UL 991

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

This revision of UL 991 dated December 27, 2024 includes the following changes in requirements:

– Clarification of requirements if no critical components are found in a failure mode and effects analysis: Figure 6.1, 6.3, and 23.4.

– Alternate test methods for the environmental stress tests: 11.1.1, 12.1, 13.1, 14.1.1, 15.1.1 – 15.1.4, 15.1.1A, 15.2.1A, 15.2.2A, 15.2.3A, 15.2.4A.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated February 16, 2024

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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 December 27, 2024.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://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

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

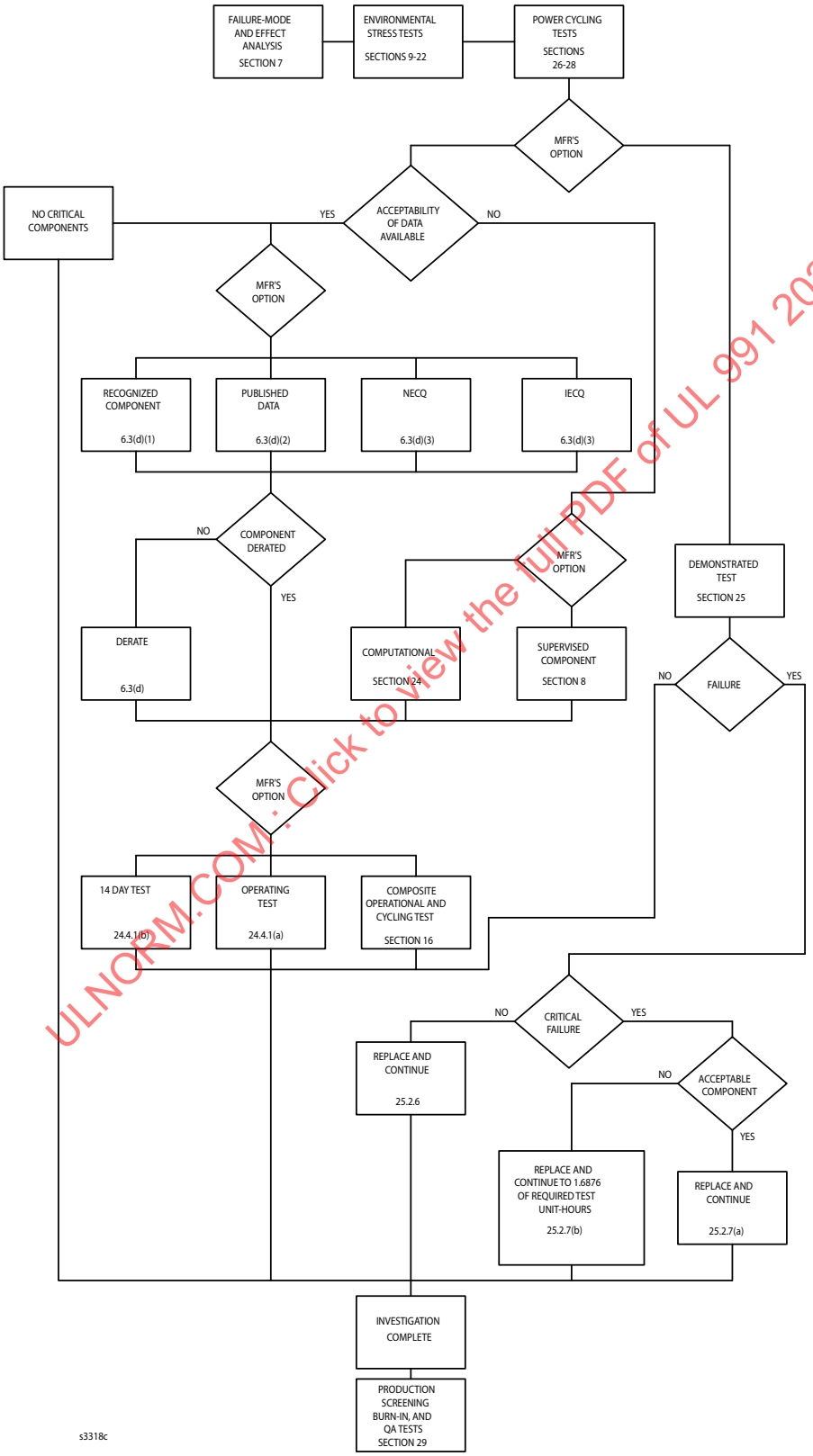
6 General

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.

Exception: Investigation of critical components is not required if the Failure-Mode and Effects Analysis (FMEA) of Section 7 does not identify any critical components.

NOTE: Some end-product standards (e.g., UL 2271) do not permit any critical components.

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.