UL 810

STANDARD FOR SAFETY

Capacitors

UL Standard for Safety for Capacitors, UL 810

Sixth Edition, Dated October 29, 2019

Summary of Topics

This revision of ANSI/UL 810 dated February 27, 2025 is being issued to include 50 Hz testing: Figure 12.1.

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated January 24, 2025.

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Standard for Capacitors

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The most recent designation of ANSI/UL 810 as an American National Standard (ANSI) occurred on February 27, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 The requirements in Part I of this Standard apply to enclosed capacitors with integral protection intended to reduce the risk of rupture and venting of the capacitor enclosure under internal fault conditions. These requirements apply to capacitors with expansion type protection rated 5 kV or less, and capacitors with segmented film type protection rated 2 kV or less that are intended for use with appliances, lighting equipment, air conditioning and refrigeration equipment, motors, and the like, that comply with the requirements for such appliances and equipment.

1.2 The requirements of Part I may also be used to evaluate the construction only of these types of capacitors with ratings greater than the values noted in 1.1 but no greater than 7.2 kV. Capacitors employing polymeric enclosures or capacitors employing a partial metallic enclosure (i.e. remainder of enclosure such as the cap/cover which is not crimped to the case) that are not provided with internal protection and intended to be located in circuits not requiring fault current protection may be evaluated using only the construction requirements of Part I.

1.3 The requirements in Part II of this standard apply to general-use power-factor-correction units consisting of one or more capacitors with or without protective fusing or overloads, with or without a switch or other disconnect device all within a protective enclosure; rated 600 V maximum and intended for power-factor correction of circuits in accordance with the National Electrical Code, NFPA 70. This equipment is intended for installation in ordinary locations, in accordance with the National Electrical Code, NFPA 70, where the ambient temperature does not exceed 40°C (104°F) maximum. See 1.4.

1.4 The requirements of Part II of this standard do not apply to power factor correction units containing automatic or other circuit monitoring/conditioning controls or automatic systems of multiple connected power factor correction units. Power factor correction units with these additional features shall be evaluated to the Standard for Industrial Control Panels, UL 508A as an industrial control panel.

1.5 A component capacitor used in a power factor correction unit as described in Part II of this Standard has been evaluated for across-the-line applications in accordance with Part I of this Standard and has been evaluated for a minimum fault current rating of 10k AFC.

1.5A The requirements in Part III cover equipment having ac voltage ratings above 1000 V, up to 46 kV, intended to provide power factor correction for AC power systems. The power factor correction banks covered by Part III of this Standard are metal-enclosed assemblies consisting of one or more shunt power capacitor(s), with or without additional controls and switching devices necessary to provide control of the power factor of the system to which the equipment is connected. The power factor correction equipment covered by Part III of this Standard may be rated for indoor or outdoor use, and cover equipment intended for use in ordinary locations in accordance with the National Electrical Code.

1.6 The requirements of Supplement SA apply to electrolytic capacitors for motor start or similar applications including dc circuits rated 600 V or less.

1.7 A capacitor that complies with the requirements in Part I of this standard is intended to be mounted within an appliance or within equipment for which an acceptable outer enclosure is provided.

1.8 The requirements in Part I, Part II, and Part III do not apply to capacitors covered by the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

1.9 Other types of capacitors may be investigated to establish compliance with these requirements, and with such additional test criteria as may be found necessary.

1A Components

1A.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as specified in this Standard;

b) Be used in accordance with its rating(s) established for the intended conditions of use; and

c) Be used within its established use limitations or conditions of acceptability.

NOTE: See Annex A for a list of additional standards covering components generally used in the products covered by this Standard.

1A.2 A component of a product covered by this Standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product;

b) Is superseded by a requirement in this Standard; or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

1A.3 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.

1A.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable UL Standard(s) that cover devices that provide those functions.

1B Units of Measurement

1B.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

1C Referenced Publications

1C.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.

1C.2 The following publications are referenced in this Standard:

ASTM A90/A90M, *Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM A653/A653M, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*

ASTM E230/E230M, *Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

IEEE 4, *Techniques for High-Voltage Testing*

IEEE No. 18, *Shunt Power Capacitors*

IEEE C37.04, *Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V*

IEEE C37.09, *Standard Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V*

IEEE C37.24, *Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear*

IEEE C37.20.3, *Metal-Enclosed Interrupter Switchgear (1 kV–38 kV)*

IEEE 386, *Separable Insulated Connector Systems for Power Distribution Systems above 600 Volts*

ANSI/NEMA CC1, *Electric Power Connection for Substations*

NFPA 70, *National Electrical Code*

UL 50, *Enclosures for Electrical Equipment, Non-Environmental Considerations*

UL 50E, *Enclosures for Electrical Equipment, Environmental Considerations*

UL 62, *Flexible Cords and Cables*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 224, *Tubing, Extruded Insulating*

UL 347, *Medium-Voltage AC Contactors, Controllers, and Control Centers*

UL 248-1, *Low-Voltage Fuses – Part 1: General Requirements*

UL 248-11, *Low-Voltage Fuses – Part 11: Plug Fuses*

UL 486A-486B, *Wire Connectors*

UL 508A, *Industrial Control Panels*

UL 723, *Test for Surface Burning Characteristics of Building Materials*

UL 746A, *Polymeric Materials – Short Term Property Evaluation*

UL 746B, *Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 796, *Printed Wiring Boards*

UL 810A, *Electrochemical Capacitors*

UL 840, *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 969, *Marking and Labeling Systems*

UL 1059, *Terminal Blocks*

UL 1332, *Organic Coatings for Steel Enclosures for Outdoor Use Electrical Equipment*

UL 4248-1, *Fuseholders – Part 1: General Requirements*

UL 60384-14, *Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains*

UL 61058-1, *Switches for Appliances – Part 1: General Requirements*

2 Glossary

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

2.2 CAPACITOR ROLL – The layered and rolled interior windings of a capacitor, which is also known as the element.

2.3 CLASS 2 CIRCUIT – A circuit supplied by a Class 2 source in accordance with Article 725 of the National Electrical Code, NFPA 70.

2.4 COMPONENT CAPACITOR – Refers to a capacitor evaluated to Part I of the Standard. A component capacitor is also referred to as "capacitor."

2.5 CONTROLLED ENVIRONMENT – An environment that is relatively free of conductive contaminants, such as carbon dust and the like, that may result from the end-use equipment in which a capacitor or power-factor correction unit is installed or due to the location of the end-use equipment, and that is provided with protection against humidity and the formation of condensation.

2.6 DRY TYPE CAPACITOR – A capacitor that contains no liquid and utilizes a solid dielectric medium other than wax.

2.7 ELECTRODE, FOIL TYPE – Capacitor plates consisting of thin metal or “foil” separated by a dielectric.

2.8 ELECTRODE, METALLIZED – Capacitor plates consisting of dielectric material covered with metallic deposits such as aluminum on the surface. This type of electrode has a tendency to self restore or "re-heal" after local breakdown of the dielectric.

2.9 ELECTROLYTE – Current conducting solution (liquid, gel, or solid) between two electrodes or plates of an electrolytic capacitor at least one of which is covered by a dielectric film.

2.10 ELECTROLYTIC CAPACITOR – A capacitor consisting of two conducting electrodes whose anode has a metal oxide film. The oxide film acts as the dielectric or insulating medium. The electrode without the film and the electrolyte serve as the cathode. Electrolytic capacitors may be provided with either a solid or liquid electrolyte and may or may not be polarized.

2.11 ENCLOSURE – In Part I enclosure refers to the capacitor element housing. In Part II enclosure refers to the ultimate housing.

2.12 FIELD-WIRING TERMINALS – Terminals to which supply, control, output, or other permanent connections are made when the unit is installed.

2.13 HAZARDOUS LIVE PARTS – A live part having a potential greater than 30 Vrms (42.4 Vpeak) or 60 Vdc between the part and ground or a grounded part, or between adjacent live parts.

2.14 INTERNAL PROTECTION BRIDGE – A device that aids in the expansion of the capacitor enclosure in a direction that will interrupt the circuit, also referred to as a pressure interrupter.

2.15 LEAD – An insulated wire provided as the electrical connection to the capacitor.

2.16 LIMITED-POWER CIRCUIT – A circuit involving a potential of not more than 30 Vrms (42.4 Vpeak) or 60 Vdc and supplied by a limited power battery, a Class 2 transformer, or a combination of a transformer and a fixed impedance that as a unit complies with all the performance requirements for a limited power source as specified in Exception No. 2 of 34.1.1.

2.17 POLE LEAST LIKELY TO STRIKE TO GROUND – A pole that, by its position or potential or both relative to other poles of a capacitor or power-factor correction unit, considered to be less likely than any other to strike to ground. In a three pole device, this pole would usually be the middle pole. It is possible for several poles to be equally least likely to strike to ground. In this case any pole may be used for the test.

2.18 POWER FACTOR – The ratio of the actual power of an AC power producing product as measured by a wattmeter to the apparent power as measured by an ammeter and a voltmeter.

2.19 POWER-FACTOR CORRECTION – Addition of capacitors to an inductive circuit in order to increase the power factor by making the total current more nearly in phase with the applied voltage.

2.20 POWER-FACTOR CORRECTION UNIT – A group of capacitors housed in one enclosure that are connected ahead of an induction load (such as large motor driven equipment) to correct the power factor of that individual load. Also referred to as a unit in this standard.

2.21 PRESSURE SENSITIVE INTERRUPTER (EXPANSION TYPE PROTECTION) – An integral protection device that assists in the expansion process by providing resistance to internal pressure caused by a build-up of gases. Also referred to as an internal protection bridge.

2.22 PRIMARY CIRCUIT – A circuit that is directly connected to the AC main supply, for example, the means for connections to the AC supply, the primary windings of transformers, motors and other loading devices.

2.23 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, injury to persons, or electrical energy – high current levels. For example, in some applications, an interlock circuit is considered to be a safety circuit.

2.24 SAFETY EXTRA LOW-VOLTAGE (SELV) CIRCUIT – A secondary circuit which is designed and protected so that under normal and single fault conditions voltages do not exceed 30 Vrms (42.4 Vpeak) or 60 Vdc.

2.25 SECONDARY CIRCUIT – A circuit conductively connected to the secondary winding of an isolating power supply transformer. A secondary circuit has no direct physical connection to a primary circuit, but is coupled to the primary by electromagnetic induction only.

2.26 SEGMENTED METALLIZED ELECTRODE (SEGMENTED FILM TYPE PROTECTION) – An integral protection means where the metallized type electrode disconnects, similar to the way a fuse operates, due to a surge in current under a fault condition.

2.27 SEPARATOR – A liner provided to insulate the contents of the electrolytic capacitor from the external metal can.

2.28 SUPPLY CIRCUIT – The circuit supplying electrical energy to the product from a branch circuit or battery feed.

2.29 VENTING MECHANISM – The means employed within an electrolytic capacitor to relieve pressure when the contents of the capacitor overheat due to a fault condition.

3 General

3.1 Components

3.1.1 *Deleted*

3.1.2 *Deleted*

3.1.3 *Deleted*

3.1.4 *Deleted*

3.2 Units of measurement

3.2.1 *Deleted*

3.3 Undated references

3.3.1 *Deleted*

PART I – CAPACITORS

CONSTRUCTION

4 Enclosure

4.1 General

4.1.1 A capacitor shall be provided within an enclosure that houses all live parts other than the supply leads, terminals, or discharge resistor.

4.2 Metallic

4.2.1 A metal enclosure shall be 0.010-in (0.25-mm) thick minimum, if of steel, and 0.016-in (0.41-mm) thick minimum, if of aluminum, brass, or copper.

4.3 Nonmetallic

4.3.1 A polymeric material used as part or all of an enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

4.3.2 A polymeric material used as part or all of an enclosure shall:

a) Comply with the flammability test – 3/4-in (19.1-mm) flame, specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

b) Be classed V-2 minimum in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

4.3.3 The following are among the factors that shall be taken into consideration when using the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, to judge the acceptability of a nonmetallic material with respect to its intended application:

a) Mechanical strength;

b) Moisture-absorbent properties;

c) Combustibility;

d) Compatibility with dielectric mediums;

e) Dielectric strength;

f) Aging characteristics; and

g) Resistance to distortion at maximum temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

4.3.4 With regard to mechanical strength, aging characteristics, and resistance to distortion at maximum temperatures of operation described in 4.3.3 (a), (f) and (g), a polymeric material used as an enclosure shall have a relative mechanical temperature index without impact of at least 70°C (158°F) or the marked temperature rating, whichever is greater, in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B. With regard to the moisture-absorbent and dielectric strength properties described in 4.3.3 (b) and (e), a polymeric material shall meet the requirements for dielectric strength as described in Table 6.1 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The compatibility with dielectric mediums is addressed with the Dielectric Voltage-Withstand Test of Section 13.

4.3.5 A nonmetallic enclosure material that also functions as an insulator shall comply with Insulating Material, Section 6.

5 Internal Protection Bridge

5.1 A polymeric material used as an internal protection bridge or pressure interrupter shall have a relative mechanical temperature index without impact in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, at least equal to that of the capacitor enclosure. See 4.3.4.

6 Insulating Material

6.1 A material used for the mounting of uninsulated capacitor terminals shall be a material rated for the application, and shall comply with the requirements specified in Table 6.1.

Exception No. 1: A polymeric insulating material that is not rated for, or does not comply with, the hot wire ignition or high current arc resistance to ignition requirements in Table 6.1 shall not be used unless the part fabricated with the polymeric material complies with the applicable testing requirements outlined in the "additional consideration for materials not meeting pre-selection test performance levels" as prescribed in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Table 6.2.

Exception No. 2: Products that have a minimum 1/2-in (12.7-mm) over surface spacing from terminal-to-terminal are not required to comply with the polymeric insulating material requirements of Table 6.1.

Table 6.1
Polymeric insulating material

Application	Properties				
		Resistance to ignition		Electrical	
		Hot wire (HWI)[b]	High current (HAI)[b]	Dielectric breakdown strength[b]	Comparative tracking index (CTI)[b]
	Minimum flammability class[a]	Maximum performance level category	Maximum performance level category	Minimum volts, V	Maximum performance level category
Contact with insulated live parts[c]	V-0	4	3	–	–
	V-1	4	2		
	V-2	4	2		
Contact with uninsulated live parts[d]	V-0	4	3	5,000	5
	V-1	3	2	5,000	5
	V-2	2	2	5,000	5

[a] The flammability classification is to be determined by the tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

[b] Tests are to be conducted in accordance with the Standard for Polymeric Materials – Short Term Property Evaluation, UL 746A. Requirements for each test are specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

[c] Also applies to a nonmetallic enclosure in contact with insulated current-carrying live parts and where there are no uninsulated current carrying parts.

[d] Also applies to a nonmetallic enclosure in contact with uninsulated live parts or where the enclosure is within 1/32 in (0.8 mm) of uninsulated live parts.

6.2 Internal insulating materials shall comply with the requirements for the Dielectric Voltage-Withstand Test, Section 13. Internal insulating materials shall have a relative mechanical temperature index without impact of at least 70°C (158°F) or the marked temperature rating marked on the capacitor, whichever is greater, in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

Exception: Internal insulating materials for capacitors not subjected to the Fault-Current Test, Section 12, shall comply with the following requirements:

a) Shall be classified HB minimum in accordance with the Standard for Tests Flammability of Plastic Material for Parts in Devices and Appliances, UL 94, or comply with the flammability – 12 mm flame test specified in the Standard for Polymeric Materials – Use in Electrical Equipment, UL 746C;

b) Shall have a relative mechanical temperature index without impact of at least 70°C (158°F) or the marked temperature rating marked on the capacitor, whichever is greater, in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

c) Shall comply with the requirements for dielectric strength criteria as described in Table 6.1 of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.3 A capacitor having a metal enclosure shall have an insulating liner of non-moisture-absorbent material between the capacitor roll and the metal enclosure. In addition, the capacitor shall resist the absorption of moisture by having the capacitor roll completely immersed in a sealing compound or other material that may be used for the purpose.

7 Leads, Terminals and Internal Wiring

7.1 A lead of a capacitor shall be rated for the voltage and current involved. The temperature rating of the insulation of the lead shall not be less than the temperature rating of the capacitor.

7.2 The connection of a lead inside a capacitor shall be secure. Strain relief shall be provided that complies with the Pull-Out Test, Section 9.

Exception: Bare leads provided for securing the capacitor to a printed wiring board need not comply with the Pull-Out Test of Section 9. Bare leads provided for this purpose shall comply with the material and minimum thickness requirements outlined in 7.5.

7.3 An integral terminal connector or terminal block employed for making electrical connections to a capacitor shall be mechanically secured to the capacitor to prevent movement that would result in reduced spacings and/or damage to connections. A terminal block shall be rated for the application and comply with the Standard for Terminal Blocks, UL 1059.

Exception: A terminal connector or terminal block may alternatively be evaluated to the requirements outlined in 7.4.

7.4 A terminal connector or terminal block shall comply with the following:

a) The insulation criteria for contact with uninsulated parts as outlined in Table 6.1;

b) The spacings criteria of Section 8;

c) The requirements of 7.5 and if intended for connection of copper wiring, be limited to copper, copper alloy or other suitable material found to prevent galvanic corrosion when in contact with the intended connection wiring (see Figure 7.1); and

d) The mold stress test of Section 11 and if provided with screw terminals, the torque test of Section SA5.3.