primary and secondary windings of a flanged bobbin-wound transformer within a nonventilated enclosure, as measured across the bobbin surface between the windings, may be as specified in Table 1.

11.5.3 Film coated magnet wire is considered insulated with regard to adjacent turns of the same winding, but is otherwise considered uninsulated.

Note: Triple-insulated magnet wire that complies with the requirements for wire insulation in the Standard for Single- and Multi-Layer Insulated Winding Wire, UL 2353*, or CAN/CSA-C22.2 No. 60950-1-03 , Information Technology Equipment – Safety-Part 1: General Requirements, or CAN/CSA-C22.2 No. 60065:03 , Audio, Video and Similar Electronic Apparatus – Safety Requirements, is considered to be insulated.*

11.6 Separation of internal wiring circuits

11.6.1 Except as noted in 11.6.1.1, unless provided with insulation rated for the highest voltage involved, insulated conductors of different circuits shall be separated by barriers or shall be segregated and shall be separated or segregated from uninsulated live parts connected to different circuits.

11.6.1.1 In a compartment or enclosure where provision for Class 1 power, lighting, non-power limited fire alarm, or medium power network-powered broadband communication circuit conductors is available for connection to Class 2 or 3 circuits, Class 2 and 3 circuit conductors may be separated from the conductors of other circuits by the following methods:

a) A reliable barrier, clamping or routing means that maintains a minimum spacing of 6.4 mm (1/4 inch) between the conductors of different circuits; or

b) When all circuit conductors operate at 150 volts or less to ground, the Class 2 and Class 3 circuits may be installed using minimum CL3, CL3R, CL3P, or cables determined equivalent. These cables shall extend beyond the jacket and be separated by a minimum of 6.4 mm (1/4 inch) or by an insulating sleeve or barrier from all other conductors.

11.6.2 Segregation of insulated conductors shall be accomplished by clamping, or an equivalent means that provides permanent separation from insulated or uninsulated live parts of a different circuit

11.6.3 A barrier used to separate or segregate internal wiring, or used to separate or segregate low voltage field wiring from line voltage parts, shall have mechanical strength. It shall be held in place to provide permanent separation and shall be rated for the temperature involved.

11.6.4 An insulating barrier shall have a minimum thickness of 0.71 mm (0.028 inch) and shall be of material as described in Clause 11.2.2 of Part 1.

12 Switches, Protective Devices, and Wiring Devices

12.3 Protective devices

12.3.5 An automatically or manually reset protective device or a replaceable overcurrent protective device shall not open when the transformer is delivering its rated output as described in the Rated Secondary Current Test in Clause 30, and the Rated Output Heating Test in Clause 31.

12.3.6 A protective device shall be located inside the transformer enclosure. The device shall be inaccessible to tampering. A transformer may be provided with a replaceable overcurrent protective device. However, it shall not be interchangeable with a device having a higher current rating, and the transformer shall be marked in accordance with Clause 17.4.6.

Note 1: The reset button or handle of a manually reset device need not be located inside the enclosure.

Note 2: For a transformer intended only for use in other equipment, as described in Clause 6.1.16 , the protective device may be located inside the enclosure of the end product.

12.3.7 When a Class 2 transformer does not comply with the current limitations of an inherently limited power source in Table 4, it shall comply with the current and power limitation of a not inherently limited power source as described in the table. Additionally, the transformer shall be provided with overcurrent protection in accordance with the Calibration Test of Overcurrent Protective Devices in Clause 29.

12.3.8 An overcurrent protective device provided to comply with Clause 12.3.7 shall not be an automatic reclosing type. When an accessible control of a manual reset overcurrent protective device is held in the on or reset position, and the protective device is automatically tripped, the contact shall not automatically return to the closed position.

12.3.9 When a replaceable type of overcurrent protective device (such as a fuse) is provided to comply with Clause 12.3.7, the device shall not be interchangeable with a device having a higher current rating.

12.3.10 An overcurrent protective device provided in the primary circuit of a Class 2 transformer shall limit the output current of a transformer in accordance with the Calibration Test of Overcurrent Protective Devices in Clause 29.

12.3.11 Component type transformers when used with external overcurrent protective devices that are not interchangeable with a device of a higher current rating may be considered Class 2 when marked in accordance with Clause 17.4.7.

12.3.12 An overcurrent device shall be rated in accordance with Table 4 and shall comply with the Calibration Test of Overcurrent-Protective Devices in Clause 29.

12.4 Separate current-limiting impedances

12.4.1 Separate current-limiting impedances such as resistors or positive temperature coefficient devices (PTCs) may be provided with a transformer.

12.5 Overtemperature protective devices

12.5.1 Thermal protectors evaluated in accordance with the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, UL 1020, or CSA C22.2 No. 209, Thermal Cut-Offs, are suitable as protective devices.

17 Markings

17.1 General

Advisory Note: *In Canada, there are two official languages, English and French. Annex C provides French translations of the markings specified in this standard. Markings required by this standard may have to be provided in other languages to conform with the language requirements of the country where the product is to be used.*

17.1.7 A Class 2 transformer shall be marked with the words " Class 2." Markings shall be located as shown in Table 11 of Part 1 and Table 5.

17.3 Ratings

17.3.1 The electrical ratings of a transformer shall include the primary voltage and frequency and the voltage and volt-amperes or amperes for each secondary winding. The ratings shall be in accordance with Table 4.

17.3.2 The secondary voltage rating of each secondary winding of a Class 2 transformer shall not be more than 30 V rms.

17.3.3 When the open circuit secondary voltage of a winding of a Class 2 transformer exceeds 15 V rms or 21.2 V peak, the transformer shall be marked in accordance with Clause D1.2.2.

Advisory Note: *This requirement applies to Class 2 transformers using Class 3 wiring methods which are intended for use in the United States.*

17.4 Details

17.4.1 A transformer shall be plainly marked to indicate which terminals (or leads) are for primary and which are for secondary windings (for example primary = "line" and secondary = "load"). Secondary winding connections shall be identified from each other.

17.4.2 A transformer with multiple secondary windings as described in Clause 4.3 having an output exceeding 30 V rms or 42.4 V peak, or a transformer with an output current exceeding the limit specified in Clause 28.1.1 or Clause 28.3.1, shall be marked where readily visible after installation, with the word "WARNING" and the following or the equivalent: "Risk of electric shock or fire, do not interconnect secondary windings." The word "WARNING" shall be in letters not less than 3.2 mm (0.125 in) high. The remaining letters shall be not less than 1.6 mm (0.063 in) high.

17.4.3 The marking specified in Clause 17.4.2 shall be located on the transformer or on a tag complying with the requirements in Clauses 17.4.4 and 17.4.5.

17.4.4 The marking specified in Clause 17.4.2 may be provided on a permanent tag secured to the transformer. The tag shall be attached so it cannot be easily removed. The tag shall also be marked "Do not remove this tag" or the equivalent, in letters not less than 2.4 mm (0.094 in) high.

17.4.5 The tag mentioned in Clause 17.4.4 shall be made of durable material that provides mechanical strength, such as cloth, plastic, or the equivalent, and shall be large enough to fit the required marking.

17.4.6 When a replaceable protective device is incorporated in a Class 2 transformer and relied upon to comply with any requirement contained in this standard, the transformer shall be legibly marked to indicate the proper replacement part and procedure. The marking shall be visible when accessing the protective device.

17.4.7 When marked in accordance with Clause 12.3.11, a transformer with an external protective device that is not interchangeable with a device of a higher rating shall be marked, "Class 2 when Used with Protector, Mfr ___, Cat. No. ___" or similar wording.

17.4.8 When the temperature rise on a field installed lead (or on any part within the compartment that the lead might contact) is more than 35°C during the rated output heating test, the transformer shall be marked with the following statement or the equivalent, at or near the point where field connections will be made: "Use wire rated for at least ___°C." The marking shall be located so that it will be readily visible during installation. The temperature value to be used in the preceding statement shall be in accordance with Table 2.

17.4.9 A transformer rated less than 110 V and not intended for use on a 110 – 120 V circuit shall be marked "For use only on ___volt circuits." The blank space shall be replaced with the intended voltage.

17.4.10 For transformers intended for use in the United States the following applies regarding Clause 8.5.9.1.4, a Class 2 transformer intended for installation with open wiring or concealed knob-and-tube wiring in accordance with Articles 398 and 394 of the National Electrical Code, ANSI/NFPA 70, shall be marked where readily visible "Suitable for use in accordance with Articles 398 and 394 of the NEC," or "Suitable for use with knob and tube or open wire."

17.4.11 For transformers intended for use in Canada the following applies: When necessary to meet the requirements of Clause 8.5.9.1.4, transformers shall be marked "For use with open wiring."

Note: In Canada, the Canadian Electrical Code, Part I, no longer permits concealed knob-and-tube wiring.

17.4.12 A transformer that has two or more windings intended to be connected in a series or parallel configuration and that has been subjected to the dielectric voltage withstand test specified in Clause 32.1.1 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 similar wording: "Windings ____ and ____ must be connected in either a parallel or series configuration." The blanks shall be filled in with the series/parallel winding identifying marking.

Note: These requirements do not apply to transformers incorporating multifilar coil sections designed for series or parallel connection that have been subjected to the Induced potential tests of Clause 32.2.

18 Tests

18.5 With regard to Clause 18.2 of Part 1, when a transformer is rated less than 110 V and is not intended for use on a 110 – 120 V circuit, the transformer shall be marked as indicated in Clause 17.4.9, and the test voltage shall be the rated voltage.

18.6 For the tests described in Clauses 27 – 37, the number of samples for each test and the order for conducting the tests shall be as specified in Table 3. The same sample may be used for more than one test if it remains undamaged from the previous test. If tests result in damage to the transformer, additional samples may be necessary to complete the test series. Unless otherwise specified, all tests shall be conducted at the test voltage specified in Table 12 of Part 1.

18.7 The tests described in Clauses 28 – 31, 33, 35, and 36 shall be conducted in an ambient air temperature within the range of 21 – 30°C (70 – 86°F).

Note: The Rated Output Heating Test in Clause 31, with or without standard fuses, but without other forms of overcurrent or overtemperature protectors, may be conducted in an ambient of 10 – 40°C (50 – 104°F).

18.8 All exposed dead metal parts of the transformer shall be connected to ground through a 3 A nondelay-type fuse for the following tests (described in Clauses 28, 29, 33, 35, and 36, respectively):

a) Output Current and Power;

b) Calibration of Overcurrent Protective Devices;

c) Overload Heating;

d) Overload of Overcurrent or Overtemperature Protective Devices; and

e) Endurance of Automatically Reset Overtemperature Protective Devices.

The transformer shall be connected to a circuit having a 20 A branch circuit protection. The transformer shall be supported on a softwood surface covered by a double layer of tissue paper and shall be draped with a double layer of cheesecloth conforming to the transformer outline. The cheesecloth shall be untreated cotton cloth 914 mm (36 in) wide, running approximately 28 – 30 m^2/kg mass (14 – 15 yds/lb mass). It shall have (as depicted in the trade) a "count of 32 by 28." This means that for any square centimeter there are 13 threads in one direction and 11 threads in the other direction (for any square inch there are 32 threads in one direction and 28 threads in the other direction).

18.9 During the test mentioned in Clause 18.8, a risk of fire or electric shock is considered to exist when any of the following occurs:

a) Opening of branch circuit protection;

b) Opening of grounding fuse;

c) Glowing or flaming of cheesecloth;

d) Emission of molten material from the transformer enclosure;

e) Development of any opening in the enclosure that exposes live parts at a potential of more than 42.4 V peak to any other part or to ground; or

f) Failure to comply with the Dielectric Voltage-Withstand after Overload Heating Test in Clause 34.

Note: The requirement specified in (a) does not apply to transformers with input voltages 250 V and greater.

27 Open Circuit Secondary Voltage Test

27.1 The open circuit voltage between any two of the secondary terminals of a Class 2 transformer shall not be more than 30 V rms, or 42.4 V peak, with or without any combination of interconnected secondary terminals, when the primary is energized in accordance with Clauses 18.5 and 18.6.

Note: The open circuit voltage between secondary terminals of a two-secondary winding transformer may exceed 42.4 V peak when secondary terminals are interconnected, if the following conditions are met:

a) The open circuit voltage between any two terminals is not more than 42.4 V peak when no connections are made between secondary terminals and

b) The transformer is marked in accordance with Clause 17.4.2.

27.2 Voltage measurements shall be made using a voltmeter having an internal impedance of not less than 3,000 ohms per volt.

28 Output Current and Power Test

28.1 Maximum current output of inherently limited transformers

28.1.1 The output current of a Class 2 transformer intended to be inherently power limited shall be tested as described in the following paragraphs. Unless the transformer is marked in accordance with Clause 17.4.2, multiple secondary windings, if any, shall be interconnected to produce maximum current.

Note: Requirements for a Class 3 transformer intended for use in the United States are located in Annex D.

28.1.2 Under the conditions described in Tests in Clause 18, and Clause 28.1.1, a resistance load shall be used to produce the largest initial value of current (including short circuit). The secondary shall be loaded with this value of resistance, and the transformer energized while at room temperature. The results comply when the current does not exceed the values specified in Table 4 for inherently limited power sources, and there is no evidence of a risk of fire or electric shock as described in Clause 18.9. The current shall be measured after the applicable time of operation:

a) When a separate current-limiting impedance is provided (such as a resistor or a positive temperature coefficient device (PTC), the current shall be measured after 5 seconds of operation.

b) When no separate current-limiting impedance is provided, the current shall be measured after 1 minute of operation.

28.1.3 The impedance of the short-circuit measuring circuit in the secondary shall not be more than 0.03 ohm. When the secondary of a transformer is provided with leads, only 305 mm (1 ft) of each lead shall be included in the short circuit.

28.1.4 When the current is interrupted by an internal or external protective device during this test, the test shall be repeated with the protective device shorted.

Note: When testing a combination of a winding and a PTC type protective devices, the PTC is not to be shorted.

28.1.5 The transformer is considered to comply with these requirements if the initial short circuit current is less than 8 A, or the maximum measured current at the time limit specified in Clause 28.1.2 is 8 A or less, and the measured secondary winding current value was not unstable due to transformer coil insulation damage.

If the current is interrupted by coil burnout before the time limit specified in Clause 28.1.2, other samples shall be tested by attempting to adjust continuously the resistance load to draw a current value of 8 A for the applicable time limit specified in Clause 28.1.2. The transformer is considered to comply with these requirements if the measured current is less than 8 A after the applicable time limit or the current is interrupted by a coil burnout.

28.1.6 If the transformer secondary winding maintained the 8 A load current for longer than the applicable time limit specified in Clause 28.1.2, another sample of the transformer is to be loaded using a resistive load adjusted to an initial load current equal to the midpoint between the maximum initial obtainable secondary winding short circuit current value and 8 A. The load resistance value shall not be subsequently adjusted during the test. After operating for the applicable time limit, the transformer is considered to comply with these requirements if the measured output current does not exceed 8 A before coil burnout or at the time limit specified in Clause 28.1.2 and Table 4.

28.1.7 When the test described in Clause 28.1.6 is interrupted again by a coil burnout and the measured current is above 8 A, another sample shall be tested as described in Clause 28.1.6. The initial current shall be adjusted to a point midway between the initial current recorded during the test in Clause 28.1.6 and 8 A. During this test, values of current versus time shall be recorded. If the current is again interrupted during operation before the applicable time limit specified in Clause 28.1.2 has elapsed, the recorded curve of current versus time shall be extended to the applicable time limit by a French curve, or exponential regression, or other mathematical curve-fitting procedure. The results comply with inherently limited requirements if this extrapolation value of current, after the applicable time limit, does not exceed 8 A.

The test data collected for use to extrapolate the current value should not include any unstable data due to coil insulation damage and the test data collected shall not be for less than 50 percent of the required test time.

28.2 Maximum current of non-inherently limited transformers

28.2.1 When the transformer does not meet inherently limited requirements, and the obtained test data is not sufficient to determine compliance with the requirements, the transformer shall be tested as described in Clauses 28.1.1 – 28.1.7, except the 8 A limit and load value shall be replaced with 1000/V max A. Protective devices shall be shorted during this test. The results comply when the maximum current does not exceed 1000/V max A for not inherently limited transformers. For the purpose of this test, the transformers need not comply with Clause 18.9 as referenced in Clause 28.1.2.

As an alternative to the test method described in Clauses 28.1.5 – 28.1.7, the maximum current may be determined when the secondary of the transformer is short-circuited using the extrapolation method in Clause 28.1.7. The results comply when the maximum current does not exceed 1000/V max A as shown in Table 4 for not inherently limited transformers.

The test data collected for use to extrapolate the current value should not include any unstable data due to coil insulation damage and the test data collected shall not be for less than 50 percent of the required test time.

28.3 Maximum power of non-inherently limited transformers

28.3.1 The maximum obtainable output power is not to exceed the value shown in Table 4. Protective devices shall be shorted out during this test. Unless the transformer is marked in accordance with Clause 17.4.2, multiple secondary windings, if any, shall be interconnected to produce maximum output power. For the purpose of this test, the transformer need not comply with Clause 18.9 as referenced in Clause 28.1.2. The maximum output power shall be determined by the following steps described in (a) – (g) below. Different samples shall be used for each condition.

a) The full load secondary voltage (V_{FL}) shall be measured at rated secondary current (I_{FL}).

b) Using the value of the open circuit voltage (V_{OC}) determined as described in the Open Circuit Secondary Voltage Test in Clause 27, the internal resistance (R_I) of the transformer shall be calculated using the formula:

$$R_I = \frac{V_{OC} - V_{FL}}{I_{FL}}$$

c) The load resistance (R_L) required in (d), (f) and (g) shall be calculated using the formula:

$$R_L = R_I \frac{\%}{1.0 - \%}$$

in which:

% is the percent of open circuit secondary voltage (for example, for the value 50, % would be equal to the value 0.5).

d) Starting with the transformer at room temperature, the transformer shall be loaded with a resistance load (R_L), calculated as described in (c), with the percent of open circuit secondary voltage (%) equal to 0.65. The ampere rating of the resistance load (R_L) shall not be less than the maximum secondary output current (I_O). At the end of 2 minutes of operation, the secondary voltage (V_O) and secondary output current (I_O) shall be measured. Once the transformer is energized, there shall be no adjustment of the resistance load (R_L).

e) The maximum output power (VA_O) shall be calculated using the formula:

$$VA_O = V_O \times I_O$$

f) When the output power (VA_O) calculated in (e) exceeds the value in Table 4, the result does not comply. When the output power (VA_O) calculated in (e) is not more than 80 percent of the value in Table 4, the result complies. When the output power (VA_O) calculated in (e) is within 20 percent of the value in Table 4, additional secondary voltage (V_O) and current (I_O) measurements are to be made and the maximum output power (VA_O) calculated with the percent of open circuit secondary voltage (%) equal to 0.6 and 0.7. The results do not comply if the calculated output power (VA_O) exceeds the value in Table 4.

g) When the maximum output power (VA_O) calculated at either the 0.6 or 0.7 level in (f) is greater than that calculated in (e), additional measurements shall be made. The resistance load (R_L) shall be set to the value calculated with the percent of open circuit secondary voltage (%) in (f) which resulted in a calculated maximum output power greater than that calculated in (e). Successive 0.05 increments shall be used to calculate R_L, and measurements shall be taken until the calculated output power (VA_O) starts to decline. The results comply when the maximum calculated output power (VA_O) does not exceed the appropriate value in Table 4.

29 Calibration Test of Overcurrent Protective Devices

29.1 An overcurrent protective device, provided as a part of a not inherently limiting Class 2 transformer shall operate to open the circuit in not more than the time indicated in Table 6 when the transformer is delivering the specified secondary current. The protective device may be located in either the primary or secondary circuit. Each test condition shall be started at room temperature. The results comply when there is no emission of flame or molten metal from the transformer enclosure and no other evidence of a risk of fire or electric shock as described in Clause 18.9.

Note: This test need not be conducted if a suitably rated (see Table 4) and calibrated fuse is provided in the output circuit.

29.2 The nominal rating noted in Clause 12.3.12 for an overcurrent protective device used can be greater than the value specified in Table 4. If so, the transformer shall be subjected to the test described in Clause 29.1.

30 Rated Secondary Current Test

30.1 A transformer marked with a secondary current rating shall be capable of delivering its rated full load secondary current continuously. When the transformer output rating is in volt-amperes or watts, the rated output current shall be determined by dividing the rated output voltage into the rated output volt-amperes or watts.

30.2 To determine whether a transformer complies with the requirement in Clause 30.1, a transformer shall be tested with a variable resistance and ammeter connected to the secondary and the primary connected to a circuit in accordance with Tests in Clause 18 of Part 1. When the transformer is rated for a range of frequencies (such as 50 – 60 Hz), or has a dual frequency rating (such as 50/60 Hz), the test shall be conducted with the supply circuit at the lowest frequency. The resistor shall be adjusted until the rated full load secondary current is drawn. When the transformer has an overtemperature or overcurrent protective device, the transformer shall be mounted so that the device is at the top. In all other cases, the transformer shall be mounted so that primary terminals or line end of the leads are on top. After 15 minutes of operation, the load shall be readjusted, if necessary, to return the current to the full load value. The circuit shall be energized for 1 hour without further adjustment. At the end of the 1 hour period, the output current shall not be less than 90 percent of the rated value, and the overtemperature or overcurrent protective device shall not function. The test shall be performed in an ambient temperature of 25 ±5°C (77 ±9°F).

30.3 With regard to Clause 30.2, when a transformer has two secondary windings, both windings shall be operated simultaneously with each secondary winding independently loaded.

31 Rated Output Heating Test

31.1 The test described in the Rated Secondary Current Test in Clause 30, shall be continued without further adjustment until temperatures become constant. Protective devices shall not be shorted out during this test. The temperature rise on various materials and parts shall not exceed the limits specified in Table 7, and protective devices shall not operate during the test.

31.2 With regard to note c of Table 7, a material's thermal conductivity can be obtained by comparing it with the known thermal conductivity of another material. A sample of the material with the unknown value of thermal conductivity shall be the same size as used in the transformer. It shall be placed in direct contact along one full side with a heated metal plate. A sample of the same size material with a known value of thermal conductivity shall be placed directly on top of the unknown material, along one full side. The change in temperature through each material shall be measured at points along the same vertical axis, and the coefficient of thermal conductivity of the unknown material may be derived from the following equation:

$$\frac{T \text{ of known material}}{T \text{ of unknown material}} = \frac{\text{coefficient of unknown material}}{\text{coefficient of known material}}$$

31.3 Other than those cases where it is specifically stated that temperature determinations shall be made by the resistance method, temperatures shall be measured by means of thermocouples. A thermocouple-measured temperature is constant when 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 shall securely contact the point of the surface to be measured. The thermocouple shall consist of wires not larger than 24 AWG (0.21 mm^2).

31.4 Coil and winding temperatures shall be determined by the resistance method.

31.5 When thermocouples are used to determine temperatures involving the heating of electrical devices, it is standard practice to use thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer-type indicating instrument or digital thermocouple monitor. Such equipment shall be used whenever referee temperature measurements are necessary. The thermocouple wire shall conform to the requirements for special thermocouples listed in the table for limits of error of thermocouples in Temperature Measurement Thermocouples, ISA MC96.1.

31.6 The temperature rise of a copper or aluminum winding shall be calculated by the following formula (windings are to be at room temperature at the start of the test):

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

in which:

Δt is the temperature rise;

t_1 is the room temperature at the beginning of the test, in °C;

t_2 is the room temperature at the end of the test, in °C;

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; and

k is 234.5 for copper and 225.0 for aluminum.

31.7 Since it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after shutdown. A curve of the resistance values against time may be plotted and extrapolated to give the value of R at shutdown. A similar result may be achieved by using the least square statistical method or other appropriate curve-fitting algorithm such as exponential regression with a computer or programmable calculator. Instrumentation by which R can be measured while the coil is energized may be used.

32 Dielectric Voltage-Withstand Test

32.1 General

32.1.1 A transformer shall be subjected for 1 minute to the application of a 60 Hz essentially sinusoidal potential with the unit at the maximum operating temperature reached in the Rated Output Heating Test in Clause 31. The results comply if there is no dielectric breakdown. The applied potential shall be:

a) 1000 V plus twice the primary test voltage as specified in Table 12 of Part 1 between the primary circuit and accessible dead metal parts.

b) 2500 V between the primary and secondary circuits.

c) 1000 V plus two times the sum of the secondary voltages between the secondary windings unless considered a single winding as described in Note 1 of Clause 11.3.1.

d) 1000 V plus twice the maximum rated secondary circuit voltage between a secondary circuit operating at more than 30 V (42.4 V peak) and accessible dead metal parts.

e) 500 V between a secondary circuit operating at 30 V (42.4 V peak) or less and accessible dead metal parts.

Note: Multifilar constructed coil sections designed for series or parallel connections subjected to the induced potential tests described in Clause 32.2 need not be subjected to the applied potential requirements in Clause 32.1.

32.1.2 To determine if a transformer complies with the requirements in Clause 32.1.1, it shall be tested by means of a transformer with a capacity of 500 VA or larger, having an output voltage that is essentially sinusoidal and can be varied. The applied potential shall be increased from zero until the required test level is reached and shall be held at that level for 1 minute. The applied potential shall be increased at a uniform rate as rapid as is consistent with its correct value indicated by the voltmeter.

Note: A 500 VA or larger capacity transformer is not required when the transformer is provided with a voltmeter to measure directly the applied output potential.

32.1.3 Dielectric breakdown, not leakage current, shall be the criterion that determines compliance. Leakage current is the normal flow of current due to imperfect insulating materials and can vary with the applied voltage. Dielectric breakdown typically occurs when there is an abrupt decrease or retarded advance of the voltmeter reading.

32.1.4 Barrier material used in lieu of spacings, or to reinforce insulation, shall be placed between two flat metal electrodes and the test voltage shall be increased to 5000 V and maintained for 1 second. There shall be no dielectric breakdown.

32.2 Induced potential

32.2.1 With regard to Clauses 25.1 and 25.2 of Part 1, the transformer shall be tested in a heated condition after the Rated Output Heating Test in Clause 31. However, the transformer may be conditioned in an oven to obtain the temperature reached as a result of the heating test.

32.2.2 A transformer with two or more windings (marked as described in Clause 17.4.12) for autotransformer operation shall additionally be tested in this manner with the transformer connected for such autotransformer operation. For a multi-winding transformer, the specified test voltage shall be applied to each winding separately. There shall not be dielectric breakdown as a result of this test.

33 Overload Heating Test

33.1 General

33.1.1 The transformer shall be subjected to the overload tests described in Clauses 33.2.1 – 33.2.8, as specified in Tests in Clause 18. A protective device that is relied upon to open the circuit as a result of the tests shall be one that has been investigated for this purpose.

33.1.2 The temperature rises specified shall be based on an assumed ambient temperature of 25°C (77°F), but a test may be conducted at any ambient temperature of 21 – 30°C (70 – 86°F). If the operation of an automatic thermal control during the test limits the temperatures under observation, no temperature higher than 25°C plus the specified maximum rise shall be acceptable.

33.2 Procedure

33.2.1 One sample of a transformer shall be operated under the conditions of Table 9 as described in Clauses 33.2.2 – 33.2.8 and Figure 1. After completion of the test, the transformer is to be subjected to the Dielectric Voltage-Withstand After Overload Heating Test as described in Clause 34.

33.2.2 The test is to be terminated when the transformer operates the full 7 hours as described in Clause 33.2.3 without a winding or protective device opening and complies with the following items:

a) The temperature rise of the coil, determined by the resistance method described in Clauses 31.6 and 31.7, does not exceed the temperature rise specified in Table 8 for the appropriate class of insulation.

b) There is no evidence of risk of fire or electric shock as described in Clause 18.9.

Note: The temperature rise specified in (a) may exceed the value specified in Table 8 if the test is continued on three samples for 15 days as described in Clause 33.2.4.

33.2.3 Condition A of Table 9 is to be used as the test condition unless the test is then interrupted by a protector or burnout before 7 hours has elapsed. The next condition in the table is then to be used. This is to continue as shown in Figure 1 until a transformer operates the full 7 hours or, if the temperature rise at the end of 7 hours exceeds the values given in Clause 33.2.2(a), until three samples of the transformer operate for 15 days as described in Clause 33.2.4. Test Conditions A – I may be run sequentially or simultaneously.

33.2.4 In accordance with the note of Clause 33.2.2(a), three samples of the transformer are to be tested for 15 days under the condition specified in Table 9 that caused the temperature rise values in Clause 33.2.2(a) to be exceeded. At the end of 15 days, the transformer shall comply with Clause 33.2.2(b). If the 15-day test is interrupted and the transformer complies with Clause 33.2.2(b), the next condition is to be used and the test is to be continued as described in Clause 33.2.3. If this 15-day test is interrupted, and the transformer does not comply with Clause 33.2.2(b), the result does not comply.

33.2.5 For the purpose of these requirements, each secondary winding tap is considered the equivalent of a secondary winding.

33.2.6 When a transformer is equipped with more than one secondary winding, each of the secondary windings is to be loaded for each condition specified in Table 9 with the other windings loaded to rated current.

33.2.7 All secondary windings are to be loaded to rated current before the abnormal condition is introduced. The loads, other than the one connected to the winding to be overloaded, are not to be readjusted thereafter.

33.2.8 For the loading conditions, a variable resistor is to be connected across the secondary winding. The tests described in Conditions A – I of Table 9 are to be continued for 7 hours unless a winding of the transformer or a protective device opens in a shorter time. When conducting the tests described in Conditions C – I of Table 9, the variable resistance load is to be adjusted to the required value as quickly as possible and readjusted, if necessary, 1 minute after application of voltage to the primary winding.

34 Dielectric Voltage-Withstand After Overload Heating Test

34.1 In Canada, not more than 10 seconds after completion of the overload heating test, a transformer shall be subjected to the Dielectric Voltage-Withstand Test in Clause 32. The transformer shall withstand, without breakdown, the application of the specified voltage for 1 minute.

In the United States, one minute after completion of the overload heating test, a transformer shall be subjected to the Dielectric Voltage-Withstand Test in Clause 32. The transformer shall withstand, without breakdown, the application of the specified voltage for 1 minute.

Note: The voltage between primary and secondary need not exceed 1000 V plus twice the primary test voltages covered in Clause 18.6 and Table 12 of Part 1.

35 Overload Test of Overcurrent or Overtemperature Protective Devices

35.1 A protective device (other than a fuse, thermal cutoff, or an automatically resettable device covered in the Endurance Test of Automatically Reset Overtemperature Protective Devices in Clause 36) provided as part of a transformer shall be capable of making and breaking the circuit for a total of 50 cycles of operation with the transformer loaded in accordance with Tests in Clause 18. When the transformer is rated for a range of frequencies (such as 50 – 60 Hz) or has a dual frequency rating (such as 50/60 Hz), the test shall be conducted at the lowest frequency. The results comply when there is no emission of flame or molten material from the transformer enclosure, or other evidence of a risk of fire or electric shock, as described in Clause 18.9, and the overcurrent protective device is operable at the end of the test.

36 Endurance Test of Automatically Reset Overtemperature Protective Devices

36.1 A transformer provided with an automatically reset over-temperature protective device shall be subjected to an endurance test. The secondary shall be loaded as described in the Output Current and Power Test in Clause 28, to produce the maximum possible current through the automatic reset device. The transformer shall be connected to a source of supply as described in Tests in Clause 18. When the transformer is rated for a range of frequencies (such as 50 – 60 Hz) or has a dual frequency rating (such as a 50/60 Hz) the test shall be conducted at the lowest frequency. The transformer shall operate for 15 days. The results comply when:

a) There is no emission of flame or molten material from the transformer enclosure;

b) There is no other evidence of a risk of fire or electric shock as described in Clause 18.9; and

c) The protective device remains operable.

When the current results in interruption of an overcurrent protective device, a new transformer shall be tested starting with the load current that caused a current of 110 percent of the overcurrent device rating to flow through the overcurrent device. If the overcurrent device opens the circuit before 15 days, a new transformer shall be tested. The load current shall be decreased in increments of 2 percent of the overcurrent device rating until a current is reached at which the overcurrent device does not open in 15 days.

Note: The test does not have to be conducted when the protective device has been previously tested at 6000 cycles of operation at the maximum measured voltage and maximum available current of the winding circuit to which it is connected as determined in the Output Current and Power Test in Clause 28.

37 Strain Relief Test

37.1 The strain relief means on a lead intended for connection to field wiring shall be subjected to a force equal to the weight of the transformer but not less than 13.4 N (3 lbs) nor more than 45 N (10 lbs). The force shall be applied to the lead for 1 minute in any direction enabled by the construction. The results comply when there is no indication of stress on the internal connections of the transformer.

TABLES

Table 1
Spacings between uninsulated primary and secondary windings of bobbin-wound transformers

(See Clause 11.5.2)

Potential involved, V rms	Minimum through air and over surface spacings, mm	(in)
150 or less	1.6	0.06
Over 150 – 600	4.8	0.19
For transformers intended for use in Canada:		
Over 150 – 750	4.8	0.19

Table 2
Wiring compartment marking

(See Clause 17.4.8 and Table 7)

Temperature rise attained during test		Value to be used in marking indicated in Clause 17.4.8
More than °C	But not more than °C	°C
35	50	75
50	65	90

Table 3
Sequence of tests and number of samples

(See Clause 18.6)

Clause	Test	Number of samples
27	Open Circuit Secondary Voltage Test	3[a]
28	Output Current and Power Test	3[a]
29	Calibration Test of Overcurrent Protective Devices	3[a]
30	Rated Secondary Current Test	3[a]
31	Rated Output Heating Test	1[a]
32	Dielectric Voltage-Withstand Test	1 or more[a]
33	Overload Heating Test	1 or more[a]
34	Dielectric Voltage-Withstand After Overload Heating Test	1 or more[a]
35	Overload Test of Overcurrent or Overtemperature Protective Devices	3[a]
36	Endurance Test of Automatically Reset Overtemperature Protective Devices	3[a]
37	Strain Relief Test (leads for field wiring)	1[b]

[a] The same samples shall be used for these tests in the order indicated; however, if a nonreplaceable protective device opens, or a coil burnout occurs as specified in Clauses 28, 29, and 33, additional samples shall be used for the remaining tests. These additional samples need not be subjected to the preceding tests.

[b] A new sample may be used and the test may be conducted in different order.

Table 4
Current and power limitations

(See Clauses 12.3.7, 12.3.12, 17.3.1, 28.1.2, 28.1.6, 28.2.1, 28.3.1, 29.1 and 29.2)

Circuit	Inherently limited transformer (overcurrent protection not required)		Not inherently limited transformer (overcurrent protection required)		
Circuit Voltage (V)	0 – 20[a]	Over 20 but no more than 30[a]	0 – 15[a]	Over 15 but no more than 20[a]	Over 20 but no more than 30[a]
Power Limitation (VA)[b]	–	–	350	250	250
Current Limitation (A)[c]	8	8	1000/V	1000/V	1000/V
Maximum Overcurrent Protection (A)	–	–	5	5	100/V
Transformer Maximum Nameplate Rating:					
Power (VA)	5 x V	100	5 x V	5 x V	100
Current (A)	5	100/V	5	5	100/V

NOTES –

1 In all cases the applied primary voltage and frequency shall be as indicated in Clause 18.5 and Table 12 of Part 1.

2 V is the maximum output voltage, regardless of load, with rated input applied.

Table 4 Continued on Next Page

Table 4 Continued

Circuit	Inherently limited transformer (overcurrent protection not required)	Not inherently limited transformer (overcurrent protection required)
3 When overcurrent protection is provided, the current limitation applies to the output of the transformer, not the value of the protective device.		
[a] Voltage ranges shows are for sinusoidal AC in indoor locations or where wet contact is not likely to occur. For nonsinusoidal AC, V shall not be greater than 42.4 V peak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used (applicable to transformers intended for use in the United States only) or V shall not be greater than 15 V for sinusoidal AC, and 21.2 V peak for nonsinusoidal AC.		
[b] Maximum volt-ampere output regardless of load, and overcurrent protection (if used) bypassed. Current-limiting impedances (if used) not bypassed.		
[c] Maximum output after 1 minute of operation under any non-capacitive load, including short circuit, and with overcurrent protection (if provided) bypassed. For a current-limiting impedance, maximum output after 5 seconds of operation under any non-capacitive load, including short-circuit, and with overcurrent protection (if provided) bypassed. Current-limiting impedances (if used) not bypassed.		

Table 5
Location of required markings for low voltage transformers

(See Clause 17.1.7)

Marking reference	Requirements	Location[a]	
		Enclosed	Open
General			
17.1.7	Class 2 marking	A	B
17.3.1	Electrical rating	A	B
17.3.3	Open circuit voltage greater than 15 V rms	A	B
17.4.6	Replaceable protective device marking	B	B
17.4.7	External protective device that is not interchangeable marking	B	B
Wiring terminal markings			
17.4.1	Identification of primary and secondary terminals	B	B
17.4.2[b]	Multiple secondary windings exceeding 30 V	B	B
17.4.8	Field installed lead with temperature rise more than 35°C	B	B
17.4.9	Transformer for use on circuits rated less than 110 V	B	B
17.4.10	Transformers in accordance with Articles 398 and 394 of the NEC	B	B
17.4.11	Transformers for use with open wiring intended for use in Canada.	B	B
[a] Required markings may be placed with an instruction manual or stuffer sheet when the transformer is such that space does not allow for markings.			

Table 5 Continued on Next Page

Table 5 Continued

Marking reference	Requirements	Location[a]	
		Enclosed	Open

[b] This marking may also be on a permanent tag secured to the transformer. If a tag is used it shall comply with Clauses 17.4.4 and 17.4.5.

For marking locations identified below, "A" is the highest order of location, and "D" is the lowest order of location. At the option of the manufacturer, a higher order of location category can be used.

A. Marking shall be visible after installation when the enclosure cover is on and the door is closed.

B. Marking shall be visible before installation:

1. When the enclosure cover is removed or the door is open;
2. When other devices are mounted nearby as intended; and
3. When devices are installed side-by-side with intended clearances.

C. Marking can be located anywhere on the device and is not required to be visible after installation.

D. Marking is on a wiring diagram or instructional manual shipped with the device.

Table 6
Maximum time to open

(See Clause 29.1)

Open circuit secondary potential, V	Secondary test current, A	Maximum time for overcurrent protective device to open, minutes
20 or less	10	2[a]
20 or less	6.75	60[b]
Over 20 to 30	200/Vmax	2[a]
Over 20 to 30	135/Vmax	60[b]

[a] The load shall be adjusted continuously to maintain the test current value shown.

[b] After 15 minutes of operation, the current shall be readjusted to return the power to the value shown.

Table 7
Maximum temperature rises

(See Clauses 11.3.5 (Part 1), 31.1 and 31.2)

	Material	°C
1.	Rubber or thermoplastic insulated conductors[a]	35
2.	Primary circuit field wiring[b]	35
3.	Fuses other than Class CC, G, J, or T, and fuses other than those with glass or ceramic bodies	65
4.	Class CC, G, J, or T fuses and those fuses with glass or ceramic bodies	85
5.	Fibre used as electric insulation	65
6.	Varnish-cloth insulation	60
7.	Phenolic composition[a]	125
8.	Wood or similar material	65
9.	Class 105(A) transformer insulation system:	
	Resistance method	75
	Thermocouple method	65
10.	Class 120(E) transformer insulation system:	
	Resistance method	85
	Thermocouple method	75
11.	Class 130(B) transformer insulation system:	
	Resistance method	95
	Thermocouple method	85
12.	Class 155(F) transformer insulation system:	
	Resistance method	115
	Thermocouple method	110
13.	Class 180(H) transformer insulation system:	
	Resistance method	135
	Thermocouple method	125
14.	Class 200(N) transformer insulation system:	
	Resistance method	150
	Thermocouple method	140
15.	Class 220(R) transformer insulation system:	
	Resistance method	165
	Thermocouple method	155
16.	Surface temperature, permanently connected transformer	60
17.	Polymeric material[d]	40°C less than its temperature rating

[a] The limitation on phenolic composition and rubber and thermoplastic insulation do not apply to compounds that have been investigated and found to be acceptable for use at a higher temperature; however, the maximum acceptable temperature rise is not to equal or exceed a value that is the acceptable temperature limit for the material in question.

[b] The maximum temperature rise at primary circuit field wiring may be 65°C if the transformer is marked in accordance with Clause 17.4.6 and Table 2.

[c] A material having a coefficient of thermal conductivity greater than 4.18 W/M•K (2.419 Btu•ft/hour•ft•°F) is considered to be metal.

[d] Material relied upon for enclosure, barriers, or direct support of live parts other than coils. Polymeric material used in a Class 105(A) coil insulation system shall have an electrical relative thermal index not less than 105°C (221°F).

Table 8
Maximum coil temperature rise for insulation systems

(See Clause 33.2.2)

Insulation system class	Temperature rise, °C
105(A)	105
120(E)	120
130(B)[a]	135
155(F)[a]	160
180(H)[a]	185
200(N)[a]	205
220(R)[a]	225

[a] Insulation shall comply with the requirements in Clause 11.3.5 of Part 1.

Table 9
Test loading conditions[a]

(See Clauses 33.2.1, 33.2.3, 33.2.4, 33.2.6, 33.2.8, and Figure 1)

Condition	Secondary winding load
A	Load used for final sample in tests described in Clauses 28.1 and 28.2
B	Rectifier to cause half wave rectified short circuit
(For conditions C – I) rated current plus indicated percent of difference between condition A and rated current:	
C	75
D	50
E	25
F	20
G	15
H	10
I	5

[a] If the maximum available secondary winding current of a transformer is considered to comply with the maximum allowable current limitation and it is impractical to obtain the one minute current value for this test, the maximum measured secondary current value at the time of coil burnout, or 8 A, may be used to determine the overload test conditions.