UL 244A

ISBN 1-55989-444-X

Solid-State Controls for Appliances

Documents
Document Sharing Hub

Full document details: UL 224a 1998

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 224a-1998

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety
for
Solid-State Controls for Appliances, UL 244A

Second Edition, Dated January 3, 1994

Revisions: This Standard contains revisions through and including February 23, 1998.

The new requirements are substantially in accordance with UL's Bulletin on this subject dated October 1, 1997. The bulletin is now obsolete and may be discarded.

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 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.

UL's Standards for Safety are copyrighted by UL. Neither a printed copy of a Standard, nor the distribution diskette for a Standard-on-Diskette and the file for the Standard on the distribution diskette should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning WordPerfect, Envoy, and Standards-on-Diskette. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports a Standards-on-Diskette only if it is used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Documents
Document Sharing Hub

Full document details: UL 224a 1998

Standards-on-Diskette purchasers agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing a Standard-on-Diskette on the purchaser's computer system.

If a single-user version Standards-on-Diskette was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access. The original distribution diskette should be stored in a safe place.

If a multiple-user version Standards-on-Diskette was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer. The number of concurrent users shall not exceed the number of users authorized for the Standards-on-Diskette version. The original distribution diskette should be stored in a safe place.

Standards-on-Diskette are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of a Standards-on-Diskette. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of a Standards-on-Diskette. An employee of an organization purchasing a Standard-on-Diskette can make a copy of the page or pages being viewed for their own fair and/or practical internal use. Because of differences in the computer/software/printer setup used by UL and those of Standards-on-Diskette purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

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

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

Copyright 1998 Underwriters Laboratories Inc.

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1998

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

Page	Date
tr1 – tr4	February 23, 1998
1	January 3, 1994 (Reprinted: February 23, 1998)
2	August 25, 1994
3	October 13, 1997
4	January 3, 1994
5 – 7	August 25, 1994
8 – 15	January 3, 1994
16	February 23, 1998
17 – 21	January 3, 1994
22, 22A, 22B	August 25, 1994
23 – 28	January 3, 1994
29	October 13, 1997
30, 31	January 3, 1994
32	October 13, 1997
33 – 54	January 3, 1994
A1	October 13, 1997
A2	January 3, 1994
CRG1 – CRG4	February 23, 1998

Documents
Document Sharing Hub
Full document details: UL 224a 1998

No Text on This Page

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1998

American National Standard

JANUARY 3, 1994 **ANSI/UL 244A-1995**
(Title Page Reprinted: February 23, 1998)

1

UL 244A

Standard for

Solid-State Controls for Appliances

First Edition – February, 1986

Second Edition

January 3, 1994

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated January 3, 1994 and August 25, 1994 except paragraph 19.1.3. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

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

Approved as ANSI/UL 244A-1987, April 28, 1987
Approved as ANSI/UL 244A-1995, January 3, 1995

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.

ISBN 1-55989-444-X

COPYRIGHT © 1986, 1998 UNDERWRITERS LABORATORIES INC.

Documents
Document Sharing Hub

Full document details: UL 224a 1998

CONTENTS

FOREWORD

INTRODUCTION

1 Scope 5
2 Undated References 6
3 Glossary 6
4 Components 8
5 Units of Measurement 8

CONSTRUCTION

6 General 9
7 Frame and Enclosure 9
8 Accessibility of Live Parts 9
9 Current-Carrying Parts 10
10 Internal Wiring 11
11 Splices and Connections 11
12 Separation of Circuits 13
13 Insulating Material 15
14 Printed-Wiring Boards 15
15 Components 16
16 Transformers 17
17 Spacings 19
18 Alternate Spacings – Clearances and Creepage Distances 21
19 Bonding of Internal Parts for Grounding 22
20 Class 2 Circuits 24

PERFORMANCE

21 General 27
22 Temperature Test 28
23 DC Offset voltage Test 32
24 Abnormal Operation Test 32
25 Limited Power Point Determination Test 33
26 Isolation Tests 38
27 Power-Switching Semiconductors 41
28 Overvoltage and Undervoltage Test 43
29 Voltage Surge Test 44
30 Power Supplies 47
31 Component Failure Test 47
32 Electronic Component Evaluation 48
33 Dielectric voltage-Withstand Test 49

MANUFACTURING AND PRODUCTION LINE TESTS

34 DC Offset voltage Test 51

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1994

RATING

35 Details 52

MARKINGS

36 General 53

APPENDIX A

Standards for Components A1

CANADIAN REQUIREMENTS COMPARISON GUIDE

Documents
Document Sharing Hub

Full document details: UL 224a 1998

FOREWORD

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

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

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

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

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

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

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1994

INTRODUCTION

1 Scope

1.1 These requirements cover component electronic controls intended to be factory installed on or in appliances and other utilization equipment rated 600 volts or less, used in ordinary dry locations as defined in the National Electrical Code, NFPA 70, and that comply with the requirements for such appliances and equipment.

1.2 For a control covered by this standard, it is assumed that no voltage greater than 600 volts above ground will be present in a control, that an isolation transformer, if provided, will generally furnish power at a lower potential than the primary voltage, and that the output of the control will not be located in a circuit operating at greater than 600 volts above ground in the end-use equipment. If conditions other than these are provided, consideration shall be given to the need for additional examination and testing.

1.3 A control covered by this standard is a single device or a series of separate components with interconnecting wiring employing one or more input power and possibly signal ports, solid-state circuitry, and one or more output switching components to directly control all or a portion of the end-use equipment load. The control may respond directly or indirectly to changes in temperature, humidity, or pressure to affect operation of an appliance, may be an electronic timer, or may electronically store or process information by virtue of a memory system.

1.4 A control intended for connection only to a low-voltage circuit of limited power supplied by a primary battery or by a Class 2 transformer where a failure of such a control would cause a risk of fire, electric shock, or injury to persons to occur in the end-use equipment, is considered to be within the scope of these requirements.

1.5 These requirements do not cover a control intended for installation in or on refrigeration or air conditioning equipment that is used in industrial applications or in hazardous locations as defined in the National Electrical Code, NFPA 70. Such equipment is covered in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Additional considerations should be given to a control which is exposed to oil, grease vapors, lint, or other contaminants and high humidity in the end application.

1.6 These requirements address the potential risks unique to the electronic nature of a control. Equipment or components employing an electronic feature shall also comply with the basic requirements contained in the applicable end-product or component standard. These requirements are intended to supplement applicable end-product or component standards and are not intended to serve as the sole basis for investigating all risks associated with a control. For example, requirements for the means of enclosing live parts, mechanical assembly of components, corrosion protection, use of polymeric materials, evaluation of internal wiring and connections within the control, calibration and the like, are not included in this standard.

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

1.7 revised August 25, 1994

Documents
Document Sharing Hub

Full document details: UL 224a 1998

2 Undated References

2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

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

3.2 CLASS 2 CIRCUIT – An isolated secondary circuit involving a potential of not more than 42.4 volts peak supplied by:

a) An inherently-limited Class 2 transformer;

b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently-limited Class 2 transformer;

c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;

d) Any combination of (a), (b), and (c) above that together comply with the performance requirements for an inherently-limited Class 2 transformer; or

e) One or more combinations of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A circuit derived from a line-connected circuit by connecting impedance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a Class 2 circuit. See Class 2 Circuits, Section 20.

3.3 CONFORMAL COATING – An insulating coating which conforms to the configuration of the object coated and is used as a protective covering against environmental conditions or when electrical spacings are insufficient.

3.4 CONTROLLED ENVIRONMENT – An environment:

a) Relatively free of conductive contaminants, such as normal cooking vapors, carbon dust, and the like, which may be a result of the end-use equipment to which a control will be installed or may be due to the location of the end-use equipment, and

b) Protected against humidity and the formation of condensation. A controlled environment may be provided by means of a:

1) Hermetically sealed enclosure;

2) Encapsulation;

3) A conformal coating; or

4) A gasketed, tight-fitting enclosure or filter system preventing contamination in conjunction with a system preventing condensation (for example, the maintaining of the surrounding air at constant temperature and a suitably low relative humidity).

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1994

3.5 DEAD-CASE-MOUNTED SEMICONDUCTOR – A semiconductor, such as a triac or silicon-controlled rectifier, employing an integral metal tab or stud that is insulated from live parts.

3.6 ELECTRICAL STRESS FACTOR – For a circuit component, the ratio of operating electrical stress to rated electrical stress. Examples include the ratio of operating wattage to maximum rated wattage of a resistor and operating voltage to maximum rated voltage of a capacitor. A circuit component having no assigned maximum operating electrical rating is made the subject of an investigation.

3.7 HAZARDOUS ENERGY – Circuit energy that involves a possible risk of fire or electric shock.

3.8 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolated secondary winding of a transformer and that has no direct connection back to the line-connected circuit (other than through the grounding means). A secondary circuit that has a direct connection back to the line-connected circuit is considered part of the line-connected circuit.

3.9 LIMITED-ENERGY CIRCUIT – A line-connected circuit in which the wattage from any point in the circuit to any return to the power supply is limited to 15 watts; or an isolated secondary circuit in which the wattage as noted above is limited to 50 watts.

3.10 LINE-CONNECTED CIRCUIT – A type of circuit in which the wiring and components are conductively connected to the branch circuit. It is also called a primary- or direct-connected circuit. See also 3.8.

3.11 OPPOSITE POLARITY – A difference in potential between two points, such that shorting of these two points would result in a condition involving an overload, rupturing of printed wiring-board-tracks, components, or fuses, and the like.

3.12 OPTICAL ISOLATOR (PHOTON-COUPLED ISOLATOR) – A circuit-coupling device that provides circuit isolation, consisting of a light source and sensor integrated into a single package.

3.13 SAFETY CIRCUIT – A primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, injury to persons, operation of controlled equipment that could result in a risk of fire, electric shock, or injury to persons, or risk of electrical energy. Examples include an interlock circuit, a circuit which limits leakage current to accessible parts, a circuit which limits the wattage to a limited-energy circuit, or a phase control or other circuit designed to limit temperatures in the end-use equipment to acceptable levels.

3.14 THYRISTOR – A bistable semiconductor device comprised of three or more junctions that can be switched from the off state to the on state or vice versa, by means of the controlled conductivity of the semiconductor, with such switching occurring within at least one quadrant of the principal voltage-current characteristics. Such switching may be random in which conduction occurs at any phase angle of the alternating current load voltage cycle or regulated in which conduction occurs at some precise phase angle or load-voltage magnitude. A phase-controlled semiconductor device is one in which the semiconductor conducts for some portion of the load-voltage cycle.

a) Bidirectional Trio de Thyristor (Triac) – A three-terminal thyristor having substantially the same switching behavior in the first and third quadrants of the principal voltage-current characteristics.

b) Silicon-Controlled Rectifier (SCR) – A reverse blocking triode thyristor. A three-terminal thyristor that conducts only for positive anode-to-cathode voltages and exhibits a reverse blocking state for negative anode-to-cathode voltages.

Documents
Document Sharing Hub
Full document details: UL 224a 1998

3.15 TRANSFORMER – The term transformer may be considered to include a motor-transformer or an autotransformer. For the purpose of these requirements, the types of transformers likely to be encountered in or supply power to controls are:

a) Class 2 – An isolation type transformer as specified in the Standard for Class 2 and Class 3 Transformers, UL 1585.

b) Power – A transformer other than Class 2 that is intended to transmit power. A power transformer may be of the isolation or nonisolation (for example, autotransformer) type.

c) Pulse – An isolation-type transformer designed to pass pulse waveforms as distinguished from sine waves. It is not considered to be a power transformer.

d) Current Sense – An isolation-type transformer designed to have its primary winding connected in series with a circuit carrying current to be measured or controlled. In window type current transformers, the primary winding is provided by a separate conductor and is not an integral part of the transformer.

e) Isolating – A transformer in which one or more secondary windings are electrically separated by insulation, spacings, or both, from the primary windings and may or may not be electrically separated from all other secondary windings.

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

4.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard; or

b) Is superseded by a requirement in this standard.

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

4.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

5 Units of Measurement

5.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

5.2 Unless indicated otherwise, voltage and current values specified in this standard are rms, and wattage values are average power.

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1994

CONSTRUCTION

6 General

6.1 A control shall employ materials which are acceptable for the particular use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 A control shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuse to which it is likely to be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.3 A risk of electric shock is considered possible at any conductive part of a control if the open circuit voltage between the part and other conductive parts or between the part and earth ground exceeds the values specified in 8.2. However, a risk may not exist if the available current through an appropriate impedance connected between the parts in question is less than the value specified in the end product standard for normal operation as determined by the type of equipment involved. A current measurement on the control alone would have to be weighed with the currents from other parts of the end equipment.

6.4 For a controlled environment, the means used to prevent contamination and condensation shall be investigated for its acceptability for the purpose. The controlled environment in a nonproduction indoor area in an ordinary location free of conductive contaminants shall be investigated for the means used to prevent condensation only.

7 Frame and Enclosure

7.1 A partial or complete enclosure of a control that is considered part of the enclosure of the end-use equipment shall be investigated under the enclosure requirements for the end-use equipment.

7.2 A part, such as a control knob, button, cover, dial, window, switch casing, or the like, that is mounted in or covers an opening and serves as a barrier to live parts, shall be considered part of the enclosure.

8 Accessibility of Live Parts

8.1 The method of judging the accessibility of an uninsulated live part that involves a risk of electric shock and other electrical parts, such as those in a safety circuit or nonlimited energy circuit, is to be determined by the end product standard.

8.2 A live part of a control is considered to involve a risk of electric shock unless it is in one of the following circuits:

a) A circuit supplied by one or more isolated secondary windings of a transformer in which the maximum possible open circuit voltage at the transformer is less than:

1) 30 volts (42.4 volts peak) where wet contact is not likely to occur; and

2) 15 volts (21.2 volts peak) where wet contact is likely to occur.

b) A circuit derived from a primary or isolated secondary circuit in which the maximum possible open circuit voltage, including voltage to earth ground, is less than the values specified in (a) by virtue of circuit impedance, regardless of the polarity.

Documents
Document Sharing Hub
Full document details: UL 224a 1998

c) A circuit derived from a primary or isolated secondary circuit in which the maximum possible open circuit voltage, including voltage to earth ground, is greater than the values specified in (a) but the available current measured through an appropriate impedance is limited by virtue of the circuit impedance to the value specified in the end-product standard for normal operation.

Each line in a circuit that employs such impedance shall satisfy the following equation:

$$Z \geq \frac{V}{I}$$

in which:

Z is the minimum impedance, including tolerances;

V is the open-circuit voltage; and

I is the current limitation of the end-product standard.

8.3 With reference to 8.2(a) and 8.2(b), if the circuit incorporates a voltage-multiplier or other circuit which increases the steady state potential, the maximum possible steady state potential shall not exceed the values specified.

8.4 Circuit elements, such as resistors, capacitors, rectifiers, and the like, which constitute the circuit impedance referred to in 8.2(b) and 8.2(c) shall be of the fixed type and shall be investigated as a unit for suitability with respect to end use conditions.

8.5 An electronic circuit element relied upon to limit the voltage, current, or both to the values specified in 8.2 shall not experience an electrical stress factor:

a) Greater than 0.5 during all conditions of normal operation; or

b) Greater than 1.0 after single component failure.

8.6 For supplies of circuits of the types specified in 8.2(b) and 8.2(c):

a) Minimum electrical spacings shall be in accordance with Section 17, Spacings, up to the point at which the voltage, current, or both is limited regardless of the maximum available power involved.

b) A risk of fire, electric shock, or injury to persons shall not result when the circuit is subjected to the 7 hour abnormal (short circuit) test specified in 30.1.1.

9 Current-Carrying Parts

9.1 A current-carrying part shall be of silver, copper, a copper-base alloy, aluminum, or other material acceptable for the application. Iron or steel shall not be used as a current-carrying part.

Exception No. 1: Stainless steel may be used as a current-carrying part.

Exception No. 2: Plated iron or steel may be used as a current-carrying part if it is used in the construction of a frame or enclosure that is intended for connection to an isolated secondary circuit or it is used as part of a component in accordance with the requirements for that component. See 11.3.1.

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1998

10 Internal Wiring

10.1 The method of judging the protection of the wiring and connections between parts of a control shall be determined in accordance with the end product standard.

10.2 Internal wiring shall be routed and secured so that neither it nor related electrical connections are likely to be subjected to stress or mechanical damage, especially wiring smaller than No. 24 AWG (0.21 mm^2) or having insulation less than 1/32 inch (0.79 mm) thick. Flexing, vibration, impact, and exposure of the wiring shall be evaluated per the end-product standard.

10.3 The internal wiring of a control, including grounding conductors, shall be suitable for the particular application when considered with respect to temperature, voltage, exposure to oil, grease, or moisture, and other conditions of service to which the wiring may be subjected.

11 Splices and Connections

11.1 General

11.1.1 Each splice and connection shall be mechanically secure and shall provide adequate and reliable electrical continuity without strain on connections and terminals. Consideration shall be given to vibration, flexing, motion, and the like, when judging the mechanical security of an electrical connection.

11.1.2 A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in a risk of fire, electric shock, or injury to persons.

11.1.3 A lead is considered to be mechanically secure when one or more of the following is provided prior to soldering:

a) A minimum of one full wrap is provided around a terminal;

b) A lead not integral with a component on a printed wiring board is passed through an eyelet or opening and if hand-soldered is bent 90 degrees to the board;

c) A lead integral with a component is inserted through an opening of a printed wiring board;

d) A lead is twisted with other conductors; or

e) A lead is inserted into a U- or V-shaped slot in the terminal.

11.1.4 Placement of a lead along a flat surface and tack soldering is not acceptable unless it can be demonstrated that a risk of fire, electric shock, or injury to persons would not result when the lead is detached.

11.1.5 Other means of securing leads, such as push-on terminals, spade-type connectors, and wire wrapping are to be investigated to determine if the mechanical security is acceptable. Quick-connect terminals shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Mechanical splicing devices shall comply with either the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A, or the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B, whichever is applicable.

Documents
Document Sharing Hub
Full document details: UL 224a 1998

11.1.6 A nongeneral use attachment plug or receptacle, or a printed-wiring board connector intended to facilitate interconnection within a control or to the end product shall be:

a) Acceptable for the current, voltage, and temperature involved; and

b) Provided with mechanical locking or securing means other than friction for providing electrical continuity, maintenance of spacings, and separation of circuits.

Exception: This requirement is not applicable if loosening or removal of the connector will not result in a risk of fire, electric shock, or injury to persons.

11.1.7 Factors to be considered in judging factory-wiring terminals and leads are the type and size of wire to be connected, the current rating of the terminals, and mechanical protection. These factors are dependent upon requirements for the end-use equipment.

11.2 Wire-wrapped connections

11.2.1 Solderless wrapped connections are not acceptable if subject to movement or flexure on the wires during normal operation or user servicing.

11.2.2 The wire for a wire-wrapped connection shall be solid, copper wire and shall be a wire size of No. 24, 22, or 20 AWG (0.511, 0.643, or 0.813 mm). Other sizes and types of wires shall be subjected to an investigation.

11.2.3 A terminal shall be made of copper or brass and have at least two sharp edges.

11.2.4 The wrap shall:

a) Have a minimum of 20 points on the corners of the terminal in contact with the wire; and

b) Have a minimum of 16 points closely wrapped with no overlapping.

See Table 11.1. A smaller number of wraps shall be subjected to an investigation. Contact points shall produce compression or flow of the conductor rather than a nick that weakens the mechanical strength of the conductor such that fracture might occur.

Table 11.1
Typical number of wraps

Number of sharp corners on the terminal	Number of closely wrapped turns	Total number of turns
4	4	5
2	8	10

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1994

11.2.5 The term "closely wrapped" in 11.2.4(b) means:

a) There shall be no gaps between adjacent turns greater than one half of the diameter of the wire exclusive of gaps on the first and last turns; and

b) The sum of all gaps on any side of a connection shall not exceed the diameter of the wire exclusive of gaps on the first and last turns.

11.2.6 11.2.5 applies only to the actual number of wraps that are required. Gaps between any additional wraps that have been added at the manufacturer's option are not included when determining compliance with 11.2.5.

11.3 Connections to frame

11.3.1 The frame or enclosure of a control shall not be used as a current-carrying part.

Exception: The frame may be used as a current-carrying part of an isolated secondary circuit.

11.3.2 If the frame is used as a current-carrying part of an isolated secondary circuit, hinges or other such movable parts shall not be relied upon as a current-carrying means.

12 Separation of Circuits

12.1 General

12.1.1 Separation of circuits:

a) Between insulated conductors or other insulated live parts of different circuits; and

b) Between insulated conductors or other insulated live parts of one circuit and uninsulated live parts of a different circuit

shall be accomplished by one or more of the means indicated in Table 12.1.

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

12.1.3 With reference to 12.1.1, a limited energy circuit derived from a circuit by limiting impedance shall be treated as one circuit.

12.1.4 Wires and cables that are part of an isolated secondary circuit shall be provided with strain relief means if stresses on the wire or cable could cause noncompliance with 12.1.1. The strain relief means shall be judged under the requirements for the end-use equipment.

Documents
Document Sharing Hub
Full document details: UL 224a 1998

Table 12.1
Separation of circuits

Part[a]			Separation requirement
Insulated		Uninsulated	
Suitable for highest voltage involved	Not suitable for highest voltage involved		
1 and 2			None
1	2		Footnote b(A)(1), (B), (C), (D)
1		2	Footnote b(A)(1), (B), (C), (D)(2), (D)(3)
	1 and 2		Footnote b(A)(1), (A)(2), (D)(2), (D)(3),
	1	2	Footnote b(A)(1), (A)(2), (D)(2), (D)(3)

[a] The numbers 1 and 2 refer to the circuits in question for which separation is to be maintained. See 12.1.1.

[b] Acceptable means of separation are:

A) Spacings – The through air spacings as indicated in Table 17.1 shall be used to determine adequate separation based on the highest voltage involved (see 17.3).

1) Require spacing.

2) Twice required spacing.

B) Double Insulation – Two separate and distinct insulations with each rated for the highest voltage involved (see 17.3) and complying with the requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

C) Reinforced Insulation – Improved basic insulation rated for the highest voltage involved with such mechanical and electrical qualities that, in itself, (1) provides the same degree of protection against risk of electric shock as two single insulations and (2) complies with UL 1097.

D) Barriers – A barrier shall be of adequate mechanical strength, reliably held in place, and suitably interposed between the parts in question when openings in the barrier are considered.

1) Metal - A metal barrier shall be located and connected so that an electrical breakdown of one or two insulations will not result in the voltage of one circuit appearing in the other circuit.

2) Insulating Material - Vulcanized fiber, polyethylene terephthalate (PETP) film, and resin-bonded mica shall have thicknesses not less than 0.028 inch (0.71 mm), 0.007 inch (0.18 mm), and 0.006 inch (0.15 mm), respectively. Other materials shall be subjected to an investigation in accordance with the requirements applied to internal barriers in the Standard for Polymeric Materials - Use in Electrical Equipment Evaluations, UL 746C.

3) Insulating Material (Sole Separation) – Insulating material shall comply with the requirements in 17.5 and 17.7.

Documents
Document Sharing Hub
This PDF Standard downloaded from www.bzfxw.com
Full document details: UL 244A 1994

12.1.5 When evaluating the required separation of the circuits in accordance with 12.1.1, consideration shall be given to such effects as deterioration of insulation resulting in abnormal operation involving overload, short-circuit, component failure conditions and the like.

13 Insulating Material

13.1 General

13.1.1 Insulating material shall be judged with respect to its acceptability for the application. Consideration shall be given to:

a) The material's mechanical strength and rigidity, resistance to ignition, dielectric strength, insulation resistance, and heat-resistant qualities, in both the aged and unaged conditions;

b) The degree to which the material is enclosed; and

c) Any other feature affecting the risk of fire, electric shock, or injury to persons.

All factors are to be considered with respect to conditions of actual service.

13.1.2 A barrier or integral part, such as an insulating washer or bushing, and a base or a support for mounting live parts shall be of moisture-resistant material that will not be adversely affected by the temperature and stresses to which it will be subjected under conditions of use.

13.1.3 Insulating material, including a barrier between parts of opposite polarity and material that may be subject to the influence of an arc shall be acceptable for the application.

13.1.4 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as sole support for uninsulated live parts.

13.2 Support of live parts

13.2.1 An uninsulated live part shall be mounted on porcelain, phenolic composition, or other material that is suitable for the particular application.

13.2.2 Polymeric material that is used to either directly or indirectly support live parts shall meet or exceed the recommended limits for the performance-level tests specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C – as applicable for the particular usage of the material.

Exception: Materials employed in a component shall comply with the requirements for the class of component involved.

14 Printed-Wiring Boards

14.1 A printed-wiring board, including the coatings, shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796. A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements in UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit need not comply with the bonding requirements in UL 796 if it is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use equipment.

Documents
Document Sharing Hub
Full document details: UL 224a 1998