UL 498B

Outline of Investigation for Receptacles with Integral Switching Means

Issue Number: 2

June 26, 2015

Summary of Topics

This is the second issue of the Outline of Investigation for Receptacles with Integral Switching Means, UL 498B. This new issue now covers a receptacle with an integral switching means where a Class 2 signaling device such as a sensor, timer or energy-management equipment is connected to the controlled receptacle by a Class 2 separable lead assembly.

UL's Outlines of Investigation are copyrighted by UL. Neither a printed nor electronic copy of an Outline of Investigation should be altered in any way. All of UL's Outlines of Investigation and all copyrights, ownerships, and rights regarding those Outlines of Investigation shall remain the sole and exclusive property of UL.

COPYRIGHT © 2015 UNDERWRITERS LABORATORIES INC.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

No Text on This Page

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

CONTENTS

INTRODUCTION

1 Scope 6
2 Components 7
3 Units of Measurement 7
4 Undated References 8
5 Glossary 8

CONSTRUCTION

6 General 11
7 Configurations 11
8 Accessibility of Live Parts 11
9 Current-Carrying Parts 13
10 Internal Wiring 13
11 Internal Splices and Connections 13
11.1 General 13
11.2 Wire-wrapped connections 14
11.3 Wiring terminals and leads 15
12 Separation of Circuits 15
13 Insulating Material 17
14 Printed-Wiring Boards 17
15 Components 18
15.1 Switching devices 18
15.2 Capacitors 18
15.3 Power-switching semiconductors 19
15.4 Isolation devices 19
16 Transformers 19
16.1 General 19
16.2 Isolation transformers 20
17 Spacings 21
18 Alternate Spacings – Clearances and Creepage Distances 23
19 Bonding of Internal Parts for Grounding 24
20 Class 2 Circuits 24
21 Class 2 Separable Lead Assembly 27

PERFORMANCE

22 General 28
23 Temperature Test 28
23.1 General 28
23.2 Operation 29
23.3 Temperature measurements 30
24 DC Offset Voltage Test 31
25 Abnormal Operation Test 31
25.1 Motor 31
25.2 Component failure 32
25.3 Abnormal switching test 33
26 Limited Power Point Determination Test 34
26.1 General 34

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

26.2 Option No. 1 34
26.3 Option No. 2 35
26.4 Component failure 36
26.5 Overload test 37
27 Isolation Tests 38
27.1 General 38
27.2 Pulse transformer burnout tests 38
27.3 Optical isolator tests 40
27.4 Component failure 40
28 Power-Switching Semiconductors 41
28.1 General 41
28.2 Overload test 42
28.3 Endurance 43
29 Voltage Surge Test 44
30 Power Supplies – Short circuit 46
31 Component Failure Test 47
32 Electronic Component Evaluation 47
33 Dielectric Voltage-Withstand Test 48
33.1 General 48
33.2 Primary circuits 48
33.3 Isolated secondary circuits 49
33.4 Transformers 50

MANUFACTURING AND PRODUCTION LINE TESTS

34 DC Offset Voltage Test 51

RATING

35 Details 51
35.1 Input 51
35.2 Output 51
35.3 Operational ambient temperature 52

MARKINGS

36 General 52
37 Installation Instructions 53

SUPPLEMENT SA - RECEPTACLES WITH INTEGRAL SWITCHING MEANS INTENDED FOR ENERGY MANAGEMENT AND BUILDING AUTOMATION

INTRODUCTION

SA1 Scope SA1

CONSTRUCTION

SA2 General SA1
SA3 Electrical Rating SA1

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL
Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015
Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

PERFORMANCE

SA4 General SA2
SA5 Overload Test SA2
SA6 Endurance Test SA4

RATING

SA7 Details SA7
SA7.1 Input SA7
SA7.2 Output SA8

MARKINGS

SA8 Details SA8

INSTALLATION INSTRUCTIONS

SA9 General SA11

APPENDIX A

Standards for Components. A1

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

INTRODUCTION

1 Scope

1.1 These requirements cover a receptacle with integral switching means rated 600 V or less, used in ordinary dry locations and intended for connection to a branch circuit in accordance with the National Electrical Code, NFPA 70.

1.2 A receptacle with integral switching means covered by this Outline shall meet the following requirements:

a) No voltage greater than 600 V above ground will be present in the device,

b) An isolation transformer, if provided, will generally furnish power at a lower potential than the primary voltage; and

c) The output of the device will not be located in a circuit operating at greater than 600 V above ground.

d) The switching device shall be integral to the receptacle.

e) A receptacle that is marked with the symbol shown in Table SA8.1 Reference No. 2 and does not employ an integral switching means intended for energy management and building automation, are covered by the Standard for Attachment Plugs and Receptacles, UL 498.

1.3 This Outline does not directly apply to, but may supplement the following standards:

a) Devices produced integrally with flexible cord or cable, covered by the Standard for Cord Sets and Power-Supply Cords, UL 817;

b) Current taps and adapters covered by the Standard for Current Taps and Adapters, UL 498A;

c) Devices employing male or female screwshells, covered by the Standard for Lampholders, UL 496;

d) Single and multipole connectors intended for factory assembly to copper or copper alloy conductors or printed wiring boards for use in data, signal, control and power applications within and between electrical equipment, covered by the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977;

e) Devices intended for installation and use in hazardous (classified) locations in accordance with the National Electrical Code, NFPA 70, covered by the Standard for Explosion-Proof and Dust-Ignition-Proof Equipment for Use in Hazardous (Classified) Locations, UL 1203;

f) Devices intended for use with telecommunications networks, covered by the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Communications Circuit Accessories, UL 1863;

g) Devices incorporating ground-fault circuit interruption circuitry, covered by the Standard for Ground-Fault Circuit Interrupters, UL 943;

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

h) Direct plug-in devices incorporating transient voltage surge suppression circuitry, covered by the Standard for Surge Protective Devices, UL 1449;

i) Direct plug-in devices incorporating electromagnetic interference filter circuitry, covered by the Standard for Electromagnetic Interference Filters, UL 1283;

j) Cord-connected, relocatable power taps intended only for indoor use as a temporary extension of a grounding alternating-current branch circuit for general use, covered by the Standard for Relocatable Power Taps, UL 1363.

k) Energy management equipment covered by the Standard for Energy Management Equipment, UL 916.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Outline 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 Outline.

2.2 A component is not required to comply with a specific requirement that:

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

b) Is superseded by a requirement in this Outline.

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

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

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

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

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

4 Undated References

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

5 Glossary

5.1 For the purpose of this Outline the following definitions apply:

5.2 CLASS 2 CIRCUIT – An isolated secondary circuit involving a potential of not more than 42.4 V 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) 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 a Class 2 circuit. See Class 2 Circuits, Section 20.

5.3 CLASS 2 SEPARABLE LEAD ASSEMBLY – Consists of a factory-made, power-limited cable assembly provided with a connector, intended for Class 2 signaling between a device such as a sensor, timer or energy-management equipment and a wired controlled receptacle.

5.4 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.

5.5 CONTROLLED ENVIRONMENT – An environment:

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

b) Not subject to humidity and the formation of condensation. A controlled environment is provided, for example, by means of a:

1) Hermetically sealed enclosure;

2) Encapsulation;

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

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.

5.6 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.

5.7 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.

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

5.9 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.

5.10 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 W; or an isolated secondary circuit in which the wattage from any point in the circuit to any return to the power supply is limited to 50 W.

5.11 LINE-CONNECTED CIRCUIT – A 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 5.9.

5.12 OPPOSITE POLARITY – A difference in potential between two points, such that shorting of these two points results in a condition involving an overload; rupturing of printed wiring-board-tracks, components, or fuses; or similar condition.

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

5.14 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 is capable of resulting in a risk of fire, electric shock, or injury to persons. 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 product to acceptable levels.

5.15 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 includes random switching in which conduction occurs at any phase angle of the alternating current load voltage cycle or regulated switching 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 TRIODE THYRISTOR (TRIAC) – A three-terminal thyristor having substantially the same switching behavior in the first and third quadrants of the principal voltage-current characteristics.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

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.

5.16 TRANSFORMER – The term includes a motor-transformer or an autotransformer. For the purpose of these requirements, the types of transformers typically encountered in or supplying power to controls are:

a) Class 2 – An isolation type transformer as specified in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

b) Power – A transformer other than Class 2 that is intended to transmit power. Included are isolation and non-isolation (such as an autotransformer) types.

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 Sensing – An isolation-type transformer designed to have the 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. Secondary windings are not required to be electrically separated from other secondary windings.

5.17 WIRED CONTROLLED RECEPTACLE – A receptacle that employs an integral switching means where a Class 2 signaling device such as a sensor, timer or energy-management equipment is connected to the device by a Class 2 separably lead assembly.

5.18 WIRELESS CONTROLLED RECEPTACLE – A receptacle that employs an integral switching means where the signaling device such as a sensor, timer or energy-management equipment is wirelessly connected to the controlled receptacle by radio-signal.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

CONSTRUCTION

6 General

6.1 In addition to the construction requirements contained in this Outline, a receptacle with integral switching means shall also comply with the applicable construction requirements of the Standard for Attachment Plugs and Receptacles, UL 498.

6.2 A receptacle with integral switching means shall employ materials that are rated 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.

6.3 A receptacle with integral switching means shall be formed and assembled so that the device has the strength and rigidity necessary to resist the foreseeable abuse to which the device is subjected, without resulting in a 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.

6.4 A risk of electric shock exists 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.

6.5 For a controlled environment, the means used to prevent contamination and condensation shall be rated for the purpose. The controlled environment in a non-production indoor area in an ordinary location free of conductive contaminants shall be evaluated for the means used to prevent condensation only.

6.6 A Class 2 separable conductor lead assembly, provided with or intended for use with a wired control receptacle, shall only be located behind the plane of the wired control receptacle mounting yoke and not be accessible when a cover plate is installed.

7 Configurations

7.1 A receptacle with integral switching means referenced in this Outline are in accordance with Wiring Devices – Dimensional Specifications, ANSI/NEMA WD6.

8 Accessibility of Live Parts

8.1 The method of determining the accessibility of an uninsulated live part that involves a risk of electric shock and other electrical parts shall be in accordance with the Standard for Attachment Plugs and Receptacles, UL 498.

8.2 A live part of a receptacle with integral switching means 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 open circuit voltage at the transformer is less than:

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

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

b) A circuit derived from a primary or isolated secondary circuit in which the maximum 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.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL
Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015
Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

c) A circuit derived from a primary or isolated secondary circuit in which the maximum open circuit voltage, including voltage to earth ground, is greater than the values specified in (a) but the available current measured through an impedance, equivalent to that in the end-use product, 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 (b), if the circuit incorporates a voltage-multiplier or other circuit which increases the steady state potential, the maximum steady state potential shall not exceed the values specified.

8.4 Circuit elements, such as resistors, capacitors, rectifiers, and similar elements, which constitute the circuit impedance referred to in 8.2(b) and (c), shall be of the fixed type and shall be evaluated as a unit for acceptability 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 (c):

a) Minimum electrical spacings shall be in accordance with Spacings, Section 17, 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 short-circuit test specified in 30.1.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

9 Current-Carrying Parts

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

10 Internal Wiring

10.1 Internal wiring shall be routed and secured so that the wiring and related electrical connections are not subjected to stress or mechanical damage, especially wiring smaller than 24 AWG (0.21 mm^2) or having insulation less than 1/32 in (0.79 mm) thick.

11 Internal Splices and Connections

11.1 General

11.1.1 Internal splices and connections shall be mechanically secure and shall provide electrical continuity without strain on connections and terminals. Vibration, flexing, motion, and similar conditions shall be taken into account when determining compliance of 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 results 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 the construction is such that a risk of fire, electric shock, or injury to persons does not result when the lead is detached.

11.1.5 A printed-wiring board connector intended to facilitate interconnection within a receptacle with integral switching means shall be:

a) Rated 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 does not result in a risk of fire, electric shock, or injury to persons.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

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 24, 22, or 20 AWG (0.511, 0.643, or 0.813 mm). Other sizes and types of wires shall be subjected to evaluation.

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 evaluation. 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 is able to 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

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

a) There shall not be 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 The requirements in 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.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

11.3 Wiring terminals and leads

11.3.1 A receptacle with integral switching means shall comply with the terminal and leads requirements of the Standard for Attachment Plugs and Receptacles, UL 498.

12 Separation of Circuits

12.1 Separation of circuits between insulated conductors or other insulated live parts of different circuits, and 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.

Table 12.1
Separation of circuits

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

[a] The letters a and b refer to separation (See 12.1) as follows:

a Separation between insulated conductors or other insulated live parts of different circuits; and

b Separation between insulated conductors or other insulated live parts of one circuit and uninsulated live parts of a different circuit.

Table 12.1 Continued on Next Page

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

Table 12.1 Continued

Part[a]			Separation requirement[b]
Insulation			
Rated for highest voltage involved	Not rated for highest voltage involved	Uninsulated	

[b] Acceptable means of separation are:

A) Spacings – The through air spacings as indicated in Table 17.1, based on the highest voltage involved, shall be used to determine compliance of separation. See 17.3.

1) Required 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 the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

D) Barriers – A barrier shall have mechanical strength for the conditions of use, be secured in place, and if there are openings in the barrier, the barrier shall be located between the parts in question so that spacings between the parts are maintained.

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 in (0.71 mm), 0.007 in (0.18 mm), and 0.006 in (0.15 mm), respectively. Other materials shall comply with the requirements applicable 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.

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

12.3 With reference to 12.1, a limited energy circuit derived from a circuit by limiting impedance shall be treated as one circuit.

12.4 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 cause noncompliance with 12.1. The strain relief means shall comply with the requirements for the end-use product.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

12.5 When determining the required separation of the circuits in accordance with 12.1, such effects as deterioration of insulation resulting in abnormal operation involving overload, short-circuit, component failure conditions and similar effects shall be taken into account.

13 Insulating Material

13.1 A receptacle with integral switching means shall comply with the insulating material requirements of the Standard for Attachment Plugs and Receptacles, UL 498.

13.2 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 the material is subjected under conditions of use.

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

13.4 Ordinary vulcanized fiber is acceptable for insulating bushings, washers, separators, and barriers, but shall not be used as sole support for uninsulated live parts.

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 non-safety circuit is not required to comply with the bonding requirements in UL 796 if board 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 product.

14.2 A printed-wiring board, including the coating, shall have a minimum flammability classification of V-2 as specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A printed-wiring board, including the coating, in a Class 2 circuit or an isolated secondary limited-energy circuit shall have a minimum flammability classification of HB as specified in UL 94.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

15 Components

15.1 Switching devices

15.1.1 An electromechanical switching device:

a) Shall have a voltage rating and a current rating, a horsepower rating, or both, not less than that of the load that the device controls; and

b) Shall be rated for the type of load that the device controls as follows:

1) General purpose ac (0.75 to 0.80 power factor) – for example, transformer load.

2) General purpose dc.

3) Resistive.

4) Tungsten lamp.

Exception: A switching device intended to control a 15-W or smaller pilot or indicating lamp is not required to be provided with a tungsten rating.

5) Electric discharge lamp.

6) Motor.

15.1.2 A switch shall be evaluated with respect to the temperature limitations of the materials employed.

15.1.3 A switching device, such as a relay, that is controlled in such a manner that the device will always switch current during the same positive or negative half of the normal ac sinusoidal waveform, shall be suitable for the current, the type of load involved, and the particular application under dc operation.

15.2 Capacitors

15.2.1 A capacitor shall employ such materials and shall be constructed so that the capacitor will not constitute a risk of fire. A capacitor shall not be adversely affected by the temperature the capacitor reaches under the most severe conditions of intended use.

15.2.2 A paper capacitor shall be impregnated or enclosed to exclude moisture.

15.2.3 A capacitor connected across the supply circuit shall comply with the Standard for Fixed Capacitors for Use in Electronic Equipment - Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

15.2.4 With reference to the requirements in 15.2.3, a capacitor, other than a motor capacitor, is considered to be across the supply circuit if, in a shorted condition, a current of more than one ampere passes through the capacitor while the control is in a heated condition. Limiting the current through the capacitor to one ampere or less by a fixed impedance or by a protective device rated one ampere or less is acceptable.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

15.2.5 A liquid-electrolyte, metalized-film or conductive-foil type electrolytic capacitor connected in a circuit capable of delivering a power greater than 15 W as determined in the Limited Power Point Determination Test, Section 26, and having a diameter of more than 0.394 in (10 mm), shall be provided with a means for relieving excessive internal pressure.

15.3 Power-switching semiconductors

15.3.1 A power-switching dead-case-mounted semiconductor shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557, for the voltage and temperature involved.

Exception: This requirement does not apply if the semiconductor is intended to be secured to an inaccessible metal part physically isolated, electrically insulated, or both from other live parts or accessible dead metal parts.

15.4 Isolation devices

15.4.1 If a device intended to provide electrical isolation, such as an optical isolator, pulse transformer, relay, or similar device, is provided to reduce the risk of fire, electric shock, or injury to persons, or because isolation is required by this Outline between specific circuits (for example, a device that isolates Class 2 circuit outputs from circuits involving a risk of electric shock), the device shall:

a) Comply with the requirements for such devices;

b) Shall be suitable for the voltage and temperature involved; and

c) Shall be subjected to the tests specified in Isolation Tests, Section 27, to determine the effects on the insulating properties of the isolating medium.

16 Transformers

16.1 General

16.1.1 A coil of a transformer shall be wound and impregnated or otherwise enclosed to exclude moisture. Coil insulation, unless inherently moisture resistant shall be treated or enclosed to render the insulation resistant to moisture. Film-coated magnet wire is not required to be additionally treated or enclosed to resist moisture absorption.

16.1.2 A Class 2 transformer shall comply with the applicable requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

16.1.3 A power transformer shall comply with the applicable requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2 and with the overload heating requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3. See 16.2.5.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

16.2 Isolation transformers

16.2.1 A transformer having separate windings shall be constructed to reduce the risk of short-circuiting, under normal and overload conditions, between primary and secondary windings or between separate adjacent secondary windings if such shorting directly or through the core results in a risk of fire or electric shock, operation of the controlled equipment in a manner that involves a risk of fire, electric shock, or injury to persons, or affect the evaluation of the circuit the transformer supplies when the additive effects of each winding are taken into account.

16.2.2 Unless otherwise noted, electrical separation between windings and between windings and the core or other dead metal parts shall be accomplished by insulation, spacings, or both and shall not rely solely upon the coating of the magnet wire.

16.2.3 With reference to 16.2.2, insulation or spacings shall be provided between:

a) Uninsulated primary wires or terminals of opposite polarity;

b) The primary winding including lead connections and terminals and each secondary winding and associated lead connections and terminals;

c) The primary winding including lead connections and terminals and the core or other dead metal parts;

d) Each secondary winding including lead connections and terminals and the core or other dead metal parts; and

e) Adjacent secondary windings including lead connections and terminals.

16.2.4 Spacings between parts noted in 16.2.3(a) – (e) shall not be less than the applicable value specified in Table 16.1. The potential involved is the maximum voltage in any winding or the normal operating voltage existing between the parts in question, whichever is greater.

Exception: Insulation or spacings are not required between parts noted in 16.2.3(d) and (e) if the risks noted in 16.2.1 are not present.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

Documents
Document Sharing Hub

Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Full document details: UL SUBJECT 498B 2015

Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT

Table 16.1
Minimum spacings at isolation transformers

Potential involved, V, rms	Through air		Over surface	
	In	(mm)	In	(mm)
0 – 50	1/16	(1.6)	1/16	(1.6)
51 – 150	1/8	(3.2)	1/4	(6.4)
151 – 250	1/4	(6.4)	3/8	(9.5)
251 – 600	3/8	(9.5)	1/2	(12.7)
NOTE – These spacings apply to coils, crossover leads, splices, uninsulated lead wires and terminals. These spacings do not apply to turn-to-turn spacings of a coil.				

16.2.5 The insulation of a pulse transformer or an isolation type power transformer shall comply with the applicable coil construction requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

17 Spacings

17.1 Unless otherwise noted and as provided in Alternate Spacings – Clearances and Creepage Distances, Section 18, spacings within a control receptacle shall be as indicated in Table 17.1:

a) Between uninsulated live parts of opposite polarity within a circuit;

b) Between an uninsulated live part of one circuit and an uninsulated live part of any other circuit; and

c) Between an uninsulated live part of any circuit and a dead metal part.

Exception No. 1: The minimum acceptable spacing of a receptacle with integral switching means contact and terminal shall comply with the spacings requirements of the Standard for Attachment Plugs and Receptacles, UL 498.

Exception No. 2: The minimum acceptable spacings specified in Table 17.1 does not apply to the inherent spacings of a component of a control, such as a switch. The acceptability of spacings of a component is based on the requirements covering that component.

Exception No. 3: At closed-in points in which contamination is not able to occur (such as the screw-and-washer construction of an insulated terminal mounted in metal), a spacing of 3/64 in (1.2 mm) is acceptable in a circuit rated at 250 V or less.

Exception No. 4: Spacings are not specified within Class 2 circuits as defined in 5.2 and complying with Class 2 Circuits, Section 20, and between such circuits and dead metal parts unless such circuits are safety circuits. If a short circuit between the parts in a Class 2 safety circuit are able to result in a risk of fire, electric shock, or injury to persons, spacings of 1/32 in (0.8 mm) are acceptable between uninsulated live parts within a Class 2 safety circuit that complies with the requirements in Class 2 Circuits, Section 20 and between such parts and dead metal, if the construction is such that spacings will be permanently maintained.

Exception No. 5: In other than safety circuits, a spacing less than the minimum specified in Table 17.1 is acceptable under the conditions described in Limited Power Point Determination Test, Section 25.

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL
--`,,,```,,,,```,,,,```,,,,`-`-`,,`,,`,`,,`---
Documents
Document Sharing Hub
Copyright UL
Provided by IHS under license with UL
No reproduction or networking permitted without license from IHS
Licensee=North Carolina State Univ/5618801100
Not for Resale, 10/17/2015 13:38:30 MDT
Full document details: UL SUBJECT 498B 2015