UL 991

Underwriters Laboratories Inc.

Standard for Safety

Tests for Safety-Related Controls Employing Solid-State Devices

UL Standard for Safety for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991

Third Edition, Dated October 22, 2004

Summary of Topics

These revisions to UL 991 are being issued to address editorial maintenance of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

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.

A reference to UL 60730-1 and/or a Part 2 standard from that series has been added to this standard. The addition of this reference provides an alternate standard for investigating components currently covered by UL 873 or UL 244A until October 19, 2016. This added reference will facilitate the use of components that have been investigated to the UL 60730 series. Such components have been determined to fulfill the requirements of the legacy standards.

UL 60730-1 (4th Edition) becomes effective on October 19, 2016. All components that were previously investigated to the requirements in UL 873 or UL 244A will have to comply with the requirements in either UL 60730-1 and/or a Part 2 standard from that series in order to maintain UL Listing or Recognition, as appropriate. UL 873 and UL 244A legacy controls standards will be withdrawn on October 19, 2016.

This is intended to provide end product manufacturers with sufficient time to a) address the impact of the standards changes during normal design changes over the intervening years, b) submit any modified products for investigation, and c) implement any necessary changes in production.

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that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

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UL 991

Standard for Tests for Safety-Related Controls Employing Solid-State Devices

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Third Edition

October 22, 2004

This UL Standard for Safety consists of the Third Edition including revisions through June 9, 2010.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

The text included in paragraphs 11.2.1, 11.3.1, 11.4.1, 11.4.2, and 11.4.3 is based on material in Electromagnetic compatibility (EMC) – Part 4: Testing and measuring techniques – Section 11: Voltage dips, short interruptions and voltage variations immunity tests, IEC 61000-4-11, First edition copyright 1994-06. This material is used in this Standard with the consent of the IEC and the American National Standards Institute (ANSI). The IEC copyrighted material has been reproduced with permission from ANSI. ANSI should be contacted regarding the reproduction of any portion of the IEC material. Copies of the IEC Publication 61000-4-11 may be purchased from ANSI, 11 West 42nd Street, New York, New York, 10036, (212)642-4900.

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INTRODUCTION

1 Scope

1.1 These requirements apply to controls that employ solid-state devices and are intended for specified safety-related protective functions.

1.2 These requirements address the potential risks unique to the electronic nature of a control. Equipment or components employing an electronic feature shall also comply with the basic construction and performance requirements contained in the applicable end-product or component standard. These requirements are intended to supplement applicable end-product or component standards and are not intended to serve as the sole basis for investigating the risks of fire, electric shock, or injury to persons associated with a control.

1.3 These requirements do not cover controls covered by end-product standards in which an electronic control investigation is specified.

1.4 Sections 9 – 22 contain standardized test methods for investigating the performance of an electronic control when subjected to particular environmental stresses. The suitability of each test to a given control shall be determined by the end-product standard(s). Determination shall include an assessment of:

a) Whether the control will be exposed to a particular environmental stress in its application, and

b) Whether the response of the control to a particular environmental stress is relevant to its intended safety-related protective function in its application.

2 Components

2.1 Except as noted in 2.2, a component of a product covered by this standard shall comply with the requirements for that component.

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.

3.2 In addition to being stated in the inch/pound units that are customary in the USA, each of the requirements in this standard is also stated in units that make the requirement conveniently usable in countries employing the various metric systems (practical SI and customary).

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

5.2 CONTROL – For the purpose of this standard, a control shall be considered a complete control, a subassembly, a circuit, or an individual component.

5.3 CRITICAL CIRCUIT – A circuit that performs one or more safety related functions and has been identified as critical in accordance with General, Section 6, and Failure Mode and Effect Analysis, Section 7.

5.4 CRITICAL COMPONENT – A component that performs one or more safety-related functions and that has been identified as critical in accordance with General, Section 6, and Failure Mode and Effect Analysis, Section 7.

5.5 CRITICAL FAILURE – A failure of a component or circuit that results in a condition, such as the risk of fire, electric shock, or injury to persons, in the end product application.

5.6 CRITICAL FUNCTION – The failure of a specific action of a control that results in a condition, such as the risk of fire, electric shock, or injury to persons in the end product application.

5.7 DECADE – 3.32 octaves.

5.8 DISTINCTIVE AUDIBLE SIGNAL – A signal obtained from various devices such as bells, horns, sirens, and buzzers, or a variance in the nature of the signal such as a continuous signal obtained under one condition and a pulsing signal under another.

5.9 ELECTROMAGNETIC INTERFERENCE (EMI) – The impairment of a desired electromagnetic signal by an electromagnetic disturbance.

5.10 ELECTROMAGNETIC SUSCEPTIBILITY – The characteristic of electronic equipment that results in undesirable responses when subjected to an electromagnetic disturbance.

5.11 OCTAVE – A range of signals having a frequency ratio of 2:1.

5.12 SUPERVISION – The monitoring of a circuit so that a fault condition will result in a trouble indication or other acceptable action.

5.13 TEST ACCELERATION FACTOR – A number, that varies with the test temperature, chosen to conduct the Demonstrated Method, Section 25. It is used to calculate the required test unit-hours.

5.14 TEST UNIT-HOURS – The mathematical product of the number of samples under test and the time of the test.

5.15 TROUBLE INDICATION – A visible or audible signal intended to indicate a fault or trouble condition, such as an open or shorted condition of a component in the device or an open or ground in the connected wiring.

5.16 USAGE LEVEL – The range of hours per year that a control is expected to be subjected to electrical or thermal stress or a combination of electrical and thermal stresses.

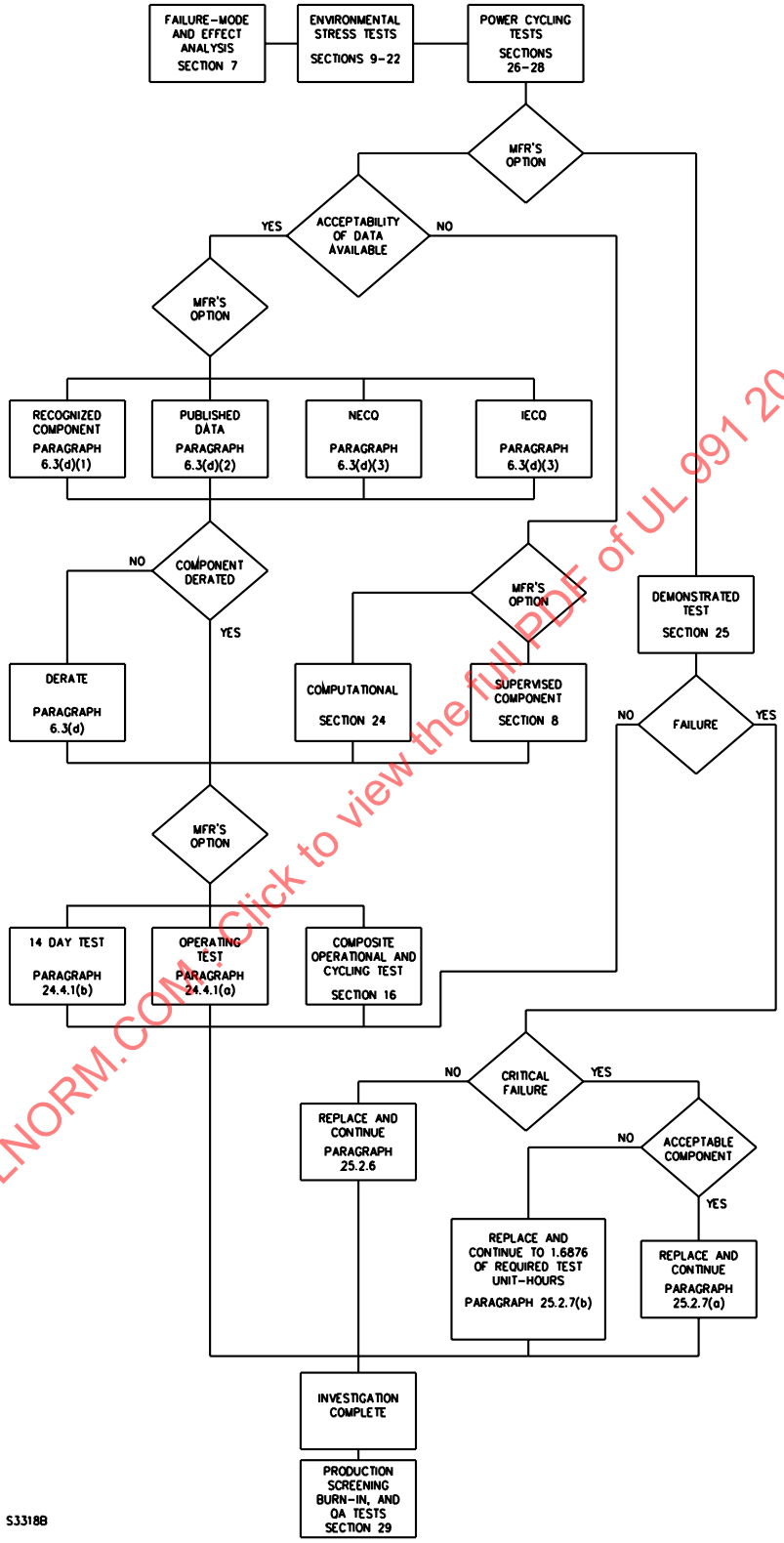
INVESTIGATION

6 General

6.1 A description of the operation and safety features of the control with respect to the controlled element shall be provided by the manufacturer and shall be used as a guide in the examination and test of the device. For example, the operation of an electronic temperature limiting control might be in an inactive state in a certain temperature range but is intended to disconnect the load from the electrical supply at a higher predetermined temperature.

6.2 A control designed for a specified safety-related protective function shall be investigated in accordance with a four part program consisting of environmental stress tests, power cycling tests, investigation of critical components, and production-line tests. The investigation of controls shall be based on Figure 6.1.

Figure 6.1
Investigation flowchart



6.3 The investigation of critical components for controls containing critical devices or components shall include one of the following:

a) Demonstrated method, Section 25;

b) Computational investigation, Section 24;

c) Electrical supervision, Section 8; or

d) Derating in accordance with the Electronic Reliability Design Handbook, Military Handbook Number 338 and has a rating derived from a test program; and

1) The component is recognized under a program in which the manufacturer of the control conducts in-coming inspections, screening, quality assurance, and burn-in tests;

2) The test data is available on the component in widely accepted, documented publications and the component complies with screening test requirements; or

3) The component has received qualification approval under the International Electrotechnical Commission Quality Assessment System for Electronic Components (IECQ) or the National Electronic Components Quality Certification System (NECQC) program.

6.4 A failure-mode and effect analysis (FMEA) in accordance with Failure-Mode and Effect Analysis (FMEA), Section 7 is required to identify critical components.

6.5 The failure of a solid-state device or an electronic component (such as due to an open or short circuit within a component) during operation of a control shall result in one or more of the following conditions:

a) No loss of declared protective function as a result of control shutdown or on the intended operation.

b) For attended products, activation of a trouble indication considered as acceptable in the end-product standard.

c) Shutdown in a manner that complies with the end-product application if the protective function has been negated.

6.6 If a failure results in a condition other than as specified in 6.5, the device or component shall be considered critical.

7 Failure-Mode and Effect Analysis (FMEA)

7.1 A fault analysis and failure mode chart of all components shall be prepared in accordance with Table 7.1. For this purpose, all active terminals of a multi-pin device shall be considered input, output, power supply, or ground.

Table 7.1
Circuit identification

Part name[a]	Mfgr[b]	Cat. No.[b]	Ratings[b]	Schematic reference[c]	Function[d]	Failure mode[e]	Failure effect[f]	Critical or non-critical[g]

[a] Each electronic component in the control to be investigated is to be included.

[b] This information is to be supplied for each critical component.

[c] Each component is to be identified as R1, C1, or an equivalent component identification.

[d] The function of each component is to be described.

[e] The effects of open and short faults are to be evaluated for each component. The following are alternatives to shorting all combinations of terminals on multiple pin components, such as integrated circuits.

1) Short each pair of adjacent pins.

2) Short each input pin to (referenced) ground.

3) Short each output pin to (referenced) ground.

4) Short each input pin to the power supply.

5) Short each output pin to the power supply.

A circuit analysis made to assess the performance of individual components under a fault condition rather than actually creating the fault to determine its effect also meets the intent of the requirements.

[f] The effect resulting from the failure on the control and also on the end use product is to be stated.

[g] The failure effect is to be identified as within the intent of General, Section 6.

8 Electrical Supervision

8.1 If permitted by the end-product standard, a circuit element may be electrically supervised so that a failure such as an open, short, or other fault involving a critical function will result in a trouble indication considered to be acceptable in the end-product standard.

8.2 A supervisory circuit is considered a critical circuit and shall comply with the applicable requirements. Supervision of a supervisory circuit is not required.

8.3 To determine if the element is acceptably supervised, the control is to be energized and operated in its intended manner, and various fault conditions are to be introduced. Each fault is to be applied separately, the response of the supervisory circuit noted, the fault removed, and the control restored to its normal operating condition prior to establishing the next fault. The introduction of the fault is to be done for each normal operating mode.

8.4 Each introduction of a fault is to result in a distinctive audible signal or other action designated as acceptable in the end-product standard.

8.5 A manual means for silencing the audible signal may be provided only if a visible trouble indicator remains activated or is simultaneously activated when the signal is silenced. Automatic silencing of the audible signal is not permitted.

8.6 When the fault is cleared, the alarm is to either give an audible signal when left in the silenced position or automatically become enabled to respond to new faults.

8.7 Disconnecting and then reconnecting the power supply to the control shall not disable a trouble indicator if a fault condition still exists.

ENVIRONMENTAL STRESS TESTS

9 General

9.1 Production samples shall perform acceptably when subjected to the applicable tests specified in Table 9.1.

Exception: Prototype samples may be tested if they are entirely representative of future production.

Table 9.1
Environmental stress tests

Tests	Section
Overvoltage and undervoltage	10
Power supply interruption	11
Transient overvoltage	12
Ramp voltage	13
Electromagnetic susceptibility	14
Electrostatic discharge	15
Composite operational and cycling test	16
Test for effects of shipping and storage	17
Thermal cycling	18
Humidity	19
Dust	20
Vibration	21
Jarring	22

9.2 The tests specified in Table 9.1 are intended to determine the ability of an electronic control to perform its intended protective function after exposure to a series of environmental stresses. Compliance is determined by having the control perform its intended function both before and after such exposures.

9.3 Unless otherwise specified, the various tests are to be performed at rated frequency and at the voltage specified in Table 9.2 with the control installed as intended in the end-product.