



UL 1564

STANDARD FOR SAFETY

Industrial Battery Chargers

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



Documents

Document Sharing Hub

UL Standard for Safety for Industrial Battery Chargers, UL 1564

Fourth Edition, Dated May 14, 2015

Summary of Topics

This Fourth Edition of ANSI/UL 1564 has been issued as an editorial update only. No changes in requirements have been made.

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.

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.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

No Text on This Page

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



Documents

Document Sharing Hub

MAY 14, 2015

1



ANSI/UL 1564-2013

UL 1564

Standard for Industrial Battery Chargers

Prior to the first edition, the requirements for the products covered by this standard were included in the Standard for Electric Battery Chargers, UL 1236.

Prior to the third edition, the requirements for Outdoor-Use Industrial Battery Chargers were included in the Outline of Investigation for Outdoor-Use Industrial Battery Chargers, UL 1564A.

First Edition – December, 1982
Second Edition – November, 1993
Third Edition – August, 2006

Fourth Edition

May 14, 2015

This ANSI/UL Standard for Safety consists of the Fourth Edition.

The most recent designation of ANSI/UL 1564 as an American National Standard (ANSI) occurred on March 26, 2013. ANSI approval for a standard does not include the Cover Page, Transmittal Pages and Title Page.

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>.

UL's Standards for Safety are copyrighted by UL. Neither a printed nor electronic copy of a Standard 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.

COPYRIGHT © 2015 UNDERWRITERS LABORATORIES INC.

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



Documents
Document Sharing Hub

No Text on This Page

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



Documents

Document Sharing Hub

CONTENTS

INTRODUCTION

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

CONSTRUCTION

6 Frame and Enclosure	8
7 Accessibility of Live Parts	14
8 Assembly	15
9 Protection Against Corrosion	15
10 Supply Connections – Permanently-Connected Products	16
10.1 General	16
10.2 Field-wiring terminals and leads	16
11 Supply Connections – Cord- and Plug-Connected Products	18
11.1 General	18
11.2 Strain relief	18
11.3 Bushings	19
12 External Connections and Wiring	20
13 Current-Carrying Parts	20
14 Internal Wiring	21
14.1 General	21
14.2 Tubing	22
14.3 Protection of wiring	22
14.4 Electrical connections	22
14.5 Separation of circuits	23
14.6 Factory wiring	23
14.7 Field wiring	24
14.8 Separation barriers	24
15 Insulating Materials	25
16 Motors	25
17 Transformers	25
17.1 General	25
17.2 Coil insulation	26
18 Resistors	28
19 Switches and Controllers	29
20 Overcurrent Protection	30
21 Lampholders	31
22 Capacitors	31
23 Printed Wiring	31
24 Spacings	32
24.1 General	32
24.2 Insulation barriers	35
24.3 Alternate spacings – clearances and creepage distances	36
24.4 Control circuits	36
25 Grounding	38
26 Bonding of Internal Parts	39

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

PERFORMANCE

27	General	41
28	Leakage Current Test	42
29	Power Input Test	45
30	Temperature Test	46
31	Intermediate Abnormal Test	49
32	Dielectric Voltage-Withstand Test	50
	32.1 General	50
	32.2 Induced potential	50
33	Humidity Conditioning	51
34	Strain Relief Test	52
35	Push-Back Relief Test	53
36	Overload Test	53
37	Grounding Impedance Test	54
38	Volt-Ampere Capacity Tests	54
	38.1 Isolated-limited-power circuit	54
	38.2 Single-wound secondary transformer	54
	38.3 Multisecundary transformer	54
39	Abnormal Operation Tests	55
	39.1 General	55
	39.2 Output short-circuit	56
	39.3 Reverse polarity	56
	39.4 Blocked rotor fan	56
	39.5 High voltage	56
	39.6 Evaluation of reduced spacings on printed-wiring boards	57
40	Burnout Test	57
	40.1 General	57
	40.2 Relay and solenoid burnout	58
	40.3 Transformer burnout	58
41	Fifteen-Day Abnormal Tests	59
42	Strength and Rigidity Tests	61
	42.1 General	61
	42.2 Impact test	61
	42.3 Drop test	61
	42.4 Tip-over test	61
43	Permanence of Marking	62
44	Bonding Conductor Test	62

MANUFACTURING AND PRODUCTION TESTS

45	Dielectric Voltage-Withstand Test	63
46	Grounding Continuity Test	65

RATINGS

47	Details	65
----	---------------	----

MARKINGS

48	General	65
49	Cautionary Markings	67

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



Documents
Document Sharing Hub

SUPPLEMENT SA - OUTDOOR-USE INDUSTRIAL BATTERY CHARGERS**GENERAL**

SA1 Scope	SA1
-----------------	-----

CONSTRUCTION

SA2 Spacings	SA1
SA3 Frame and Enclosure	SA1
SA4 Supply Connections	SA4
SA5 External Connections and Wiring	SA4

PERFORMANCE

SA6 Temperature	SA4
SA7 Rain Conditioning	SA5
SA8 Physical Properties	SA8
SA8.1 Accelerated aging tests	SA8
SA8.2 Metallic coating thickness	SA9

MARKINGS

SA9 Details	SA10
-------------------	------

APPENDIX A

Standards for Components.....	A1
-------------------------------	----

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



Documents
Document Sharing Hub

INTRODUCTION

1 Scope

1.1 These requirements cover battery chargers rated 600 volts or less. They are intended to be used in accordance with the National Electrical Code, NFPA 70, to charge industrial storage batteries which are used to provide power for material handling trucks, tractors, personnel carriers, and similar motive equipment. These chargers may be either cord and plug connected or permanently connected.

1.2 A battery charger that is not a complete assembly and depends upon installation in an end product for compliance with the requirements in this Standard is investigated under the requirements of this Standard and the standard for the end product.

1.3 These requirements do not cover:

- a) Battery chargers for use in a marina, boatyard, or other marine application;
- b) Battery chargers for fire protection signaling service;
- c) Household battery chargers;
- d) Automotive battery chargers;
- e) Battery chargers for use with an internal combustion engine driving a centrifugal fire pump;
or
- f) Appliances or systems in which a battery charger is used.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

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

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

2.3 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.

4 Undated References

4.1 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.

5 Glossary

5.1 In the following text, the term "product" is used to mean an industrial battery charger.

5.2 For the purpose of this standard, the following definitions apply.

5.3 CLASS 2 TRANSFORMER – A step-down transformer complying 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, or the Standard for Class 2 Power Units, UL 1310.

5.4 INDUSTRIAL BATTERY – A battery that is intended for cycling service and is rated in number of cells and in ampere-hours delivered at the 6-hour discharge rate.

5.5 LIMITED-ENERGY CIRCUIT – An ac or dc circuit having a voltage not exceeding 1000 volts and the energy limited to 100 volt-amperes by either a secondary winding of a transformer, one or more resistors complying with 24.4.10 and 24.4.11, or a regulating network complying with 24.4.1.

5.6 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving an alternating current voltage of not more than 30 volts, rms (42.4 volts peak), or a direct current voltage of not more than 60 volts and supplied by either of the following:

a) An inherently limited Class 2 transformer or power unit or a not inherently limited Class 2 transformer or power unit and an overcurrent protective device that is:

- 1) Not of the automatic reclosing type;
- 2) Trip-free from the reclosing mechanism; and
- 3) Either not readily interchangeable with a device of a different rating or a marking in accordance with 48.5 is provided.

b) A combination of an isolated transformer secondary winding and one or more resistors or a regulating network complying with 24.4.10 that complies with all the performance requirements for an inherently limited Class 2 transformer or power source.

CONSTRUCTION

6 Frame and Enclosure

6.1 A product shall be formed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is subjected, without increasing the risk of fire, electric shock, or injury to persons due to a total or partial collapse resulting in a reduction of spacings, loosening or displacement of parts, or other serious defects.

6.2 A product that complies with the requirements in 6.3 – 6.8 is considered to comply with the requirements in 6.1.

6.3 A product shall be provided with an enclosure that shall house all parts – other than the power-supply cord or primary connector and the output leads or terminals – that present a risk of fire, electric shock, or injury to persons under any condition of use.

6.4 The thickness of a sheet-metal enclosure shall not be less than that specified in Tables 6.1 and 6.2, except that uncoated steel shall not be less than 0.032 inch (0.81 mm) thick, zinc-coated steel shall not be less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall not be less than 0.045 inch (1.14 mm) thick at points at which a wiring system is to be connected.

Table 6.1
Thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness, inch (mm)	
Maximum width ^b	Maximum length ^c	Maximum width ^b	Maximum length ^c	Uncoated	Zinc coated
inches (cm)	inches (cm)	inches (cm)	inches (cm)		
4.0 (10.2)	Not limited	6.25 (15.9)	Not limited	0.020 (0.51)	0.023 (0.58)
4.75 (12.1)	5.75 (14.6)	6.75 (17.1)	8.25 (21.0)		
6.0 (15.2)	Not limited	9.5 (24.1)	Not limited	0.026 (0.66)	0.029 (0.74)
7.0 (17.8)	8.75 (22.2)	10.0 (25.4)	12.5 (31.8)		
8.0 (20.3)	Not limited	12.0 (30.5)	Not limited	0.032 (0.81)	0.034 (0.86)
9.0 (22.9)	11.5 (29.2)	13.0 (33.0)	16.0 (40.6)		
12.5 (31.8)	Not limited	19.5 (49.5)	Not limited	0.042 (1.07)	0.045 (1.14)
14.0 (35.6)	18.0 (45.7)	21.0 (53.3)	25.0 (63.5)		
18.0 (45.7)	Not limited	27.0 (68.6)	Not limited	0.053 (1.35)	0.056 (1.42)
20.0 (50.8)	25.0 (63.5)	29.0 (73.7)	36.0 (91.4)		
22.0 (55.9)	Not limited	33.0 (83.8)	Not limited	0.060 (1.52)	0.063 (1.60)
25.0 (63.5)	31.0 (78.7)	35.0 (88.9)	43.0 (109.2)	43.0 (109.2)	
25.0 (63.5)	Not limited	39.0 (99.1)	Not limited	0.067 (1.70)	0.070 (1.78)
29.0 (73.7)	36.0 (91.4)	41.0 (104.1)	51.0 (129.5)		
33.0 (83.8)	Not limited	51.0 (129.5)	Not limited	0.080 (2.03)	0.084 (2.13)
38.0 (96.5)	47.0 (119.4)	54.0 (137.2)	66.0 (167.6)		
42.0 (106.7)	Not limited	64.0 (162.6)	Not limited	0.093 (2.36)	0.097 (2.46)
47.0 (119.4)	59.0 (149.9)	68.0 (172.7)	84.0 (213.4)		
52.0 (132.1)	Not limited	80.0 (203.2)	Not limited	0.108 (2.74)	0.111 (2.82)
60.0 (152.4)	74.0 (188.0)	84.0 (213.4)	103.0 (261.6)		

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

Table 6.1 Continued on Next Page

Documents
Document Sharing Hub

Table 6.1 Continued

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness, inch (mm)	
Maximum width ^b inches (cm)	Maximum length ^c inches (cm)	Maximum width ^b inches (cm)	Maximum length ^c inches (cm)	Uncoated	Zinc coated
63.0 (160.0) 73.0 (185.4)	Not limited 90.0 (228.6)	97.0 (246.4) 103.0 (261.6)	Not limited 127.0 (322.6)	0.123 (3.12)	0.126 (3.20)

^a See 6.5.

^b The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

^c Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or is fastened to an adjacent surface not normally removed in use.

Table 6.2
Thickness of sheet metal for enclosures – aluminum, copper, or brass

Without supporting frame ^a		With supporting frame or equivalent reinforcing ^a		Minimum thickness, inch (mm)
Maximum width ^b inches (cm)	Maximum length ^c inches (cm)	Maximum width ^b inches (cm)	Maximum length ^c inches (cm)	
3.0 (7.6) 3.5 (8.9)	Not limited 4.0 (10.2)	7.0 (17.8) 8.5 (21.6)	Not limited 9.5 (24.1)	0.023 (0.58)
4.0 (10.2) 5.0 (12.7)	Not limited 6.0 (15.2)	10.0 (25.4) 10.5 (26.7)	Not limited 13.5 (34.3)	0.029 (0.74)
6.0 (15.2) 6.5 (16.5)	Not limited 8.0 (20.3)	14.0 (35.6) 15.0 (38.1)	Not limited 18.0 (45.7)	0.036 (0.91)
8.0 (20.3) 9.5 (24.1)	Not limited 11.5 (29.2)	19.0 (48.3) 21.0 (53.3)	Not limited 25.0 (63.5)	0.045 (1.14)
12.0 (30.5) 14.0 (35.6)	Not limited 16.0 (40.6)	28.0 (71.1) 30.0 (76.2)	Not limited 37.0 (94.0)	0.058 (1.47)
18.0 (45.7) 20.0 (50.8)	Not limited 25.0 (63.5)	42.0 (106.7) 45.0 (114.3)	Not limited 55.0 (139.7)	0.075 (1.91)
25.0 (63.5) 29.0 (73.7)	Not limited 36.0 (91.4)	60.0 (152.4) 64.0 (162.6)	Not limited 78.0 (198.1)	0.095 (2.41)
37.0 (94.0) 42.0 (106.7)	Not limited 53.0 (134.6)	87.0 (221.0) 93.0 (236.2)	Not limited 114.0 (289.6)	0.122 (3.10)
52.0 (132.1) 60.0 (152.4)	Not limited 74.0 (188.0)	123.0 (312.4) 130.0 (330.2)	Not limited 160.0 (406.4)	0.153 (3.89)

^a See 6.5.

^b The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

^c Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or is fastened to an adjacent surface not normally removed in use.

6.5 With reference to Tables 6.1 and 6.2, a supporting frame is a structure of angle, channel, or a folded rigid section of sheet metal, that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments that may be

applied by the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without a supporting frame includes:

- a) A single sheet with single formed flanges (formed edges);
- b) A single sheet that is corrugated or ribbed; and
- c) An enclosure surface loosely attached to a frame (for example, by means of spring clips).

6.6 An enclosure consisting of wire mesh, perforated screens, or grillwork shall be provided with a rigid supporting frame such that the deformation of a guard or enclosure does not result in contact with live parts.

6.7 The diameter of the wires of a screen shall not be less than 0.0598 inch (1.519 mm) if the screen openings are 1/2 square inch (3.2 cm²) or less in area and shall not be less than 0.100 inch (2.54 mm) for larger screen openings.

6.8 Perforated sheet steel and sheet steel used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) thick, 0.058 inch (1.47 mm) thick if nonferrous, if the mesh openings or perforations are 1/2 square inch (3.2 cm²) or less in area, and shall not be less than 0.080 inch (2.03 mm) thick, 0.112 inch (2.84 mm) thick if non-ferrous, for larger openings.

Exception: In a small charger where the indentation of a guard or enclosure does not affect the clearance between uninsulated, movable, current-carrying parts and grounded metal, 0.020 inch (0.51 mm) steel or 0.029 inch (0.74 mm) nonferrous expanded metal mesh may be employed, provided that:

- a) The exposed mesh on any one side or surface of the battery charger that is so protected has an area of 72 square inches (465 cm²) or less and does not have any dimension greater than 12 inches (305 mm); or*
- b) The width of the protected opening is 3-1/2 inches (88.9 mm) or less.*

6.9 If an electrical instrument, such as a meter, forms part of the enclosure, the face or the back of the instrument housing, or both together, shall comply with the requirements for an enclosure.

Exception No. 1: This requirement does not apply to an electrical instrument connected in a secondary circuit where damage to or deterioration of the materials of which the housing is made does not result in a risk of fire or electric shock.

Exception No. 2: This requirement does not apply to a meter complying with the Standard for Electrical Analog Instruments – Panel Board Types, UL 1437.

6.10 Material supporting terminals or used as internal electrical insulation of an electrical instrument shall comply with the requirements in Insulating Materials, Section 15. The acceptability of spacings between live and dead metal parts connected to the enclosure within the instrument shall be determined by compliance with the requirements in 32.1.1.

Exception No. 1: This requirement does not apply to an electrical instrument connected in a secondary circuit where damage to or deterioration of the materials does not result in a risk of fire or electric shock.

Exception No. 2: This requirement does not apply to a meter complying with the Standard for Electrical Analog Instruments – Panel Board Types, UL 1437.

6.11 Supporting feet of a product that form part of the enclosure or are needed for ventilation shall be reliably secured and the aging, physical, and flammability properties of the material shall be investigated. The effect of oil and the absorption of moisture on the mounting feet are also to be considered.

Exception: Supporting feet may be accepted without testing if they do not form part of the enclosure and are not needed to provide ventilation.

6.12 An enclosure, frame, or cover of a material other than sheet metal shall provide protection equivalent to that required by 6.4.

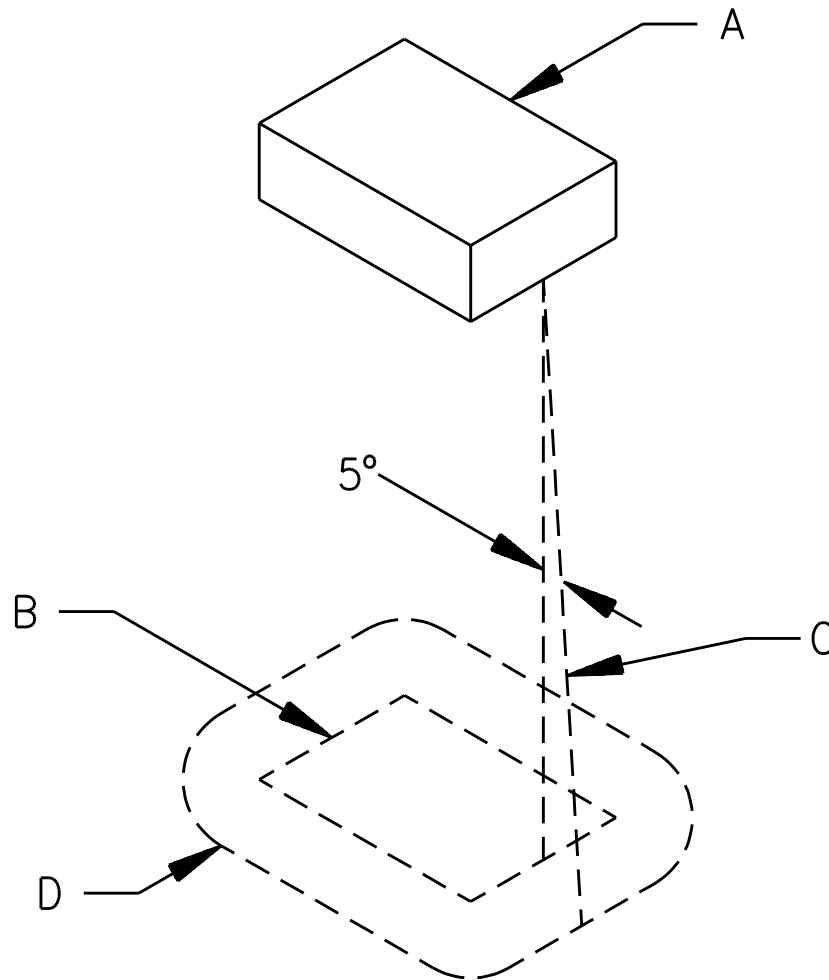
6.13 Among the factors taken into consideration when judging the acceptability of a nonmetallic enclosure are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;
- d) Combustibility;
- e) Resistance to distortion at temperatures to which the material may be subjected under conditions of normal or abnormal usage; and
- f) Resistance to arcing.

The enclosure material shall not display a loss of a property beyond the minimum acceptable level as a result of aging. See the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.14 The combination of enclosure and internal barriers of a product shall prevent molten metal, burning insulation, flaming particles, or the like, from falling onto combustible materials, including the surface upon which the charger is supported. See Figure 6.1. An internal barrier may be an integral part of a component or of the charger enclosure. Compliance shall be determined in accordance with 6.15 and 6.16.

Figure 6.1
Location and extent of barrier



SA0604-1

a – Region to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded, and will consist of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

b – Projection of outline of component on horizontal plane.

c – Inclined line that traces out minimum area of barrier. When moving, the line is always

- 1) Tangent to the component;
- 2) 5 degrees from the vertical; and
- 3) So oriented that the area traced out on a horizontal plane is maximum.

d – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

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



Documents
Document Sharing Hub

6.15 To comply with the requirement in 6.14, an enclosure having openings in the bottom wall shall be provided with a barrier in accordance with Figure 6.1 unless the components enclosed are as described in the following:

- a) Individually enclosed when arcing parts such as a switch, relay, or contactor are involved.
- b) A motor without openings in the bottom of the housing unless:
 - 1) The overload protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the product when the motor is energized under each of the following fault conditions:
 - i) Open main winding;
 - ii) Open starting winding; and
 - iii) Starting switch short-circuited;
 - 2) The motor is provided with a thermal protector that is sensitive to temperature and current and that will prevent the temperature of the motor winding from exceeding:
 - i) 125°C (257°F) when the motor is running at the maximum load at which it can operate without causing the protector to cycle; and
 - ii) 150°C (302°F) with the rotor of the motor locked; or
 - 3) The motor complies with the requirements for impedance-protected motors and the temperature of the motor winding does not exceed 150°C during the first 72 hours of operation with the rotor locked.
- c) Internal wiring insulated with neoprene, thermoplastic, impregnated fiber-glass, or an equally flame-retardant material.
- d) An individually enclosed fuse, such as an extractor type. Consideration shall be given to a fuse enclosed within a transformer winding.

Exception: A battery charger marked in accordance with 49.5 need not comply with (a) and (d).

6.16 If a ventilating opening is located in the bottom of the enclosure, a component having a magnetic winding or coil, such as a relay or solenoid shall either be:

- a) Individually and completely enclosed; or
- b) If applicable, subjected to the burnout tests described in 40.1 and 40.2.

7 Accessibility of Live Parts

7.1 To reduce the risk of unintentional contact by persons with an uninsulated live part, an opening in the enclosure shall comply with 7.2.

7.2 Openings in an enclosure, including holes, louvers, and openings protected by means of wire screening, expanded metal, or perforated covers, shall be of such size or shape that no opening permits passage of a rod having a diameter of 1/2 inch (12.7 mm).

Exception: If the distance between any live part and the enclosure is 4 inches (102 mm) or more, an opening may be larger than 1/2 inch but shall not permit passage of a rod having a diameter of 3/4 inch (19.1 mm).

7.3 A door or cover that provides access to a live part that can result in a risk of electric shock shall be securely held in place so that a tool is required to open or remove it.

7.4 A door or cover that does not provide access to a live part that involves a risk of electric shock shall be securely held in place, but need not be secured so that it is necessary to use a tool to open or remove it.

7.5 A door or cover of an enclosure shall be hinged or attached in an equivalent manner if it provides access to an overload-protective device, the normal functioning of which requires renewal, or if it is necessary to open the door or cover in connection with the normal operation of the protective device. A door or cover providing access to a fuseholder shall be tight-fitting and shall be reliably held closed.

7.6 The operating handle of a circuit breaker, the operating button of a manually operable protector, the capped portion of an extractor-type fuseholder, or a similar part may project outside the enclosure.

7.7 Glass or thermoplastic covering an opening for user servicing, such as replacing a pilot lamp, and that is intended to reduce the risk of unintentional contact with live parts, shall be:

- a) A material complying with the:
 - 1) Impact test specified in 42.2;
 - 2) Abnormal Operation Tests, Section 39; and
 - 3) Enclosure flammability tests for thermoplastics as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; and
- b) Reliably retained in place.

8 Assembly

8.1 An uninsulated live part shall be secured to the base or surface so that it is prevented from rotating or shifting in position as the result of normal stresses when such movement results in a reduction of spacings below the minimum acceptable values. See 24.1.1.

8.2 A component, such as a rectifier element, control switch, lampholder, attachment plug receptacle, or plug connector shall be mounted securely and shall be prevented from turning by means other than friction between surfaces, such as a properly applied lockwasher.

Exception No. 1: A switch need not be mounted as described if the following conditions are met:

- a) The switch is a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch;*
- b) The means for mounting the switch makes it unlikely that operation of the switch will loosen it;*
- c) Spacings are not reduced below the minimum acceptable values if the switch rotates; and*
- d) Normal operation of the switch is by mechanical means rather than by direct contact by persons.*

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a sealed neon pilot or indicator light, if rotation cannot reduce spacings below the minimum acceptable value.

9 Protection Against Corrosion

9.1 Iron and steel parts shall be protected against corrosion by enameling, painting, galvanizing, plating, or an equivalent means.

Exception No. 1: Bearings, laminations, and other similar parts of iron or steel, such as washers and screws, do not need to be protected from corrosion.

Exception No. 2: A part the corrosion of which would not result in a risk of fire, electric shock, or injury to persons does not need to be protected from corrosion.

10 Supply Connections – Permanently-Connected Products

10.1 General

10.1.1 The provisions for the input connections to a product shall consist of either a means of permanent wiring connections as specified in this Section or a power supply cord in accordance with Supply Connections – Cord- and Plug-Connected Products, Section 11.

10.1.2 A product intended for permanent connection to the power supply shall have provision for the connection of a wiring system.

10.1.3 A knockout in a sheet-metal enclosure shall be secured and shall be removable without undue deformation of the enclosure.

10.1.4 A knockout shall be surrounded by a flat surface large enough to seat a conduit bushing or locknut of the appropriate size.

10.1.5 A field-wiring compartment in which power supply connections are to be made shall be located so that the connections may be readily inspected after the product is installed as intended.

10.1.6 A field-wiring compartment intended for connection of a wiring system shall be attached to the product so that it is prevented from turning.

10.1.7 A field-wiring compartment shall provide protection for wiring from sharp edges, including screw threads, burrs, fins, moving parts, and the like, that may abrade the insulation on conductors or otherwise damage the wiring.

10.1.8 If a separate field-wiring compartment is not provided, space for field-wiring connections shall be located near the connecting means and shall permit routing of the wiring away from live parts and from sharp edges, including screw threads, burrs, fins, moving parts, and the like.

10.2 Field-wiring terminals and leads

10.2.1 A field-wiring terminal is a terminal to which power-supply, control, output, or other permanent connections will be made in the field when the charger is installed.

10.2.2 Field-wiring terminals or leads shall be acceptable for the connection of conductors having an ampacity appropriate for the rating of the charger.

10.2.3 A wiring terminal shall be provided with a soldering lug or pressure terminal connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception: A wire-binding screw or stud-and-nut terminal may be employed for connection of a 10 AWG (5.3 mm²) or smaller conductor. A stud-and-nut terminal is one in which the conductor is wrapped around a stud and retained by a nut.

10.2.4 A wiring terminal shall be prevented from turning or shifting in position by a means other than friction between surfaces. This may be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part by a lockwasher; or by an equivalent method.

10.2.5 A wire-binding screw or stud at a field-wiring terminal shall not be smaller than No. 10.

Exception No. 1: A No. 8 screw or stud may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm²) conductor.

Exception No. 2: A No. 6 screw or stud may be used for the connection of a 16 AWG (1.3 mm²) or 18 AWG (0.8 mm²) circuit conductor.

10.2.6 A wire binding screw or stud-and-nut terminal shall be capable of accommodating a three-quarter loop.

10.2.7 A wire-binding screw shall thread into metal.

10.2.8 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick.

Exception: A plate not less than 0.030 inch (0.76 mm) thick is acceptable for use with a 14 AWG (2.1 mm²) or smaller conductor.

10.2.9 There shall be two or more full threads in the metal of a terminal plate. The metal may be extruded at the tapped hole to provide at least two full threads.

10.2.10 Upturned lugs, a cupped washer, or the equivalent shall be capable of retaining a conductor of the size required in 10.2.2 but not smaller than 14 AWG (2.1 mm²) under the head of the screw.

10.2.11 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

Exception: A lead may be less than 6 inches long if it is evident that the use of a longer lead might result in a risk of fire or electric shock.

10.2.12 A field-wiring terminal intended for connection of a grounded circuit conductor shall be made of, or plated with, metal substantially white in color and shall be readily distinguishable from other terminals; or properly and clearly identified in some other manner, such as on an attached wiring diagram.

10.2.13 The surface of a lead for the connection of a grounded circuit conductor shall be white or gray and shall be readily distinguishable from other leads.

10.2.14 A product provided with wiring terminals or leads and rated 125 or 125/250 volts or less and employing one or more of the following shall have one terminal or lead identified for connection of the grounded conductor of a supply circuit:

- a) A lamp or element-holder of the Edison-screw-shell type;
- b) A single-pole switch; or

- c) A single-pole automatic control.

The terminal or lead intended to be connected to a grounded conductor of a supply circuit shall be the one that is connected to screw shells of lamp-holders or element-holders, and to which are connected no single-pole switches or single-pole automatic controls.

11 Supply Connections – Cord- and Plug-Connected Products

11.1 General

11.1.1 The provisions for input connections that do not comply with Supply Connections – Permanently-Connected Products, Section 10, shall have a power supply cord that complies with the requirements of this Section.

11.1.2 A product shall employ a Type S, SE, SO, ST, STO, SJ, SJE, SJO, SJT, or SJTO power-supply cord and an attachment plug for connection to the supply circuit.

11.1.3 The length of cord external to the charger and including the attachment plug shall be not less than 6 feet (1.83 m) as measured to the face of the attachment plug.

11.1.4 The current and voltage ratings of a flexible cord and attachment plug for a product shall not be less than the input rating of the charger; except that if the product load is continuous for 3 hours or more, the ampacity of the attachment plug shall not be less than 125 percent of the input rating.

11.1.5 In a product rated 125 or 125/250 volts (3-wire) or less, the screw shell of an Edison screw-shell lampholder shall be electrically connected to the cord conductor intended to be grounded. A switch or overcurrent-protective device of the single-pole type, other than an automatic control without a marked "off" position, shall be connected in a circuit to the cord conductor not intended to be grounded.

11.2 Strain relief

11.2.1 Strain relief shall be provided to prevent mechanical stress, such as a pull or twist, on the supply cord or output cord from being transmitted to terminals, splices, or interior wiring. Compliance shall be determined by subjecting the cord to the Strain Relief Test, Section 34.

11.2.2 A metal strain-relief clamp or band is acceptable without supplementary protection on Type SJ or heavier cord.

11.2.3 Means shall be provided to prevent the flexible cord or lead from being pushed into the enclosure through the cord-entry hole when such displacement results in:

- a) Subjecting the supply cord or lead to mechanical damage;
- b) Exposing the supply cord or lead to a temperature higher than that for which it is rated;
- c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or
- d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with Section 35, Push-Back Relief Test.

11.3 Bushings

11.3.1 A bushing or the equivalent shall be provided at a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case. The bushing shall be substantial, reliably secured in place, and shall have a smooth, rounded surface against which the cord may bear.

Exception: For a cord hole in wood, porcelain, phenolic composition, or other acceptable non-conductive material, a smooth, rounded surface is considered to be the equivalent of an insulating bushing.

11.3.2 Ceramic materials and some molded compositions are acceptable for insulating bushings.

11.3.3 Vulcanized fiber may be employed if the bushing is not less than 3/64 inch (1.2 mm) thick, and if formed and secured in place so that it will not be adversely affected by conditions of ordinary moisture.

11.3.4 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be used in the frame of a motor or in the enclosure of a capacitor attached to a motor provided the bushing is:

- a) At least 3/64 inch (1.2 mm) thick; and
- b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound.

11.3.5 A bushing of a material mentioned in 11.3.4 may be used at any point in a product if used in conjunction with a type of cord for which an insulating bushing is not required.

11.3.6 If a bushing of a material mentioned in 11.3.4 is used, the hole in which the bushing is mounted shall be smooth and free from sharp edges.

11.3.7 An insulating bushing molded integrally with the supply cord is acceptable provided the built-up section is not less than 1/16 inch (1.6 mm) thick where the cord passes through the enclosure.

11.3.8 An insulating metal grommet is acceptable as an insulating bushing if the insulating material is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

12 External Connections and Wiring

12.1 A connector for the output circuit shall have a voltage rating equal to the output rating of the charger and shall comply with the requirements in the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977. A connector shall:

- a) Have a nonstandard pin configuration; and
- b) Be polarized.

12.2 Output wiring shall be attached to or provided with the product. It shall be of a size and rating acceptable for the application and shall be either:

- a) A flexible cord of Type S, SE, SO, ST, STO, SJ, SJE, SJO, SJT, SJTO, EV, EVJ, EVE, EVJE, EVT, or EVJT; or
- b) Individual conductors that comply with the requirements in 12.3.

12.3 With reference to 12.2(b), the individual conductors shall be insulated with neoprene or other equivalent insulation. Equivalent insulation shall withstand flexing, handling, and impact in the temperature range of minus 29 to plus 54°C (minus 20 to plus 130°F). The minimum average insulation thickness shall not be less than 0.060 inch (1.52 mm) for 8 – 2 AWG (8.4 – 33.6 mm²) wire and 0.080 inch (2.03 mm) for 1 – 4/0 AWG (42.4 – 107 mm²) wire.

12.4 Live parts shall be recessed from the face of the connector to reduce the possibility of a short circuit.

12.5 A metal enclosure of a product shall not be connected to an electrical circuit of the charger.

Exception: A secondary circuit rated 50 volts or less may be connected to the enclosure provided it is marked in accordance with 49.7.

13 Current-Carrying Parts

13.1 A current-carrying part shall be of silver, copper, a copper alloy, or other material acceptable for the application.

13.2 Plated iron or steel may be used for a current-carrying part:

- a) If acceptable in accordance with 4.1; or
- b) Within a motor.

14 Internal Wiring

14.1 General

14.1.1 The internal wiring of a product shall be of a type and size specified in this Section. Other types of wiring may be accepted based on:

- a) Exposure to oil, grease, or other substances that may have a deleterious effect on the insulation;
- b) The temperature and voltage; and
- c) Other conditions of service to which the wiring may be subjected.

Exception: Internal wiring in a secondary circuit of 50 volts open circuit or less, if it is acceptable when judged as bare wire with respect to intermingling with the primary circuit wiring and separation from other uninsulated live parts and grounded metal need not comply with this Section.

14.1.2 The minimum average thickness of insulation on wiring shall not be less than 3/64 inch (1.2 mm) for unbraided neoprene-insulated wire, 1/32 inch (0.8 mm) for thermoplastic-insulated wire, 1/32 inch for rubber-insulated wire with an impregnated braid, and 1/64 inch (0.4 mm) for cross-linked synthetic polymer.

Exception: Internal wiring as defined in the Exception to 14.1.1 need not comply.

14.1.3 The length of the power-supply cord inside a product shall not be more than that needed for the electrical connections.

14.1.4 The jacket of a flexible cord inside the enclosure shall not be stripped to expose the individual conductors unless:

- a) The insulation on the individual conductors is equivalent to that required by 14.1.2;
- b) The individual conductors are supported in a manner that maintains separation from live parts and dead metal parts; or
- c) Supplementary insulation equivalent to that required by 14.1.2 is reliably secured on each individual conductor.

14.2 Tubing

14.2.1 Insulation on internal wiring consisting of coated fabric, thermoplastic, or other types of tubing is to be considered with respect to the electrical, mechanical, and flammability properties of the material.

14.3 Protection of wiring

14.3.1 Internal wiring shall be protected if, when judged in accordance with 7.2, it is accessible.

Exception: Internal wiring need not be protected if it is located and secured within the enclosure so that it is not likely to be subjected to stress or mechanical damage.

14.3.2 Wires within an enclosure, compartment, raceway, or the like, shall be located or protected so that they cannot contact any sharp edge, burr, fin, screw threads, moving part, or the like, that may damage the conductor insulation.

14.3.3 A hole in a sheet metal wall within the overall enclosure of a product through which insulated wires pass shall be provided with a bushing.

14.4 Electrical connections

14.4.1 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or in a component winding, shall be terminated at each end by a method acceptable for the combination of metals involved at the points of connection.

14.4.2 With reference to 14.4.1, a wire-binding screw, a stud-and-nut terminal, or a pressure wire connector used as a terminating device shall be evaluated by conducting heat cycling tests in accordance with the Standard for Wire Connectors, UL 486A-486B.

14.4.3 All splices and connections shall be mechanically secure and shall make reliable electrical contact.

14.4.4 A soldered connection shall be mechanically secured before being soldered.

14.4.5 A splice shall be provided with insulation equivalent to that of the wires involved.

Exception: Insulation is not required when the splice is supported in a manner that maintains spacings from live parts and dead metal parts in accordance with Spacings, Section 24.

14.4.6 If the voltage involved is less than 250 volts, insulation consisting of two layers of acceptable thermoplastic tape or one layer of friction tape and one layer of rubber tape, which has been investigated and found acceptable for the purpose, is acceptable on a splice. An insulated splicing device is acceptable within the limits of voltage and temperature ratings of the device.

14.4.7 In determining if splice insulation consisting of coated fabric, thermoplastic, or other tubing is acceptable, consideration is to be given to such factors as dielectric properties, heat-resistant and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.