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**Underwriters Laboratories Inc.®**A not-for-profit organization dedicated to public safety
and committed to quality service**February 17, 1995****Revision pages for****Standard for****Primary Safety Controls for Gas- and Oil-Fired Appliances****UL 372, Fifth Edition**

Attached to this transmittal notice is a revision of the Fifth edition of UL 372.

A CHANGE ON A PAGE DATED FEBRUARY 17, 1995 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT EXCEPT FOR PARAGRAPHS 3.17.1, 3.31, 4.7, 30.A1, SECTIONS 4A, 30A, 30B, AND 30C, WHICH BECOME EFFECTIVE JANUARY 2, 1998 AS INDICATED IN THE SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM. TO RETAIN THE REQUIREMENTS IN EFFECT UNTIL JANUARY 2, 1998, DO NOT DISCARD THE PREVIOUS PAGES CONTAINING THE REQUIREMENTS SPECIFIED ABOVE UNTIL THIS FUTURE EFFECTIVE DATE.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this standard unless the applicant specifically requests that the product be judged under the current requirements. However, should the applicant elect this option, it should be noted that compliance with all the requirements in this standard will be required as a condition of continued Listing and Follow-Up Services after the effective date and understanding of this should be signified in writing.

The new and revised requirements are substantially in accordance with UL's bulletins on this subject dated September 30, 1993 and March 14, 1994. These bulletins are now obsolete and may be discarded.

Revised and/or additional pages may be issued from time to time.

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

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4, 5	February 11, 1994
6 – 10, 11, 12, 12A, 13, 14	February 17, 1995
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Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated February 11, 1994. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

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Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest published set of revision pages.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover primary safety controls for gas, gas-oil, and oil-fired appliances. These safety controls are intended to sense the presence or absence of flame and, in the event of ignition failure or unintentional flame extinguishment, cause safety shutdown.

1.2 These requirements are not intended to include those primary safety controls for gas appliances that are of the type intended primarily for use with gas appliances having inputs of 400,000 Btu per hour (120 kW) or less per individual combustion chamber.

1.3 Requirements for the installation and use of primary safety controls are included in Standards of the National Fire Protection Association, such as those for the installation of:

Oil-Burning Equipment, ANSI/NFPA 31-1987,

National Fuel Gas Code, NFPA 54, ANSI Z223.1-1988,

Ovens and Furnaces, ANSI/NFPA 86-1990, and

Furnace Explosions/Implosions in Multiple Burner Boiler-Furnaces, ANSI/NFPA 85C-1991.

1.4 Requirements for the installation of oil-burning equipment are included in codes such as:

The BOCA National Mechanical Code,

The Standard Mechanical Code, and

The Uniform Mechanical Code.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those in use when the standard was developed, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the level of safety for the user of the product as originally anticipated by the intent of this standard.

2 General

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

2.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

2.4 Specific components are recognized as being 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 for which they have been recognized. If a value for measurement is followed by a value in other units in parenthesis, the second value may be only approximate. The first stated value is the requirement.

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

3.2 **3.2 revised and relocated as 3.10.1 February 17, 1995**

3.3 COMBUSTION SAFEGUARD – See "Control, Primary Safety, 3.7."

3.4 CONTROL, INPUT (COMBUSTION) – A control that automatically regulates the firing rate at predetermined air-fuel ratio in accordance with load demand. It may be a type that positions the air and fuel supplies for low fire and high fire as required to meet the load demands, or it may be a modulating type that gradually varies the air and fuel supplies within limits to meet the load demand.

3.5 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.

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

3.7 CONTROL, PRIMARY SAFETY – An automatic control that monitors the operation of a gas-fired or an oil-fired burner. It normally consists of the following sections that may be integrated into a common unit or may be separate units, interconnected by wiring:

Programming unit – A device that programs the burner through start-up and shutdown operations in response to signals from regulating, limiting, and monitoring devices. It also provides the timings, as required, in proper sequence, for purging, flame establishing periods, and in case of flame failure, for safety shutdown (lockout).

Combustion detector – A device that is responsive to flame properties. It monitors the flame at the point of flame supervision and transmits a signal to the programming unit, indicating absence or presence of flame.

An ignition source and/or an ignition device may be included as part of the primary safety control.

3.7 revised February 17, 1995

3.8 CONTROL, SAFETY – An automatic control or interlock (including a relay, switch, or other auxiliary equipment used in conjunction therewith to form a safety-control system) that is intended to reduce a risk of fire, electric shock, or injury to persons.

3.9 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 (42.4 volts peak) or direct current and supplied by a primary battery or by a Class 2 transformer, or by a combination of transformer and fixed impedance, each of which, as a unit, complies with the 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.

3.10 FLAME-FAILURE RESPONSE TIME – The interval between the occurrence of flame extinguishment and de-energizing the safety shutoff circuit.

3.10.1 FLAME DETECTOR – See Control, Primary Safety, 3.7.

3.2 revised and relocated as 3.10.1 February 17, 1995

3.11 IGNITION, CONTINUOUS – Ignition by an igniter is continuously maintained at ignition temperature throughout the time the burner is in service, whether the main burner is firing or not.

3.12 IGNITION, INTERMITTENT – Ignition by an igniter that is automatically energized each time the main burner is to be fired. Ignition is maintained during the entire period that the main burner is firing.

3.13 IGNITION, INTERRUPTED – Ignition by an igniter that is automatically energized each time the main burner is to be fired. Ignition is maintained during the main burner flame-establishing period and then automatically cut off.

3.14 IGNITION, MANUAL – Ignition by a device or source that is manually energized.

3.15 IGNITION, PROVED – Ignition by an igniter that is supervised by a primary safety control sensing the presence of energy for ignition prior to permitting the main burner fuel to be delivered to the combustion zone.

3.16 IGNITION, UNPROVED – Ignition by an igniter assumed to be energized during the main burner flame-establishing period.

3.17 INTERLOCK – A control to prove the physical state of a required condition and to furnish the proof to the primary safety-control circuit.

3.17.1 LOCKOUT

- a) Volatile lockout – Denotes the safety shutdown condition of the control such that a restart can be accomplished by either a manual reset at the control or by an interruption of the power supply and its subsequent restoration.
- b) Non-volatile lockout – Denotes the safety shutdown condition of the control such that a restart can be accomplished only by a manual reset of the reset means at the control.

Added 3.17.1 January 2, 1998

3.18 MAIN BURNER FLAME-ESTABLISHING PERIOD – The interval of time the main burner fuel safety shutoff valves are permitted to be open before the primary safety control is required to supervise the main burner flame.

3.19 MANUAL RESET – The manual operation required after safety shutdown before the appliance can be restarted.

3.20 PILOT – A flame, smaller than the main flame, that is utilized to ignite the fuel at the main burner or burners.

3.21 PILOT, CONTINUOUS – A pilot that burns without turndown throughout the entire time the burner assembly is in service, whether the main burner is firing or not.

3.22 PILOT, EXPANDING – A pilot that burns throughout the entire time the burner assembly is in service, whether the main burner is firing or not. Upon a call for heat, the pilot is automatically expanded. The pilot may be turned down automatically at the end of the main burner flame-establishing period.

3.23 PILOT, FLAME-ESTABLISHING PERIOD – The interval of time fuel is permitted to be delivered to a proved pilot before the primary safety control is required to prove pilot flame.

3.24 PILOT, INTERMITTENT – A pilot that is lighted automatically each time there is a call for heat. It burns during the entire period that the main burner is firing.

3.25 PILOT, INTERRUPTED – A pilot that is lighted automatically each time there is a call for heat. The pilot fuel is cut off automatically at the end of the main burner flame-establishing period.

3.26 PILOT, PROVED – A pilot flame supervised by a primary safety control.

3.27 PURGE – To introduce air into the combustion chamber and the appliance flue passages in such volume and manner as to replace the air or gas-air mixture contained therein.

3.28 RECYCLE – A characteristic in some programming primary safety controls for automatically lighted burners that, upon accidental flame failure during a normal firing cycle and the subsequent shutoff of main burner fuel, will provide, after a preestablished shutdown period and under a normal starting program, one attempt to automatically light the main burner.

3.29 **RELIGHT** – A characteristic in some programming primary safety controls providing interrupted ignition for automatically lighted burners that, upon accidental flame failure during a normal firing cycle, will cause the ignition energy to be restored in not more than 0.8 seconds; then, if the main burner flame is not reestablished, safety shutdown occurs.

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

3.31 **SAFETY SHUTDOWN** – Denotes the de-energization of the fuel flow means by the control such that restart takes place only by a manual reset of the control or by automatic action of the control to recycle.

Revised 3.31 January 2, 1998

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

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

3A Instructions

Section 3A added February 17, 1995

3A.1 Table 3A.1 summarizes the information that is to be provided on or with a control in the form of marking, installation instructions or some form of communication for test and investigation purposes to judge compliance with the requirements in this Standard.

CONSTRUCTION

4 General

4.1 The primary input circuit of a safety control shall be 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.

4.2 A safety programming circuit of a primary safety control:

- a) Shall permit operation of the controlled equipment only when the circuit is closed, or
- b) Shall be such that failure to close the circuit, or an accidental open circuit will cause the fuel to be shut off within the prescribed flame-failure response time declared by the manufacturer or prevent an attempt to start the burner.

4.2 revised February 17, 1995

Table 4.1
Primary safety-control timings in seconds

Table 4.1 deleted February 17, 1995

4.3 The control circuit shall be such that it will permit the connection of limit controls that can directly open the circuits that function to interrupt the delivery of fuel for combustion.

Table 3A.1
Information to be provided on or with the control for proper use and
investigation of the control

Information	Details of requirements are covered in:	Method by which information shall be provided ^a
· Identification of manufactures or vendor	41.1(a)	M, I
· Control designation	41.1(b), 41.7	M, I
· Electrical ratings	40.1 – 40.3	M, I
· Information in regard to electrical connections	8.1.7, 8.2.8, 41.1(f), 41.6	M, I
· Limitations for mounting	22.2, 22.3	M, I
· Use of other than 60C rated wiring material	Table 27.1, footnote a; 41.2, 41.3	M, I
· Use of specific fittings	8.1.9	M, I
· Use of common disconnect	41.4	M, I
· Cautionary markings	42.1, 42.2	M, I
· Elevated and low ambient temperature ratings	41.5	I
· Operating sequence	4.4	I
· Minimum purge time, if applicable	4.14	I
· Maximum pilot flame establishing period, if applicable		
· At rated voltage	4.10, 4.13, 4.13.1	I
· At minimum voltage at which the control will operate	4.11, 4.13, 4.13.1	C
· Maximum main flame establishing period, if applicable		
· At rated voltage	4.10, 4.13, 4.13.1	I
· At minimum voltage at which the control will operate	4.10, 4.11, 4.13, 4.13.1	C
· Maximum flame-failure response time		
· At rated voltage	4.11, 4.13, 4.13.1	I
· At minimum voltage at which the control will operate	4.10, 4.11, 4.13, 4.13.1	C
^a M – Information to be provided by marking on the control. I – Information is to be provided in the installation instructions furnished with the control. C – Information that needs to be communicated for testing and investigation purposes only.		

Table 3A.1 added February 17, 1995

4.4 The control circuit shall provide a safe-start component check so that either no attempt to start the burner will be made, the control remains in the prepurge state (if provided as part of the programming) or the fuel will be shut off within the declared maximum pilot or main flame establishing period whichever is applicable, if the flame detection system, due to some fault, produces a signal indicating the presence of flame. For controls that incorporate electronic circuits, compliance is to be determined by Section 30A, FMEA Procedures. For controls not subject to FMEA Procedures, compliance is to be determined by simulating a flame prior to initiating the burner start-up and then observing that either burner operations does not occur or that safety shutdown occurs without exceeding the declared pilot or main burner flame establishing period.

* 4.4 revised February 17, 1995*

4.5 With reference to 4.4, the faults to be considered are indicated in 30A.3.

4.5 revised February 17, 1995

4.6 A control shall not permit continued cycles of burner operation without providing all the required safety programming, including the provisions for purge if such is declared as part of the control programming. Faults of the circuit components shall not negate any part of the safety programming or alter the sequence of operations. For controls that incorporate electronic circuits, compliance is to be determined by Section 30A, FMEA Procedures. For controls not subject to FMEA Procedures, compliance is to be determined by safe-start component check in accordance with 4.4 which shall include a continuity check of the circuit to establish that all circuit components are operational.

4.6 revised February 17, 1995

4.7 When the control interrupts the burner operation because of ignition, flame or control failure this shall result in safety shutdown and volatile or non-volatile lockout. See 3.17.1 and 3.31.

Exception: If declared by the manufacturer the control may provide an attempt to restart the burner through a recycle or relight operation. See 3.28 and 3.29, respectively.

Revised 4.7 January 2, 1998

4.8 A cover of a control shall be equipped with an interlock if opening or removal of the cover may cause the system to falsely indicate the presence of flame that, in turn, may result in a risk of fire or injury to persons.

4.9 Induction or capacity effects from extraneous sources, variations in field-installed control-circuit wiring, or accidental grounding of circuits, including flame rods, shall not cause a control to falsely indicate flame when the control is installed in accordance with the manufacturer's instructions. A special cable or shield required for this purpose shall be furnished with each control.

4.10 A primary safety control shall provide at least the following operations, in proper sequence, for programming the start-up and shut-down of the burner in accordance with the manufacturer's declared timings:

- a) Pilot or main burner flame establishing period or both.
- b) Safety shutdown within the flame-failure response time in the event of flame failure.
- c) Volatile or non-volatile lockout.

4.10 revised February 17, 1995

4.11 For the operations indicated in 4.10 the manufacturer shall declare the timings at the rated voltage and at the rated minimum and maximum ambient temperature ratings. For test purposes only, the timings for these operations have to be declared also at the minimum voltage at which the control operates to energize the fuel flow means.

4.11 revised February 17, 1995

4.12 **4.12 revised and relocated as 25.5 February 17, 1995**

4.13 The timings for pilot or main flame establishing period or both and for flame-failure response time shall not exceed the declared maximum timings when tested at the rated voltage and in the rated high and low ambient temperature in accordance with 28.2.1 - 28.2.4. The timings shall be tested also at the minimum voltage at which the control operates to energize the fuel flow means and at 110 percent rated voltage for both the low and high ambient temperature ratings (see 4.13.1).

Exception: For controls for which the timings are provided by an electrically heated bimetal timer, the timings under any combined conditions of low or high ambient temperature and increased or decreased voltage shall not exceed the maximum declared timing by more than 300 percent.

4.13 revised February 17, 1995

4.13.1 With respect to 4.13, if the declared high ambient temperature rating is less than 66°C (150°F) the timings are to be tested at 66°C instead of the rated high ambient temperature. Also, if the declared low ambient temperature rating is higher than 0°C (32°F), the timings are to be tested at 0°C instead of the rated low ambient temperature. The same tolerances that are specified in 4.13 apply to any combination of the test ambient and voltage at which the control continues to operate.

4.13.1 added February 17, 1995

4.14 If provision for purge is provided as part of the control programming, the observed purge timings at rated voltage and declared ambient shall not be less than declared timings. The minimum observed timings under a combination of any voltage from 70 to 110 percent of rated voltage, with any ambient from 0 to 66°C (32 to 150°F), shall not be less than 80 percent of rated timings. If the control is rated for use in ambients above or below those specified, the minimum observed timings shall not be less than 80 percent of declared timing at any combination of the declared high or low ambient and increased or decreased test voltage.

4.14 revised February 17, 1995

4.15 In accordance with the definition in 3.10 the flame-failure response time is to be the interval between the occurrence of flame extinguishment and the time all fuel shutoffs are de-energized, except that for controls that use a thermally actuated combustion detector (see 4.17) the timing shall be the interval measured from the time the sensing device first detects loss of flame to the time all fuel shutoffs are de-energized.

4.15 revised February 17, 1995

4.16 **4.16 deleted February 17, 1995**

4.17 A thermally-actuated combustion-detector shall respond to a change in the temperature of flame or flue gases (that is, respond to an increase or decrease in temperature rather than upon attaining a predetermined temperature). Such a detector shall indicate flame outage in not more than 20 seconds when tested in accordance with 28.5.

4.18 The safety programming of a primary safety control shall be such that the ignition system of an automatically lighted burner will be activated only before or simultaneously with the delivery of fuel to the ignition zone. If means for ignition are cut off before or at the termination of the pilot flame-establishing period or after the main flame has been established, the ignition (pilot and any pilot or mainflame igniter) shall remain off for the duration of that operating cycle.

Exception 1: For recycle type controls (see 3.28) the ignition means may be reenergized for an attempt to restart the burner after in accordance with recycle procedures that are part of the control programming.

Exception 2: For relight type controls (see 3.29) the ignition may be restored in not more than 0.8 seconds immediately following accidental extinguishment of the supervised flame.

4.18 revised February 17, 1995

4.19 Operating parts shall not sag, distort, melt, or oxidize during any of the tests specified herein.

4.20 An operating spring shall be retained and arranged to reduce abrasion, binding, buckling, or interference with its free movement.

4.21 Unless the cover construction complies with the requirements for hinged covers in 5.2.3 and 5.2.6, and unless all live parts are protected as required by 12.6, a handle, knob, or other operating means provided for manual manipulation shall be arranged so that such manipulation may be done exterior to the control enclosure. The position of such operating means shall be marked, if necessary, as a guide for proper operation.

4.22 A device that involves manual operations that might be done only at the time of installation, during servicing procedures, or seasonally, need not comply with 4.21 provided that the construction complies with the requirements in 4.25, 4.26, 12.6, 12.11, 12.12, and 12.15.

4.23 Controls that are to be adjusted only at the time of installation, during servicing, or seasonally, shall be judged with respect to the foregoing requirement.

4.24 Mechanical service functions that may have to be performed with the equipment energized include: operation of valves or connection to fittings that may be necessary during charging or pneumatic-system adjustment, adjusting water control, or expansion valves; adjusting the setting of temperature or pressure controls with or without marked dial settings; resetting control trip mechanism; operating manual switches; adjusting air-flow dampers. A factory-set and sealed control, having the set point sealed as described in 21.2 and 21.3 and not having marking or instructions for adjustment, is not considered to be adjustable.

4.25 An adjustable or resettable electrical control or manual switching device may be located or oriented with respect to uninsulated live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the intended direction of access if uninsulated live parts are not located:

- a) In front (in the direction of access) of the mechanism, and
- b) Near any side or behind the mechanism, unless guarded.

4.26 Parts of a control that are subject to contact during normal operation, adjustments, and user servicing shall be free of sharp corners and edges.

4.27 **Relocated as 27.11 February 17, 1995**

4A Safety Related Software

Added Section 4A January 2, 1998

4A.1 Primary safety controls that employ microprocessors that include safety-related software shall be evaluated using the Standard for Safety-Related Software, UL 1998.

4A.2 When applying the requirements in the Standard for Safety-Related Software, UL 1998, the software Class shall be defined as Class 2.

4A.3 A failure in the software during its intended operation shall not result in a loss of declared protective function as specified by the manufacturer, and the following is to occur:

- a) The overall control operates normally within the declared timings and sequence, or
- b) The control operates to de-energize the fuel delivery circuit within the declared flame failure response time and either establishes safety shutdown or fails to subsequently initiate a burner startup, or completes the current burner operating cycle normally but will either fail to subsequently start the burner or will establish safety shutdown.

5 Frame and Enclosure

5.1 General

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

Revised 5.1.1 effective February 25, 1996

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

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

5.1.4 Cast metal for an enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch (6.4 mm) thick at tapped holes for conduit; except that, other than at plain or threaded conduit holes, die-cast metal shall not be less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm²) or having any dimension greater than 6 inches (152.4 mm), and shall not be less than 1/16 inch (1.6 mm) thick for an area of 24 square inches or less and having no dimensions greater than 6 inches. The area limitations for metal 1/16 inch thick 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 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 thick die-cast metal for an enclosure housing only low-voltage circuits.

5.1.5 The thickness of a sheet-metal enclosure shall be as indicated in Tables 5.1 and 5.2, except that steel shall not be less than 0.032 inch (0.81 mm) thick [0.034 inch (0.86 mm) if zinc-coated] and nonferrous metal shall not be less than 0.45 inch (1.14 mm) thick at points where a wiring system is to be connected.

5.1.6 A transformer shall be housed within its own enclosure or within the main enclosure of a control within a combination thereof. A sheet-steel transformer enclosure shall have a thickness of not less than 0.026 inch (0.6 mm) if uncoated and not less than 0.029 inch (0.74 mm) if galvanized, except that sheet steel having a thickness of not less than 0.020 inch (0.51 mm) if uncoated and not less than 0.023 inch (0.58 mm) if galvanized may be used for a drawn end bell having maximum dimensions of 2-1/4 inches (57.2 mm) on the flat portion and 1-1/2 inches (38.1 mm) at the base of the drawn portion. A cast-metal transformer enclosure shall comply with the requirements in 5.1.4.

5.1.7 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 not be less than 1/16 inch (1.6 mm) thick. 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 not be less than 1/8 inch (3.2 mm) thick.

5.1.8 The mechanical strength of a:

- a) Nonmetallic enclosure, and
- b) Nonmetallic part (such as a reset knob, lever, or button) protruding through a hole in the enclosure larger than the area of a 7/8 inch (22.2 mm) diameter circle

shall be at least equivalent to a sheet metal enclosure of the minimum thickness specified in Table 5.1.

5.1.8 separated into 5.1.8 and 5.1.8.1 February 17, 1995

5.1.8.1 A nonmetallic part protruding through a hole less than the area of a 7/8 inch (22.2 mm) diameter circle shall be of noncombustible material.

5.1.8 separated into 5.1.8 and 5.1.8.1 February 17, 1995

11.2 All exposed dead metal parts requiring grounding shall be electrically connected to an equipment grounding terminal or lead.

11.3 To determine if a part is likely to become energized, it shall be evaluated on the basis of factors such as proximity to wiring and live parts, thickness and type of insulation, and by tests that may include burnout and dielectric withstand after overload, endurance, conditioning, or aging. Guards, baffles, and internal covers that do not require tools for removal will be removed when determining whether a part is exposed to contact. A part that can be contacted by a 3/4 inch (19.1 mm) diameter rod of any length or by the probe illustrated in Figure 12.1, when inserted through openings in permanently attached guards or baffles, is considered exposed for the purposes of grounding.

Revised 11.2 effective February 25, 1996

11.4 A metal part as described below need not to be grounded:

- a) An adhesive-attached metal-foil marking, screw, handle, or the like, that is located on the outside of enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts.
- b) An isolated metal part, such as a magnet frame or armature, small assembly screw, or the like, that is separated from wiring and uninsulated live parts.
- c) A panel or cover that does not enclose uninsulated live parts if insulated parts and wiring are separated from the panel or cover.
- d) A panel or cover that is insulated from electrical components and wiring by an attached insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick.
- e) A part on the back side of a component mounting panel or a part located so as to require major disassembly by using tools, unless it is likely that servicing will be done while energized after the disassembly has been made.

11.5 Except as indicated in 11.4, uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors and other electrical components, interconnecting tubing and piping, and the like shall be bonded for grounding if they may be contacted by the user or service personnel.

11.6 A soldering lug, a push-in (screwless) connector, or a quick-connect or similar friction-fit connector shall not be used for a field-connected grounding terminal.

11.7 An internal connection for bonding internal parts to the enclosure for grounding (but not for a field-installed grounding conductor) may employ a quick-connect terminal, provided the connector is not liable to be displaced. The terminal shall be limited for use with a branch circuit protective device rated 60 amperes or less and the size of the quick-connect terminal shall be as specified in Table 11.1.

11.8 The equipment-grounding terminal or lead grounding point shall be connected to the frame or enclosure by a positive means, such as by a bolted or screwed connection. The grounding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. The grounding point shall be located so that it is unlikely that the grounding means will be removed during normal servicing.

11.9 Except as indicated in 11.10, the circuitry of a control shall be arranged so that the equipment-grounding connection or conductor, the enclosure, the frame, the component-mounting panel, and the earth ground do not carry current except in the instance of an electrical fault.

Table 11.1
Quick-connect terminals

Maximum rating of branch circuit protective device, amperes	Nominal dimensions of quick-connect terminals,	
	Inch	(mm)
20 amperes or less	0.020 by 0.187 by 1/4	(0.51 by 4.75 by 6.35)
	0.032 by 0.187 by 1/4	(0.81 by 4.75 by 6.35)
	0.032 by 0.205 by 1/4	(0.81 by 0.52 by 6.35)
60 amperes or less	0.032 by 1/4 by 5/16	(0.81 by 6.35 by 7.94)

11.10 A single-point reference ground may be employed in a low-voltage or isolated limited secondary circuit. The enclosure, frame, or panel, including bolted joints may carry the current of a low-voltage circuit. In neither of these instances is such current to be carried through the field-equipment grounding means, the metallic raceway or other power-supply grounding means, or the earth ground.

11.11 A grounded-circuit conductor shall not be grounded at or in conjunction with a control.

11.12 Live parts and wiring shall be maintained away from unbonded parts, such as relay and contactor magnets and armatures by clamping, routing, or equivalent means.

11.13 If a component such as a remote sensor is likely to be separated from its normal grounding means after installation in the end-use appliance for purposes of testing or adjustment while the equipment is energized, it shall be provided with a bonding terminal or a bonding conductor that does not require removal for such service.

11.14 A bonding conductor shall be of copper, a copper alloy, or other material acceptable for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or equivalent means. A separate bonding conductor or strap shall:

- a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame, and
- b) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

11.15 Bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, or welded or soldered connections using materials having a melting point greater than 850°F (455°C) or by an equivalent construction complying with the requirements in 11.20. A bonding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material.

11.16 The continuity of a grounding system shall not rely on the dimensional integrity of nonmetallic material.

11.17 A single machine screw that is used for bonding purposes through screw threads shall engage at least two full threads in the metal. Two sheet metal or machine screws shall be considered an equivalent construction.

24 Reset Mechanism

24.1 A control shall not reset or be resettable without the circuit providing the functions in accordance with 4.4.

24.2 A control shall not reset as a result of ambient temperature changes above minus 35°C (minus 31°F).

24.3 A manually operated reset device shall be trip-free; that is, the automatic tripping shall be independent of the manipulation or position of the reset button, handle, lever, and the like.

24.4 A manually operated reset advice of a control shall not cause the control to function as an automatic-reset device if the reset means is held in the reset or on position.

24.5 A control with a manual reset shall be resettable exterior to the control enclosure, except that it may be resettable upon opening a cover if the cover construction complies with the requirements specified in 5.2.3 and 5.2.6, and the control complies with the requirements in 5.1.2.

24.6 A manually operated reset mechanism shall not subject the operating mechanism or means of support to undue strain.

PERFORMANCE

25 General

25.1 Except as otherwise indicated, representative commercial samples of a control shall be subjected to the applicable tests described herein. The order of tests, as far as applicable, shall be as indicated in Table 25.1; and, unless otherwise indicated, the various tests shall be conducted at rated frequency and ambient, and at the voltage indicated in the table.

25.2 An alternating-current control having no frequency rating is to be tested on a circuit having a frequency of 60 cycles, except that a circuit having a lower frequency may be employed if agreeable to those concerned.

25.3 A control that must be mounted in a definite position in order to function properly is to be tested in that position, provided that directions for mounting in the correct position are given on the control or on an instruction sheet supplied with the control. When mounted as intended, the control shall withstand without moving a torque of 100 pound-inches (11.3 N·m).

25.4 If the components of the control that provide the programming and safety shutdown timings in accordance with 4.10 and 4.14 are stressed during any of the specified tests, the timing determinations are to be made before and after these tests. The maximum or minimum timings declared by the manufacturer shall not be exceeded before and after performed tests.

25.4 revised February 17, 1995

25.5 Ambient temperature is assumed to be that normally prevailing in occupiable spaces. Normal room ambient temperature for the purpose of any of the tests in this standard is to be maintained between 21.1 and 25°C (70 and 77°F).

4.12 revised and relocated as 25.5 February 17, 1995

Table 25.1
Test voltages

Test	Voltage rating of control and load terminals and corresponding test potential in volts ^a					Numbers of paragraphs that apply
	110 – 120	220 – 240	245 – 277	440 – 480	550 – 600	
Input	120	240	277	480	600	26.1
Temperature	120	240	277	480	600	27.1 – 27.8
Electromagnet –						17.1 and 28.2
Overvoltage, ac or dc	132	264	305	528	660	
Undervoltage, ac	102	204	235	408	510	
Undervoltage, dc	96	192	222	384	480	
Minimum pull-in	84	168	194	336	420	28.3 and 28.4
Overload	120	240	277	480	600	29.1 – 29.14
Endurance	120	240	277	480	600	30.1 – 30.4
Dielectric withstand	As described in text					31.1 – 31.11
Volt-ampere capacity	120	240	277	480	600	32.1 – 32.3
Burnout	120	240	277	480	600	33.1 – 33.4
Short circuit	120	240	277	480	600	34.1 – 34.3

^a If the rating of the control does not fall within any of the indicated voltage ranges, it is to be tested at its rated voltage.

26 Input Test

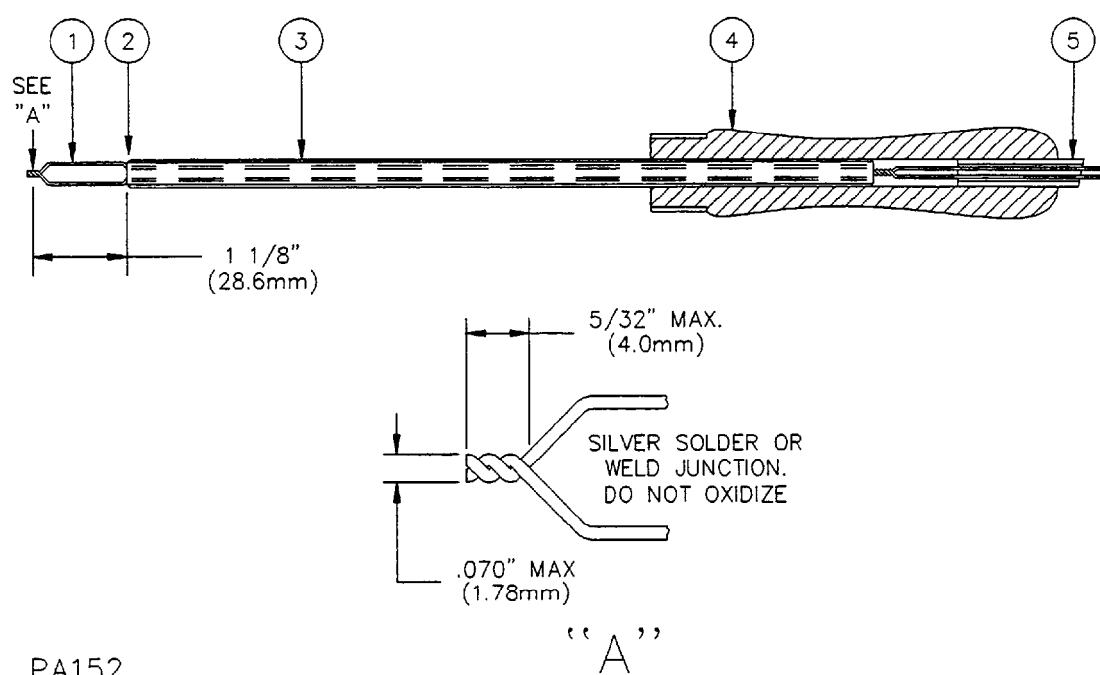
26.1 The input to a control shall not exceed the marked rating of the control by more than 10 percent when it is operated under the conditions of normal use and with the control connected to a supply circuit as indicated in Table 25.1.

27 Temperature Test

27.1 A control, when tested under conditions described in 27.2 – 27.8, shall not attain a temperature at any point sufficiently high to constitute a risk of fire or to damage any materials employed in the control, nor show temperature rises at specific points greater than those indicated in Table 27.1.

27.2 All values for temperature rises specified in Table 27.1 apply to a control intended for use in ambient temperatures normally prevailing in occupiable spaces, that usually are not higher than 25°C (77°F) but may be as high as 40°C (104°F) occasionally and for brief periods. Tests of a control for service with such ambient temperatures may be conducted (without correction) and with any ambient temperature in the range of 10 – 40°C (50 – 104°F). If a control is intended specifically for use in a prevailing ambient temperature constantly more than 25°C, the test of the control is to be made in such higher ambient temperature, and the temperature rises specified in the table are to be reduced by the amount of the difference between that higher ambient temperature and 25°C.

Figure 27.2
Thermocouple for flue-gas temperature



PA152

1. No. 20 AWG (0.51 mm^2) iron constantan, asbestos, or woven-glass-covered thermocouple wires extending from hot junction to potentiometer or reference junction.
2. 1 - Leeds & Northrup Standard 714B, or equal, 1/4 inch (6.4 mm) outside diameter of two-hole porcelain insulator cut to length and ends beveled on two sides.
3. 1 - 5/16 inch (7.9 mm) outside diameter by 0.032 inch (0.81 mm) wall tubing, Ream if necessary, to fit over insulator; then crimp ends over beveled ends of insulator.
4. 1 - Small wooden handle.
5. 1 - Piece of rubber tubing, approximately 5/16 by 3/32 by 2 inches long (7.9 by 50.8 mm long).
6. In lieu of individual components described in 1,2 and 3 above, any combination of preassembled parts of tubing, insulators and thermocouples may be used.

27.9 During the temperature test described in 27.1 – 27.8, the maximum temperature rise of a knob, handle, or button that may be contacted by the user during normal operation shall not be greater than the value specified in Table 27.2.

Table 27.2
Maximum surface temperature rise

Surface	Maximum temperature rise
Metal	35°C (63°F)
Nonmetallic	60°C (108°F)

27.10 The temperature rises specified in Table 27.2 are not applicable to a control intended specifically for use in a prevailing ambient temperature constantly more than 85°C (185°F).

27.11 With reference to 27.9, a knob or button made of a nonmetallic material that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is judged as a nonmetallic part.

4.27 relocated as 27.11 February 17, 1995

28 Operation Test

28.1 An electromagnet shall withstand 10 percent above its rated voltage continuously without damage to the operating coil and operate successfully at 20 percent less than rated voltage if for use on direct current, or at 15 percent less than rated voltage, if for use on alternating current. A control having a voltage rating within one of the ranges specified in Table 25.1 is to be tested at the test voltage specified in that table.

28.2 For the operation at minimum voltage, the coil is to be subjected to the normal high-voltage until equilibrium temperature is reached and then tested immediately for closing at the minimum voltage.

28.2.1 With reference to 4.10, 4.11, 4.13, 4.13.1, 4.14, and 4.15, compliance with the manufacturer's declared maximum and minimum timings, as applicable, shall be determined by tests. For these tests the control shall be connected to the rated power supply that is variable between the specified decreased and increased voltage values. No external loads need to be connected except for lamps to indicate operating sequence and time of operation. For tests that involve proving of flame either an actual flame or appropriate flame simulation may be used.

28.2.1 added February 17, 1995

28.2.2 For low and high ambient temperature tests the control is to be placed in an ambient chamber where the temperature is maintained within plus or minus 3°C (5°F) of the specified test ambient. The control shall be held in the test ambient temperature for at least 4 hours before conducting the tests.

28.2.2 added February 17, 1995

28.2.3 Tests shall be conducted on one sample control, at least two tests for each of the timings. The time interval between the tests shall be at least 15 minutes, unless the previous test does not influence the results of the subsequent test. If the test starts with the control energized and in an operating mode, the control shall be operated in that mode at least 15 minutes before starting the test.

28.2.3 added February 17, 1995

28.2.4 None of the timings shall exceed or be less than the manufacturer's declared maximum or minimum values, as applicable, except as specified by 4.13, 4.13.1 and 4.14 for the combination of low or high ambient and increased or decreased voltage conditions.

28.2.4 added February 17, 1995

28.3 With reference to 4.11, tests are to be conducted to determine that either the fuel delivery means are not energized at a voltage lower than the declared value by the manufacturer or that safety shutdown occurs within the manufacturer's maximum declared timing if the voltage is reduced to below the declared value.

28.3 revised February 17, 1995

28.4 To determine compliance with the requirements in 28.3, the control is to be tested in its normal mounting position while placed in an ambient maintained:

- a) At normal room temperature, 25°C (77°F), and
- b) At the control's rated ambient temperature if different from 25°C.

28.5 To determine that it complies with the requirement in 4.17, a combustion detector intended to be inserted into a chimney connector or heat exchanger is to be installed on the chimney connector of the boiler described in 27.6. A burner-mounted type of combustion detector is to be applied as intended to a burner installed to fire that or a similar boiler. The boiler is to be fired as described in 27.6 until equilibrium temperatures are attained, and then the burner is to be shut off. During the 20 seconds immediately following flame extinguishment, the flue-gas temperature is to drop approximately 125°C (225°F).

29.14 For a grounded-neutral system, the enclosure is to be connected during the test through a 30 ampere cartridge fuse to the grounded conductor of the circuit. For any other system, the enclosure is to be connected through such a fuse to the live pole least likely to arc to ground.

Table 29.2
Full-load motor-running currents in
amperes corresponding to various
DC horsepower (kW output) ratings

Rating		Volts		
Horsepower (kW)		110 – 120	220 – 240	550 – 600
1/10	(0.08)	2.0	1.0	—
1/8	(0.09)	2.2	1.1	—
1/6	(0.13)	2.4	1.2	—
1/4	(0.19)	3.1	1.6	—
1/3	(0.25)	4.1	2.0	—
1/2	(0.37)	5.4	2.7	—
3/4	(0.56)	7.6	3.8	1.6
1	(0.75)	9.5	4.7	2.0
1-1/2	(1.12)	13.2	6.6	2.7
2	(1.49)	17.0	8.5	3.6
3	(2.24)	25.0	12.2	5.2
5	(3.73)	40.0	20.0	8.3

Table 29.3
Full-load motor-running currents in amperes
corresponding to various AC
horsepower (kW output) ratings

Horsepower (kW)		110 – 120 volts			220 – 240 volts			440 – 480 volts		550 – 600 volts	
		Single- phase	Two- phase	Three- phase	Single- phase	Two- phase	Three- phase	Two- phase	Three- phase	Two- phase	Three- phase
1/10	(0.08)	3.0	—	—	1.5	—	—	—	—	—	—
1/8	(0.09)	3.8	—	—	1.9	—	—	—	—	—	—
1/6	(0.13)	4.4	—	—	2.2	—	—	—	—	—	—
1/4	(0.19)	5.8	—	—	2.9	—	—	—	—	—	—
1/3	(0.25)	7.2	—	—	3.6	—	—	—	—	—	—
1/2	(0.37)	9.8	4.0	4.0	4.9	2.0	2.0	1.0	1.0	0.8	0.8
3/4	(0.56)	13.8	4.8	5.6	6.9	2.4	2.8	1.2	1.4	1.0	1.1
1	(0.75)	16.0	6.4	7.2	8.0	3.2	3.6	1.6	1.8	1.3	1.4
1-1/2	(1.12)	20.0	9.0	10.4	10.0	4.5	5.2	2.3	2.6	1.8	2.1
2	(1.49)	24.0	11.8	13.6	12.0	5.9	6.8	3.0	3.4	2.4	2.7
3	(2.24)	34.0	16.6	19.2	17.0	8.3	9.6	4.2	4.8	3.3	3.9
5	(3.73)	56.0	26.4	30.4	28.0	13.2	15.2	6.6	7.6	5.3	6.1

30 Endurance Test

30.A1 The tests described in 30.1 - 30.4 are for testing the contacts of electromagnetic relays and other non-electronic switching devices. These conditions may be used to test the complete controls or the switching devices separately, if the switching devices are combined with electronic circuits that need to be subjected to thermal cycling tests in accordance with Section 30A, see also 30A.1.

Added 30.A1 effective January 2, 1998

30.1 A control shall perform successfully when operated manually, thermally, or by means of an acceptable machine, as appropriate, for the number of cycles specified in 30.2, and at a rate of 6 cycles per minute unless the nature of the device requires a longer time to complete a cycle of operation. If an electrical load is involved, and except as otherwise noted, a switch is to make and break its rated current at the voltage specified in Table 25.1. There shall be no electrical or mechanical failure of the control, nor undue burning, pitting, or welding of the contacts. A switch contact for control of a motor is to be tested with full-load motor current; if the switch is rated in horsepower instead of full-load motor current, the latter value is to be determined from Table 29.2 or 29.3, whichever is applicable. If the switch contact controls a direct-current motor and if the specified rate of operation is 6 cycles per minute, the potential of the test circuit is to be 50 percent of the value in Table 25.1.

30.2 The conditions for the endurance test are to be as described in 29.8 – 29.14. The endurance test for a control is to consist of at least 100,000 cycles. A manual-reset safety switch or device in a control is to be tested for at least 6000 cycles. A switch not normally called upon to make and break a load, but that will do so when the control functions to prevent abnormal operation of the controlled equipment, is to be tested for at least 6000 cycles under that load.

30.3 A switch intended for pilot duty shall perform acceptably when operated for the number of cycles specified in 29.2, making and breaking a circuit of rated frequency and at the voltage specified in Table 25.1. There shall be no electrical or mechanical failure of the control, nor undue pitting or burning of contacts. Unless the nature of the control requires a longer time to complete a cycle of operation, the rate of speed of operation for the test is to be as follows: for a manually operable control, the first 1000 cycles are to be at the rate of 1 cycle per second (except that the first 10 or 12 operations are to be made as rapidly as possible) and the remaining cycles are to be at the rate of 6 cycles per minute, with the switch closed for approximately 1 second each cycle; and for a self-actuated control the entire number of cycles is to be at the rate of 6 cycles per minute, with the switch closed for approximately 1 second each cycle. The load is to consist of an electromagnet representative of the magnet-coil load intended to be controlled. The normal current is to be determined from the voltage and volt-ampere rating of the control. The test current is to be the normal current; and for an alternating-current rating, the power factor is to be 0.35 or less and the inrush current is to be ten times the normal current. The test is to be conducted with the contactor free to operate, that is, not blocked either open or closed.

30.4 If a control requiring an endurance test of 100,000 cycles has two or more electrical ratings (that is, different currents at different voltages) that are approximately equal in volt-amperes, it may be tested for not less than 25,000 cycles at each rating, but the total number of cycles on any one sample is not to be more than 100,000. At least one sample, however, is to be tested for a total of 100,000 operations.

30A FMEA Procedures

Added Section 30A January 2, 1998

30A.1 To determine compliance with 4.4 and 4.6, a control that includes electronic circuits and components is to be subjected to a component failure mode effect analysis in accordance with 30A.2 -30A.5. A control is considered to be in compliance if, with one component faulted, it operates in accordance with either (a), (b), or (c).

a) The control continues to operate normally within the declared timings and sequence. In this event the component is to be left in the failed state, the control is deenergized, and a second component is to be faulted (see 30A.5) until all circuit components are faulted, one at a time, in conjunction with the original component faulted. The control shall still continue to operate within the declared timings and sequence or (b) or (c) will occur.

b) The control operates to de-energize the fuel delivery circuit within the declared flame failure response time and either establishes safety shutdown or fails to subsequently initiate a burner start-up.

c) The control completes the current burner operating cycle but will either fail to subsequently start the burner or will establish safety shutdown.

30A.2 For this analysis the control is to be at normal room temperature of $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) and energized at rated voltage. However, tests are to be conducted also at 85 percent and 110 percent rated voltage and in rated high and low ambients if it is observed that introduction of faults may affect the control programming and response timings.

30A.3 Except as indicated in 30A.1(a), faults are to be introduced to one component at a time and observations for each fault are to be continued for sufficiently long time to determine the ultimate effect. The faults indicated in Table 30A.1 are to be considered.

Table 30A.1
Electrical faults

Component	Type of fault	
	Open circuit	Short circuit
Resistor		
Thin film	yes	no
Metal film	yes	no
Wire wound	yes	no
All others	yes	yes
Capacitors	yes	yes
Diodes	yes	yes
Transistors		
Each pin connection to circuit ^a	yes	Not applicable
Pins to each other ^b	Not applicable	yes
Integrated circuits		
Each pin connection to circuit ^a	yes	Not applicable
Adjacent pins to each other ^b	Not applicable	yes
Each pin to referenced ground ^a	Not applicable	yes
Each pin to power supply ^a	Not applicable	yes
Relay coils	yes	no
^a One pin at a time only.		
^b One pair of the pins at a time only.		

30A.4 If faulting of a component damages the component or other components and renders the circuit inoperational after the fault is removed, the damaged components are to be replaced for analysis of other faults.

30A.5 With respect to 30A.1(a) if two or more components are provided for redundancy so as to guard against an unsafe operation with the fault of a single component, only one of the redundant components is to be faulted at the time, provided that:

- a) The failure of one of the components does not electronically overload the others, and
- b) A single fault occurring in the circuit does not place a faulted condition on redundant components.

30B Mains Borne Perturbations, Magnetic and Electromagnetic Disturbances

Added Section 30B effective January 2, 1998

30B.1 General

30B.1.1 The controls that include solid-state circuits or components is to be subjected to tests specified in 30B.1.2 – 30B.7.3 in accordance with the Standard For Tests For Safety-Related Controls Employing Solid-State Devices, UL 991, except using the test parameters and conditions included in 30B.1.2 – 30B.7.3.

30B.1.2 After each test the control shall operate in accordance with either (a), (b), (c), (d), (e) or (f), as specified in 30B.1.3 – 30B.7.3.

- a) The control continues to operate in its normal operating sequence and declared timings.
- b) The control operates to de-energize the fuel flow means or both the fuel flow means and the ignition source.
- c) The control completes the current operating cycle with either the fuel flow means or both the fuel flow means and the ignition source de-energized and fails to start the subsequent cycle.
- d) The control completes the current cycle with either the fuel flow means or both the fuel flow means and the ignition source de-energized and initiates a new start-up procedure and thereafter operates in its normal operating sequence and declared timings.
- e) For the disturbances applied during the normal running condition with the flame being proved, the control may initiate a reignition procedure, if designed to do so, and thereafter operates in its normal operating sequence and declared timings.
- f) The control goes into safety shutdown condition.

30B.1.3 With reference to 30B.1.2, the determination for normal operation is to be made at normal room temperature of $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$) and at rated voltage. However, tests are to be conducted also at 85 percent and 110 percent rated voltage and in rated high and low ambients if it is observed that introduction of the disturbances may have affected the control programming and response timings.

30B.1.4 A separate sample is to be used for each test except, at the option of the manufacturer, multiple tests may be performed on a single sample. In this case after each test it is to be determined that the control operates in its normal operating sequence and declared timings. See 30B.1.3.

30B.2 Voltage dips and interruptions

30B.2.1 After the application of each voltage dip or voltage interruption as described in 30B.2.2 and 30B.2.3 the control shall comply with the criteria specified in Tables 30B.2 and 30B.3 as applicable for the specific operating sequence during which the dip or the interruption was applied. The dips and interruptions applied during the pilot or main burner flame establishing period (30B.2.3(b)) shall not extend the flame establishing period by a time longer than the applied voltage dip or interruption.

30B.2.2 The control is to be initially operated at its rated voltage and then subjected to instantaneous voltage dips and voltage interruptions in accordance with 30B.2.3 and Table 30B.1:

Table 30B.1
Voltage dip and interruptions test

Test	Test Conditions	
	Percent of dip based on rated voltage	Duration of dip or interruption
Voltage dips	30	0.5 second
	60	0.5 second
Voltage interruptions	100	1/2 and 1 cycle of supply waveform
	100	0.5 second
	100	60 seconds

30B.2.3 Each voltage dip or voltage interruption test is to be performed three times in each of the following operating conditions.

- During the standby time or purge.
- During the pilot flame establishing period, if one is provided as part of the programming sequence or during the main flame establishing period, if the pilot flame establishing period is not part of the programming sequence.
- During the normal running condition with the control sensing flame or simulated flame.
- While the control is in lockout condition.

Table 30B.2
Required performance for voltage dip tests

Voltage dip applied during the operating sequence indicated by the referenced item of 30B.2.3	Required performance as indicated by the referenced item of 30B.1.2	
	30 percent of rated voltage	60 percent of rated voltage
(a)	(a), (d)	(a), (d), (f)
(b)	(a), (d)	(a), (d), (f)
(c)	(a), (d), (e)	(a), (d), (e), (f)
(d)	(a) ^a	(a) ^a

^a Systems in volatile lockout may restart. Systems in non-volatile lockout shall remain in lockout.

Table 30B.3
Required performance for voltage interruption tests

Voltage interruption applied during the operating sequence indicated by the referenced item of 30B.2.3	Required performance as indicated by the referenced item of 30B.1.2		
	1 cycle of waveform	0.5 second	60 seconds
(a)	(a), (d)	(a), (d), (f)	(d), (f)
(b)	(a), (d)	(a), (d), (f)	(d), (f)
(c)	(a), (d), (e)	(a), (d), (e), (f)	(d), (f)
(d)	(a) ^a	(a) ^b	(a) ^b

^a Systems shall remain in lockout.

^b Systems in volatile lockout may restart. Systems in non-volatile lockout shall remain in lockout.

30B.3 Ramp voltage tests

30B.3.1 After each of the tests in 30B.3.2 and 30B.3.3 the control shall operate in accordance with any of the operating conditions specified in 30B.1.2.

30B.3.2 Each control is to be subjected to a gradual input voltage increase starting initially with the voltage reduced to 20 percent of rated input. The voltage is then continuously increased to rated voltage at the rate of 40 percent of rated voltage per second. This test is to be repeated three times in each of the operating conditions specified in 30B.2.2.

30B.3.3 Each control is to be subjected to a gradual voltage decrease. Starting with the rated voltage, the input is to be decreased to 20 percent of rated voltage at the rate of 40 percent of rated voltage per second. This test is to be repeated three times in each of the operating conditions specified in 30B.2.2.

30B.4 Voltage/current surge tests

30B.4.1 After each of the severity level I tests for low voltage controls and severity level II tests for line voltage controls the controls shall operate in accordance with 30B.1.2(a). After each of the severity level II tests for low voltage controls and severity level III tests for line voltage controls the controls shall operate in accordance with any one of the criteria specified in 30B.1.2.

30B.4.2 Using the unidirectional wave surge generator circuit and waveshapes shown in the Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, under Transient Overvoltage Test and the severity levels specified in 30B.4.3 each control is to be subjected to fire impulses at each polarity, plus (+) and minus (-), applied in turn, between the power supply terminals of the control and between each of the load terminals, at intervals not less than 60 seconds. For these tests the control is to be energized at rated voltage. Approximately half of the tests are to be conducted with the control in the lockout condition and the other half during other operating sequences which are considered to be most likely effected by the voltage or current surges.

30B.4.3 Both the low voltage and line voltage rated controls are to be tested at two of the severity levels of the peak values of open-circuit voltage and short-circuit current of the surges, in accordance with Table 30B.4.

Table 30B.4
Maximum input

Maximum rated input voltage, V	Peak value of the surges					
	Severity level I		Severity level II		Severity Level III	
	kV	kA	kV	kA	kV	kA
30	0.5	0.25	0.8	0.4	—	—
300	—	—	1.6	0.8	2.5	1.25

30B.5 Ring wave test

30B.5.1 The ring wave test is to be conducted the same as voltage/current surge tests in 30B.4.1 – 30B.4.3 except by using a ring wave generator that produces a test wave form consisting of a pulse with a rise time of 0.5 microsecond followed by an oscillation at 100 KHz with a decrement such that each peak is 60 percent of the preceding peak.

30B.5.2 The severity levels based on the rated input voltages and the peak voltage of the pulse shall be the same as specified in 30B.4.2. The acceptance criteria after each test shall be the same as specified in 30B.4.3.

30B.6 Electrostatic discharge tests

30B.6.1 Each control is to be subjected to electrostatic-discharge tests in accordance with the Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, except as described in 30B.6.2 and 30B.6.3. After each of the severity level I tests the controls shall operate in accordance with 30B.1.2(b). After each of the severity level II tests the controls shall operate in accordance with any one of the criteria specified in 30B.1.2.

30B.6.2 Each control is to be subjected to five sequences of discharges at two severity levels of voltage ranges. At severity level I the range is to be 2.0 to 5.0 kV ± 5 percent; at severity level II the range is to be 2.0 to 15.0 kV ± 5 percent. The discharges are to be applied to all accessible surfaces, including the surfaces which are accessible after detachment of the parts that need to be removed for installation of the control. The discharge electrode tip is to be moved as fast as possible toward the control.

30B.6.3 Two of the five discharges are to be applied with the control in the lockout condition. The remaining three discharges are to be applied with the control in operating sequences which are considered to be most affected by the discharges.

30B.7 Radiated electromagnetic field test

30B.7.1 Each control is to be subjected to tests in accordance with Radiated EMI tests in the Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, except as described in 30B.7.2.

30B.7.2 Each control is to be subjected to two sweeps of the frequency range of 27 MHz to 500 MHz at two severity levels of the field strength. At the severity level I the field strength shall be 3 Volts/meter, at the severity level II the field strength shall be 10 Volts/meter.

30B.7.3 One of the sweeps is to be conducted while the control is in the lockout condition. The other sweep is to be conducted with the control operating in a sequence which is considered to be most affected by the electromagnetic radiation.

30C Thermal cycling test for electronic devices

Added Section 30C January 2, 1998

30C.1 The controls that include electronic circuits or devices is to be subjected to a 14 day thermal cycling test as described in 30C.2 - 30C.5. Warning – Risk of electric shock if condensation forms during this test. Conduct this test in a room with a low relative humidity.

30C.2 The control is to be tested in an ambient chamber in which the temperature can be varied between the minimum and maximum temperature declared by the manufacturer in accordance with 30C.3. During the test the control is to be energized at 110 percent of rated voltage except for 30 minutes during each 24 hour period it is to be reduced to 90 percent of rated voltage. The change in voltage is not to be synchronized with the change in the ambient temperature. The load terminals of the control is to be connected to the maximum rated loads as declared by the manufacturer.

30C.3 The ambient temperature during the test is to be varied between the manufacturer's specified minimum temperature and maximum temperature. The rate of change in the temperature is to be approximately 1°C (2°F) per minute. When the minimum or maximum ambient temperature is reached, that temperature is to be maintained for one hour before initiating another change.

30C.4 During the test the control is to be cycled through its normal operational modes of start-up, flame sensing, and shutdown at the fastest rate possible up to a maximum of six operating cycles per minute.

30C.5 If convenient the testing of the contacts of the non-electronic switching devices can be combined with test described in 30C.1 - 30C.3. For this, the number of cycles accumulated during the test in accordance with 30C.1 - 30C.3 shall be recorded. After completion of the 14 day test the test voltage is to be adjusted to rated voltage and the test ambient temperature is to be maintained at the manufacturer's declared maximum ambient rating. The test is then to be continued to accumulate a total of 100,000 cycles of operation.

31 Dielectric Voltage-Withstand Test

31.1 High-voltage portions of a control shall withstand for 1 minute without breakdown the application of a 60 hertz potential of 1000 volts plus twice maximum rated voltage of the circuits involved between:

- a) Uninsulated high-voltage live parts and grounded or exposed metal parts of the enclosure with the contacts open and closed,
- b) High-voltage terminals of opposite polarity with the contacts closed,

36.4 With regard to 36.1 – 36.3, distortion of the enclosure does not constitute a failure. The test may be discontinued when noticeable distortion occurs.

37 Tests on Covers

37.1 A snap-on cover that gives access to bare live parts and that does not require a tool for removal shall withstand the following tests:

- a) A cover that can be removed with one hand shall not be released when a squeezing force of 14 pounds (62.3 N) is applied at any two points that are not more than 5 inches (127 mm) apart, as measured by a tape stretched tightly over that portion of the surface of the cover that would be encompassed by the palm of the hand. The test is to be performed before and after ten removal and replacement operations;
- b) A cover shall not become disengaged from the case when a direct pull of 14 pounds is applied. For this test, the cover is to be gripped at any two convenient points. The test is to be performed before and after ten removal and replacement operations; and
- c) A cover shall withstand an impact of 1 foot-pound (1.36 J) applied to the accessible faces of the cover (one blow per face) without being displaced. The radius of the ball used for this test is not to be less than 1 inch (25.4 mm).

37.2 All nonmetallic covers that give access to bare live parts shall comply with the requirements in 37.1 both with the cover screws tightened, and with the cover screws loosened one full turn.

38 Marking Plate Adhesion Tests

38.1 General

38.1.1 To determine if a pressure-sensitive label or a label secured by cement or adhesive is of a permanent nature, representative samples are to be subjected to the applicable tests described in 38.2.1 - 38.6.1. In each test, three samples of the label are to be applied to test panel surfaces representative of the intended application. Labels intended for indoor residential equipment may be subjected to the humidity test in lieu of the immersion test.

38.1.1 revised February 17, 1995

38.1.2 The label is considered to be of a permanent nature if:

- a) Immediately following removal from each test medium, and
- b) After being exposed to room temperature for 24 hours following removal from each test medium:
 - 1) Each sample demonstrates good adhesion and the edges are not curled.
 - 2) The label resists defacement or removal as demonstrated by scraping across the test panel with a flat metal blade 1/32 inch (0.8 mm) thick, held at right angles to the test panel.
 - 3) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

38.2 Oven-aging test

38.2.1 Samples are to be placed in an air oven for 240 hours maintained at the temperature indicated in Table 38.1.

Table 38.1
Maximum aging temperatures

Maximum temperature, during normal-temperature test, of surface to which applied degrees C (F)	Test temperature, degrees C (F)
60 (140) or less	87 (189)
80 (176) or less	105 (221)
100 (212) or less	121 (250)
125 (257) or less	150 (302)
150 (302) or less	180 (356)

38.3 Humidity test

38.3.1 Samples are to be exposed for 72 hours in a controlled atmosphere having a relative humidity of 85 ± 5 percent at a temperature of $32 \pm 2^\circ\text{C}$ ($90 \pm 4^\circ\text{F}$).

38.4 Immersion test

38.4.1 Samples are to be placed in a controlled atmosphere maintained at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) with a 50 ± 5 percent relative humidity for 24 hours. The samples are then to be immersed in water at a temperature of $21 \pm 2^\circ\text{C}$ ($69.8 \pm 3.6^\circ\text{F}$) for a period of 48 hours.

38.5 Standard-atmosphere test

38.5.1 Samples are to be placed in a controlled atmosphere maintained at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) with a 50 ± 5 percent relative humidity for 72 hours.

38.6 Unusual-condition exposure test

38.6.1 If the labels are exposed to unusual conditions in service (such as medicants, detergents, oils, or the like), samples are to be placed in a controlled atmosphere maintained at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) with a 50 ± 5 percent relative humidity for 25 hours. The samples are then to be immersed in a representative solution of service use maintained at $21 \pm 2^\circ\text{C}$ ($69.8 \pm 3.6^\circ\text{F}$) for 48 hours. For exposure to detergents, the solution is to consist of a mixture of 25 grams of a commercial detergent per liter of water.