UL 858A

STANDARD FOR SAFETY

Safety-Related Solid-State Controls for Household Electric Ranges

UL Standard for Safety for Safety-Related Solid-State Controls for Household Electric Ranges, UL 858A

Third Edition, Dated April 12, 2007

Summary of Topics

This revision to ANSI/UL 858A is being issued to remove the reference to the withdrawal date of UL 873 and UL 244A.

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 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that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.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 858A

Standard for Safety-Related Solid-State Controls for Household Electric Ranges

First Edition – September, 1989
Second Edition – February, 1995

Third Edition

April 12, 2007

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through December 17, 2013.

The most recent designation of ANSI/UL 858A as an American National Standard (ANSI) occurred on September 25, 2012. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or effective date information.

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.

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INTRODUCTION

1 Scope

1.1 The requirements in this standard cover safety-related solid-state controls used in household electric ranges. These requirements supplement and, in some cases, amend the requirements in the Standard for Household Electric Ranges, UL 858, the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, and the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

1.1 revised December 17, 2013

1.2 These requirements cover a solid-state control that performs any of the following functions:

a) Controls cooktop heating elements.

b) Controls oven normal operating temperatures.

c) Controls oven self-cleaning cycle operating temperatures.

d) Controls oven self-cleaning cycle door lock system.

e) Controls required signal lights or audible alarms.

f) Serves as a temperature-limiting control for any of the functions noted in (a) – (e).

g) Controls a function essential for the appliance to comply with a specific requirement in the Standard for Household Electric Ranges, UL 858.

2 General Requirements

2.1 General

2.1.1 For the purpose of this standard, a control includes a complete control assembly, a subassembly, a circuit, or an individual component.

2.1.2 A description of the normal and intended operation of a control with respect to the controlled element shall be provided by the manufacturer and used as a guide for analysis and test purposes. For example, the description might state that the control is intended to monitor certain temperatures and disconnect the controlled element from the electrical supply when a higher predetermined temperature is attained.

2.1.3 When a control is intended to perform multiple protective functions (such as temperature-regulating, temperature-limiting, self-clean door lock control, and similar functions), the manufacturer is to identify those components or circuits that are involved in each protective function, and also any component or circuits that are common to multiple functions.

2.2 Components

2.2.1 Except as indicated in 2.2.2, 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 commonly used in the products covered by this standard.

2.2.2 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.

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

2.2.4 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.

2.3 Units of measurement

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

2.4 References

2.4.1 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.

3 Glossary

3.1 SUPERVISION – The monitoring of a circuit so that a malfunction results in a trouble indication.

3.2 THERMAL-LINK – A non-resettable device incorporating a thermal element which will open a circuit once only when exposed for a sufficient length of time to a temperature in excess of that which it has been designed.

3.3 TROUBLE INDICATION – An audible signal, which may be supplemented by a visual signal, intended to indicate a fault or trouble condition, such as the open-circuit or short-circuit of a component in the control or an open-circuit or short-circuit to grounded metal in the connected wiring.

INVESTIGATION

4 General Requirements

4.1 General

4.1.1 Unless otherwise specified in this standard, a solid-state control shall comply with the Standard for Solid-State Controls for Appliances, UL 244A. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

4.1.1 revised December 17, 2013

4.1.2 A solid-state control shall comply with the applicable requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

4.1.2 revised December 17, 2013

4.1.3 A transient voltage suppression assembly supplied as part of a solid-state control shall comply with the Standard for Surge Protective Devices, UL 1449.

4.1.3 revised June 3, 2010

4.1.4 All solid-state controls are to be subjected to each of the following:

a) The Environmental Stress Tests, Sections 9 – 15 and 17 – 19, in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991,

b) The Power Cycling Test, Section 13,

c) The Failure Mode and Effect Analysis, Section 6, and

d) The Production Tests requirements specified in Section 14 in UL 858A and Supplement SA, in UL 991.

4.1.5 Other than indicated in 8.1.1, Demonstrated Test Method, Section 8, is to be conducted on each complete control assembly, subassembly, circuit, or individual component:

a) That is critical,

b) That is a required supervising circuit,

c) The failure mode of which is undefined, as determined by the Failure Mode and Effect Analysis, or

d) That performs a temperature-limiting function (See 5.2).

4.1.6 When a risk of fire is to be determined, a risk of fire test indicator is to be used that consists of two layers of cheesecloth draped over the control when the control alone is tested or over the complete appliance when the appliance is tested. Ignition of the cheesecloth is indication of a risk of fire. See 4.1.8.

4.1.7 The cheesecloth is to be bleached cotton cloth running 14 – 15 yd^2/lb (26 – 28 m^2 /kg) and having what is known in the trade as a count of 32 by 28, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 threads in the other direction). Tests involving cheesecloth are to be conducted in a closed draft-free room.

4.1.8 When a risk of shock is to be determined, a risk of shock test indicator is to be used that consists of a 3-A nontime-delay fuse connected in the grounding conductor of the supply to the control or to the product. Any neutral bonding conductor or strap is to be open-circuited. Opening of the fuse is indication of a risk of electric shock.

4.1.9 A control is able to be assigned one or two temperature ratings, T_{max} or T_a. T_{max} refers to the maximum control ambient temperature to which the control is intended to be exposed in the end-use application under any operating mode for which component temperature measurements are specified in the Standard for Household Electric Ranges, UL 858, and is used in conjunction with 8.2.5, 9.2, and 13.3. T_a refers to the control use ambient temperature and is the same as T_{max}, unless the Exception to 8.2.4 is used.

4.1.10 When a control performs a safety-related function that is not specifically addressed in this standard, the criteria for identifying any critical components, Demonstrated Test Method test level, and usage level shall be determined by a separate investigation. Factors to be evaluated shall include:

a) The severity of possible risks of electric shock, fire, and injury to persons resulting from a component failure,

b) The extent and frequency of exposure to possible risks of electric shock, fire, and injury to persons,

c) Whether or not a component malfunction directly results in a risk of electric shock, fire, or injury to persons,

d) The extent of user involvement in initiating or reducing the risk of electric shock, fire, or injury to persons, or where additional abnormal conditions are required to exist, and

e) Whether or not a control malfunction is evident to the user prior to the user being exposed to a risk of electric shock, fire, or injury to persons.

See 1.2(g).

4.2 Spacings

4.2.1 Spacings within a control shall be maintained in accordance with the spacing requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception: Spacings within a control that are reduced in accordance with the applicable requirements in the Standard for Solid-State Controls for Appliances, UL 244A, comply with UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

4.2.1 revised December 17, 2013

4.3 Temperature test

4.3.1 A control shall comply with the temperature test requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception No. 1: The temperature rise of a component or material that exceeds the maximum specified in UL 873, shall not exceed the maximum temperature rise specified in the Standard for Solid-State Controls for Appliances, UL 244A. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception No. 2: For a component or material for which a maximum temperature rise is not specified in UL 873, the maximum temperature rises specified in UL 244A shall be applicable. For a component or material for which no maximum temperature rise is specified in either UL 873 or UL 244A, the temperature limit shall be established by means of a separate investigation. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

4.3.1 revised December 17, 2013

5 Limiting Controls

5.1 A limiting function shall be independent of any regulating function. A single component, including an electromechanical component, shall not be critical to both functions.

Exception No. 1: This requirement does not apply to a component that malfunctions and renders the control, or the external components controlled, totally inoperable or inoperable to the extent that it is not usable to perform any intended function and does not introduce a risk of fire, electric shock, or injury to persons.

Exception No. 2: This requirement does not apply when, with the component malfunctioned:

a) The appliance complies with the applicable abnormal operation tests in the Standard for Household Electric Ranges, UL 858,

b) The activation of a trouble indication that complies with the requirements for Electrical Supervision, Section 7, results, and

c) A risk of fire, electric shock, or injury to persons is not introduced.

5.2 In all cases, a solid-state limiting control is to be subjected to the Demonstrated Test Method, Section 8. For the Demonstrated Test Method, the test and usage levels assigned to a limiting function in a solid-state control are to be as specified in Table 5.1.

Table 5.1
Limiting control test levels

Limiting control application	Test level	Usage level hours per year
Continuous operation[a], with a solid-state regulating control	2	More than 1000
Continuous operation[a], with a mechanical regulating control	1	More than 1000
Intermittent operation[b], with a solid-state regulating control	2	101 – 1000
Intermittent operation[b], with a mechanical regulating control	1	101 – 1000
Self-clean operation[c], with a solid-state regulating control	2	100 or less
Self-clean operation[c], with a mechanical regulating control	1	100 or less

[a] Continuous operation means those components performing the limiting function are electrically or thermally stressed whenever the appliance is connected to the power supply.

[b] Intermittent operation means those components performing the limiting function are electrically or thermally stressed whenever the appliance is operated in any mode.

[c] Self-clean operation means those components performing the limiting function are electrically or thermally stressed only during the self-cleaning cycle.

6 Failure Mode and Effect Analysis FMEA

6.1 A failure mode and effect analysis (FMEA) of the solid-state control is to be made in accordance with 6.2 – 6.13. The failure of a component of a control shall result in one or more of the following conditions. These conditions are summarized in Figures 6.1 – 6.7 and in Table 6.1. In each case, there shall be no increase in the risk of fire, electric shock, or injury to persons, the control shall continue to comply with all applicable requirements in this standard and the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, and the appliance shall comply with the applicable requirements in the Standard for Household Electric Ranges, UL 858. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

a) The control continues to perform its intended operation.

b) The characteristics (set point, the cycling rate, and similar characteristics) of the self-clean operation of the control do not significantly change, unless such a change is investigated in accordance with the fire and explosion requirements in UL 858. See the general fire and explosion requirements in UL 858 for additional details.

c) The control activates a trouble indication that complies with the requirements for Electrical Supervision, Section 7 (See 6.2).

d) The control de-energizes the connections to the appliance or the element controlled without introducing a condition identified as critical in Table 6.1 and Figures 6.1 – 6.7, and the control prevents re-energization of these connections.

e) The control does not operate to energize a controlled component under normal operating conditions or in any operating mode due to user accessible adjustment in any position.

f) The connections to the appliance do not operate and are unable to operate in a condition identified as noncompliance in Table 6.1 and Figures 6.1 – 6.7.

g) The connections to the appliance continue to operate in a condition identified as critical in Table 6.1 and Figures 6.1 – 6.7 and the control complies with Demonstrated Test Method, Section 8.

6.1 revised December 17, 2013

6.2 A control having a component identified as critical, and a control having a component the failure mode of which is undefined, is to be subjected to the Demonstrated Test Method, Section 8, using the applicable test and usage levels specified in Figures 6.1 – 6.7. Except as indicated in Figures 6.1 – 6.7, supervision of critical components shall not exempt a control from the Demonstrated Test Method.

6.3 A control that performs multiple functions shall be investigated with respect to the requirements for each safety-related function. For example, a self-cleaning oven temperature-regulating control – that reduces the risk of heating elements from becoming energized until the oven door is locked – shall be investigated with respect to the applicable requirements for a self-cleaning oven door lock control as well as the requirements for a self-cleaning oven temperature-regulating control.

6.4 When redundant components are supplied for a task and the failure mode of one does not affect the operation of the other, the control is still required to comply with the applicable requirements in this standard.

Table 6.1
Critical and noncompliance component failure

COOKTOP ELEMENT CONTROL – SEE Figure 6.1
Noncompliance
Energization of a heating element in other than the low heat mode from an ″off″ condition, without an integral mechanical off position.
Critical
1. Loss of the 2 step on function or the 1 step off function.
2. Energization of a heating element in the low heat mode without an integral mechanical off position.
3. Exposed terminal is made live during insertion or removal of a cooktop element or module.
OVEN TEMPERATURE REGULATING CONTROL – SEE Figure 6.2
Noncompliance
None
Critical
There is a positive calibration change at the maximum cutout set point temperature. The extent of the criticality of the component is determined by whether or not the control automatically locks the oven door or de-energize the oven, or a thermal-link or manual- reset type limiting device functions, and whether or not the appliance complies with the applicable Component Failure Tests in the Standard for Household Electric Ranges, UL 858.
SELF-CLEANING OVEN DOOR LOCK CONTROL – SEE Figure 6.3
Noncompliance
1. Oven door does not lock during self-cleaning operation before the oven temperature exceeds 316°C (600°F).
2. Locked oven door unlocks during self-cleaning operation while oven temperature exceeds 316°C (600°F).
Critical
Oven door automatically locks during normal operation; that is, when oven temperature is below 316°C (600°F) and the control is not in the self-clean mode.
SELF-CLEANING OVEN TEMPERATURE-REGULATING CONTROL – SEE Figure 6.4

Table 6.1 Continued on Next Page

Table 6.1 Continued

	Noncompliance
None	
	Critical
1.	Loss of the 2 step on function or the 1 step off function.
2.	The peak maximum self-cleaning oven temperature set point differs from the original value by more than ±5 percent measured in degrees Fahrenheit.
SIGNAL LIGHTS AND INDICATORS – SEE Figure 6.5	

Table 6.1 Continued on Next Page

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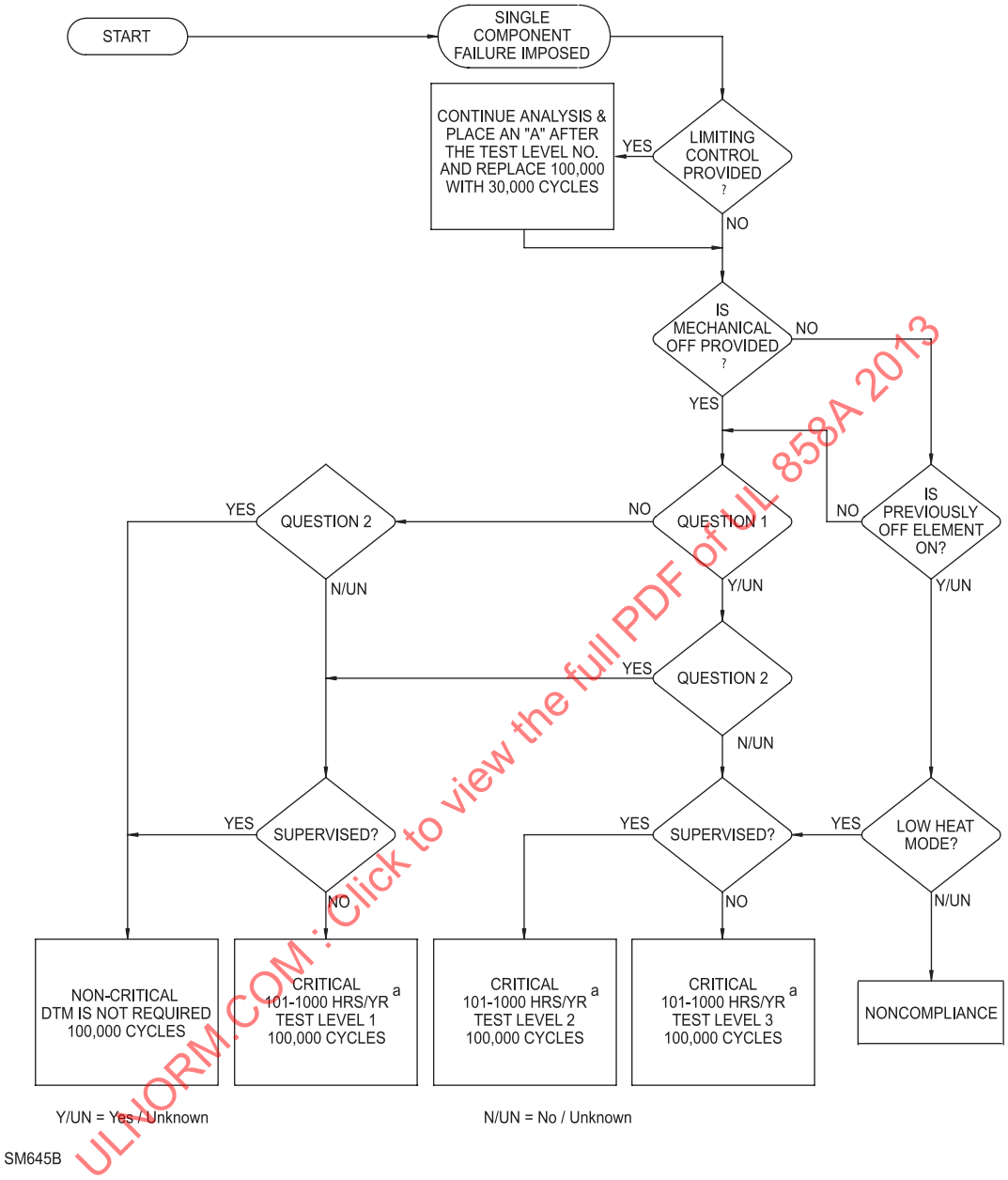
Table 6.1 Continued

Noncompliance
None
Critical
Loss of the proper function of the indicator.
SUPERVISION CIRCUIT – SEE Figure 6.6
Noncompliance
None
Critical
Loss of the supervision function.
TEMPERATURE-LIMITING CONTROL (FOR ALL MODES OF OPERATION OF APPLIANCE) – SEE Figure 6.7
Noncompliance
None
Critical
A component failure is noncritical when the appliance complies with the applicable abnormal operation (stalled fan and shorted thermostat) tests in UL 858 with the component failed and the rest of the appliance operating in the abnormal operating conditions specified in UL 858.
NOTE – Use of a supervision circuit that complies with Electrical Supervision, Section 7, is able to reduce the critical condition test level, or change a critical condition to a noncritical condition as noted in Figures 6.1 – 6.5.

Figure 6.1
Critical condition and test category flow chart – cooktop element control



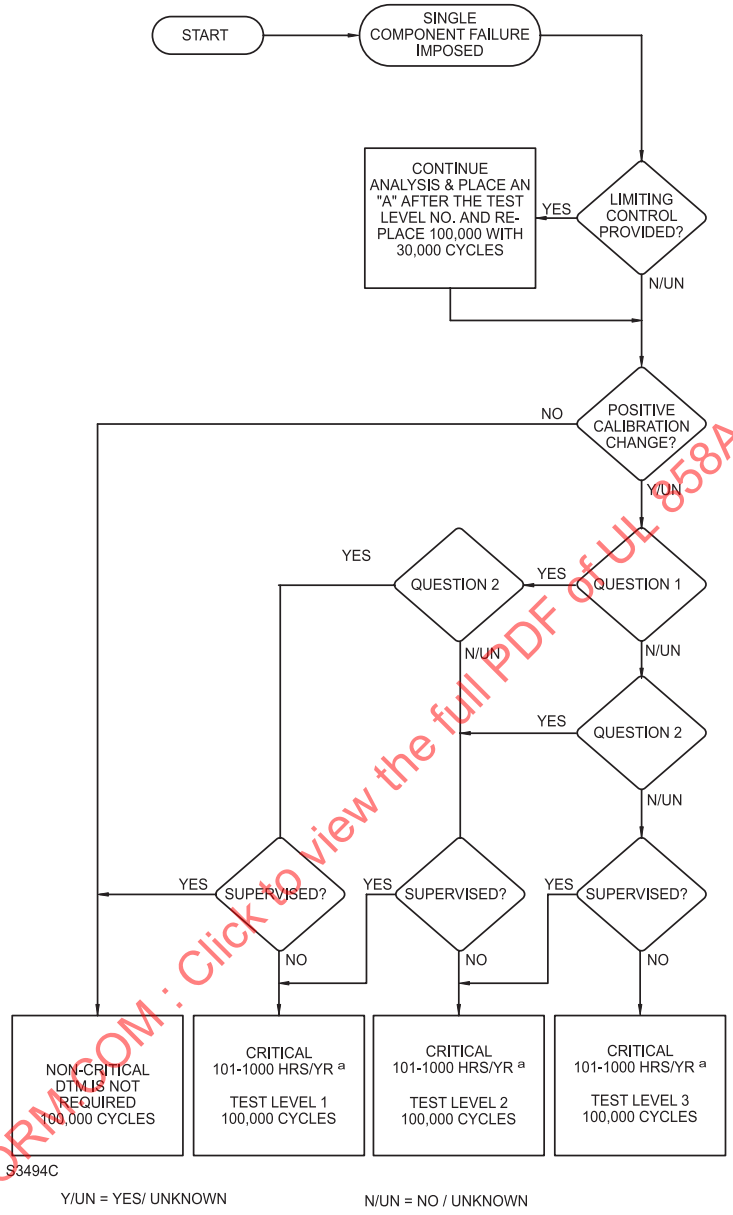
Question 1: Does a terminal or pin, which is exposed during insertion or removal of a removable component heating element or module, become live?

Question 2: Does the 2 step on and 1 step off features of the control still function?

[a] See 6.5 (c) – (e).

Note – See Table 8.1 for test levels.

Figure 6.2
Critical condition and test category flow chart – oven temperature-regulating control



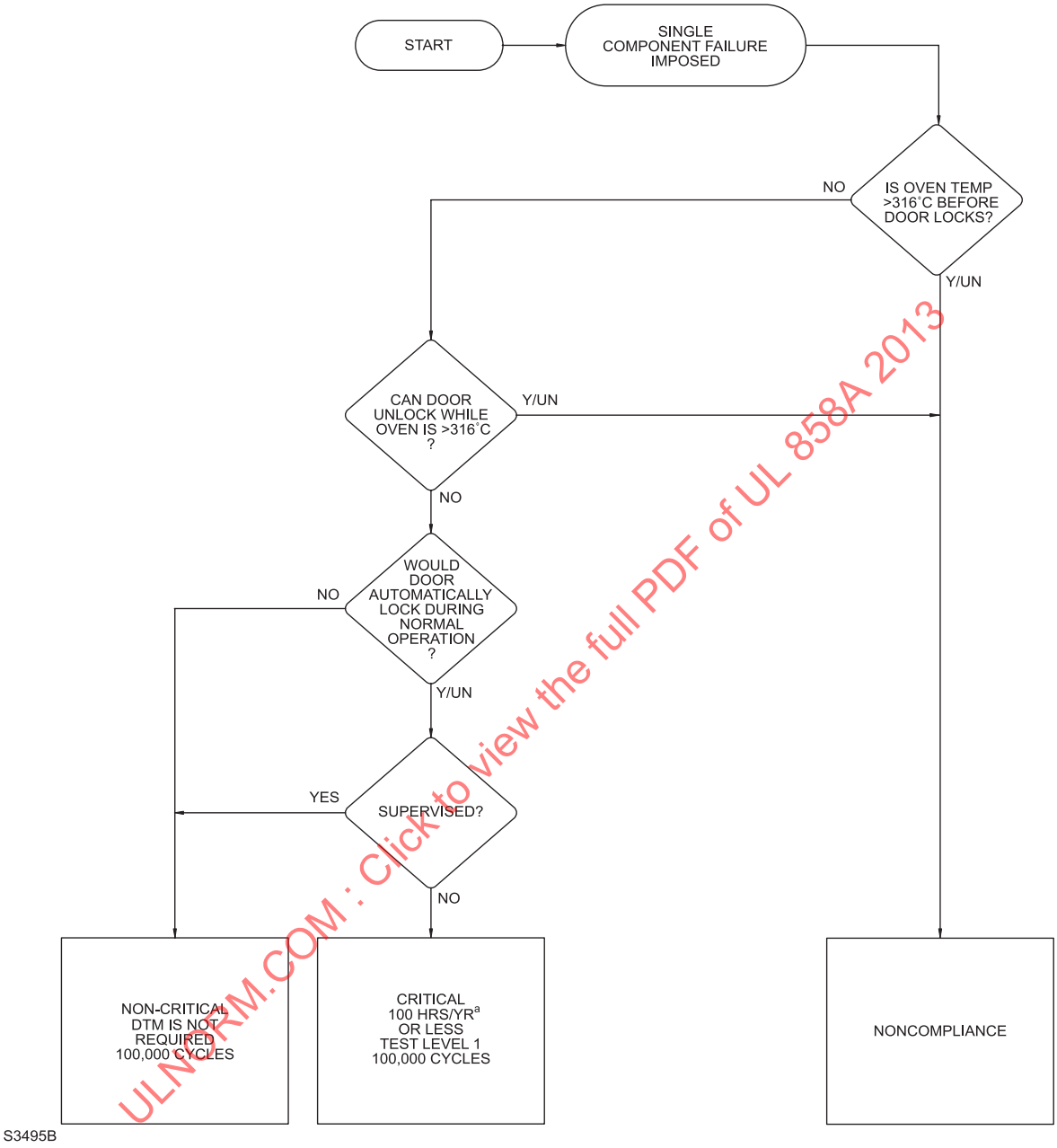
Question 1: Does the appliance comply with the applicable Component Failure Tests in Standard for Household Electric Ranges, UL 858?

Question 2: Does the control automatically lock the oven door, de-energize the oven, or does a thermal-link or manual-reset type limiting device function?

[a] See 6.5 (c) – (e).

Note – See Table 8.1 for test levels.

Figure 6.3
Critical condition and test category flow chart – self-cleaning oven door lock control



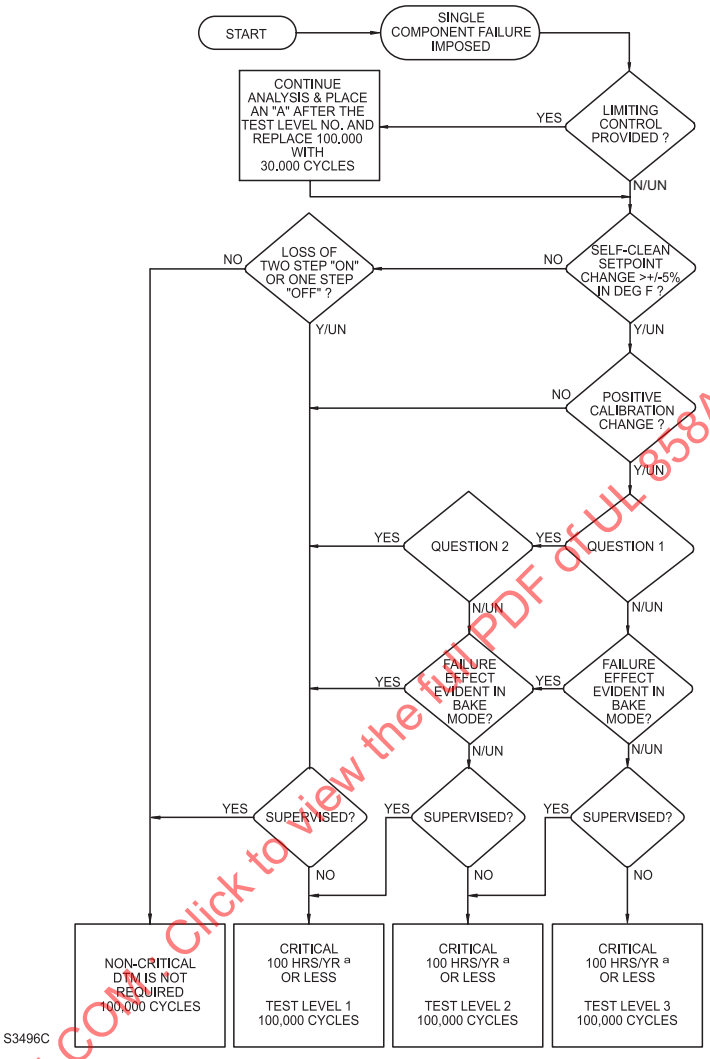
Y/UN = Yes / Unknown

N/UN = No / Unknown

[a] See 6.5 (c) – (e).

Note – See Table 8.1 for test levels.

Figure 6.4
Critical condition and test category flow chart – self-cleaning oven temperature-regulating control



Y/UN = Yes / Unknown

N/UN = No / Unknown

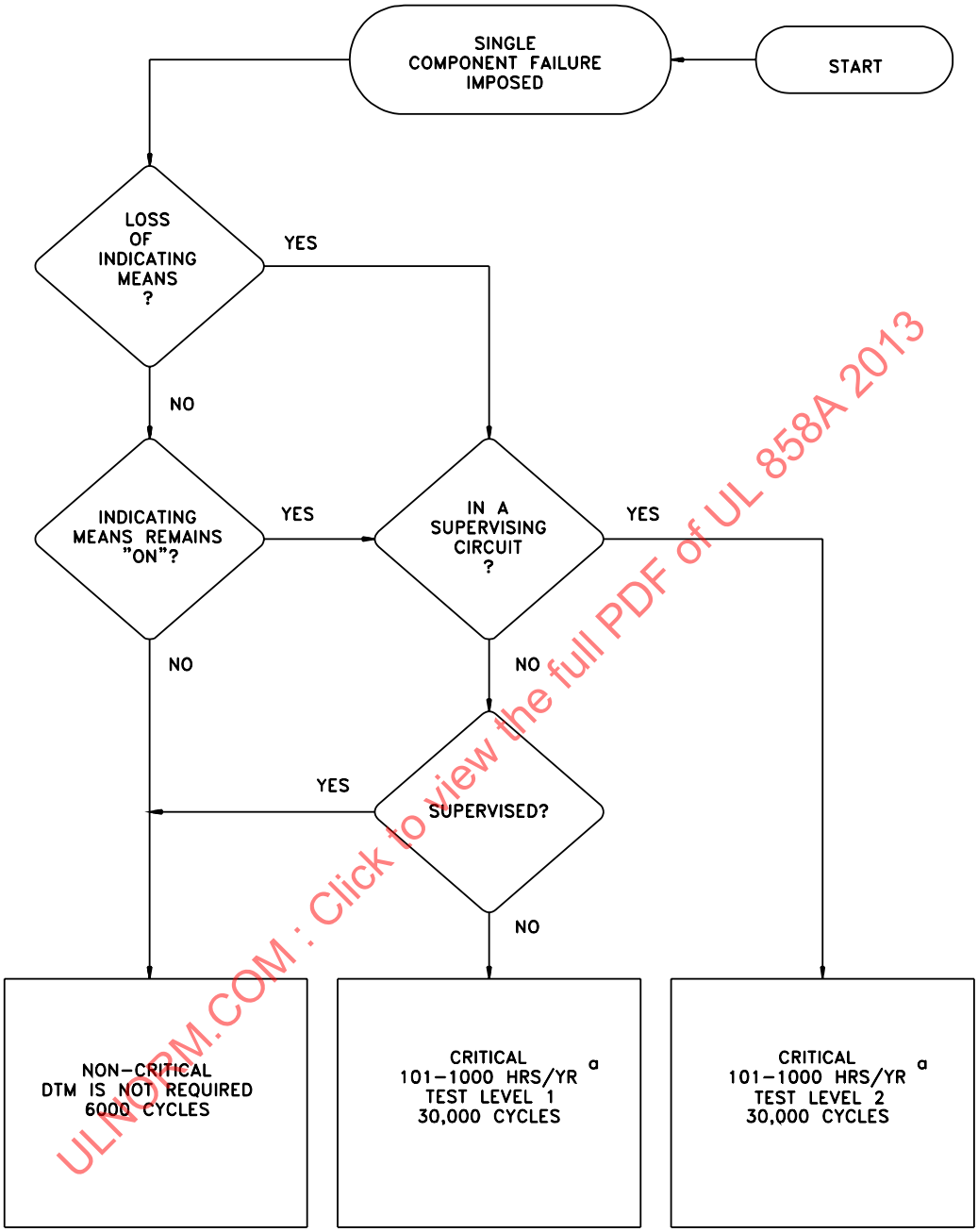
Question 1: Does the appliance comply with the applicable Component Failure Tests in Standard for Household Electric Ranges, UL 858?

Question 2: Does the appliance comply with the applicable temperature tests in UL 858 with the component failed, the rest of the control functioning normally, and any other temperature-regulating or -limiting controls defeated?

[a] See 6.5 (c) – (e).

Note – See Table 8.1 for test levels.

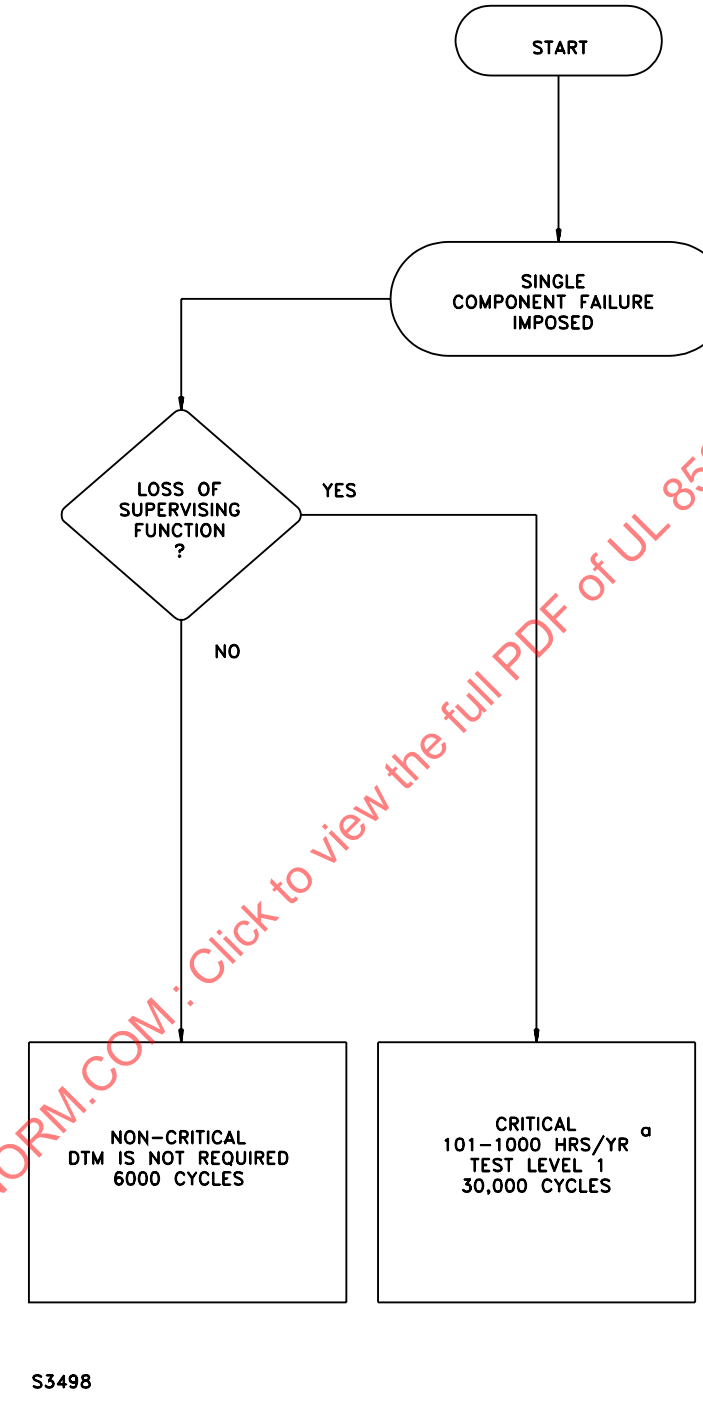
Figure 6.5
Critical condition and test category flow chart – signaling lights and indication



[a] See 6.5 (c) – (e).

Note – See Table 8.1 for test levels.

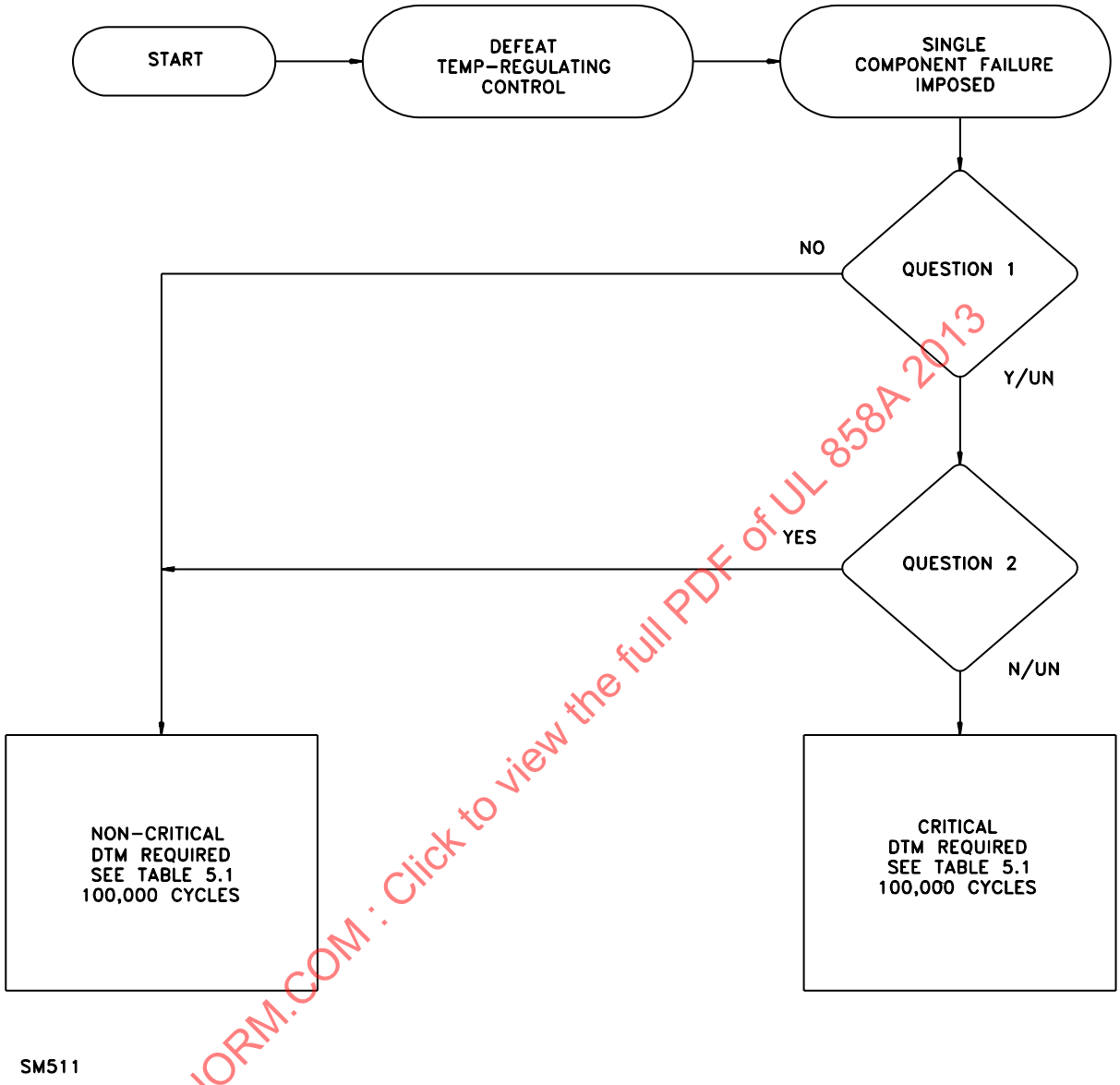
Figure 6.6
Critical condition and test category flow chart – supervision circuits



[a] See 6.5 (c) – (e).

Note – See Table 8.1 for test levels.

Figure 6.7
Critical condition and test category flow chart – temperature-limiting controls and circuits



Y/UN = Yes / Unknown

N/UN = No / Unknown

Question 1: Does the cutout temperature of the temperature-limiting control vary from the as-received cutout temperature by more than 5 percent of the as-received setpoint Fahrenheit temperature, or by more than 10°F (6°C), whichever is greater?

Question 2: Does the appliance comply with the applicable abnormal operation (stalled fan and shorted thermostat) tests in Standard for Household Electric Ranges, UL 858 with the component failed and the rest of the appliance operating in the abnormal conditions specified in UL 858?

6.5 In Figures 6.1 – 6.7 and Table 6.1, the following apply:

a) Temperatures referenced are oven temperatures measured in accordance with the applicable Temperature Tests in the Standard for Household Electric Ranges, UL 858.

b) The ″supervised″ decision refers to whether or not a system complying with of Electrical Supervision, Section 7, is supplied for any control circuit elements the failure of which changes the applicable flow chart path preceding the ″supervised″ decision.

c) If the component is stressed electrically or thermally only when a particular function is initiated, then the usage level is not to be changed from the level indicated in the figure involved. A component is considered to be thermally stressed whenever it is subjected to ambient temperatures above normal room temperature, 77°F (25°C).

d) If the component is stressed electrically or thermally whenever the appliance is operated in any mode, then the usage level is to be no less than the 101 – 1000 hours per year level, which, in certain cases, means an increase in the level from that indicated in the figure involved.

e) If the component is stressed electrically or thermally whenever the appliance is connected to the supply, then the usage level is to be the greater than 1000 hours per year level, which, in certain cases, means an increase in the level from that indicated in the figure involved.

f) With regard to Figure 6.1, low heat mode is a condition in which a cook top element is controlled, by techniques such as electronic clipping or by cycling on and off, at less than 10 percent of its rated wattage, and not more than 200 W average, as measured over an operating cycle.

g) A positive calibration change is an increase in the cutout temperature of a temperature-sensing assembly by more than 10 percent of the maximum as-received cutout set point temperature, at the set point temperature measured in degrees Fahrenheit in accordance with the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. [For example, a control with a maximum as-received set point temperature of 550°F (288°C) is considered to have a positive calibration change when a calibration shift at the maximum set point exceeds 55°F (30.6°C).] Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

h) Mechanical off position refers to a control position in which the air-gap switching contacts:

1) Are mechanically held open so that they are unable to close when the control is in the off position,

2) Must be actuated each time a cook top element is energized, and

3) Do not close as a result of failure of any combination of electronic components.

i) Loss of proper indicator function is a condition in which any required indicating signal (light, sound, or the equivalent) is either continuously off and thereby does not serve to indicate, or continuously on.

j) In Figures 6.1, 6.2, and 6.4 for the test levels 1A, 2A, and 3A, the required number of test unit-hours is to be 80 percent of the number of test unit-hours calculated for test levels 1, 2, and 3, respectively.

k) DTM is an abbreviation for Demonstrated Test Method, Section 8.

l) In Figure 6.4, a failure effect is considered to be evident in the bake mode when during such operation a trouble indication functions as intended, a thermal-link or manual reset temperature-limiting device operates, or operation is affected to the extent that it is unable to be used in the intended manner, for example, in the bake mode the oven does not reach temperatures of 350°F (176.7°C) or the oven always goes to, and remains in, the full on condition.

m) The analysis is to be made with any adjustable features, including software, that affect the maximum set point and that are not factory set and sealed adjusted to the position(s) or value(s) that represent the worst case setting(s).

n) Only a limiting control that functions when the corresponding regulating control is defeated during the Abnormal Operation Tests in the UL 858, is able to be used to reduce the demonstrated test method test unit-hours and reduce the endurance test requirements for a regulating control.

o) With regard to Figure 6.4, a component failure which does not change the set point of the self-clean cycle by more than ±5 percent in degrees Fahrenheit elicits a ″no″ response to the question, ″Self-clean set point change > ±5 percent in degrees F?″. Alternatively, at the manufacturer's request, the effect of a component failure is to be determined in accordance with 6.14.

p) With regard to the one step off function of the control in Figures 6.1 and 6.4, if more than one off pad or circuit is supplied, the requirements apply to each pad or circuit independently, regardless whether any other pads or circuits still function properly or not.

q) The initiation of a single component failure shall be identified during all possible operating modes, including full on, standby, and full off.

6.5 revised December 17, 2013

6.6 All possible component failure modes are to be analyzed to ultimate results. Components, such as resistors and capacitors, are to fail in either open-circuit or short-circuit mode. Semiconductors are to fail in the open-circuit or short-circuit mode. Other failure modes also require evaluation. See 6.7 and 6.8. Analysis of the circuit, the control, and the appliance, or actual tests on the system is an alternate method to determine the effect of each failure for each component.

6.6.1 In a power supply circuit, regulating components that limit the output voltage or current are to be faulted, as described in 6.6. If the ultimate results are not immediately evident, the test shall be continued for a minimum of two hours. After ultimate conditions have been obtained and/or after the two hour period, the effect on the safety related functionality is to be determined.

6.6.1 added September 25, 2012

6.7 Other failure modes that are to be evaluated include half wave conditions of a triac, intermediate voltage conditions of a switching transistor, and nonlinear ac response of a triac, diac, or a capacitor.

6.8 In conducting a failure mode and effect analysis on multi-pin components such as integrated circuits, the following short-circuit conditions are to be evaluated.

a) Each pair of adjacent pins.

b) Each input pin to referenced ground pin.

c) Each output pin to referenced ground pin.

No Text on This Page

d) Each input pin to each power supply pin, in turn.

e) Each output pin to each power supply pin, in turn.

6.9 More than one component failure is not to be imposed as an initial test condition. However, the effects of the failure of other components that are additionally stressed electrically and/or thermally as a result of a single component failure are to be included in the analysis to ultimate results.

Exception: When analyzing a circuit that is intended to function under abnormal conditions (for example, limiting circuits, supervision circuits, and similar circuits) some circuits require a simulated malfunction of a temperature-regulating control or other components as a pre-existing condition in order to result in the circuit under evaluation to perform its intended function.

6.10 When the failure of a component results in the de-energization of the connections to the appliance, the components in the circuit involved in the de-energization of these connections are to be included in the analysis.

6.11 Failure of the component being controlled, such as a heating element or a signal light, or failure of a lead or connection to the component is not to be included in the failure mode and effect analysis.

6.12 Failure of switches, relays, and similar components is to be included in the analysis and evaluation. When a switch, relay, or a similar component is identified as a critical component, it shall comply with the Overload and Endurance test described in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

6.12 revised December 17, 2013

6.13 A list of all electrical components in the control is to be supplied by the manufacturer along with a failure effect statement for each component. Each component on the list is to be identified as critical, undefined, or not critical as determined by 6.1.

6.14 With respect to 6.5(o), when, with the control installed in the end-use appliance, the appliance complies with the Fire and Explosion Test requirements for self-cleaning ovens in the Standard for Household Electric Ranges, UL 858 while simulating a failure of the control component, a ″no″ response is elicited to the question ″Self-clean set point change > ±5 percent in degrees F?″

6.15 The presence of a temperature-limiting function is not evaluated during the failure mode and effect analysis of a temperature-regulating control, except to reduce the number of DTM test unit-hours and the endurance test cycles in accordance with 6.5 (j) and (m).

6.16 The failure mode and effect analysis of a temperature-limiting control or circuit that performs a temperature-limiting function is to be conducted by first defeating any components that make or break load current during any normal appliance function to simulate a worst-case malfunction of the corresponding temperature-regulating control(s) or circuits that perform temperature-regulating functions, and then evaluating the failure of single components one at a time of the temperature-limiting control or circuit. See Figure 6.7.

Exception: A triac, relay, or similar power-handling component that makes or breaks load current during normal operation of the appliance is not restricted from remaining operational while determining compliance with the requirements for temperature-limiting controls, when:

a) The appliance complies with the Abnormal Operation Test requirements for temperature-limiting devices in pilot-duty configurations in the Standard for Household Electric Ranges, UL 858, and

b) The power-handling component is determined to be a noncritical component with respect to the temperature-limiting function.

7 Electrical Supervision

7.1 Other than specified in 7.2 – 7.7, a control shall comply with the requirements for electrical supervision contained in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

7.2 In the event the supervision of a critical component results in a lower test level assignment in accordance with Figures 6.1 – 6.5, the supervision circuit shall comply with the supervision requirements, the appliance shall be marked, and the appliance instruction manual shall include the instructions described in the Standard for Household Electric Ranges, UL 858.

7.3 The distinctive audible trouble indication shall be obtained from one or more different sounding devices, such as bells, horns, sirens, or buzzers, or from a single device, such as an electronic horn, that generates a continuous signal under one condition and a pulsing signal under another condition. The audible device shall also comply with the applicable requirements in the Standard for Household Electric Ranges, UL 858.

7.4 A trouble indicator is not required to be activated when the control is called upon to perform a function not affected by the fault; for example, controlling another part of the end-use appliance.

7.5 A switch or equivalent means shall only be employed to silence the audible trouble indication when the control includes a visible trouble indicator that remains activated, or is simultaneously activated, when the audible trouble indication is switched off. When the audible indicator silencing means is returned to the unsilenced position, the audible indicator shall come on or the visual indicator shall remain on. The visual indicator shall comply with the requirements for visibility and the requirements for visual indicators in the Standard for Household Electric Ranges, UL 858. Activation of the silencing device when a trouble condition does not exist shall not result in the activation of an audible or visual trouble indication.

7.6 The audible trouble indicator shall activate in the event of a fault, regardless of the position of the silencing means.

7.7 Where electrical supervision is supplied for a critical component, an analysis of the supervision circuit shall be made in accordance with Table 6.1 and Figure 6.6. Test and usage levels are to be assigned for use in determining compliance with Demonstrated Test Method, Section 8.

Exception: This requirement does not apply to a circuit that uses a momentary contact switch to silence the trouble indicator

8 Demonstrated Test Method

8.1 General

8.1.1 When a failure of a solid-state control component results in a critical condition as determined in the Failure Mode and Effect Analysis, Section 6, or when the control performs a temperature limiting function, the control is to be subjected to the test procedure described in 8.1.2 – 8.3.8.

Exception: A control other than a limiting control is not required to be subjected to this test when all critical components are derated in accordance with the Electronic Reliability Design Handbook, Military Handbook Number 338 and has a rating derived from a comparable test program; and

a) The components are investigated under a comparable program in which the manufacturer of the control conducts incoming inspections, screening, quality assurance, and burn-in tests, and have a reliability rating equivalent to that required by 8.2.1 for the usage level, test level, and temperature involved; or

b) The components have 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 with a reliability rating equivalent to that required by 8.2.1 for the usage level, test level, and temperature involved.

8.1.2 During the test, an electronic component shall not fail in a manner identified as critical in accordance with the Failure Mode and Effect Analysis, Section 6.

8.1.3 At the conclusion of this test, the control is to be cooled to a room ambient temperature of 20 – 30°C (68 – 86°F). The control shall perform as intended during 50 cycles of operation in all intended modes. In addition, for a control that performs a temperature limiting function, the set point shall comply with the calibration verification requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, unless with the control installed in the appliance, the appliance complies with the applicable abnormal operation tests in the Standard for Household Electric Ranges, UL 858. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

8.1.3 revised December 17, 2013

8.2 Test unit-hours

8.2.1 The procedure described in 8.2.2 – 8.2.9 is to be used to determine the required number of test units, test hours, and test temperature in order to determine the test unit-hours.

8.2.2 The control is to be categorized with respect to use hours per year and test level in accordance with Table 5.1 or Figures 6.1 – 6.6, as applicable.

8.2.3 Table 8.1 is to be used to determine the multiplier for the control according to usage level and test level.

Table 8.1
Multiples for usage and test levels

Usage level Hours/year	Test level		
	1	2	3
1 – 100	46.38	57.63	69.64
101 – 1000	463.80	576.30	696.40
Greater than 1000	4638.00	5763.00	6964.00

8.2.4 The control use ambient temperature (T_a) is to be the maximum rated temperature of the control by the manufacturer or, when the end-application is known, the maximum control ambient temperature (T_{max}) recorded in the end-use application under any operating mode for which component temperature measurements are specified in the Standard for Household Electric Ranges, UL 858.

Exception: The control use ambient temperature (T_a) is also calculated using the alternate method specified in the Standard for Household Electric Ranges, UL 858.

8.2.5 The specified test temperature (T_t) is to be chosen at the discretion of the control manufacturer. However, T_t is not to be lower than the maximum control ambient temperature (T_{max}) to which the control is exposed in the end-use application during the applicable tests in UL 858 where component temperature measurements are specified. The alternate method of determining T_a described in the Exception to 8.2.4 has no effect on the choice of T_t.

8.2.6 The equation in Table 8.2 is to be used to determine the test acceleration factor (TAF). Figures 8.1 and 8.2 are able to be used to estimate the test acceleration factor for controls intended for use at the specified ambient temperatures for activation energy values of 0.65 eV. This is done by projecting the chosen test temperature vertically until it intersects the appropriate ambient line. The ordinate value of this intersection point is the test acceleration factor.

Table 8.2
Test acceleration factor equation

Equation
$TAF = ln^{-1}\left[\left(\frac{1}{T_t} - \frac{1}{T_a}\right)\frac{E_A}{k} + 4.6052\right]$

Table 8.2 Continued on Next Page

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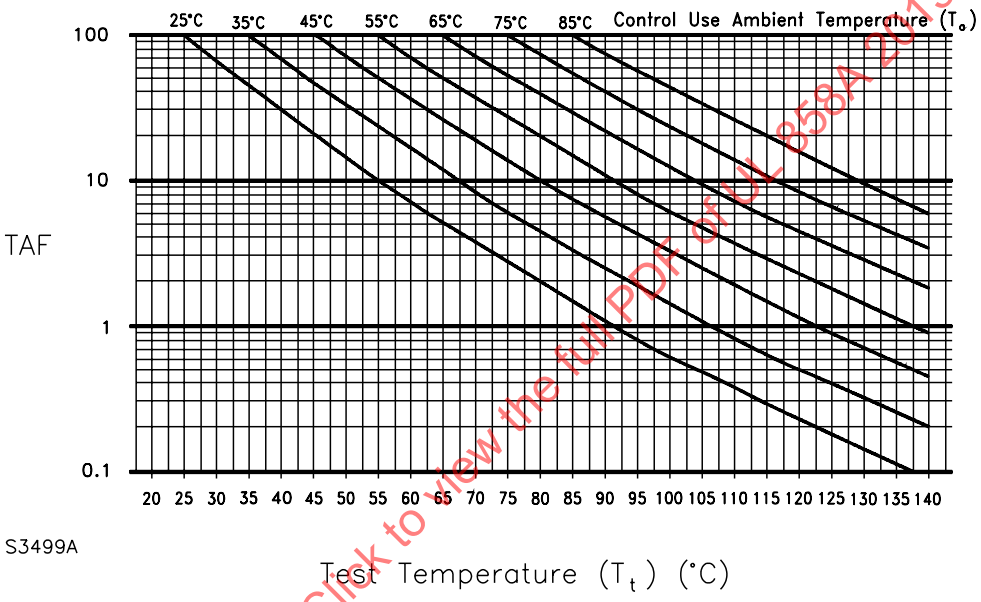
Table 8.2 Continued

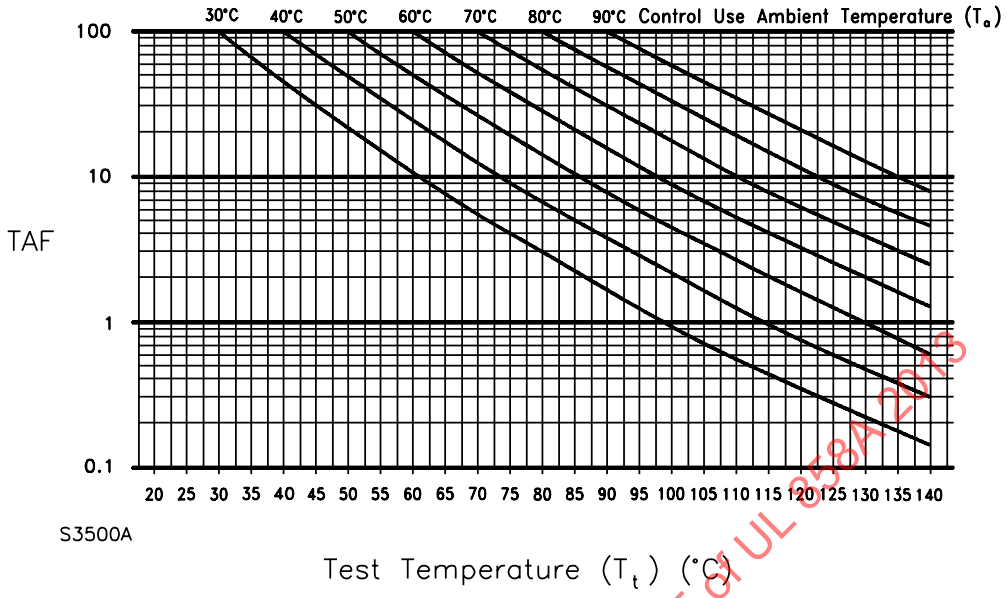
Equation
kelvin (K) = Degrees Celsius (°C) + 273.15.
T_t = Specified test temperature expressed in kelvin.
T_a = Control use ambient temperature expressed in kelvin.
TAF = Test acceleration factor.
k = 8.61708 x 10^{-5} eV/K
E_A = Minimum activation energy of a critical component under test expressed in electron-volts (eV). See 8.2.9.

Figure 8.1
Test acceleration factor (TAF) 25 – 85°C ambient in 10°C increments[a]



[a] For this graph, the TAF is calculated with an assumed activation energy (E_A) of 0.65 eV.

Figure 8.2
Test acceleration factor (TAF) 30 – 90°C ambient in 10°C increments[a]



[a] For this graph, the TAF is calculated with an assumed activation energy (E_A) of 0.65 eV.

8.2.7 The required number of test unit-hours is the product of the multiplier and the test acceleration factor.

8.2.8 The number of units to be tested and the number of test hours per unit are to be chosen such that at least the minimum units are tested for the minimum hours specified in Table 8.3.

Table 8.3
Minimum requirements for test unit-hours

Test unit-hours	Minimum units	Minimum test hours per unit
Less than 1000	20	24
1000 – 6000	20	50
Greater than 6000	25	240

8.2.9 The activation energy (EA) of a failure mechanism that results in a critical component to fail first is to be determined experimentally by observing the times-to-failure of different lots of a component at different temperatures in accordance with the procedure described in 8.2.10 – 8.2.13 or, at the manufacturer's option, an activation energy value of 0.65 eV is to be assumed.

8.2.10 The Arrhenius equation describing the relationship between the temperature and the velocity coefficient of chemical reactions is to be used to judge the relationship between component life and temperature. This equation, as applied in this case, indicates that the natural logarithm of component life is a linear function of the reciprocal of the absolute temperature. The best fit of the slope and intercept of the straight line that relates the natural logarithm of component life to the reciprocal temperature is to be determined by the least-squares method of linear regression analysis.