5085-2

Low Voltage Transformers – Part 2: General Purpose Transformers

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UL Standard for Safety for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2

First Edition, Dated April 17, 2006

Revisions: This Standard contains revisions through and including June 1, 2007.

Summary of Topics

This revision to ANSI/UL 5085-1 is being issued to revise the effective date information in the Preface to indicate that the standard is now in effect. CSA is not issuing a revision at this time. The change will be incorporated into the CSA version the next time UL and CSA modify the standard.

Text that has been changed in any manner is marked with a vertical line in the margin.

The revisions dated June 1, 2007 include a reprinted title page (page1) for this Standard.

The revisions dated June 1, 2007 were issued to revise the UL effective date information in the Preface.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

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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 preface. 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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.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.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-2	June 1, 2007
3-4	April 17, 2006
5-6	June 1, 2007
7-36	April 17, 2006

No Text on This Page

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Low Voltage Transformers – Part 2: General Purpose Transformers

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ANSI/UL 5085-2-2006

Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (CSA) and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of CSA and UL. CSA 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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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. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

The most recent designation of ANSI/UL 5085-2 as an American National Standard (ANSI) occurred on April 17, 2006. The ANSI approval for this standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface.

This ANSI/UL Standard for Safety, which consists of the First edition including revisions through June 1, 2007, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

CONTENTS

Annex C (Informative)

Preface

This is the common CSA and UL standard for low voltage transformers. It is the first edition of CSA C22.2 No. 66.2 and the first edition of UL 5085-2. This edition of CSA C22.2 No. 66.2 supersedes the requirements of CSA C22.2 No. 66 published in 1988. This edition of UL 5085-2 supersedes the Twelfth edition of UL 506 published in 2000.

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

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.

This Standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

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 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.

CSA Effective Date

The effective date for CSA International will be announced through CSA Informs or a CSA certification notice.

UL Effective Date

This Standard is now in effect.

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 2: GENERAL PURPOSE 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 of Part 2 cover:

a) Air-cooled transformers and reactors for general use;

b) Autotransformers;

c) Ferroresonant transformers;

d) Cord-connected transformers; and

e) Transformers incorporating overcurrent or over-temperature protective devices, transient voltage surge protectors, or capacitors.

1.7 These requirements do not cover Class 2 and Class 3 transformers (which are evaluated in Part 3).

1.8 Part 2 is intended to be used in conjunction with Part 1. The numbering of the clauses in Part 2 corresponds to the numbered clauses in Part 1. The requirements in Part 1 apply unless modified by Part 2.

5 Mechanical Assembly

5.4 A transformer weighing more than 45 kg (100 lbs) shall be provided with a means for lifting by a fork lift, cable, sling, or similar method. The lifting means may be provided on the transformer core or frame if the transformer has a removable top cover. The lifting means shall be subjected to the Lifting or Mounting Means Test in Clause 37.

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

6 Enclosure

6.5 Openings

6.5.2 Openings shall prevent passage of a straight rod 12.7 mm (0.5 in) in diameter. When the distance between live parts and the enclosure and between the plane of the ventilation opening and live parts is 102 mm (4 in) or more, openings shall be constructed so that they will prevent passage of a rod 19 mm (0.75 in) in diameter. When the distance between the plane of the opening and uninsulated live parts is less than 102 mm, the rod shall have a cross-section of 13.4 mm (0.53 in).

8 Connections

8.1 General

8.1.4 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.

Note: Studs or wire binding screws may be used for field connections when the full load current of the terminal is 24 A or less and the transformer is marked in accordance with Clause 17.5.5. The studs or wire binding screws may be used for the field connection of 10 AWG (5.3 mm^2) or smaller conductors.

8.4 Pressure terminal connectors

8.4.5 More than one wire connector may be provided for a single connection point to allow for connection of the various size conductors which require accommodation. In such case, each connector shall be marked in accordance with Clause 17.5.7.

8.5 Leads

8.5.9 A transformer lead shall:

a) Be of stranded wire.

b) Not be smaller than 14 AWG (2.1 mm^2) copper or 12 AWG (3.3 mm^2) aluminum.

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

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). A secondary lead of a transformer of the type described in Clause 6.4.6 of Part 1 shall have a minimum length of 457 mm (18 in) available for connection.

Note: 18 AWG (0.82 mm^2) copper wire may be used as a lead for a transformer when the transformer is provided with a wiring compartment or is intended for mounting on an outlet box.

8.5.10 When a transformer is not intended for outlet box mounting and is not provided with a terminal or winding compartment, the leads shall enter the enclosure either through a nipple or other means for the attachment of rigid metal conduit. Alternatively, the leads shall enter through separate holes that provide a spacing of not less than 6.4 mm (0.25 in) between the conductors and not less than 12.7 mm (0.5 in) between the conductors and the plane of the transformer support.

8.5.11 Transformers, and their external leads, intended for installation in other enclosures (e.g., control circuit transformers housed with industrial control equipment) may have:

a) Primary and secondary leads in the same opening, when they have insulation suitable for the highest voltage involved and a temperature rating of at least 105°C (221°F) and

b) Metal grommets or smooth, folded edges.

8.5.12 One of the secondary terminals or leads of an autotransformer intended for operation on a circuit of 150 V or less to ground shall be identified for the connection of a grounded circuit conductor. It shall be directly connected to a similarly identified primary terminal or lead. The identification shall be as specified in Clause 17.5.1.

8.6 Splice compartment

8.6.1 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 1.

8.7 Wiring compartment

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

8.7.2 There shall be enough wiring space to accommodate connections to the transformer as specified in Clauses 8.8.1 – 8.8.6. 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; and

c) Connection of a transformer for buck or boost use.

The wiring space extension assembly shall comply with the requirements in Enclosures in Clause 6 of Part 1, and shall be marked as specified in Clauses 17.5.11 and 17.5.12.

8.8 Wire bending space

8.8.1 A wiring space shall be clear of all obstructions and have a cross-sectional area not less than 250 percent of the total cross-sectional area of the maximum number of wires intended for installation in the wiring space. The minimum width or depth shall not be less than that shown in Table 2.

8.8.2 Except as specified in Clause 8.8.1, wire bending space (for field wiring including the neutral) for the maximum size and number of wires intended shall not be less than:

a) The values specified in Table 3 or

b) The values specified in Table 4 when the wire connectors are readily removable to facilitate connection.

8.8.3 For wires that do not enter an enclosure through the portion of the wall opposite the field wiring terminals, wire bending space shall not be less than that shown in Table 5 for the maximum size and number of wires intended when:

a) They are required to make only one 90 degree bend after the wires enter the enclosure or

b) The wires enter a space having a width not less than that shown in Table 3 for the maximum size and number of wire(s) intended, and this space opens directly into the wire bending space.

In both cases the intended wiring method shall be ensured by suitably located knockouts, openings, or by a diagram supplied with the equipment.

8.8.4 The wire bending space at a field wiring terminal shall be measured:

a) From the enclosure wall opposite it;

b) From the center of the conductor opening on the face of the wire connector; and

c) From the line in which the wire leaves the connector (when the connector is at the smallest angle to the perpendicular) to the enclosure wall that it can assume without defeating any integral means provided to prevent turning.

A connector shall not be directed at a corner or a recess in an enclosure to obtain the required bending space.

8.8.5 When a terminal is provided with one or more wire connectors for connecting multiple wires, the bending space shall be measured from the wire opening closest to the wall of the enclosure.

8.8.6 When a wire is restricted by a barrier or obstruction from being bent in a single 90-degree or S bend between the terminal and any approved permitted enclosure entrance point, the wire bending space shall be measured from the end of the barrier or obstruction to the wall toward which the wire is directed, in a line perpendicular to the wall.

8.8.7 When the measurement is being made, a barrier, shoulder, or similar item shall be disregarded when it does not reduce the radius to which the wire must be bent.

8.8.8 Wire bending space at other than field wiring terminals shall have a minimum dimension not less than that shown in Table 5. Only one 90-degree bend shall be allowed within that space.

8.8.9 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 a similar means for making field connections. The jumpers (or similar means) shall be packaged with the transformer, and the transformer shall be marked in accordance with Clause 17.5.13.

8.9 Receptacles

8.9.1 If provided, an output receptacle shall be protected by an overcurrent device rated no more than that of the receptacle.

Note: Overcurrent protection is not required when the transformer cannot deliver a current more than the rating of the receptacle under any condition of loading.

11 Spacings and Insulation

11.1.2 In addition to those spacings specified in Clause 11.1.2 of Part 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 6 for a transformer intended for use in a 40°C (104°F) ambient (i.e., industrial applications for transformers).

11.4 Insulation used in lieu of spacings

11.4.10 With regard to the requirement in Clause 11.4.1 of Part 1, insulation and spacings shall not be specified between windings that are intended for interconnection (i.e., series/parallel connections). Those windings shall comply with the marking specified in Clause 17.5.14 and shall also be subjected to the dielectric voltage test specified in Clause 29.1.1.

13 Current-Carrying Parts

13.11 With regard to the requirement in Clause 13.2 of Part 1:

a) An aluminum current-carrying part is not required to 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 and

b) 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 Clause 17.5.10.

14 Cord-Connected Transformers

14.2 A flexible cord, when used for connection to the supply circuit, shall comply with Clauses 14.3 – 14.6 and be provided with an attachment plug. The attachment plug shall be polarized or of the grounding-type.

14.3 A supply cord shall be:

a) Of a type that is intended for the usage;

b) Intended for use at a voltage and ampacity not less than the rated voltage and ampacity of the transformer; and

c) Rated for either:

1) Extra-hard or hard usage type (for transformers intended for use in the United States for example, Type S, SE, SO, SP-3, SPT-3, ST, STO, SJ, SJE, SJO, SJT, or SJTO for transformers with a mass over 5 kg (11 lbs)) or

2) Not for hard usage types (for transformers intended for use in the United States, for example, Type SP-2, SPE-2, SPT-2, SV, SVE, or SVT for transformers with a mass of 5 kg and less).

14.4 The ampacity of the attachment plug shall not be less than 125 percent of the input rating.

14.5 When a transformer with a power supply cord can be adapted for use on two or more different voltages by field alteration of internal connections, the attachment plug provided with the unit shall be of a type required for the voltage and current for which the unit is shipped from the factory.

14.6 Cord-connected transformers shall be subjected to the Leakage Current and Power Input Tests specified in Clauses 35 and 36 respectively.

15 Strain Relief

15.3 Strain relief shall be provided to prevent mechanical twisting or stress on a supply cord from being transmitted to terminals, splices, or wiring or other connections inside the transformer. The means for preventing twisting shall be evaluated by inspection. The suitability of the strain relief shall be evaluated in accordance with the Strain Relief Test in Clause 38.

15.4 A metal strain-relief clamp or band is acceptable without supplementary protection on a Type SV, SVO, SJ, SJE, SJO, S, SO, SJT, SJTO, ST, or STO cord. A metal strain-relief clamp or band is acceptable on a Type SP-2, SPE-2, SPT-2, SVE, SVT, or SVTO cord only when supplementary nonconductive, mechanical protection is provided over the cord.

15.5 When a knot in a flexible cord serves as strain relief, the surfaces that the knot touches shall be free from burrs, fins, sharp edges, and projections that can damage the cord.

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 transformer shall be rated in volts and amperes or volt-amperes. The unit shall be marked with the following electrical ratings:

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

b) Number of phases (except for single phase);

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. The primary capacity in amperes shall also be included when the transformer is cord-connected.

17.3 Environmental condition enclosures

17.3.1 A transformer shall be marked with the environmental type number or numbers (as specified in the Standard for Enclosures for Electrical Equipment, UL 50, or CAN/CSA-C22.2 No. 94, Special Purpose Enclosures) for 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.

17.3.2 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. ____.″

17.3.3 The hood described in Clause 17.3.2 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.

17.3.4 A transformer marked ″Type 3R Enclosure″ (or with a similar marking) 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.

17.4 Details

17.4.1 Markings shall be located as shown in Table 11 of Part 1 and Table 7. Markings are required to be beneath a cover and visible during installation. They are not required to be visible after installation. Markings specified for a separate instruction sheet may be located on a transformer if either readily visible after or during installation and beneath a removable cover.

17.4.2 With regard to Tables 8 and 9, a transformer shall be marked with a temperature class that is less than or equal to the rating of the insulation system used.

17.4.3 A transformer weighing more than 45 kilograms (100 lbs) shall be marked with its weight in kilograms (lbs).

17.4.4 An autotransformer shall be marked ″autotransformer.″

17.4.5 A polyphase transformer shall be provided with a wiring diagram.

17.4.6 A transformer rated 25 kVA or more shall be marked with the percent impedance.

17.4.7 When the temperature rise on a transformer enclosure is more than 65°C, the transformer shall be clearly marked. The marking shall indicate:

a) The minimum separations (the distance X and Y in Figure 1) required between the enclosure and adjacent surfaces to prevent temperatures from reaching more than 90°C (194°F) on the adjacent surfaces and

b) A minimum height of ___ m (__ft.) at which the transformer may be mounted. The marking shall be located so that it will be plainly visible after the transformer has been installed as intended.

17.4.8 When tested in accordance with the Temperature (Heating) Test in Clause 26, a transformer enclosure with a receptacle attaining a temperature rise that exceeds 35°C but not greater than 45°C shall be plainly marked with the following or equivalent wording:

″Warning: Surface temperature may exceed 60°C. Do not place line cords or other material on this unit.″

17.5 Wiring

17.5.1 With regard to Clause 8.5.12, a terminal for the connection of a grounded conductor shall be distinguishable from the other terminals. It shall be provided with a metallic-plated coating that is white. When wire leads are provided in place of terminals for the transformer, the identified lead shall be white or gray and shall be readily distinguishable from the other leads.

17.5.2 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. The 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).

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

17.5.4 During the temperature test, when 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. The marking shall be located at or near the points where field connections will be made. The statement to be used (or one that is similar) shall be selected in accordance with Table 10.

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.″

17.5.5 When the pressure terminal connectors, the wire-bending space, and the wiring space of a transformer are intended for both copper and aluminum wire, the transformer shall be marked (independent of any marking of the terminals) with the following or similar statement: ″Use aluminum or copper wire,″ or ″AL-CU.″ This marking may be combined with that specified in Clause 17.5.4.

17.5.6 A transformer constructed for line and load conductors with a single 90 degree bend shall be provided with a wiring diagram specifying the wiring method used to accomplish the 90 degree bend.

17.5.7 When more than one connector is provided at a single connection point in accordance with Clause 8.4.5, each connector shall be identified with the wire size or range of wire sizes for which it is intended.

17.5.8 When 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.

17.5.9 When 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.

17.5.10 When it is necessary to provide a corrosion-inhibiting compound in accordance with Clause 13.11, instructions for applying the compound shall be provided.

17.5.11 A transformer intended for a connection that requires a wiring space extension assembly, as described in Clause 8.7.2, shall be marked with instructions for determining the catalog number of the assembly.

17.5.12 A wiring space extension assembly, as described in Clause 8.7.2, shall be marked with its catalog number and with the manufacturer's identification.

17.5.13 A transformer that is provided with jumpers or similar means for making field connections in accordance with Clause 8.8.9 shall be marked to identify how the jumpers or equivalent means are to be connected for parallel operation and series operation of the transformer.

17.5.14 A transformer that has two or more windings intended to be connected in a series or parallel configuration and has been subjected to the dielectric voltage withstand test specified in Clause 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 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 29.2.1.

18 Tests

18.6 Representative samples of a transformer shall be subjected to the tests noted below in the following order:

Single sample: Voltage Measurement Test, Clause 27; Impedance Test (if applicable), Clause 28; Temperature (Heating) Test, Clause 26; Dielectric Voltage-Withstand Test, Clause 29; Overload Test, Clause 30; Repeated Dielectric Voltage-Withstand Test, Clause 31.

The following alternate test method can be used with two samples:

a) First sample: Voltage Measurement Test, Clause 27; Impedance Test (if applicable), Clause 28; Temperature (Heating) Test, Clause 26; Dielectric Voltage-Withstand Test, Clause 29.

b) Second sample: Voltage Measurement Test, Clause 27; Overload Test, Clause 30; Repeated Dielectric Voltage-Withstand Test, Clause 31; Dielectric Voltage-Withstand Test, Clause A1 of Annex A.

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

a) For a single phase transformer:

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

b) For a three phase transformer:

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

18.8 A transformer shall be weighed. It shall also be subjected to the Lifting and Mounting Means Test specified in Clause 37.1. When the transformer weighs more than 45 kilograms (100 lbs), it shall be marked in accordance with Clause 17.4.3.

18.9 Results obtained from the tests described in Clauses 26 – 36 performed on transformers with aluminum windings can be used to represent transformers with copper windings, as long as the size and number of windings of the copper windings are identical to those of the aluminum windings. However, results of tests conducted on transformers with copper windings cannot be used to represent transformers with aluminum windings.

21 Bonding Conductor Test

21.5 In addition to the applicable requirements specified in Part 1, cord-connected transformers shall be subjected to the following test. A 60 Hz current of twice the rating of the attachment plug cap, but not less than 30 A, shall be applied between a dead metal part intended for grounding and the grounding terminal means for the period specified in Table 13 of Part 1. A potential drop shall be measured between the grounded part and grounding terminal means at the end of this period.

21.6 Results comply when:

a) The measured potential drop does not exceed 4 V and

b) There is no evidence of melting of any metal bond nor heating or burning that would create a risk of fire or electric shock.

26 Temperature (Heating) Test

26.6 With the frame or enclosure grounded, a transformer shall operate continuously at the test voltage specified in Table 12 of Part 1 and rated frequency with the secondary delivering full load secondary current. For multi-tap transformers, the tap with the highest rated voltage shall be tested. When the transformer is rated for a range of frequencies (such as 50 – 60 Hz), the test shall be conducted with the supply circuit at the lowest frequency. Transformers rated 50/60 Hz shall be tested at either 50 Hz or at 60 Hz plus 120 percent of the rated input voltage of the transformer. The test shall be conducted until constant temperatures are attained. The surface temperature rise or the temperature rise of the coil windings shall not exceed the values specified in Tables 8 and 9. There shall be no degradation of the insulation system or any part of the transformer.

Note: The surface temperature rise or the temperature rise of the coil windings may be determined using methods specified in the Standard Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.91.

26.7 In the test mentioned in Clause 26.6, the load shall consist of resistance. The load shall be adjusted until full load secondary current flows. After 15 minutes of operation, the load shall be readjusted, when necessary, to restore the current to full load value, but no further adjustment shall be made thereafter. Winding temperature rises (for determining the temperatures on the winding insulation) shall be measured by the resistance method.

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

Note: Conductors may be sized on a basis of 60°C (140°F) ampacity if the transformer is marked in accordance with Clause 17.5.4 (b) or (d).

26.9 A ferroresonant transformer having a (marked) primary voltage range shall be tested at the voltage resulting in the greatest input power condition as determined by the test specified in Clause 18.3 of Part 1. A ferroresonant transformer having multiple primary or secondary voltage ratings, or both, shall be tested at the voltage resulting in the greatest input power condition as determined by the test specified in Clause 18.3 of Part 1.

26.10 The temperature rise on the enclosure of a transformer intended for wall mounting shall not be greater than 80°C during the heating test when:

a) The temperature test is conducted with the transformer mounted in an alcove as described in Clause 26.11 and Figure 1;

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

c) The transformer is marked in accordance with Clause 17.4.7.

26.11 The side wall and the top of the test alcove represented in Figure 1 shall consist of 9.5-mm (0.374-in) thick fir plywood. The rear wall (on which the transformer is mounted) shall be of 19.1-mm (0.75-in) thick plywood. The inner surfaces of the test alcove shall be painted dull black, and the transformer shall be mounted in the intended manner. The horizontal dimensions of the walls and top shall extend beyond the transformer by at least 30.5 cm (1 ft).

27 Voltage Measurement Test

27.1 For purposes of comparison with voltages measured as described in Clauses 30.1 and 30.2, each secondary open-circuit voltage shall be measured with the primary connected to a test voltage and frequency supply source as indicated in Table 12 of Part 1 and Clause 18.4 of Part 1 respectively.

28 Impedance Test

28.1 The percent impedance of a transformer rated 25 kVA or more shall be determined in accordance with the Standard Test Code for Dry-Type Distribution and Power Transformers, ANSI/IEEE C57.12.91. The marked value may be used if it is within ±10 percent of the determined value. The determined value shall be corrected to the transformer temperature rise plus 20°C as shown in item 13 of Table 8 and Table 9.

29 Dielectric Voltage-Withstand Test

29.1 Applied potential

29.1.1 Within 5 minutes of the termination of the Temperature (Heating) Test in Clause 26, 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 11. The terminal ends and taps of the winding under test shall be electrically connected to each other and to one output terminal of the voltage source. All other terminals and parts (including core and enclosure) shall be connected to the other terminal of the voltage source. There shall not be dielectric breakdown.

For a transformer provided with the marking described in Clause 17.5.2, 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.

A transformer with multifilar windings marked as specified in Clause 17.5.14 shall be subjected to a potential of 1500 V between windings intended to be connected in parallel or in series.

Note 1: When the core and/or coil are insulated so as not to be accessible, connection of the core to the testing transformer is not required.

Note 2: Multifilar constructed coil sections designed for series or parallel connections subjected to the induced potential tests described in Clause 29.2.1 need not be subjected to the applied potential requirements of Table 11.

29.1.2 When the transformer has an extended winding, the rated voltage indicated in Table 11 shall 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 shall be supplied from a 500 VA or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential shall be increased from zero until the required test level is reached. It shall be held at that level for 1 minute. The increase in the applied potential shall be at a uniform rate as rapid as is consistent with its correct value indicated by a voltmeter. There shall be no dielectric breakdown.

29.1.4 The machine used to measure dielectric breakdown shall be adjusted so that the sensitivity is no less than 5 mA when the test voltage is applied to the product.

29.2 Induced potential

29.2.1 While in a heated condition, a transformer shall be subjected to this test. The voltage and potential shall be as specified in Clauses 26.1 and 26.2 of Part 1. A transformer with two or more windings (marked as described in Clause 17.5.14) 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 a dielectric breakdown as a result of this test.

30 Overload Test

30.1 A transformer shall be subjected to the test conditions described in Clause 30.2. The stabilized surface or core temperature recorded on the transformer during the second 50 percent load operation shall not be 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 in Clause 27. As an option, a protective device, if provided, may be bypassed when conducting this test.

30.2 The transformer shall be operated as described in the Temperature (Heating) Test in Clause 26, except that the load shall be 50 percent of the rated value, until the core or (if encapsulated) surface temperatures stabilize. After stabilization, the load shall be adjusted until 200 percent of rated secondary current is reached. After 2 minutes of operation, the load shall be readjusted, if necessary, to restore the current to 200 percent, but no further adjustment is to be made thereafter. The duration of this overload shall be 30 minutes. The load is then to be restored to the original 50 percent of rated value. It shall be held at that value until the core temperature again stabilizes or until the temperature drops to within 5°C (9°F) of the original stabilized 50-percent load-current temperature (whichever occurs first). This temperature value shall be compared with the original 50-percent load stabilized condition, as specified in Clause 30.1. Then, the secondary load shall be removed. With the primary energized, the secondary voltage(s) shall be measured and compared with the original output voltage measurements.

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

A protective device, when provided, shall be bypassed when the device opens while the load is adjusted after the surface temperatures have stabilized.

31 Repeated Dielectric Voltage-Withstand Test

31.1 Following the Overload Test in Clause 30, the transformer shall be subjected to a repeated dielectric voltage-withstand test. The test potential shall be 65 percent of the value originally specified. After this test, the transformer shall perform as intended.

32 Maximum Output Power and Short Circuit Tests for Line-Connected Transformers

32.1 When supplied at its maximum rated input voltage, a transformer shall not emit flame or molten metal and shall not become a shock hazard when operated under short circuit conditions or when delivering maximum output power for one hour, or until the conditions described in Clauses 32.2 or 32.3 are achieved.

32.2 If the test is interrupted by a resettable device, the test shall be repeated under that abnormal condition for 50 cycles of operation.

32.3 If the test is interrupted by the opening of an approved fuse, the test shall be discontinued. The results shall be considered acceptable when the criteria specified in Clause 32.1 are met.

33 Short Circuit Test on Transformers with Output Receptacles

33.1 A transformer with output receptacles, when tested as specified in the following clauses, shall not constitute a hazardous condition as described in Clause 33.4. Immediately after the test, the transformer shall be subjected to the Applied potential test in Clause 29.1.

33.2 During this test each transformer shall:

a) Be placed on two layers of bleached cheesecloth running 26 to 28 m^2/kg and having what is known to the trade as a count of 32 by 28;

b) Have all exposed dead metal parts connected to ground through a 3 A non-time-delay fuse; and

c) Be connected in a circuit with a supply circuit fuse rated at twice the ampacity of the attachment plug.

33.3 The transformer shall operate at the voltage and frequency specified in Tests in Clause 18 of Part 1. However, when the rated input voltage of the transformer is specified as a range, the test shall be done at the lowest and highest voltages. Each output of the transformer shall be short circuited in turn with other outputs not loaded. The test shall be continued for 7 hours or until an overcurrent protective device operates.

33.4 A hazardous condition shall not exist during the test. Examples of a hazardous condition are:

a) An opening of the supply circuit fuse;

b) An opening of the ground fuse;

c) Glowing of the cheesecloth;

d) Emission of flame or molten material from the enclosure;

e) Exposure of live metals; or

f) Dielectric breakdown as a result of the Applied potential test in Clause 29.1

34 Maximum Output Power Test on Transformers with Output Receptacles

34.1 A transformer with output receptacles, when tested as specified in Clause 34.2, shall comply with the test requirements of Clause 34.3.

34.2 The test conditions shall be as specified in Clauses 33.2 and 33.3. However, instead of short circuiting the output, a resistive load shall be connected to the output and the load shall be adjusted until a condition of maximum power is achieved. The load shall be readjusted after 15 minutes of operation, when necessary, to restore the current to the maximum power value. However, no further adjustment shall be made thereafter. This test shall continue for a period of 7 hours or until an overcurrent protective device operates.

34.3 A hazardous condition as described in Clause 33.4 shall not exist during this test. Additionally, the ampacity of the receptacles shall not be exceeded. Immediately after the test the transformer shall be subjected to the dielectric test in Applied potential in Clause 29.1.

35 Leakage Current Test

35.1 The leakage current of a cord-connected transformer when tested in accordance with Clauses 35.2 – 35.6 shall not be more than 0.5 mA for a non-stationary transformer or 0.75 mA for a stationary transformer.

A unit that is required to have primary-circuit filtering to meet the applicable electromagnetic compatibility (EMC) regulations may have higher leakage current levels at accessible parts provided that the unit complies with the following:

a) Leakage current does not exceed 5.0 mA and the unit complies with the grounding requirements in Grounding in Clause 10 of Part 1 or

b) Leakage current does not exceed 5 percent of the input current determined in accordance with the Power Input Test in Clause 36, and all of the following conditions are met:

1) The unit complies with the grounding requirements in Grounding in Clause 10 of Part 1;

2) The unit is not supplied through a standard configuration 125 V, 15 A nor 125 V, 20 A non-locking type plug;

3) Provision is made for connecting, and earth-grounding, all the metal frames of the transformer; and

4) Suitable installation instructions are provided.

35.2 All exposed conductive surfaces shall be tested for leakage currents. When simultaneously accessible, the leakage currents from these surfaces shall be measured to the grounded supply conductor individually as well as collectively and from one surface to another. Parts are considered to be exposed surfaces unless guarded by an enclosure as defined in Enclosures in Clause 6 of Part 1. Surfaces are considered simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to output terminals operating at voltages less than

30 V rms (42.4 V peak) or 60 V dc. When all accessible surfaces are bonded together and connected to the grounding conductor of the power supply cord, the leakage current shall be measured between the grounding conductor and the grounded supply conductor.

35.3 When a conductive surface other than metal is used for the enclosure or a part of the enclosure, the leakage current shall be measured using a metal foil with an area of 10 x 20 cm (3.9 x 7.9 in) in contact with the surface. When the surface is less than 10 x 20 cm, the metal foil shall be the same size as the surface. The metal foil shall not remain in place long enough to affect the temperature of the power unit.

35.4 The circuit for the leakage current measurement shall be as illustrated in Figure 2. The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument. The measurement instrument shall comply with all of the following:

a) The meter shall have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

b) The meter shall indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kHz, the measurement circuit shall have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 mA, the measurement shall not have an error of more than 5 percent at 60 Hz.

35.5 Unless the meter is being used to measure leakage from one part of a transformer to another, the meter shall be connected between an accessible part and the grounded supply conductor.

35.6 A sample of the transformer shall be tested for leakage current starting with the as-received condition (the as-received condition meaning the unit has not been energized except for occurrences that are part of the production-line testing) but with the grounding conductor, if any, open at the attachment plug. The supply voltage shall be adjusted to the test voltage specified in Table 12 of Part 1. The test sequence, with reference to the measuring circuit, Figure 2, shall be as follows:

a) With switch S1 open, the transformer shall be without load and connected to the measuring circuit. The leakage current shall be measured using both positions of switch S2 and with any switching devices in all their operating positions.

b) Switch S1 shall then be closed energizing the transformer and within 5 seconds the leakage current shall be measured using both positions of switch S2, and with any switching devices in all their operating positions.

c) The leakage current shall be monitored until thermal stabilization. Both positions of switch S2 shall be used in making this measurement. Thermal stabilization shall be obtained by operation as in the temperature test.

35.7 In general, the complete leakage current test program as described in Clause 35.6 shall be conducted without interruption for other tests. With the concurrence of those concerned, the leakage current tests may be interrupted to conduct other nondestructive tests.

36 Power Input Test

36.1 The current input to a cord-connected transformer, when connected to a supply adjusted to the test voltage specified in Table 12 of Part 1, shall not be more than 110 percent of the rated value. The transformer shall be loaded to rated output and the current measured within one minute of the application of the load.

37 Lifting or Mounting Means Test

37.1 The lifting or mounting means of a transformers specified in Clause 5.3 of Part 1 or Clause 6.4.3 of Part 1, respectively, shall be subjected to the direct application of a force equal to a minimum of four times the weight of the transformer (the weight of the transformer plus a force of three times the weight of the transformer).

37.2 When there is more than one hook, bracket, or hole intended for use with a lifting cable, the test shall be conducted with the cable arranged so that the load will be equally divided. The cable under load shall be at an angle of 60 degrees maximum from the horizontal plane. A spreader bar shall not be used with the cable. See Figure 3 for an example of a typical test set-up.

37.3 The force shall be gradually applied between the hole, hook, or bracket and that part of the transformer to which it is secured (by any convenient means). The force shall be maintained for 5 minutes. For convenience, 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.

38 Strain Relief Test

38.1 Where required by Clause 15.3, leads and flexible cords shall be subjected to a direct pull applied for 1 minute as follows:

a) For output cords where the output voltage is less than 30 V ac, the force shall be 89 N (20 lbs);

b) For input and output cords other than (a), the force shall be 156 N (35 lbs); and

c) For leads, the force shall be equal to the weight of the transformer but not less than 13 N (3 lbs) nor more than 45 N (10 lbs).

There shall not be indication of stress on the connections inside the transformer.

TABLES

Table 1
Field splice compartment size
(See Clause 8.6.1)

Minimum coil rating, A	Minimum usable volume per coil lead,	
	cm^3	$(in)^3$
12	37	1.25
20	41	2.5
24	49.2	3.0
40	82	5.0
70	152	9.25
110	275	16.7
160	492	30.0
250	900	55.0

Table 2
Wiring space
(See Clause 8.8.1)

Maximum size of wire,		Minimum width or depth of wiring space,	
mm^2	(AWG/kcmil)	mm	(in)
2.1 and 3.3	14 and 12	9	0.35
5.3	10	9	0.35
8.4	8	12	0.5
13.3	6	15	0.6
21.5	4	19	0.75
26.7	3	19	0.75
33.6	2	22	0.9
42.4	1	25	1
53.5	1/0	25	1
67.4	2/0	25	1
85	3/0	28	1.1
107.2	4/0	31	1.2

Table 3
Wire bending space
(See Clauses 8.8.2 and 8.8.3)

Wire size,		Wires per terminal mm (in)						
mm^2	(AWG/kcmil)	1		2		3		4 or more
2.1 – 5.3	14 – 10	Not specified						
8.4	8	38	1.5	–		–		–
13.3	6	38	1.5	–		–		–
21.15	4	50	2	–		–		–
26.7	3	50	2	–		–		–
33.6	2	63	2.5	–		–		–
42.4	1	76	3	–		–		–
53.5	1/0	127	5	127	5	177	7	–
67.4	2/0	152	6	152	6	190	7.5	–
85	3/0	165	6.5	165	6.5	203	8	–
107.2	4/0	177	7	177	7	215	8.5	–

Table 4
Wire bending space where wire connectors are readily removable
(See Clause 8.8.2)

Wire size,		Wires per terminal mm (in)						
mm^2	(AWG/kcmil)	1		2		3		4 or more
2.1 – 5.3	14 – 10	Not specified						
8.4	8	38	1.5	–		–		–
13.3	6	38	1.5	–		–		–
21.15	4	50	2	–		–		–
26.7	3	50	2	–		–		–
33.6	2	63	2.5	–		–		–
42.4	1	76	3	–		–		–
53.5	1/0	127	5	127	5	177	7	–
67.4	2/0	152	6	152	6	190	7-1/2	–
85	3/0	152	6-1/2	152	6	203	8-1/8	–
107.2	4/0	152	7	152	6	203	8-1/8	–

Table 5
Wire bending space where wire connectors are not readily removable
(See Clauses 8.8.3 and 8.8.8)

Wire size		Wires per terminal mm (in)									
mm^2	(AWG/kcmil)	1		2		3		4		5	
2.1 – 5.3	14 – 10	Not specified									
8.4 – 13.3	8 – 6	38	1.5	–		–		–		–	
21.15 – 26.7	4 – 3	50.8	2	–		–		–		–	
33.6	2	63.5	2.5	–		–		–		–	
42.4	1	76.2	3	–		–		–		–	
53.5 – 67.4	1/0 – 2/0	88.9	3.5	–		–		–		–	
85 – 107.2	3/0 – 4/0	102	4	127	5	–		–		–	
127	250	114	4 .5	152	6	203	8	–		–	
152 – 177	300 – 350	127	5	152	6	203	8	254	10	–	
203 – 253	400 – 500	152	6	203	8	254	10	305	12	–	
304 – 355	600 – 700	203	8	203	8	254	10	305	12	356	14
380 – 456	750 – 900	203	8	254	10	305	12	356	14	405	16

Table 6
Minimum spacings at wiring terminals for transformers intended for industrial control applications
(See Clause 11.1.2)

Potential involved[a], V	Through air,		Over surface[b],	
	mm	(in)	mm	(in)
0 – 50	3.2	0.125	6.4	0.25
51 – 150	6.4	0.25	6.4	0.25
151 – 300	6.4	0.25	9.5	0.374
301 – 600	9.5	0.374	12.7	0.5
For transformers intended for use in Canada:				
Over 600 – 750	9.5	0.374	12.7	0.5

[a] The potential involved is to include consideration of voltages obtained in elevated voltage use of winding or windings when the transformer is marked in accordance with Clause 17.5.2.

[b] Gaps less than 0.33 mm (0.013 in) are to be disregarded (bridged) in determining over surface spacings.

Table 7
Location of required markings for low voltage transformers
(See Clause 17.4.1)

Marking reference	Requirements	Location[a]	
		Enclosed	Open
General			
17.1.7 (a), (b), (c), and (d)	Electrical ratings	A	B
17.4.2	Temperature class	A	B
17.4.3	Transformer weight	C	C
17.4.4	Autotransformer marking	A	B
17.4.5	Polyphase wiring diagram	D	D
17.4.6	Impedance marking	B	B
Enclosure markings			
17.3.1	Environmental type number or numbers	A	–
17.3.2	Rainproof enclosure for use with a field-installed hood	A	–
17.3.3[b]	Rainproof hood marking	B	–
17.3.4	Holes drilled during field installation	B	–
17.4.7 (a) and (b)	Separation and height marking for transformer enclosures with a temperature rise of more than 65°C.	A	–
17.4.8	Transformer enclosure with a receptacle exceeding 35°C but not greater than 45°C.	A	–
Wiring terminal markings			
17.5.2	Elevated voltage marking	B	B
17.5.3	Voltage rating for each tap	A	B
17.5.4	Minimum insulation temperature rating for field conductors	B	B
17.5.5	Aluminum/copper marking	B	B

Table 7 Continued on Next Page

Table 7 Continued

Marking reference	Requirements	Location[a]	
		Enclosed	Open
17.5.6	90 degree bend wiring diagram	D	D
17.5.7	Wire size or range of wire sizes for connectors	B	B
17.5.8	Wire terminal suitable for securing more than one conductor	B	B
17.5.9	Special tool for terminal connector	B	B
17.5.10	Application of corrosion-inhibiting compound	D	D
17.5.13	Jumper marking for series/parallel connection	D	D
17.5.14 (a) and (b)	Series/parallel configuration	D	D
Wiring compartment			
17.5.11	Instructions for wiring space extension	D	–
17.5.12	Marking for wiring space extension	B	–

[a] 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.

[b] The hood identification markings specified in Clause 17.3.3 shall be readily visible on the hood after installation. Instructions for installing the hood may be provided on a separate instruction sheet.

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 8
Maximum temperature rises for transformers rated 10 kVA and less
(See Clauses 11.3.5 (Part 1), 17.4.2, 26.6, 28.1, and Table 9)

Materials or components				°C
1.	Field-wiring conductors or any surface that may be contacted by field wiring.			35[a]
2.	Pressure-terminal connectors for field-installed conductors other than as specified in item 3.			50
3.	Pressure-terminal connectors used in circuits rated 110 A or less and marked for use with 75°C (167°F) wire or 90°C (194°F) wire.			65
4.	Pressure terminals or wire connectors for internal wiring with aluminum conductors unless the conductor has been investigated for higher temperature.			50
5.	Wire insulation or insulating tubing			35[b]
6.	Fiber used as electrical insulation			65
7	Any point on the exterior of the transformer enclosure than as specified in Clauses 17.4.7, 26.10, and 26.11.			65
8.	Enclosures with a receptacle			35[c]
9.	Contacts and fuses			65
10.	Type S, SJ, SJO, and SO cords			35[d]
11.	Sealing compounds			Melting point minus 40
12.	Capacitors			Marked temperature limit minus 25
13.	Coil winding by change-of-resistance method specified in Clause 11.3 of Part 1:			
	Insulation system	**Ambient**	**Hot spot differential[e]**	
	General purpose transformers:[b]			
	Class 105(A)	25	10	70
	Class 120(E)	25	10	80
	Class 130(B)	25	10	95
	Class 155(F)	25	15	115
	Class 180(H)	25	20	135
	Class 200(N)	25	25	150
	Class 220(R)	25	30	165

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

[a] The maximum temperature rise for 75°C (167°F) wire is 50°C and for 90°C (194°F) wire is 65°C. See also Clause 17.5.4.

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

[c] Temperature rises in excess of 35°C, but not greater than 45°C, comply when the enclosure is marked in accordance with Clause 17.4.8.

[d] The limitation on rubber insulation does not apply to compounds that have been investigated and recognized as having special heat-resisting properties.

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

Table 9
Maximum temperature rises for transformers rated more than 10 kVA based on an ambient temperature of 40°C (104°F)
(See Clauses 11.3.5 (Part 1), 17.4.2, 26.6, and 28.1)

	Material or component	°C
1.	Field-wiring conductors or any surface that may be contacted by field wiring.	20[a]
2.	Pressure-terminal connectors for field-installed conductors other than as specified in item 3.	35
3.	Pressure-terminal connectors used in circuits rated 110 A or less and marked for use with 75°C (167°F) wire or 90°C (194°F) wire.	50
4.	Pressure terminals or wire connectors for internal wiring with aluminum conductors unless the conductor has been investigated for higher temperature.	35
5.	Wire insulation or insulating tubing	20[b]
6.	Fiber used as electrical insulation	50
7	Any point on the exterior of the transformer enclosure than as specified in Clauses 17.4.7, 26.10, and 26.11.	50
8.	Enclosures with a receptacle	35[c]
9.	Contacts and fuses	50
10.	Type S, SJ, SJO, and SO cords	20[d]
11.	Sealing compounds	Melting point minus 55
12.	Capacitors	Marked temperature limit minus 40
13.	Coil winding by change-of-resistance method specified in Clause 11.3 of Part 1:	

Insulation system	Ambient	Hot spot differential[e]	
Transformers intended for industrial control applications:[f, g, h]			
Class 105(A)	40	10	55
Class 130(B)	40	10	80
Class 155(F)	40	15	100
Class 180(H)	40	20	120
Class 200(N)	40	25	135

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

[a] The maximum temperature rise for 75°C (167°F) wire is 50°C and for 90°C (194°F) wire is 65°C. See also Clause 17.5.4.

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

[c] Temperature rises in excess of 35°C, but not greater than 45°C comply when the enclosure is marked in accordance with Clause 17.4.8.

[d] The limitation on rubber insulation does not apply to compounds that have been investigated and recognized as having special heat-resisting properties.

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

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

[g] Industrial control transformers are covered within this description.

[h] Temperature rises for windings of encapsulated transformers rated not more than 30 kVA are not prohibited from being the same as those specified in item 13 of Table 8.

Table 10
Wiring compartment marking
(See Clause 17.5.4)

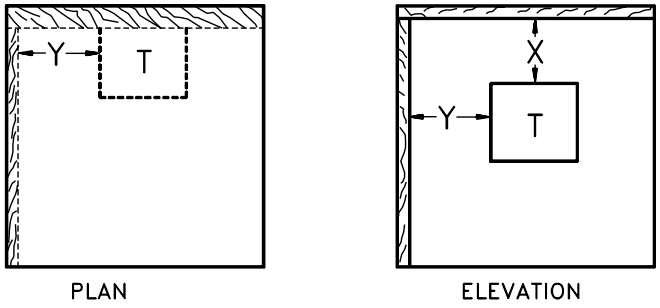
Temperature attained during test				Value to be used in marking in 17.5.4	
Higher than		But not higher than			
°C	(°F)	°C	(°F)	°C	(°F)
60	140	75	167	75	167
75	167	90	194	90	194

Table 11
Applied potential
(See Clauses 29.1.1, 29.1.2, A1.8 (Annex A), and A1.9 (Annex A))

Transformer type or size	Rated voltage of windings, V	Applied test potential, rms V
250 VA or less	25 or less	1050
	26 – 250	1500
	251 – 600	2500
For transformers intended for use in Canada:	251 – 750	2500
More than 250 VA	250 or less	2500
	251 – 600	4000
For transformers intended for use in Canada	750 or less	2500

FIGURES

Figure 1
Transformer test set-up
(See Clauses 17.4.7, 26.10, and 26.11)



NOTES:

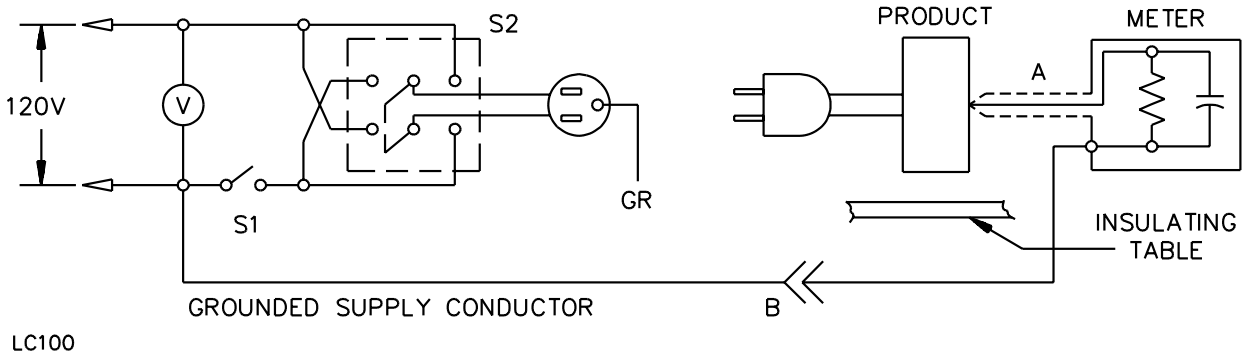
T is the transformer.

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

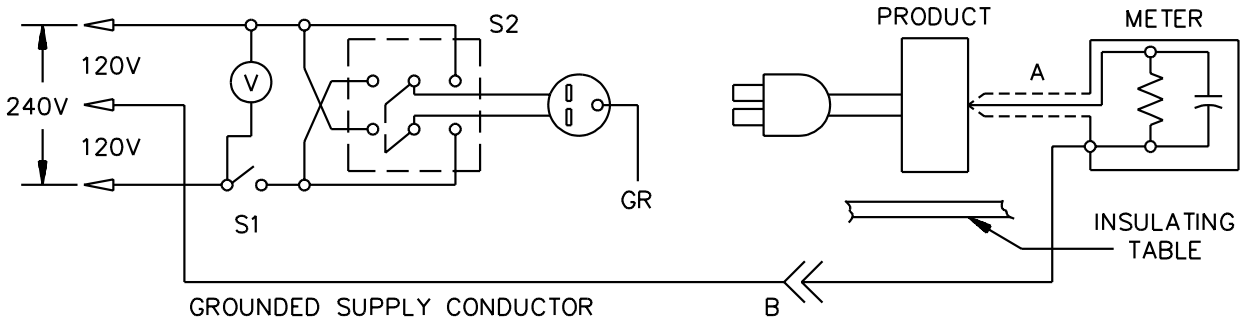
Y is the minimum spacing between the hotter end of the transformer and the adjacent side wall. If the temperature of the right end of the transformer is higher than that of the left end, the side wall shall be to the right instead of to the left as shown.

Figure 2
Leakage current measurement circuit
(See Clauses 35.4 and 35.6)

A. Transformer intended for connection to a 120-volt power supply.

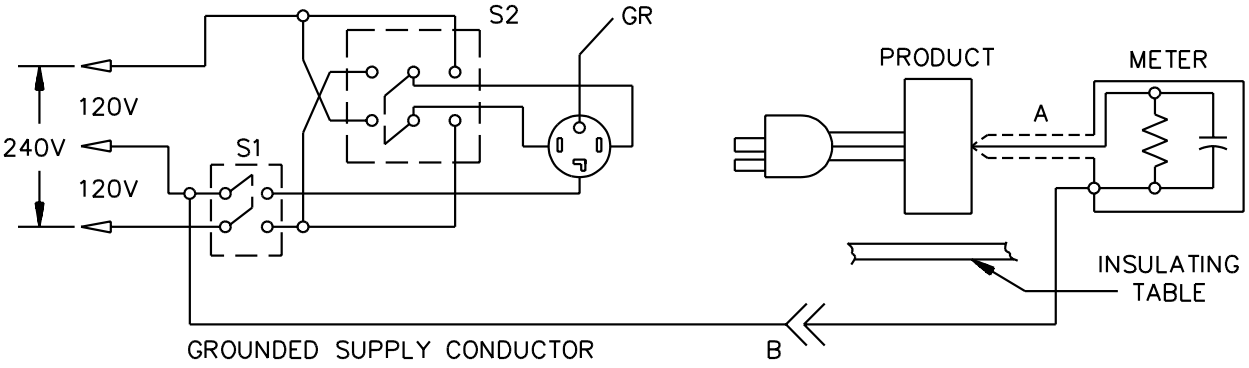


B. Transformer intended for connection to a 3-wire, grounded neutral power supply, as illustrated.



LC200

C. Transformer intended for connection to a 3-wire, grounded neutral power supply, as illustrated.



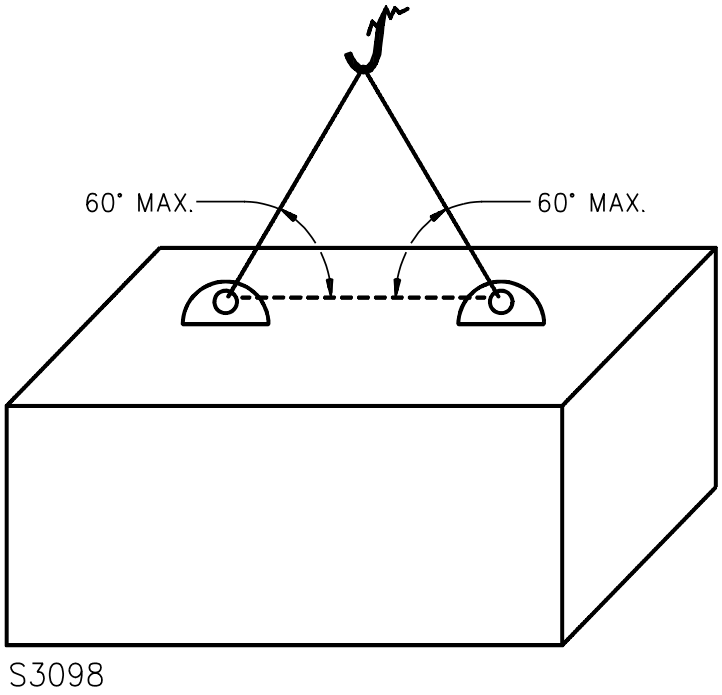
LC300

NOTES:

A – Probe with shielded lead.

B – Separated and used as clip with measuring currents from one part of device to another.

Figure 3
Lifting and mounting means test configuration
(See Clause 37.2)



Annex A (Informative)

Manufacturing and Production Line Tests

Note: *This annex is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.*

A1 Dielectric Voltage-Withstand Test

A1.7 A transformer with spacings described in Note 1 of Clause 11.1.3 of Part 1 shall be subjected to the application of a potential at a frequency within the range of 40 – 70 Hz. The potential shall 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 shall be electrically connected to each other and to one output terminal of the testing transformer. All other terminals and parts (including core and enclosure) shall be connected to the other terminal of the testing transformer. There shall not be dielectric breakdown.

Note 1: For a transformer marked as described in Clause 17.5.2, the applied potential between each winding and:

a) The metal of the core and the enclosure and

b) 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 marked.

Note 2: When the core and the coil are electrically insulated so that they are not accessible, connection of the core to the testing transformer is not necessary.

A1.8 The applied potential during the test shall be as specified in Table 11. When the test time is 1 second instead of 1 minute, the applied potential shall be equal to the required value plus an additional 20 percent of the value.

A1.9 When the transformer has an extended winding, the ″rated voltage″ specified in Table 11 shall include the voltage of the extended portion of the winding, even though both terminals of the extended portion are not available for external connection.

Annex C (Informative)

C1 French Translations of Markings

Clause	English	French
17.3.2	Rainproof-Type 3R Enclosure when provided with hood catalog No. ____.	Enveloppe à l'épreuve de la pluie de type 3R si elle est dotée d'un couvercle dont la référence au catalogue est ___.
17.3.3	Rainproof hood catalog No. ____ for Type ____ transformer.	Couvercle d'enveloppe à l'épreuve de la pluie, référence au catalogue _____ pour transformateur de type____.
17.3.4	Type 3R Enclosure	Enveloppe de type
17.4.4	autotransformer	autotransformateur
17.4.8	Warning: Surface temperature may exceed 60°C. Do not place line cords or other material on this unit.	Avertissement: La température de surface peut dépasser 60°C. Ne pas mettre de cordons d'alimentation ou autre matériel sur cet appareil.
17.5.2	For additional connections and data, see instruction No.____.	Pour d'autres connexions et données, voir l'instruction no _____.
17.5.4(a)	For field connections, use wires insulated for a minimum of 75°C	Pour les connexions à pied d'œuvre, utiliser du fil dont l'isolant convient pour au moins 75°C.
17.5.4(b)	For field connections, use wires insulated for a minimum of 75°C and sized on the basis of 60°C ampacity.	Pour les connexions à pied d'œuvre, utiliser du fil dont l'isolant convient pour au moins 75°C et dont la grosseur est établie en fonction d'un courant admissible à 60°C.
17.5.4(c)	For field connections, use wires insulated for a minimum of 90°C and sized on the basis of 75°C ampacity.	Pour les connexions à pied d'œuvre, utiliser du fil dont l'isolant convient pour au moins 90°C et dont la grosseur est établie en fonction d'un courant admissible à 75°C.
17.5.4(d)	For field connections, use wires insulated for a minimum of 90°C and sized on the basis of 60°C ampacity.	Pour les connexions à pied d'œuvre, utiliser du fil dont l'isolant convient pour au moins 90°C et dont la grosseur est établie en fonction d'un courant admissible à 60°C.
17.5.5	Use aluminum or copper wire.	Utiliser des fils en aluminium ou en cuivre.
17.5.5	Windings ____ and ____ must be connected in either a parallel or series configuration.	Les enroulements ____ et ____ doivent être raccordés en parallèle ou en série.
17.5.14	Windings ____ and ____ must be connected in either a parallel or series configuration.	Les enroulements ____ et ____ doivent être raccordés en parallèle ou en série.

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