



UL 353

Underwriters Laboratories Inc. Standard for Safety

Limit Controls



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



Documents
Document Sharing Hub

UL Standard for Safety for Limit Controls, UL 353

Fifth Edition, Dated September 23, 1994

Summary of Topics

These revisions to UL 353 are being issued to revise the requirements covering surge protective devices in Section 3A.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The new/revised requirements are substantially in accordance with Proposal(s) on this subject dated August 26, 2011.

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.

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that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

No Text on This Page

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



Documents

Document Sharing Hub

SEPTEMBER 23, 1994

(Title Page Reprinted: November 8, 2011)

1

UL 353

Standard for Limit Controls

First Edition – July, 1970

Second Edition – August, 1971

Third Edition – December, 1974

Fourth Edition – March, 1989

Fifth Edition

September 23, 1994

This UL Standard for Safety consists of the Fifth Edition including revisions through November 8, 2011.

The Department of Defense (DoD) has adopted UL 353 on January 27, 1992. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 © 2011 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	5
2 General	6
2.1 Units of measurement	6
2.2 Components	6
3 Glossary	6

CONSTRUCTION

3A Components	6B
3A.1 General	6B
3A.2 Attachment plugs, receptacles, connectors, and terminals	7
3A.3 Batteries and battery chargers	8
3A.4 Electrical boxes and raceways	8A
3A.5 Capacitors and filters	8A
3A.5A Surge Protective Devices	8A
3A.6 Gaskets and seals	8D
3A.7 Insulation systems	8D
3A.8 Overcurrent protection	8D
3A.9 Marking and labeling systems	8E
3A.10 Power supplies	8E
3A.11 Printed wiring boards	8E
3A.12 Semiconductors	8F
3A.13 Supplemental insulation, insulating bushings, and assembly aids	8F
3A.14 Valves (electrically operated) and solenoids	8F
4 General	8G
4A Safety Related Software	9
4B Electronic Controls	9
5 Materials	10
6 Frame and Enclosure	10
6.1 General	10
6.1A Polymeric materials and enclosures	13
6.2 Accessibility of live parts	13
6.3 Covers and doors	15
6.4 Openings	16
7 Corrosion Protection	17
8 Insulating Material	18
9 Field Wiring Connections	19
9.1 General	19
9.2 Terminals	20A
9.3 Wiring space	22A
10 Current-Carrying Parts	22A
11 Internal Wiring	22A
12 Grounding	23
13 Protection of Users and Service Personnel	27
14 Transformers	29
15 Fuseholders	30
16 Switches	30
17 Coil Windings and Film-Coated Wire (Magnet Wire)	30A

18	Spacings	30A
18.1	General	30A
18.2	High-voltage circuits	30A
18.3	Low-voltage circuits	32
19	Alternate Spacings – Clearances and Creepage Distances	33
20	Separation of Circuits	33
20.1	General	33
20.2	Barriers	34
21	Calibration Means	34
22	Mounting	34
23	Operating Mechanism	35
24	Adjustment and Stops	35
25	Reset Mechanism	35

PERFORMANCE

26	General Tests	36
27	Input Test	37
28	Temperature Test	37
28.1	General	37
28.2	Temperature test of temperature control for air or other gas	40
28.3	Temperature test of temperature control for liquids	41
28.4	Temperature test of steam pressure or boiler water-level limit control	41
28.5	Temperature test of stack-mounted control	42
29	Operation Tests	44
29.1	General	44
29.2	Test of immersion-type temperature-operated control	46
29.3	Test of surface-mounted temperature-operated control for hot-water heating systems	46
29.4	Test of pressure-operated control	46
29.5	Test of electromagnet	47
30	Overload Test	47
31	Endurance Test	50
31A	Failure Mode Effect Analysis (FMEA) Procedures	52
31B	Mains Borne Perturbations, Magnetic and Electromagnetic Disturbances	52A
31B.1	General	52A
31B.2	Voltage dips and interruptions	52B
31B.3	Ramp voltage tests	52C
31B.4	Voltage/current surge tests	52C
31B.5	Ring wave test	52D
31B.6	Electrostatic discharge tests	52D
31B.7	Radiated electromagnet field test	52E
31C	Thermal Cycling Test for Electronic Devices	52E
32	Dielectric Voltage-Withstand Test	52F
33	Volt-Ampere Capacity Test	53
34	Burnout Test	53
35	Short Circuit Test	54
36	Leakage Test	55
37	Strength of Parts Test	56
38	Parts Containing Liquid Metal	56A
39	10-Day Moist Ammonia Air Stress Cracking Test	57
40	Push-In Terminals Test	58
40.1	Pullout test	58
40.2	Temperature test	58

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



Documents

Document Sharing Hub

41 Volume Change Test	59
-----------------------------	----



No Text on This Page



42 Weight Loss Test	60
---------------------------	----

MANUFACTURING AND PRODUCTION TESTS

43 General	60
------------------	----

RATING

44 Rating	60
-----------------	----

MARKING

45 General Marking	61
46 Cautionary Markings	63
47 Markings (Visibility and Permanence)	63
47.1 General	63
47.2 Oven-aging test	64
47.3 Immersion test	64
47.4 Standard-atmosphere test	64
47.5 Unusual-condition exposure test	65

INSTRUCTIONS

48 Installation Instructions	65
------------------------------------	----

SUPPLEMENT SA - SOFTWARE IN PROGRAMMABLE COMPONENTS

SA1 Application of Requirements	SA1
SA2 General	SA1
1A General	SA1
SA3 Qualification of Design, Implementation, and Verification Tools	SA1
SA4 Measures to Address Microelectronic Hardware Failure Modes	SA2
SA5 Documentation	SA2
SA6 Identification	SA2

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



Documents
Document Sharing Hub

This page intentionally left blank.

*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 limit controls, furnace fan controls, and other interlocks which are essentially switches responding to changes in liquid level, pressure, or temperature. Although not limited to such specific applications, these safety controls include those intended primarily to safeguard heating appliances, heating systems, processing systems, and air-conditioning and ventilating systems.

1.2 These requirements do not cover thermal protectors for motors and fluorescent-lamp ballasts.

1.3 These controls are for use in ordinary locations. Requirements for the installation and use of limit controls are included in Standards of the National Fire Protection Association, such as those for Installation of:

Air-Conditioning and Ventilating Systems, NFPA 90A-1993,

Warm-Air Heating and Air-Conditioning Systems, NFPA 90B-1993,

Oil-Burning Equipment, NFPA 31, ANSI Z95.1-1993,

National Fuel Gas Code, NFPA 54-1990,

Ovens and Furnaces, NFPA 86-1990, and

Prevention of Furnace Explosions in Fuel Oil and Natural Gas-Fired Watertube Boiler Furnaces With One Burner, NFPA 85C-1991.

1.4 These requirements cover equipment rated not more than 600 volts and intended for installation in accordance with the requirements of the National Electrical Code, ANSI/NFPA 70.

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

1.5 revised April 30, 2001

2 General

2.1 Units of measurement

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

2.1.1 revised April 30, 2001

2.2 Components

2.2 deleted April 22, 2011

2.2.1 *deleted April 22, 2011.*

2.2.2 *deleted April 22, 2011.*

2.2.3 *deleted April 22, 2011.*

2.2.4 *deleted April 22, 2011.*

3 Glossary

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

3.1A COMPONENT – A device or fabricated part of the control covered by the scope of a safety standard dedicated to the purpose. When incorporated in a control, equipment otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as thermoplastic or copper, are not considered components.

3.1A added April 22, 2011

3.2 CONTROL, FAN – An automatic control responsive to changes in temperature, intended to control the operation of the fan on forced air appliances.

3.3 CONTROL, LIMIT – An automatic safety control responsive to changes in liquid level, pressure, or temperature and normally set beyond the operating range for limiting the operation of the controlled equipment.

3.4 CONTROL, OPERATING – A control, other than a safety control or interlock to start or regulate appliances according to load demand and to stop or regulate output on satisfaction of demand or upon reaching normal temperature or pressure in the appliances. Operating controls may also actuate auxiliary equipment.

3.5 CONTROL, SAFETY or PROTECTIVE – Automatic controls and interlocks (including relays, switches and other auxiliary equipment used in conjunction therewith to form a safety-control system) which are intended to prevent unsafe operation of the controlled equipment.

3.5 revised April 22, 2011

3.5A CONTROL, WATER HEATER REGULATING – An automatic control responsive to changes in temperature, intended to regulate the operation of the water heater and provides protective function.

3.5A added April 22, 2011

3.5B CONTROL, WATER HEATER LIMIT – A manual type control responsive to changes in temperature, intended to provide protective function of the water heater.

3.5B added April 22, 2011

3.6 ELECTRICAL CIRCUITS:

a) High-Voltage Circuit – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage or an isolated limited secondary circuit.

b) Low-Voltage Circuit – A circuit involving a potential of not more than 30 volts alternating current (ac) [42.4 volts peak or direct current (dc)] and supplied by a primary battery or by a standard Class 2 transformer, or by a combination of transformer and fixed impedance which, as a unit, complies with all the performance requirements for a Class 2 transformer. (A circuit derived from a source of supply classified as a high-voltage circuit, using resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage nor an isolated limited secondary circuit.)

c) Safety-Control Circuit – A circuit involving one or more safety controls.

d) Isolated Limited Secondary Circuit – A circuit of limited energy derived from an isolated secondary winding of a transformer having a maximum capacity of 100 volt-amperes and open-circuit secondary voltage not exceeding 1000 volts.

e) Intrinsically Safe Circuit – A circuit involving equipment and wiring which is incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. Abnormal conditions include accidental damage to any part of the equipment or wiring, insulation or other failure of electrical components, application of overvoltage, adjustment and maintenance operations, and other similar conditions.

3.7 INTERLOCK – A control to prove the physical state of a required condition, and to furnish that proof to the primary safety-control circuit. A limit control is a type of interlock.

3.8 REPEATABILITY – The ability of a control or interlock to maintain a constant set point characteristic.

3.9 SET POINT – A predetermined value to which a control or interlock is adjusted and at which it performs its intended function.

3.10 SUPERVISE – To sense a condition requiring attention and initiate corrective action if necessary.

3.11 TOOLS, SPECIAL – Those tools that are not generally available on the open retail market.

3.12 VENT LIMITING MEANS – A means which limits the flow of fluid from an atmospheric diaphragm chamber to the atmosphere.

CONSTRUCTION

3A Components

3A added April 22, 2011

3A.1 General

3A.1.1 A component of a product covered by this standard shall:

- a) Comply with the requirements for that component as indicated in this standard;
- b) Be used in accordance with its rating(s) established for the intended conditions of use;
- c) Be used within its established use limitations; and
- d) Additionally comply with the applicable requirements of this standard.

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product, or*
- b) Is superseded by a requirement in this end product standard, or*
- c) Is separately evaluated when forming part of another component, provided the component is used within its established ratings and limitations.*

Exception No. 2: A component complying with a component standard other than those cited in this standard is acceptable if:

- a) The component also complies with the applicable component standard as cited in this standard; or*
- b) The component standard:*
 - 1) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, NFPA 70, where appropriate;*
 - 2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, and*
 - 3) Any use limitations of the other component standard is identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.*

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



Documents
Document Sharing Hub

3A.1.2 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) that cover devices that provide those functions.

Exception: Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component standard(s) need not be applied.

3A.1.3 A component not anticipated by the requirements of this standard, not specifically covered by the component standards as cited in this standard, and that involves a risk of electric shock, fire, or personal injury, shall be additionally evaluated in accordance with the applicable standard, and shall comply with items (b) – (d) of 3A.1.1.

3A.1.4 With regard to a component being additionally evaluated, reference to construction and performance requirements in another end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of UL 353.

3A.1.5 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.

3A.2 Attachment plugs, receptacles, connectors, and terminals

3A.2.1 Attachment plugs and receptacles shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See 3A.2.9.

3A.2.2 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with UL 310.

3A.2.3 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977. See 3A.2.9.

3A.2.4 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

3A.2.5 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, UL 486C.

3A.2.6 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings shall comply with the Standard for Multi-Pole Splicing Wire Connectors, UL 2459. See 3A.2.9.

3A.2.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

3A.2.8 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

Exception: A fabricated part performing the function of a terminal block need not comply with UL 1059 if the part complies with the requirements of Insulating Material, Section 8; Field Wiring Connections, Section 10; Current-Carrying Parts, Section 10; and Spacings, Section 18 of this standard. This exception does not apply to protective conductor terminal blocks.

3A.2.9 Female devices (such as receptacles and connectors) that are intended, or that may be used, to interrupt current in the end product, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector. For example, a connector that can be used to interrupt the current of a motor load shall have a suitable horsepower rating when tested with its mating plug.

3A.2.10 Bonding devices, ground clamps, grounding and bonding bushings and locknuts, and similar equipment, shall comply with the Standard for Grounding and Bonding Equipment, UL 467.

3A.3 Batteries and battery chargers

3A.3.1 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in the Standard for Lithium Batteries, UL 1642. A lithium ion multiple cell battery, and a lithium ion battery pack, shall comply with the applicable requirements for secondary lithium cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

3A.3.2 Rechargeable nickel cadmium (Ni-Cad) cells and battery packs shall comply with the applicable construction and performance requirements of this standard.

3A.3.3 Rechargeable nickel metal-hydride (Ni-MH) battery cells and packs shall comply with the construction and performance requirements of this standard, or the applicable requirements for secondary cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

3A.4 Electrical boxes and raceways

3A.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of the National Electrical Code, NFPA 70 and that comply with one of the following standards:

- a) Standard for Metallic Outlet Boxes, UL 514A;
- b) Standard for Conduit, Tubing, and Cable Fittings, UL 514B;
- c) Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C; or
- d) Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D.

3A.5 Capacitors and filters

3A.5 revised November 8, 2011

3A.5.1 A capacitor located in the line voltage circuit shall comply with the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

3A.5.2 Electromagnetic interference filters with integral enclosures shall comply with the Standard for Electromagnetic Interference Filters, UL 1283.

3A.5.3 *deleted November 8, 2011.*

3A.5A Surge Protective Devices

3A.5A added November 8, 2011

3A.5A.1 Surge Protective Devices (SPDs), including air gaps and metal oxide varistors (MOVs), shall comply with the requirements in the Standard for Surge Protective Devices, UL 1449. Paragraphs 3A.5A.2 through 3A.5A.6 are applicable.

Exception: These requirements do not apply to SPDs located in a Class 2 circuit.

3A.5A.2 Type 1, 2, or 3 SPDs and Type 1, 2 or 3 Component Assemblies SPDs shall:

- a) Maintain a Maximum Continuous Operating Voltage (MCOV) rating equal to or greater than working voltage of the circuit connected, and
- b) Maintain the appropriate Type Rating for the application in accordance with Table 3A.1.

Table 3A.1
Type 1, 2, or 3 Ratings

Application	Type Rating
Line side of service equipment	1
Load side of service equipment or feeder circuit applications	1 or 2
Branch circuit or control circuit applications	1 or 2 or 3

3A.5A.3 Type 4 or Type 5 discrete component SPDs and Type 4 component assemblies shall have a Maximum Continuous Operating Voltage (MCOV) rating equal to or greater than the phase-to-phase (line-to-line) voltage of the system supply.

Exception: If the Type 4 or 5 SPDs and Type 4 Component Assemblies have been subjected to all the Current Tests in accordance with UL 1449, section 39 during its investigation, the MCOV may have a rating equal to or greater than the working voltage of the circuit connected.

3A.5A.4 Type 4 or Type 5 discrete component SPDs and Type 4 Component Assemblies shall be rated in accordance with (a) or (b) or (c):

a) A Type 4 discrete component SPD rated for use in Type 1-3 applications may be used in applications indicated in Table 3A.1, or

b) A Type 4 discrete component SPD rated for use in Type 1 - 3 applications or "other" applications shall have an Operating Duty Cycle Voltage (V_p) and Peak Current (A_p) in accordance with Table 3A.2, based on the working voltage of the circuit connected, or

Exception: For SPDs used in other than across-the-line applications such as across the contacts of a switching relay or in a non-isolated electronic circuit, the additional circuit impedance in series with the SPD can be considered when determining the required SPD ratings. The Operating Duty Cycle Peak Current (A_p) rating of the SPD may be less than that defined in Table 3A.2 provided the A_p rating is equal to or is greater than the surge current parameters determine by a calculation that accounts for fixed series impedance inherent in the circuit. [The calculated A_p would be equal to V_p divided by the combined known impedance inherent in the circuit plus 2 ohms, which is the anticipated source impedance].

c) A Type 5 discrete component SPD or Type 4 component assemblies shall be rated with a Nominal Discharge Current, NDC (I_n) in accordance with Table 3A.2, based on the working voltage of the circuit connected.

Exception: For SPDs used in other than across-the-line applications such as across the contacts of a switching relay or in a non-isolated electronic circuit, the additional circuit impedance in series with the SPD can be considered when determining the required SPD ratings. The Nominal Discharge Current rating, I_n , of the SPD may be less than that defined Table 3A.2 provided the I_n rating is equal to or is greater than the surge current parameters determine by a calculation that accounts for fixed series impedance inherent in the circuit. [The calculated I_n would be equal to V_p divided by the combined known impedance inherent in the circuit plus 2 ohms, which is the anticipated source impedance].

Table 3A.2
Required Ratings of Type 4 or 5 SPDs

SPD Circuit Characteristic				Required ratings of Type 4 or 5 SPDs	
Phase-to-Ground Voltage, Vac ^a by Overvoltage Category ^b				Minimum Operating Duty Cycle Peak voltage (kV _p)(1.2 x 50 µs)	Operating Duty Cycle Peak Current or Minimum Nominal Discharge Current, NDC (In) A
I	II	III	IV		
50	-	-	-	0.33	165
100	50	-	-	0.50	250
150	100	50	-	0.80	400
300	150	100	50	1.5	750
600	300	150	100	2.5	1250
-	600	300	150	4.0	2000
-	-	600	300	6.0	3000

^a For ungrounded systems or systems with one phase grounded, the phase-to-ground voltage is considered to be the same as the phase-to-phase voltage for the purposes of using this table.

^b Typical examples of categories for products are given below. Users of this standard will need to establish that rated impulse voltage values are appropriate for the expected applications of the products covered.

Category IV - Primary Supply Circuit Level. Overhead lines and cable systems including distribution and its associated overcurrent protective equipment (equipment installed at the service entrance).

Category III - Distribution Circuit Level. Fixed wiring and associated equipment (not electrical loads) connected to the primary supply level, Category IV.

Category II - Load Circuit Level. Appliances and portable equipment and the like connected to the distribution level, Category III.

Category I - Signal Circuit Level. Special equipment or parts of equipment such as low-voltage electronic logic systems, remote controls, signaling and power limited (per NEC Article 725) circuits connected to the load level, Category II.

3A.5A.5 Electronic safety controls shall, in addition to the requirements noted in 3A.5A.2 and 3A.5A.3, be subjected to a subsequent transient overvoltage test sequence in the end-use equipment application as defined by the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, with the SPD installed as intended. To minimize testing of the end-use equipment involving multiple alternate SPDs sources or types, the SPD with the highest Measured Limited Voltage rating or Voltage Protective Rating, as applicable, shall be tested in the transient overvoltage test sequence. The highest rated SPD can represent multiple alternate SPDs sources or types.

Exception: If the electronic safety control complies with the transient overvoltage test program when tested with the SPD removed, the SPD need only comply with 3A.5A.2 and 3A.5A.3

3A.5A.6 SPDs are not permitted to be used between line / mains / non-Class 2 circuits and Class 2 circuits.

3A.5A.7 Discrete SPDs (such as MOVs, gas tubes, etc., with or without coating) shall be considered non-insulated live conductive parts. Spacings between discrete SPDs and metal parts shall comply with the spacing requirements of this standard.

3A.6 Gaskets and seals

3A.6.1 Gaskets and seals shall comply with the Standard for Gaskets and Seals, UL 157. Also, the requirements of Section 41, Volume Change test, and Section 42, Weight loss test, are applicable, as appropriate.

3A.7 Insulation systems

3A.7.1 Materials used in an insulation system that operates above Class 105 (A) temperatures shall comply with the Standard for Systems of Insulating Materials – General, UL 1446.

3A.7.2 All insulation systems employing integral ground insulation shall comply with the requirements specified in the Standard for Systems of Insulating Materials – General, UL 1446.

3A.8 Overcurrent protection

3A.8.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, and the applicable Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another appropriate standard for the fuse are considered to comply with this requirement.

3A.8.2 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A, need not comply with UL 489.

3A.8.3 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

3A.8.4 Supplementary protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

3A.8.5 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

3A.9 Marking and labeling systems

3A.9.1 A marking and labeling system shall comply with Standard for Marking and Labeling Systems, UL 969, under the specified environmental conditions.

Exception: A marking or labeling system that complies with Section 47 of this standard is considered to fulfill the requirement.

3A.10 Power supplies

3A.10.1 A Class 2 power supply shall comply with one of the following:

- a) The Standard for Class 2 Power Units, UL 1310; or
- b) The Standard for Information Technology Equipment, Part 1: General Requirements, UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

3A.10.2 A non-Class 2 power supply shall comply with one of the following:

- a) The Standard for Power Units Other Than Class 2, UL 1012; or
- b) The Standard for Information Technology Equipment, Part 1: General Requirements, UL 60950-1.

3A.11 Printed wiring boards

3A.11.1 Printed wiring boards, including the coatings, shall comply with the Standard for Printed-Wiring Boards, UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit is not required to comply with the bonding requirements in the UL 796 if the 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.

3A.12 Semiconductors

3A.12.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard of Safety for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of section 32 of this standard.

3A.12.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product standard shall comply with the Standard for Safety for Optical Isolators, UL 1577. The dielectric voltage withstand tests required by UL 1577 shall be conducted applying the criteria of section 32 of this standard.

3A.13 Supplemental insulation, insulating bushings, and assembly aids

3A.13.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) shall comply with the following:

- a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;
- b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441;
- c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

3A.13.2 Wire positioning devices shall comply with sections 8 and 20. A device that complies with the Standard for Positioning Devices, UL 1565, is considered to comply with this requirement.

3A.13.3 Insulating bushings that comply with 3A.1 and the Standard for Insulating Bushings, UL 635, are considered to comply with the requirements of this Standard. Tests specified in this standard (e.g. Strain Relief Test) shall be performed, as required, to confirm the combination of the insulating bushing and the supporting parts are suitable.

3A.14 Valves (electrically operated) and solenoids

3A.14.1 Electrically operated valves shall comply with the:

- a) Standard for Electrically Operated Valves, UL 429; or
- b) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use, Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, UL 60730-2-8.

3A.14.2 Solenoids shall comply with the applicable construction and performance requirements of this standard.

4 General

4.1 A component of a control shall be used in accordance with 3A.1.

4.1 revised April 22, 2011

4.2 A safety control incorporating a transformer, relay, or the like, shall be supplied by a circuit consisting of a two-wire, one-side grounded system having a voltage rating of not more than a nominal 120 volts. A switch or protective device shall be in the circuit electrically connected to the ungrounded supply conductor.

4.3 A control shall withstand without damage or shift of calibration in excess of limits specified in 29.1.5 – 29.1.9, the effects of overriding temperature or pressure on the sensing element when tested in accordance with these requirements.

4.4 Switch contacts, a resistance heating element, or an item that may arc or glow in a control for supervising a flammable gas shall not be located in a compartment containing the gas, including a compartment that may contain gas in case of the rupture of a bellows or diaphragm.

Exception No. 1: Electrical parts including switch contacts and resistance elements may be located in a gas-containing compartment of a control intended for use only in an intrinsically safe circuit.

Exception No. 2: A coil may be located in a gas-containing compartment of a control rated at not more than 125 volt ac provided the coil assembly (coil and leads) is encapsulated, and is arranged and located so that only one side of the encapsulated coil assembly is exposed to the gas.

4.5 A temperature operated limit control actuated by a change in the pressure of a fluid confined in a self-contained bulb or capillary tube shall be designed in conformance with 4.6 and 4.9 or 4.7 – 4.9.

4.6 The upward shift of operating temperature upon loss of any of the fluid-charge shall not exceed 5 percent of the initial operating temperature based on degrees Fahrenheit.

4.7 As an alternate to 4.6, if the design is such that the contacts of the control will not assume an open position upon loss of the fluid-charge and/or loss of a small amount of the charge may cause an upward shift of operating temperature, the control shall conform with 4.8 and the fluid-charge containing parts of each control shall be subjected to the following production test by the manufacturer.

a) Prior to filling the system with the charge, the complete system consisting of the bulb, capillary tube, and the diaphragm or bellows shall be checked for leakage with air or gas. There shall be no evidence of leakage at a pressure 50 percent greater than that developed within the system when the control sensing element is subjected to a temperature of 110 percent of the rated nominal operating temperature of the control, and

b) After determining the operating temperature of the completely assembled control, the sensing element shall be subjected to its maximum rated operating temperature for a period of 24 hours. Following this exposure test, the control is to be cooled to 77°F (25°C). The operating temperature of the control is to be determined. There shall be no deviation from the original operating temperature;

c) With reference to (a) and (b) above, other tests may be considered and accepted if found to achieve the results contemplated.

4.8 The temperature sensing element shall be located or constructed so that it is not likely to be damaged during installation or use. The bulb and capillary tube of a remote sensing element shall conform to 37.4. A separate shroud or sleeve may be employed for protection of the bulb and capillary tubing to achieve conformance with 37.4.

4.9 The contacts of the control shall remain closed at an ambient temperature of 0°F (minus 17.8°C).

4.10 The maximum temperature set point of a control shall not exceed the safe limits of temperature of bimetals or other materials employed in the zone of the media to be controlled.

4.11 A pressure control, in which a flexible diaphragm, bellows or similar construction constitutes the only flammable-fluid seal, shall have the atmospheric side of the diaphragm or bellows enclosed in a casing constructed to limit external leakage in the event of diaphragm or bellows rupture, or shall have provisions for connection of a vent pipe or tubing intended to use routed to the outdoors or other location acceptable for venting. See 5.5, 5.6, and 36.5.

4.12 A control that is intended to supervise the pressure of fuel oil Nos. 1 – 6 is not required to comply with 4.11 provided three samples of the control, when subjected to a 100,000-cycle endurance test, comply with 31.1 without leakage during the test and when subjected to a hydrostatic test of four times the rated pressure following the Endurance Test, Section 31, the control complies with 5.5 or 5.6.

4.13 The requirement of 4.11 and 4.12 do not apply to a pressure-operated control part subjected to pressure in a self-contained system, such as a bulb or capillary tube arrangement.

4.14 Metal parts coming in contact with a diaphragm shall have no sharp edges, burrs, projections, etc., which might chafe or abrade the diaphragm.

4.15 An operation spring shall be retained and arranged to prevent abrasion, binding, buckling, or interference with its free movement.

4.16 A liquid level limit control may include snubbers, time delay, or other means to delay control action for the purpose of preventing unnecessary shut-downs due to fluctuating liquid level. Such means shall conform with all requirements for materials, secureness, spacings, etc., specified herein and shall be so constructed that its failure will not negate the function of the control. Under normal service conditions the time delay shall not exceed 90 seconds. See 29.1.11.

4A Safety Related Software

4A.1 Fan, regulating, water heater temperature-regulating, and limit controls that employ microprocessors that include safety-related software shall be evaluated using the Standard for Software in Programmable Components, UL 1998, as modified in Supplement SA of this Standard, Software in Programmable Components.

Exception: Unless otherwise declared by the manufacturer or determined by specific end-product application, water feed controls are generally considered as operating (non-safety) controls and a software evaluation per clause 4A.2 is not required.

Revised 4A.1 effective June 30, 2011

4A.2 When applying the requirements in the Standard for Software in Programmable Components, UL 1998, the software Class for boiler liquid level controls, pressure limit controls, and temperature limit controls shall be defined as Class 2. The software Class for fan controls and for regulating controls shall be defined as Class 1.

4B Electronic Controls

4B.1 Fan, regulating, water heater temperature-regulating, and limit controls shall be designed so that failure of an electronic component results in either continued operation with all safety functions operating properly or detection of the fault and safe shutdown of the control. The faults to be evaluated are specified in 31A.3.

Exception: Unless otherwise declared by the manufacturer or determined by specific end-product application, water feed controls are generally considered as operating (non-safety) controls. As such, the relevant safety requirements of this standard apply with respect to electric shock and fire hazards.

Revised 4B.1 effective June 30, 2011

4B.2 For controls that incorporate electronic circuits, compliance is to be determined by Section 31A, Failure Mode Effect Analysis (FMEA) Procedures, 31B, Mains Borne Perturbations, Magnetic and Electromagnetic Disturbances, and 31C, Thermal Cycling Test for Electronic Devices.

5 Materials

5.1 A fluid-confining part (for example, a pressure switch for gas or oil) or an operating part, if deterioration or breakage of the part will allow leakage of a fluid that may result in a risk of injury to persons or prevents the control from functioning, shall be made of material having a melting point (solidus temperature) of not less than 950°F (510°C) and a tensile strength of not less than 10,000 psi (68.9 MPa) at 400°F (204°C). Such a part shall not sag, distort, melt, oxidize, or leak fuel during any of the tests specified in this standard.

Exception: The requirements regarding melting point and tensile strength do not apply to a seal ring, diaphragm, or gasket that is resistant to the action of fluid with which it may be in contact.

5.2 A part, including a sheath, capillary tube, bulb, well, bellows, or diaphragm, shall be resistant to atmospheric corrosion and attack by the liquid or gas it may contact in service if failure of the part will permit external leakage of a combustible fluid or cause the control to malfunction.

5.3 A brass alloy containing less than 81 percent copper and more than 9 percent zinc is not considered resistant to the corrosive effects of fuel oils.

5.4 A part made of brass containing more than 15 percent zinc shall withstand the 10-Day Moist Ammonia Air Stress Cracking Test, Section 39, if failure of the part in operation of the controlled equipment may result in a risk of fire, explosion, or injury to persons.

5.5 If a control with a bellows, Bourdon tube, diaphragm, or similar element is made of Type 316 or 321 stainless steel, or material of equivalent resistance to corrosion, it shall be constructed so that leakage from a ruptured element will be into the control enclosure, the leakage shall be released to the exterior of the control before entering any opening provided for conduit connection.

5.6 If a control with a bellows, Bourdon tube, diaphragm, or similar element is made of Type 301 stainless steel, or material of equivalent resistance to corrosion, it shall be constructed so that leakage from a ruptured element will be to the exterior of the control enclosure only.

6 Frame and Enclosure

6.1 General

6.1.1 The mechanism of a control shall be protected by an enclosure to avoid damage to or interference with operating parts.

6.1.1 effective November 3, 1995

6.1.2 An electron tube shall be enclosed or protected against damage. Such tubes, as well as means provided for manual manipulation, shall be so located with respect to uninsulated live parts that there will be no liability of a person coming in contact with such live parts during the normal changing of the tube or during manual manipulation of parts intended for such purpose.

6.1.3 A piece such as a dial or nameplate which is in effect a part of the enclosure, shall be of a metal or other material as specified for the enclosure.

6.1.4 A nonmetallic part such as a reset knob, lever, or button protruding through a hole in the enclosure shall be made of self-extinguishing material if the hole is not larger than the area of a 7/8 inch (22.2 mm) diameter circle. Nonmetallic parts protruding through a hole larger than the area of a 7/8 inch (22.2 mm) diameter circle shall be made of materials conforming to 6.1.10.

6.1.5 Openings for connection to piping (including vent lines) shall be threaded in accordance with the Standard for General Purpose (Inch) Pipe Threads, ANSI/ASME B1.20.1-1983(R1992).

6.1.6 Cast metal for an enclosure shall be at least 1/8 inch (3.2 mm) in thickness at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch (6.4 mm) in thickness at tapped holes for conduit; except that, other than at plain or threaded conduit holes die-cast metal shall be not less than 3/32 inch (2.4 mm) in thickness for an area greater than 24 square inches (155 cm²) or having any dimension greater than 6 inches (152.4 mm), and shall be not less than 1/16 inch (1.6 mm) in thickness for an area of 24 square inches (155 cm²) or less and having no dimensions greater than 6 inches (152.4 mm). The area limitations for metal 1/16 inch (1.6 mm) in thickness may be obtained by the provision of reinforcing ribs subdividing a larger area. Die-cast metal of 0.035 inch (0.89 mm) minimum thickness may be employed in lieu of 1/16 inch (1.6 mm) thick die-cast metal if the enclosure will not be used as a splice box and if the voltage rating of the complete control is such that the potential between any two conductors does not exceed 250 volts ac or dc, and die-cast metal of 0.028 inch (0.71 mm) minimum thickness may be employed in lieu of 1/16 inch (1.6 mm) thick die-cast metal for an enclosure housing only low-voltage circuits.

6.1.7 The thickness of a sheet-metal enclosure shall be as indicated in Table 6.1, except that steel shall be not less than 0.032 inch (0.81 mm) thickness [0.034 inch (0.86 mm) if zinc-coated] and nonferrous metal shall be not less than 0.045 inch (1.14 mm) in thickness at points where a wiring system is to be connected.

6.1.8 A transformer shall be housed within its own enclosure or within the main enclosure of a control or within a combination thereof. A sheet-steel transformer enclosure shall have a thickness of not less than 0.026 inch (0.6 mm) (No. 22 MSG) if uncoated and not less than 0.029 inch (0.74 mm) (No. 22 GSG) if galvanized; except that sheet steel having a thickness of not less than 0.020 inch (0.51 mm) (No. 24 MSG) if uncoated and not less than 0.023 inch (0.85 mm) (No. 24 GSG) if galvanized may be used for a drawn end bell having maximum dimensions of 2-1/4 inch (57.2 mm) on the flat portion and 1-1/2 inch (38.1 mm) at the base of the drawn portion. A cast-metal transformer enclosure shall comply with the requirements of 6.1.6.

6.1.9 Glass covering an observation opening shall be secured in place so that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts. Glass for an opening not more than 4 inches (101.6 mm) in any dimension shall be not less than 1/16 inch (1.6 mm) in thickness. Glass for a larger opening, but not more than 144 square inches (929 cm²) in area and having no dimension greater than 12 inches (304.8 mm), shall be not less than 1/8 inch (3.2 mm) in thickness.

6.1.10 *deleted April 22, 2011.*

No Text on This Page

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



Documents

Document Sharing Hub

Table 6.1
Thickness of sheet metal
Table 6.1 revised September 30, 2010

Maximum dimensions of enclosure			Minimum thickness of sheet metal in inches											
			Steel ^a						Copper, brass, or aluminum ^a					
			Without supporting member			Without reinforcing support			Without reinforcing support			Without supporting member		
			Zinc-coated		Uncoated		Zinc-coated		Uncoated		Zinc-coated		Uncoated	
Group	Length or width		Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
A	3	76.4	0.023 ^c (24)	0.584	0.020 ^c (24)	0.508	0.023 ^c (24)	0.584	0.020 ^c (24)	0.508	0.023 ^d (22)	0.584	0.023 ^d (22)	0.584
B	8	203.2	0.029 ^{6c} (22)	0.740	0.026 ^c (24)	0.660	0.023 ^c (24)	0.584	0.020 ^c (24)	0.508	0.036 (18)	0.910	0.029 (20)	0.740
C	12	304.8	0.034 (20)	0.864	0.032 (24)	0.813	0.023 ^c (24)	0.584	0.020 ^c (24)	0.508	0.045 (16)	1.143	0.029 (16)	0.740
D	18	457.2	0.045 (18)	1.143	0.042 (20)	1.067	0.034 (20)	0.864	0.032 (20)	0.813	0.058 (14)	1.473	0.045 (16)	1.143
E	24	609.6	0.056 (16)	1.422	0.053 (18)	1.346	0.045 (18)	1.143	0.042 (18)	1.067	0.075 (12)	1.905	0.058 (14)	1.473
F	48	1219.2	0.070 (14)	1.778	0.067 (16)	1.702	0.056 (16)	1.422	0.053 (16)	1.346	0.095 (10)	2.413	0.075 (12)	1.905
G	60	1524.0	0.097 (12)	2.464	0.093 (16)	2.362	0.056 (16)	1.422	0.053 (16)	1.346	0.122 (8)	3.099	0.075 (12)	1.905
H	Over 60	1524.0	0.126 (10)	3.200	0.123 (16)	3.124	0.056 (16)	1.422	0.053 (16)	1.346	0.153 (6)	3.886	0.075 (12)	1.905

^a The figures in parentheses are the GSG numbers (for zinc-coated steel), the MSG numbers (for uncoated steel), and the AWG numbers (B&S) numbers (for copper, brass, or aluminum) which provide the specified minimum thickness of metal.

^b Volume of enclosure not more than 12 cubic inches (196.7 cm³).

^c Sheet steel for an enclosure intended for outdoor use (raintight) is required to be not less than 0.034 inch (0.87 mm) (No. 20 GSG) in thickness if zinc coated and not less than 0.032 inch (0.81 mm) in thickness if uncoated (No. 20 MSG).

^d Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (raintight) is required to be not less than 0.029 inch (0.74 mm) in thickness (20 AWG).

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



Documents
Document Sharing Hub

6.1.11 *deleted April 22, 2011.*

6.1.12 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if a construction that has been determined to be equivalent is used, there shall not be less than 3 threads in the metal, and the construction of the control shall be such that a conduit bushing can be attached as intended.

6.1.13 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal; and there shall be a smooth, rounded inlet hole for the conductors that affords protection to the conductors that have been determined to be equivalent to that provided by a standard conduit bushing and that has an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

6.1.14 In an enclosure threaded for support by rigid conduit, at least five full threads shall be provided for engaging the conduit.

6.1.15 Except as noted in 6.1.18, a conduit hub or nipple attached to the enclosure of a control by swaging, staking, or similar means shall withstand, without pulling apart, a direct pull of 200 pounds (890 N), a bending moment of 600 pound-inches (67.8 N·m), and a torque of 600 pound-inches (67.8 N·m), each applied in turn for 5 minutes.

6.1.16 For the pullout test, the control is to be supported by rigid conduit in the intended manner and is to support a weight of 200 pounds (90.7 kg).

6.1.17 For the bending and twisting tests, the control is to be rigidly supported by means other than the conduit fittings. In the bending test, the force is to be applied to the conduit at right angles to its axis, and the lever arm is measured from the wall of the enclosure in which the hub or stud is located to the point of application of the bending force. In the torsion test, the force is to be applied to the conduit in a direction tending to tighten the connection, and the lever arm is to be measured from the center of the conduit.

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



Documents
Document Sharing Hub

6.1.18 With regard to 6.1.16 and 6.1.17, distortion of the enclosure does not constitute a failure. The test may be discontinued when noticeable distortion occurs.



No Text on This Page

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



Documents
Document Sharing Hub

6.1.19 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

- a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4 inch (6.4 mm) maximum dimension; and
- b) 0.027 inch (0.69 mm) steel or 0.032 inch (0.81 mm) nonferrous metal for a hole having a 1-3/8 inch (34.9 mm) maximum dimension.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

6.1A Polymeric materials and enclosures

6.1A added April 22, 2011

6.1A.1 The mechanical strength of a nonmetallic enclosure shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 6.1.

6.1A.2 Unless otherwise specified in sections 6 and 8, polymeric electrical insulating materials and polymeric enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The material flammability class is determined by tests in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

6.1A.3 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. This requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

6.2 Accessibility of live parts

6.2.1 Electrical parts of controls shall be located or enclosed to reduce the risk of unintentional contact with an uninsulated live part. Additionally, electrical parts shall be located or enclosed so that protection against unintentional contact or shorting of live parts that could result in a malfunction of the controlled equipment is provided. For the purpose of these requirements, film-coated wire is considered to be an uninsulated live part.

Exception: An enclosure is not required for a device intended for assembly as part of another device.

6.2.2 An opening in an enclosure of a control may be used if an accessibility probe as illustrated in Figure 6.1, when inserted into the opening, cannot be made to touch any part that involves the risk of electric shock to the end-user or service personnel. However, in no case shall the opening be large enough to permit the entrance of a 1 inch (25.4 mm) diameter rod.

6.2.3 The accessibility probe shall be articulated into any configuration and shall be rotated or angled to any position before, during, or after insertion into the opening, and the penetration shall be to any depth allowed by the opening size, including minimal depth combined with maximum articulation.