



UL 810B

STANDARD FOR SAFETY

DC Power Capacitors

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UL Standard for Safety for DC Power Capacitors, UL 810B

Second Edition, Dated June 10, 2021

Summary of Topics

This second edition of ANSI/UL 810B dated June 10, 2021 includes the following changes in requirements:

- Clarified the scope in [1.3](#) and deleted the Internal Fuse Operation Test.***
- Added references for wiring standards in [9.1](#).***
- Added a means to evaluate polymeric material property in [6.3.4](#).***
- Clarified the thermal rating of insulating materials in the capacitor in [8.2](#).***
- Made miscellaneous revisions throughout the Standard.***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 2, 2021.

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UL 810B

Standard for DC Power Capacitors

First Edition – May 2016

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June 10, 2021

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The most recent designation of ANSI/UL 810B as an American National Standard (ANSI) occurred on June 10, 2021. 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 UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 The requirements of this Standard apply to dc power capacitors with or without integral protection intended to reduce the risk of rupture and venting of the capacitor enclosure under internal fault conditions. These requirements apply to capacitors that are intended for use in dc power electronic applications such as switching circuits, dc filtering, and renewable energy systems.

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

1.3 This standard does not include requirements for electrochemical capacitors, which are covered under the Standard for Electrochemical Capacitors, UL 810A, and AC motor capacitors or power factor correction capacitors, which are covered under the Standard for Capacitors, UL 810.

2 Components

2.1 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.

2.2 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.

2.3 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.

2.4 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.

3 Units of Measurement

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

4 Referenced Publications

4.1 Any undated reference to a code or standard appearing in the requirements of this Standard shall be interpreted as referring to the latest edition of that code or standard.

4.2 The following publications are referenced in this Standard:

UL 44, *Thermoset-Insulated Wires and Cables*

UL 66, *Fixture Wire*

UL 83, *Wires and Cables, Thermoplastic-Insulated*

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

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

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

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

UL 758, *Appliance Wiring Material*

UL 810, *Capacitors*

UL 810A, *Electrochemical Capacitors*

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

UL 1059, *Terminal Blocks*

5 Glossary

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

5.2 CAPACITOR ELEMENT – The layered and rolled interior electrode windings of a capacitor, which is also known as the roll.

5.3 COMPONENT CAPACITOR – A capacitor intended for building into other equipment. A component capacitor is also referred to as "capacitor."

5.4 DRY TYPE CAPACITOR – A capacitor that contains no liquid and utilizes a solid filling material other than wax.

5.5 ELECTRODE, FOIL TYPE – Capacitor plates consisting of thin metal or "foil" separated by a dielectric. This type of electrode is not self-healing.

5.6 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 and is often referred to as "self-healing".

5.7 FILLING MATERIAL – Substance located within a capacitor enclosure that may also form all or part of the enclosure and that may or may not serve as insulation. The filling material is typically oil, polyurethane or epoxy.

5.8 ENCLOSURE – Refers to the capacitor element housing. It may also be referred to as a casing.

5.9 LEAD – A conductor used to connect the capacitor roll to the means of termination. Typically wire, brass, copper either with integral insulating material or the addition of insulating material.

5.10 INTERNAL PROTECTION BRIDGE (EXPANSION TYPE PROTECTION) – An integral protection device that interrupts the circuit during expansion of the capacitor enclosure due to internal pressure build-up from overheating. It is also referred to as a PRESSURE SENSITIVE INTERRUPTER.

5.11 RATED VOLTAGE (U_{Ndc}) – The specified maximum operating peak voltage for continuous operation for a dc capacitor.

5.12 RIPPLE VOLTAGE (U_R) – peak-to-peak alternating component of the unidirectional voltage from a dc power source.

CONSTRUCTION

6 Enclosure

6.1 General

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

6.2 Metallic

6.2.1 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.

6.3 Nonmetallic

6.3.1 A polymeric material used as part or all of an enclosure shall comply with the applicable requirements in UL 746C.

6.3.2 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 UL 746C; or
- b) Be classed V-2 minimum in accordance with UL 94.

6.3.3 The following are among the factors that shall be taken into consideration when using 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.

6.3.4 With regard to mechanical strength, aging characteristics, and resistance to distortion at maximum temperatures of operation described in [6.3.3](#) (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 UL 746B. With regard to the moisture-absorbent and dielectric strength properties described in [6.3.3](#) (b) and (e), a polymeric material shall meet the requirements for dielectric strength as described in the Material Property Considerations table of UL 746C. The compatibility with dielectric mediums is addressed with the Dielectric Voltage Withstand Test of Section [16](#).

6.3.5 A nonmetallic enclosure material that also functions as an insulator shall comply with Insulating Material, Section [8](#).

7 Internal Protection Bridge

7.1 A polymeric material used as an internal protection bridge/pressure interrupter shall have a relative mechanical temperature index without impact in accordance with UL 746B, at least equal to that of the capacitor enclosure. See [6.3.4](#).

8 Insulating Material

8.1 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 8.1](#).

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 8.1](#) 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 Additional Considerations for Materials Not Meeting Pre-Selection Test Performance Levels table of UL 746C.

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 8.1](#).

Table 8.1
Polymeric Insulating Material

Application	Properties				
	Minimum flammability class ^a	Resistance to ignition		Electrical	
		Hot wire (HWI) ^b	High current (HAI) ^b	Dielectric breakdown strength ^b	Comparative tracking index (CTI) ^b
		Maximum performance level category	Maximum performance level category	Minimum volts	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	5000	5
	V-1	3	2	5000	5
	V-2	2	2	5000	5

^a The flammability classification is to be determined by the tests described in UL 94.

^b Tests are to be conducted in accordance with UL 746A. Requirements for each test are specified in 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.

8.2 Internal insulating materials shall comply with the requirements for the Dielectric Voltage-Withstand Tests, Section 16. 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 UL 746B.

Exception: Internal insulating materials for capacitors marked “unprotected” per 22.1(g) shall comply with the following requirements:

a) Shall be classified HB minimum in accordance with UL 94, or comply with the flammability – 12 mm flame test specified in 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 UL 746B; and

c) Shall comply with the requirements for dielectric strength criteria as described in the Material Property Considerations table of UL 746C.

8.3 A capacitor having a metal enclosure shall have an insulating liner of nonmoisture-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.

9 Leads, Terminals and Internal Wiring

9.1 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. Standards that may apply for these leads include UL 44, UL 66, UL 83, and UL 758.

9.2 The connection of a lead inside a capacitor shall be secure. Strain relief shall be provided that complies with the Pull-Out Test, Section [12](#).

Exception: Bare leads provided for securing the capacitor to a printed wiring board need not comply with the Pull-Out Test, Section [12](#). Bare leads provided for this purpose shall comply with the material and minimum thickness requirements outlined in [9.5](#).

9.3 With reference to [9.2](#) 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 UL 1059.

Exception: A terminal connector or terminal block may alternatively be evaluated to the requirements outlined in [9.4](#).

9.4 With reference to [9.3](#) a terminal connector or terminal block shall comply with the following:

- a) The insulation criteria for contact with uninsulated parts as outlined in [Table 8.1](#);
- b) The spacings criteria of Section [10](#);
- c) The requirements of [9.5](#) 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 9.1](#)); and
- d) The mold stress test of Section [15](#) and if provided with screw terminals, the torque test of Section [13](#).

Figure 9.1
Metal Compatibility Chart

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 Zn on steel, Zn on iron or steel	Aluminum	Cd on steel	Al/Mg alloy	Mild steel	Duralumin	Lead	Cr on steel, soft solder	Cr on Ni on steel, tin on steel, 12% Cr stainless steel	High Cr stainless steel	Copper, copper alloys	Silver solder, austenitic stainless steel	Ni on steel	Silver	Rh on Ag on Cu, silver/gold alloy	Carbon	Gold, platinum	
0	0.05	0.55	0.7	0.8	0.85	0.9	1.0	1.05	1.1	1.15	1.25	1.35	1.4	1.45	1.6	1.65	1.7	1.75	Magnesium, magnesium alloys
	0	0.05	0.2	0.3	0.35	0.4	0.5	0.55	0.6	0.65	0.75	0.85	0.9	0.95	1.1	1.15	1.2	1.25	Zinc, zinc alloys
		0	0.15	0.25	0.3	0.35	0.45	0.5	0.55	0.6	0.7	0.8	0.85	0.9	1.05	1.1	1.15	1.2	80 tin/20 Zn on steel, Zn on iron or steel
			0	0.1	0.15	0.2	0.3	0.35	0.4	0.45	0.55	0.65	0.7	0.75	0.9	0.95	1.0	1.05	Aluminum
				0	0.05	0.1	0.2	0.25	0.3	0.35	0.45	0.55	0.6	0.65	0.8	0.85	0.9	0.95	Cd on steel
					0	0.05	0.15	0.2	0.25	0.3	0.4	0.5	0.55	0.6	0.75	0.8	0.85	0.9	Al/Mg alloy
						0	0.1	0.15	0.2	0.25	0.35	0.45	0.5	0.55	0.7	0.75	0.8	0.85	Mild steel
							0	0.05	0.1	0.15	0.25	0.35	0.4	0.45	0.6	0.65	0.7	0.75	Duralumin
								0	0.05	0.1	0.2	0.3	0.35	0.4	0.55	0.6	0.66	0.7	Lead
									0	0.05	0.15	0.25	0.3	0.35	0.5	0.55	0.6	0.65	Cr on steel, soft solder
										0	0.1	0.2	0.25	0.3	0.45	0.5	0.55	0.6	Cr on Ni on steel, tin on steel, 12% Cr stainless steel
											0	0.1	0.15	0.2	0.35	0.4	0.45	0.5	High Cr stainless steel
												0	0.05	0.1	0.25	0.3	0.35	0.4	Copper, copper alloys
													0	0.05	0.2	0.25	0.3	0.35	Silver solder, austenitic stainless steel
														0	0.15	0.2	0.25	0.3	Ni on steel
															0	0.05	0.1	0.15	Silver
																0	0.05	0.1	Rh on Ag on Cu, silver/gold alloy
																	0	0.05	Carbon
																		0	Gold, platinum

NOTE. — Corrosion due to electrochemical action between dissimilar metals which are in contact is minimized if the combined electrochemical potential is below about 0.6V. In the following table the combined electrochemical potentials are listed for a number of pairs of metals in common use; combinations above the dividing line should be avoided.

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9.5 A wiring terminal of a capacitor shall be provided with a soldering lug, pressure terminal connector, wire-binding screw, or quick-connect terminal rated for securing the size of the conductor to be connected. The terminal material shall be at least 0.020-in (0.51-mm) thick and shall be of copper, copper alloy, tin plated steel, or other metal rated for the application. Wire-binding screws shall be limited to connections with 10 AWG (5.3 mm²) or smaller conductors.

Exception: For capacitors rated over 5000 V, a terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030-in (0.76-mm) thick for a 14 AWG (2.1 mm²) or smaller wire and not less than 0.050-in (1.27-mm) thick for a wire larger than 14 AWG (2.1 mm²). There shall be sufficient threads to provide two full threads engagement with the screw.

9.6 A quick-connect terminal shall be provided with a detent, such as a dimple (depression) or hole in a tab that acts to engage a raised portion on the connector providing a latching means for the mating parts.

Exception: Capacitors employing terminal forks for securement of the capacitor to a printed wiring board are not required to be provided with a detent. The terminal fork shall comply with the material and minimum thickness requirements outlined in [9.5](#).

9.7 Insulated conductors serving as internal wiring and sleeving serving as insulation for uninsulated internal conductors shall be rated for the voltage, temperature, and other conditions of use to which they are subjected in the intended application and in accordance with the applicable component standard. See Section [2](#) for component requirements.

Exception: Insulated sleeving employed for internal conductors and/or connections molded from a thermoplastic material not previously evaluated in accordance with an applicable component standard may alternatively be evaluated to the Conductor Insulation Test of Section [14](#).

10 Spacings

10.1 General

10.1.1 The electrical spacing between an uninsulated live part, and an uninsulated live part of opposite polarity, or a grounded-metal part shall not be less than the applicable value specified in [Table 10.1](#).

Exception No. 1: Electrical spacings are not specified for those parts that are inside the enclosure and that are surrounded by a dielectric medium. See [8.3](#).

Exception No. 2: As an alternative to the spacing requirements of [Table 10.1](#), the spacing requirements in UL 840 may be used. See [10.2](#) for details. In determining the pollution degree and overvoltage category, the end-use application is to be considered, and may require characteristics different than those indicated in [10.2.2](#) and [10.2.3](#).

**Table 10.1
Spacings**

Capacitor rating Vdc	Minimum spacings			
	Through air		Over surface	
	in	(mm)	in	(mm)
0 – 150	1/8	(3.2)	1/4	(6.4)
151 – 300	1/4	(6.4)	3/8	(9.5)
301 – 660	3/8	(9.5)	1/2	(12.7)
661 – 2000	3/4	(19.1)	3/4	(19.1)
2001 – 5000	3/4	(19.1)	1	(25.4)
5001 – 7200	2	(50.8)	3-1/2	(88.9)

10.2 Alternative spacings

10.2.1 As an alternative to the spacing requirements of [Table 10.1](#), the spacing requirements in UL 840 may be used. The spacing requirements of UL 840 shall not be used for field wiring terminals, or spacings to a dead metal enclosure. In determining the pollution degree and overvoltage category, the end-use application is to be considered, and may require characteristics different than those indicated in [10.2.2](#) and [10.2.3](#).

10.2.2 It is anticipated that the level of pollution expected or controlled for indoor use equipment will be pollution degree 2. For outdoor use equipment, pollution degree 3 is expected. Hermetically sealed or encapsulated enclosures, or coated printed wiring boards in compliance with the printed wiring board coating performance test in UL 840 are considered pollution degree 1.

10.2.3 It is anticipated that a capacitor unit will be rated overvoltage category I and overvoltage category II as defined in UL 840.

10.2.4 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product.

10.2.5 All printed wiring boards are considered to have a minimum comparative tracking index of 100 without further investigation.

PERFORMANCE**11 General**

11.1 [Table 11.1](#) identifies the tests in this standard and the sample requirement for each test. Samples tested are to be representative of production.

Table 11.1
Samples for Tests

Test	Section	Sample Number	Device to be tested
Pull-Out	12	6	Capacitors with leads
Torque	13	6	Capacitors with terminals
Conductor Insulation	14	15	Insulation
Mold Stress Relief	15	3	Terminal block
Dielectric Voltage Withstand	16	1	Capacitor
Heating (Sealing)	17	3	Capacitor
Humidity	18	1	Capacitor
Surge Discharge Test	19	1	Capacitor
Fault	20	10	Capacitor

11.2 The tests contained in this standard may result in explosions, fire and emissions of flammable and/or toxic fumes, leakage of hazardous chemicals as well as electric shock. It is important that personnel use extreme caution when conducting any of these tests and that they be protected from flying fragments, leaked fluids, explosive force, toxic vapors and chemicals and sudden release of heat and noise that could result from testing. To prevent injury, protective equipment and clothing should be utilized when conducting testing. Short-circuiting or rapid discharging can lead to very hazardous currents, and large dc capacitors that are not completely discharged and are overheated as a result of testing may still be hazardous. Destructive tests such as the surge discharge test, the fault test and internal fuse operation test should be conducted in a protective area/room remote from the technician. The test area is to be well ventilated to protect personnel from possible harmful fumes or gases and care should be taken to prevent exposure to leaked fluids. Test facilities shall be equipped to contain, mitigate, and exhaust toxic fumes and particulate matter, leaked fluid and other hazardous substances that may be generated during the tests of this Standard.

12 Pull-Out Test

12.1 With reference to [9.2](#), the connection for a capacitor lead shall withstand the pull-out test described in [12.2](#) without any evidence of lead pull out.

12.2 Six samples of a capacitor are to be subjected to a gradual force applied to each lead for 1 min in a direction perpendicular to the plane of the surface at which the lead enters the capacitor. The force shall be:

- a) 20 lbf (89 N) for 18 AWG (0.82 mm²) and larger leads; or
- b) 8 lbf (36 N) for leads smaller than 18 AWG (0.82 mm²).

13 Torque Test (Screw Terminals)

13.1 This test is conducted on capacitors with screw terminals only.

13.2 The nuts or screws shall be tightened to the torque specified in [Table 13.1](#), then loosened. The torque shall then be re-applied gradually, over a period of time not less than 1 min.

13.3 As a result of the test, the screw material shall resist breaking or stress cracking.

Table 13.1
Torque Test Values

Thread diameter		Torque	
in	(mm)	lbf·ft	(N·m)
1/8	(3.0)	0.37	(0.5)
9/64	(3.5)	0.59	(0.8)
5/32	(4.0)	0.89	(1.2)
3/16	(5.0)	1.33	(1.8)
7/32	(5.5)	1.62	(2.2)
1/4	(6.0)	1.84	(2.5)
5/16	(8.0)	3.69	(5)
3/8	(10.0)	5.16	(7)
1/2	(12.0)	8.85	(12)

14 Conductor Insulation Test

14.1 Fifteen samples of the tubular style insulation employed in capacitors are to be conditioned in accordance with [Table 14.1](#). The fifteen samples are to be 4-in (102-mm) diameter or square in the minimum thickness used or are to be of a size representative of the end-use and subjected to the following test outlined in [14.2](#) and [14.3](#).

14.2 Following the conditioning, each sample is to be subjected to a dielectric voltage within a test chamber. The electrodes of the dielectric equipment shall be placed on opposite sides and in the center of the sample. The voltage is to be applied at a uniform rate of 500 V/s until breakdown occurs. When physical evidence of dielectric breakdown is not apparent, the voltage is to be reapplied until a more positive indication is produced.

14.3 As a result of this test, the average breakdown value for each set of samples shall be no less than 5000 V. In addition, the average breakdown value for all 10 conditioned samples (subjected to either oven conditioning or moist air conditioning) shall be no less than one-half the value of the as-received samples. For example, when the as-received samples had a breakdown of 15,000 V, then the conditioned samples shall not have a breakdown less than 7500 V.

Table 14.1
Conductor Insulation Conditioning

Number of Samples	Conditioning
5	As received
5	Oven exposure at 100 °C ±2 °C (212 °F ±3.6 °F) for 72 h, or the rated temperature of the capacitor, if rated higher than 100 °C (212 °F)
5	Exposure to moist air (90 % ±5 % RH) at a temperature of 30 °C ±2 °C (86 °F ±3.6 °F) for 24 h

15 Mold Stress Relief Test (Terminals Blocks/Terminal Connectors)

15.1 A terminal block and terminal connector evaluated in accordance with [9.4](#) shall be conditioned in an air-circulating oven for 7 h at a temperature of 10 °C (50 °F) plus the maximum rated temperature of the intended capacitor. At the conclusion of the conditioning, the terminal block shall be examined for damage such as cracking, warping or loosening of contacts.

15.2 As a result of the conditioning, there shall be no sign of damage to the terminal connection device such as cracking, warping or loosening of contacts.

16 Dielectric Voltage-Withstand Test

16.1 Test between terminals and enclosure

16.1.1 Capacitors having all terminals insulated from the enclosure shall be subjected to a dielectric voltage-withstand test as described in [16.1.2](#). There shall be no dielectric breakdown of any sample tested.

16.1.2 To determine if a capacitor complies with the requirements in [16.1.1](#), the capacitor is to be tested using a 500 VA or larger capacity transformer, the output voltage of which can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 min. The increase in applied potential is to be at a substantially uniform rate as rapid as is consistent with correct indication of its value by a voltmeter.

16.1.3 As an alternative, a dc potential equal to 1.4 times the ac potential specified in [16.1.4](#) may be used.

16.1.4 The test voltage applied shall consist of a 50 Hz or 60 Hz alternating potential of thousand volts plus twice the rated voltage applied between terminals and enclosure.

16.1.5 A capacitor with a nonmetallic enclosure is to be tested by applying the voltage between the terminals and a metal foil tightly wrapped around and contacting all surfaces other than the surface on which the terminals are attached.

16.2 Test between terminals

16.2.1 Capacitors shall be subjected to a dielectric voltage-withstand test as described in [16.2.2](#). There shall be no dielectric breakdown of any sample tested.

16.2.2 To determine if a capacitor complies with the requirements in [16.2.1](#), the capacitor is to be tested using a dc potential as noted in [16.2.4](#).

16.2.3 The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 min. The increase in applied potential is to be at a substantially uniform rate as rapid as is consistent with correct indication of its value by a voltmeter.

16.2.4 The test voltage applied shall consist of a dc potential of:

- a) One and a half times the maximum rated voltage applied between terminals for capacitors with metallized film electrodes; or
- b) Two times the maximum rated voltage applied between terminals for capacitors with other than metallized film electrodes.

17 Heating (Sealing) Test

17.1 Capacitors other than dry type capacitors shall be subjected to the heating test as noted below. During the test, temperatures on the capacitor case shall be monitored by means of a thermocouple.

17.2 The capacitor shall be mounted in a position most likely to reveal leakage within a test chamber at a temperature $10^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ($50^{\circ}\text{F} \pm 3.6^{\circ}\text{F}$) higher than the maximum permissible capacitor operating

temperature. The capacitor shall be subjected to the elevated temperature until it reaches thermal stabilization at the test temperature. After thermal stabilization, the capacitor shall be maintained at the test temperature for an additional hour. At the conclusion of the conditioning, the capacitor shall be removed from the test chamber and allowed to cool to room temperature.

17.3 After cooling to room temperature, the capacitor shall be visually examined for leakage and other signs of damage. As a result of the conditioning, there shall be no visible signs of liquid leakage or other damage.

18 Humidity Test

18.1 Prior to the humidity conditioning, the capacitor is to be stored at 20 °C ±5 °C (68 °F ±9 °F) for 24 h at 45 % – 75 % relative humidity (RH). The capacitor is then to be subjected to humidity conditioning for 48 h in a chamber at 32 °C ±2 °C (89.6 °F ±3.6 °F) at a relative humidity (RH) of 88 % ±2 %.

18.2 Immediately after completion of the humidity exposure with the sample removed from the chamber, the capacitor is subjected to a Dielectric Voltage Withstand Test in accordance with [16.1](#).

18.3 As a result of the humidity conditioning, there is to be no evidence of dielectric breakdown of the capacitor.

19 Surge Discharge Test

19.1 The capacitor is to be charged by means of a dc source and then discharged through a short-circuiting device (i.e. spark gap) connected as close as possible to the capacitor terminals. The capacitor is to be subjected to five such discharges. Large capacitors may require more than 10 min to complete the five discharges.

19.2 The test voltage shall be equal to 1.1 U_{Ndc} . If, a maximum surge current is specified by the manufacturer, the discharge current is to be adjusted by varying the charging voltage and the impedance of the discharge circuit to a value of:

$$I_{test} = 1.1 I_s$$

Where:

I_s is the specified surge current.

19.3 As soon as possible after the discharges, the capacitor is to be subjected to the dielectric voltage withstand test of [16.2](#).

20 Fault Test

20.1 General

20.1.1 The fault test is conducted on both capacitors with metallized electrodes (i.e. self-healing type) and non-metallized electrodes (i.e. non-self-healing type) provided with internal protection such as expansion type protection marked as “protected” per [22.1](#)(g). Capacitors not found in compliance with the fault test are marked “unprotected” per [22.1](#)(h).

20.1.2 The purpose of the test is to determine the ability of a capacitor with a pre-faulted element to safely withstand the application of a high dc voltage and current.

20.2 Requirements

20.2.1 As a result of the fault test, there shall be no fire or explosion of the capacitors under test and the tested samples are to comply with the dielectric voltage withstand test requirements.

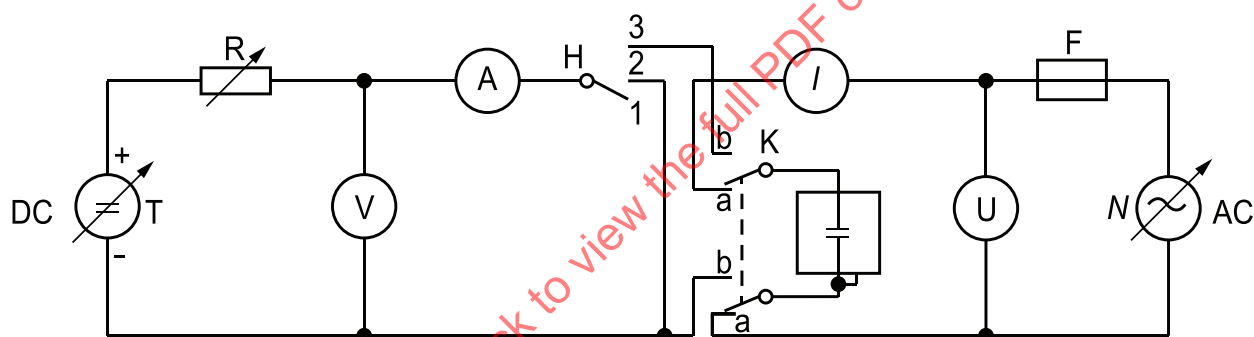
20.3 Conditioning

20.3.1 The capacitor is placed in an air circulating oven having a temperature set to equal the maximum ambient air temperature for the operating temperature of the capacitor. Temperatures on the surface of the capacitor are measured using a thermocouple.

20.4 Fault test circuits

20.4.1 When the temperature on the capacitor surface is stabilized at the oven temperature, the capacitor is connected to the fault test circuit shown in [Figure 20.1](#) and subjected to the fault test.

Figure 20.1
Fault Test Circuit



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Circuit Key

- T – High voltage high impedance dc generator (for applying faults)
- N – High voltage high current dc (with superimposed ac ripple) generator ([20.2](#) or [20.3](#))
- K – Capacitor under test
- A – Ammeter
- I – Ammeter
- H – Switch
- K – Switch
- V – Voltmeter
- U – Voltmeter
- F – Fuse
- R – Variable resistance

20.4.2 Fuse F in the test circuit of [Figure 20.1](#) is to have a voltage rating sufficient for the test circuit, and its rated current is to be $\geq 2 I_{\max}$ of the capacitor under test, where $I_{\max}$ is the maximum continuous current rating of the capacitor.

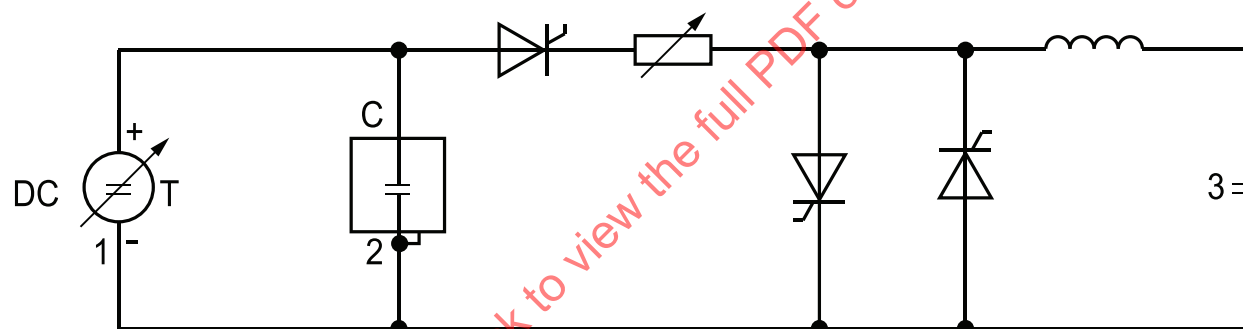
20.4.3 The N voltage source is a dc generator with a superimposed ripple voltage (U_R) (ac component). An example of an N generator circuit is shown in [Figure 20.2](#). An alternate N generator circuit is shown in [Figure 20.3](#). In this case, a high dc current is generated by an ac high current supply with a diode bridge. The dc and ac generators are to be adjustable.

NOTE 1 – If the capacitor unit is used in parallel connection with other capacitor units, the test should be performed by putting a corresponding capacitance in parallel with the N source generator.

NOTE 2 – The ac voltage should be selected in such way as to allow a circulation of the short-circuit current.

NOTE 3 – If the capacitor unit is too large or too small to comply with the test parameters, the test should be performed on agreement between the manufacturer and user.

Figure 20.2
N Generator Circuit (Option 1)



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Circuit Key

- 1 – High voltage, high current dc generator
- 2 – Capacitor under test
- 3 – Inverter, thyristors, inductors