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IS 1569 (1976): Capacitors for use in tubular fluorescent high pressure mercury and low pressure sodium vapour discharge lamp circuit [ETD 23: Electric Lamps and their Auxiliaries]



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IS : 1569 - 1976

*Indian Standard*

SPECIFICATION FOR  
CAPACITORS FOR USE IN TUBULAR  
FLUORESCENT, HIGH PRESSURE MERCURY  
AND LOW PRESSURE SODIUM VAPOUR  
DISCHARGE LAMP CIRCUITS

*( First Revision )*

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**INDIAN STANDARDS INSTITUTION**  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

# *Indian Standard*

## SPECIFICATION FOR CAPACITORS FOR USE IN TUBULAR FLUORESCENT, HIGH PRESSURE MERCURY AND LOW PRESSURE SODIUM VAPOUR DISCHARGE LAMP CIRCUITS

### ( *First Revision* )

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## IS:1569-1976

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*Indian Standard*  
SPECIFICATION FOR  
CAPACITORS FOR USE IN TUBULAR  
FLUORESCENT, HIGH PRESSURE MERCURY  
AND LOW PRESSURE SODIUM VAPOUR  
DISCHARGE LAMP CIRCUITS  
( *First Revision* )

**0. FOREWORD**

**0.1** This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 12 July 1976, after the draft finalized by the Electric Lamps and Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

**0.2** This standard was first published in 1963 and the revision has been prepared with a view to updating the contents and lining up with other standards for similar capacitors.

**0.3** In preparing this revision, assistance has been derived from IEC document 34C (Central Office) 59 'Draft Recommendations for capacitors for use in tubular fluorescent, high pressure mercury and low pressure sodium vapour discharge lamp circuits' issued by International Electrotechnical Commission.

**0.4** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960\*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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**1. SCOPE**

**1.1** This standard specifies the requirements for both self-healing and non-self-healing continuously rated ac capacitors of up to and including 2.5 kVAR, and not less than 0.1  $\mu$ F having a rated voltage not exceeding 1 000 V, which are intended for use in discharge lamp circuits, operating at 50 Hz and at altitudes up to 3 000 m.

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\*Rules for rounding off numerical values ( *revised* ).

**1.1.1** It covers capacitors intended for connection in shunt, series or an effective combination of these.

**1.1.2** It covers only impregnated or unimpregnated capacitors having a dielectric of paper, plastic film, or a combination of both, either metallized or with metal foil electrodes.

**1.2** The standard does not cover radio-interference suppressor capacitors.

## **2. TERMINOLOGY**

**2.0** For the purpose of this standard, the following definitions shall apply.

**2.1 Rated Voltage ( $U$ )** — The rms value of the sinusoidal voltage to which the capacitor is designed to withstand continuously, and from which the test conditions are derived.

**2.2 Rated Maximum Temperature ( $t_c$ )** — That temperature, in degrees Celsius, which shall not be exceeded by the hottest part of the capacitor surface during operation in service.

**NOTE** — The internal losses in a capacitor, though small, do result in the surface temperature being above ambient air temperature and due allowance for this should be made. The temperature difference will depend upon the nature of the enclosure.

**2.3 Rated Minimum Temperature ( $t_{c \min}$ )** — That temperature, in degrees Celsius, of any part of the surface of the capacitor below which the capacitor shall not be energized.

**2.4 Discharge Resistor** — A resistor connected across the terminals of a capacitor to eliminate shock hazard from the charge stored in the capacitor.

**2.5 Creepage Distances** — Distances in air measured along the surface of insulating material.

**2.6 Self-Healing** — A metallized or plastic-film capacitor that restores itself in the event of breakdown of the dielectric.

**2.7 Non-Self-Healing** — A capacitor which is not self-healing.

**2.8 Routine Tests** — Tests carried out on each item to check requirements which are likely to vary during production.

**2.9 Acceptance Tests** — Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

**2.10 Type Tests** — Tests carried out to prove conformity with this specification. These are intended to prove the general quality and design of a given type of a capacitor.

### **3. GENERAL REQUIREMENTS**

#### **3.1 General**

**3.1.1** Capacitors shall be mechanically robust and shall be so designed and constructed so as to minimize the effects thereon of moisture in the atmosphere and of temperature changes during use.

**3.1.2** All exposed metal parts shall be constructed of non-ferrous material or shall be protected against corrosion.

**NOTE** — Tests for checking the mechanical robustness and the protection against rusting of ferrous material are under consideration.

**3.1.3** External insulation material shall be substantially non-hygroscopic.

#### **3.2 Terminations**

**3.2.1** Terminations shall be provided by means of either cables ( tails ) or terminals ( screw, solder tag or the like )\*. Terminations shall be capable of accepting the size and number of conductors appropriate to the rating and application of the capacitor. Cable ( tails ) shall be suitable for the rating of the capacitor but in no case shall they be smaller than 0.5 mm<sup>2</sup> and their insulation shall be appropriate to the capacitor rated voltage and temperatures.

**3.2.2** The materials, design and proportions of all terminals shall be such that a connection made thereto will not slacken or overheat under the normal conditions of use.

**3.2.3** Terminals and connections shall be of such a form that the connection remains electrically sound and mechanically secure under all normal conditions of service.

**3.2.4** The capacitors container, if of metal, shall either be fitted with an earthing terminal or shall be capable of being earthed ( or connected to other metal parts, if any, of the lamp fitting ) by clamping or by an appropriate fixing bracket. The part of the container to which such a clamp is fitted, or the fixing bracket attached thereto, shall be free from paint or other non-conducting covering in order to ensure the maintenance of good electrical contact. This requirement, however, shall not apply to metal cased capacitors completely covered in an insulating material.

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\*See also IS : 6585-1972 Specification for screwless terminal and electrical connections for lighting fittings.

### 3.3 Creepage Distances and Clearances

**3.3.1** The creepage paths over external surfaces of terminal insulation and the clearances between the exterior parts of terminal connections or between such live parts and the metal container of the capacitor, if any, shall be not less than the minimum values given in Table 1.

**TABLE 1 MINIMUM CREEPAGE DISTANCES AND CLEARANCES**

RATED VOLTAGE	UP TO AND INCLUD- ING 24 V	ABOVE 24 V UP TO AND INCLUD- ING 250 V	ABOVE 250 V UP TO AND INCLUD- ING 500 V	ABOVE 500 V UP TO AND INCLUD- ING 1 000 V
(1)	(2)	(3)	(4)	(5)
	mm	mm	mm	mm
<b>a) Creepage Distance:</b>				
i) Between live parts of different polarity	2	3(2)*	5	6
ii) Between live parts and accessible metal parts which are permanently fixed to the capacitor including screws of devices for fixing covers or fixing the capacitor to its support	2	4(2)* 3†	6 3†	7
<b>b) Clearance:</b>				
i) Between live parts of different polarity	2	3(2)*	5	6
ii) Between live parts and accessible metal parts which are permanently fixed to the capacitor, including screws or devices for fixing covers or fixing the capacitor to its support	2	4(2)* 3†	6 3†	7
iii) Between live parts and a flat supporting surface or a loose metal cover, if any, if the construction does not ensure that the values given under (b)(ii), are maintained under the most unfavourable conditions	2	6	10	12

\*The values between brackets apply to creepage distances and clearances protected against dirt by a closely fitted cover. For permanently sealed off or compound filled spaces, creepage distance and clearances are not checked.

†For glass or other insulation with equivalent tracking qualities.

**3.3.2** These minimum distances shall apply to the terminals with or without the external wiring connected. They are not intended to apply to internal creepage distances and clearances.

**3.4** The contribution to the creepage distance of any groove less than 1 mm wide shall be limited to its width. Any air-gap of less than 1 mm shall be ignored in computing the total air path.

**3.5 Voltage Rating** — Capacitors shall be rated for any one voltage not exceeding 1 000 V rms.

**3.5.1** Capacitors shall be capable of withstanding for prolonged periods a voltage not exceeding 110 percent of their rated voltage within the temperature ratings.

NOTE — This latter requirement is intended to cover variations in voltage due to supply fluctuations and is considered to be checked as prescribed in 5.14.

**3.6 Fuses** — Where an internal fuse is fitted it shall be adequately protected, enclosed and insulated so far as to prevent flashover to, or contact with, the capacitor container in normal service in the event of the operation of the fuse.

NOTE — In establishing the design of any internal fuse, the possibility of short-circuits occurring external to the capacitor should be taken into account.

**3.7 Discharge Resistors** — Capacitors may have a discharge resistor of suitable wattage rating permanently connected across their terminals. If fitted, a discharge resistor shall have a value such that it will discharge the capacitor from the peak of the ac voltage applied to it, to a voltage not exceeding 50 V, within 1 minute. Allowance shall be made for the maximum capacitance tolerance of the capacitor, the tolerance of the resistor, and a voltage which is 10 percent above its rated value ( *see* Appendix A ).




NOTE 1 — Within the overall lamp circuit it is essential that a discharge path be provided for any capacitor. It is recommended that this should be by means of a resistor integral with the capacitor but other arrangements are possible.

NOTE 2 — In certain cases, for example, luminaires connected by plugs, 50 V within 1 minute may not be acceptable.

## 4. MARKING

**4.1** Capacitors shall be legibly marked as follows:

- a) The name or trade-mark of the manufacturer or responsible vendor;
- b) Manufacturer's catalogue number and/or model reference;
- c) Rated capacitance and tolerance;
- d) Rated voltage;

- e) When a discharge resistor is fitted, the symbol  ;
- f) When a fuse is fitted, the symbol  ;
- g) Rated frequency or frequency range;
- h) Rated minimum and maximum temperatures, the symbol  for example—10/70°C;
- j) If the capacitor is self-healing, the symbol 'Sp'; and
- k) The period of manufacture which may be in code form.

#### 4.2.1 The capacitors may also be marked with the ISI Certification Mark.

**NOTE**—The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

## 5. TESTS

### 5.1 Type Tests

#### 5.1.1 The following shall constitute type tests:

- a) Visual examination ( *see* 5.4 );
- b) Sealing and heating test ( *see* 5.5 );
- c) Voltage proof test ( *see* 5.5 );
- d) High voltage test to container ( *see* 5.7 );
- e) Capacitance measurement test ( *see* 5.8 );
- f) Discharge resistor test ( *see* 5.9 );
- g) Thermal stability test ( *see* 5.10 );
- h) Self-healing test ( for self-healing capacitors only ) ( *see* 5.11 );
- j) Damp heat (insulating resistance and high voltage) test ( *see* 5.12 );
- k) Endurance test ( *see* 5.13 ); and
- m) Destruction test ( for self-healing capacitors only ) ( *see* 5.14 ).


**AMENDMENT NO. 1      JANUARY 1981**  
**TO**  
**IS : 1569-1976 SPECIFICATION FOR CAPACITORS**  
**FOR USE IN TUBULAR FLUORESCENT, HIGH**  
**PRESSURE MERCURY AND LOW PRESSURE**  
**SODIUM VAPOUR DISCHARGE**  
**LAMP CIRCUITS**

*( First Revision )*


**Alterations**

[ Page 8, clause 4.1 (h) and (j) ] — Substitute the following for the existing matter:

“h) Rated minimum and maximum temperatures, for example, 10/70°C;

j) If a capacitor is self-healing, the symbol ‘Sp’ or  ;  
and ”.

( Page 12, clause 5.11 ) — Substitute the following for the existing clause:

“**5.11 Self-Healing Test** — This test shall be applied only to capacitors marked ‘Sp’ or  [ see 4.1 (j) ].”

( ETDC 23 )

**5.1.2 General Requirements** — Unless otherwise specified, tests shall be carried out at a temperature of  $27 \pm 5^{\circ}\text{C}$ , using where appropriate, a voltage source as detailed in Appendix B.

Test temperatures specified in particular clauses shall be subject to a tolerance of  $\pm 2^{\circ}\text{C}$ , unless otherwise stated.

Unless otherwise specified, the type shall be deemed to comply with any one clause if not more than 1 failure occurs in the test of that clause. If 3 or more failures occur the type shall be rejected. If 2 failures occur in any one test, that test, and any preceding tests which may have influenced the test results, shall be repeated on the same quantity of capacitors and if any further failures occur the type shall be rejected.

NOTE 1 — In addition to those specified, tests at the rated maximum and minimum temperatures are under consideration.

NOTE 2 — If the test in 5.13 has to be repeated, the test in 5.14 may be made at the same time and using capacitors which have passed the test in 5.13.

**5.1.3 Testing Sequence** — A quantity of 72 capacitors, or in the case of self-healing types, 82 capacitors, shall be taken and divided into 4 groups containing respectively 10, 5, 17, and 40 or 50 capacitors.

The following initial tests shall be applied to all these capacitors in the order given:

- a) Sealing and heating test ( see 5.5 ),
- b) Voltage proof test ( see 5.6 ),
- c) High voltage test to container ( see 5.7 ),
- d) Capacitance measurement test ( see 5.8 ), and
- e) Discharge resistor test ( see 5.9 ) ( where appropriate ).

The first group of 10 capacitors, which have passed initial tests shall be subjected to the following tests in the order stated:

- a) Thermal stability test ( see 5.10 ), and
- b) Self-healing test ( for self-healing capacitors only ) ( see 5.11 ).

The second group containing 5 capacitors, which have passed initial tests shall be subjected to the damp heat test ( see 5.12 ).

The third group, containing 17 capacitors, which have passed initial tests shall be used for the endurance and destruction tests ( see 5.13 and 5.14 ).

The fourth group, containing 40 ( or 50 ) capacitors, which have passed initial tests shall be retained as spares in case repeat tests are required as specified in the various clauses.

**5.2 Acceptance Tests** — The following shall constitute acceptance tests, which shall be carried out on samples selected at random from each lot:

- a) Visual examination ( *see* 5.4 ),
- b) High voltage test to container ( *see* 5.7 ),
- c) Capacitance measurement test ( *see* 5.8 ), and
- d) Thermal stability test ( *see* 5.10 ).

**5.2.1** The sampling procedure and criteria of acceptance shall be subject to agreement between the supplier and the purchaser. In the absence of such an agreement, the sampling procedure detailed in Appendix C may be followed.

**5.3 Routine Tests** — The following shall constitute routine tests:

- a) Visual examination ( *see* 5.4 ),
- b) Sealing and heating test ( *see* 5.5 ),
- c) Voltage proof tests ( *see* 5.6 ),
- d) High voltage test to container ( *see* 5.7 ),
- e) Capacitance measurement test ( *see* 5.8 ), and
- f) Discharge resistor test ( *see* 5.9 ).

**5.4 Visual Examination** — The capacitors shall be visually examined to check conformity with the requirements specified in 3.

**5.5 Sealing and Heating Test** — The unenergized capacitors shall be placed in an oven in a position most conducive to the leakage of impregnant or filling material and heated throughout to 10°C above their rated maximum temperature ( $t_c$ ). They shall be maintained at this temperature for 1 hour.

**5.5.1** Leakage of impregnant or filling material shall not occur during this test.

**5.5.2** The capacitor shall not become open-circuited during this test.

**5.5.3** For routine test, the testing time shall be for a further hour after all parts of the capacitor have reached the prescribed temperature.

**5.6 Voltage Proof Test** — Non-self-healing capacitors shall withstand at room temperature an ac voltage of  $2.15 U_n$  applied between terminals for a period of 10 seconds.

**5.6.1** Self-healing capacitors shall withstand at room temperature an ac voltage of  $1.5 U_n$  applied between terminals for a period of 10 seconds.

**5.6.2** For self-healing capacitors, self-healing breakdowns (clearings) are allowed during the test.

**5.6.3** Initially not more than half the test voltage shall be applied, following which it shall be raised gradually to the full value.

**5.6.4** For routine test, non-self-healing capacitors shall withstand at room temperature an ac voltage of  $2.15 U_n$  applied between terminals for 2 seconds.

**5.6.5** Alternatively for non-self-healing capacitors, and at the discretion of the manufacturer, a dc voltage may be used which shall be  $4.3 U_n$  applied between terminals for 2 seconds.

**5.6.6** The full test voltage may be applied directly provided that over-voltage transients do not occur.

NOTE — Attention is drawn to the fact that repetition of this test may be harmful to the capacitor.

**5.7 High Voltage Test to Container** — Each capacitor shall withstand at 50 Hz, a test voltage of 2 000 V rms or  $(2 U_n + 1\,000)$  V, whichever is the greater, applied for a period of 1 minute between the terminals of the capacitor joined together and its container.

**5.7.1** Initially not more than half the test voltage shall be applied, following which it shall be raised gradually to the full value.

**5.7.2** For capacitors having containers of insulating materials the test voltage shall be applied between terminals and metal mountings or between terminals and metal test electrodes surrounding and in contact with the surface of the container.

**5.7.3** For routine test, each capacitor shall withstand at 50 Hz a test voltage of 2 000 V rms or  $(2 U_n + 1\,000)$  V, whichever is greater, applied for a period of 2 seconds between the terminals of the capacitor joined together and the container.

**5.7.4** The full test voltage may be applied directly provided that over-voltage transients do not occur.

**5.8 Capacitance Measurement Test** — The capacitance of each capacitor when measured at 50 Hz, shall be within the tolerance limits marked on the container.

**5.8.1** Capacitance shall be measured using a method which excludes errors due to harmonics. The accuracy of measurement shall be better than 1 percent of the capacitance measured. The measuring voltage shall not be higher than the rated voltage of the capacitor; the frequency shall be as near as possible to the 50 Hz. Measurement at other frequencies is allowed provided that the frequency dependence of the capacitance is very small. The measured capacitance shall not deviate from the rated capacitance by more than  $\pm 5$  percent for series capacitors and  $\pm 10$  percent for parallel capacitors. This tolerance should be marked on the capacitors.

**5.9 Discharge Resistor Test** — The value of the discharge resistor, if fitted, shall be measured using a dc supply of voltage not exceeding  $\sqrt{2}U_n$ . The resistance so measured shall not exceed the value as determined in accordance with Appendix A.

## 5.10 Thermal Stability Test

**5.10.1 Procedure** — The capacitors shall be heated to and maintained at a temperature of  $10^\circ\text{C}$  above their rated maximum temperature for 6 hours, without any voltage being applied to their terminals.

At the end of this period, an rms voltage in accordance with Table 2 at 50 Hz shall be applied for a further period of 6 hours, during which the mean temperature on the oven in which the capacitor is placed shall be maintained to a value  $10^\circ\text{C}$  above its rated maximum temperature.

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**TABLE 2 THERMAL STABILITY TEST**

REACTIVE POWER OF CAPACITOR CALCULATED FROM ITS RATING	TEST VOLTAGE
(1)	(2)
Reactive power up to 1 kVAr	$1.25 U_n$
Reactive power above 1 kVAr	$1.20 U_n$

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**5.10.2 Conditions for Compliance** — The capacitance shall be measured before and after the test in accordance with 5.8 and a change in capacitance of more than 5 percent or a non-self-healing breakdown shall constitute a failure.

**5.11 Self-Healing Test** — This test shall be applied only to capacitors marked  $S_p$  [ see 4.1 (j) ].

**5.11.1** The capacitor shall be subjected for one minute to an ac voltage of  $2.15 U_n$ .

**5.11.2** If fewer than 5 self-healing breakdowns (clearings) occur during this time, the voltage shall be increased slowly until 5 clearings have occurred since the beginning of the test or until the voltage has reached  $3.5 U_n$ . The voltage shall then be decreased to 0.8 times its initial value and maintained for 10 seconds. One additional clearing in each capacitor shall be permitted during this period.

**5.11.3** If, however, 5 or more clearings occur, the voltage shall then be decreased to 0.8 times its initial value and maintained for 10 seconds. One additional clearing in each capacitor shall be permitted during this period.

**5.11.4** The capacitors shall be deemed to have passed the test if the change of capacitance is not greater than 1 percent.

**5.11.5** Self-healing breakdowns during the test may be detected by an oscilloscope or by acoustic or high-frequency test methods.

NOTE — Testing circuits are under consideration.

**5.12 Damp Heat (Insulation Resistance and High Voltage) Test** — The 5 capacitors shall be placed in a humidity test chamber complying with the requirements of 5.12.1 and subjected to treatment in accordance with 5.12.2 and 5.12.3.

**5.12.1 Conditioning Chamber** — The chamber used for this test shall be capable of maintaining the temperature, in any region where the capacitors are placed, at  $40 \pm 2^\circ\text{C}$ , and the relative humidity at not less than 90 percent and not more than 95 percent. The air in the chamber shall be circulated and the chamber shall be so designed that mist or water droplets cannot fall on the capacitors.

#### **5.12.2 Treatment**

- a) The capacitors shall be introduced into the chamber and subjected to the conditions specified in 5.12.1 for 21 days.

Care shall be taken, at the time of introduction, that the formation of droplets of water is kept to a minimum. This may be done by preheating the capacitors to a temperature a little above  $42^\circ\text{C}$ .

- b) Voltage shall not be applied to the terminals of the capacitors during this test.
- c) If desired, the test may be interrupted not more frequently than every 7 days for the test specified in 5.12.4. The chamber door shall be opened for the shortest possible time.

**5.12.3 Recovery** — After removal from the test chamber at the end of the twenty-first day the capacitors shall be permitted to recover for a period of 1 to 2 hours and shall then be subjected to the tests following in the order stated.

**5.12.4 Final Measurements** — Where capacitors are enclosed in insulating casings, they shall have a wrapping of thin metal foil applied during the tests given in 5.12.4.1 and 5.12.4.2.

**5.12.4.1 Insulation resistance between capacitor terminals and container** — The insulation resistance shall be measured at room temperature with a dc voltage of between 300 V and 500 V, applied for 1 minute between the terminals or the terminal connections, bonded together, and the casing. None of the capacitors shall have an insulation resistance less than 10 megohms.

**5.12.4.2 Voltage test between terminals and container** — Each capacitor shall be tested in accordance with, and comply with the requirements of 5.7.

**5.12.4.3 Voltage test between terminals** — Each capacitor shall be tested between terminals in accordance with, and comply with the requirements of 5.6. If more than one capacitor fails during these tests the type shall be rejected. If one capacitor failure occurs, a further 5 capacitors shall be taken and subjected to the requirements of this clause. If further failures occur, the type shall be rejected.

### 5.13 Endurance Test

**5.13.1 Test Procedure** — Twelve of the capacitors forming the third group referred to in 5.1.3 shall be mounted in an oven in a position conducive to the leakage of impregnant or filling material and be subjected to 84 cycles of heat and voltage as set out in Appendix D.

During the heating period of each cycle, the capacitors shall be heated to their rated maximum temperature and shall be connected to an ac 50 Hz voltage as appropriate, as indicated in Table 3.

**TABLE 3 ENDURANCE TEST**

DESIGNATION	RATING	TEST VOLTAGE
(1)	(2)	(3)
Any	All ratings at 240 V or less and 50°C or less, 50 Hz	1.25 $U_n$
Non-self-healing	Other ratings, 50 Hz	1.5 $U_n$
Self-healing	Other ratings, 50 Hz	1.25 $U_n$

**NOTE** — The rating of capacitors given in the first line of Table 3, having ratings of 240 V or less and 50°C or less, 50 Hz corresponds to a type of capacitor, employing metal foil electrodes and paper dielectric impregnated with chlorinated wax. Because of the particular properties of the dielectric, these capacitors are limited in their operation to a maximum rated voltage of 240 V ac and a maximum rated temperature of 50°C. These properties also limit the overvoltage capability of the capacitors so that reduced endurance test levels shall be employed. Satisfactory performance of these capacitors has been obtained over many years for operation within these limitations.

**5.13.2 Conditions for Compliance** — The capacitance shall be measured before and after the test in accordance with 5.8 and a change in capacitance of more than 5 percent, a non-self-healing breakdown or leakage of impregnant, shall constitute a failure.

If 2 failures have occurred, then in order to save testing time, the test in 5.14 may be made using 5 of the capacitors which have passed the endurance test together with 5 new capacitors which have passed the initial tests detailed in 5.1.3 (a) to (e). At the same time the endurance test is repeated on 10 further capacitors.

Figure 1 illustrates the procedure in respect of sample quantities used during the endurance and destruction tests ( see 5.13 and 5.14 ).

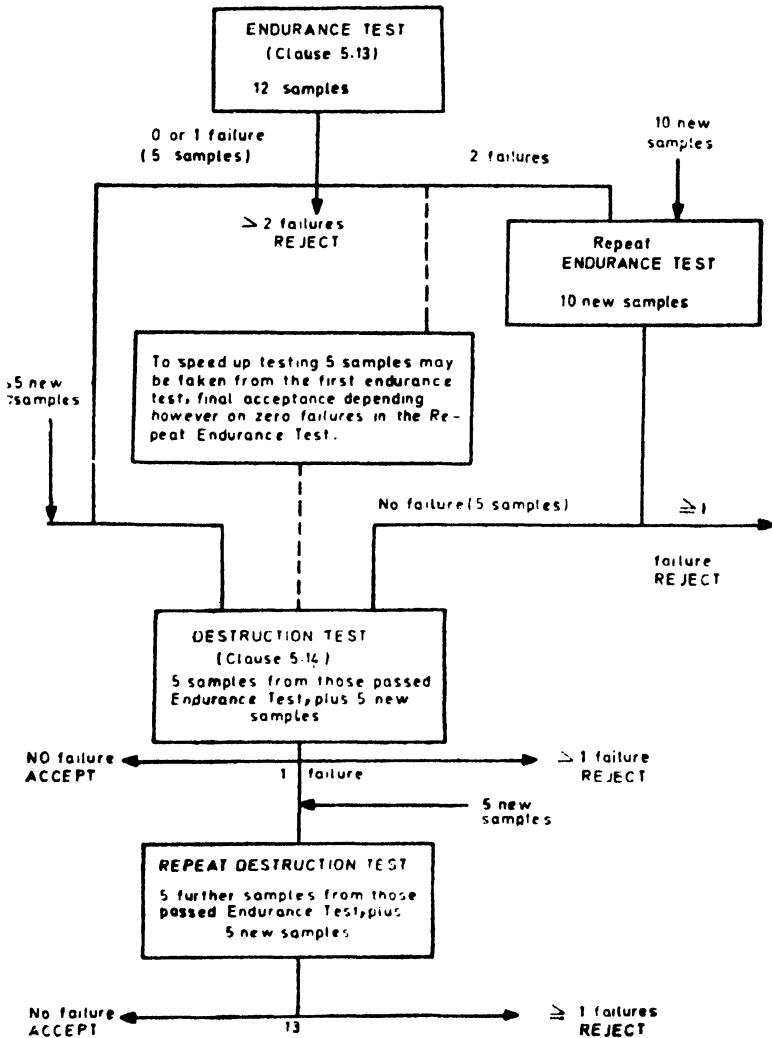


FIG. 1 PROCEDURES IN RESPECT OF SAMPLE QUANTITIES AND APPRECIATION OF THE RESULTS

#### 5.14 Destruction Test ( Self-Healing Capacitors Only )

NOTE — Tests for non-self-healing capacitors are under consideration.

**5.14.1** The test shall be carried out on 10 capacitors, 5 of which have passed the initial test detailed in 5.1.3 (a) to (e), and 5 having passed, in addition, the test of 5.13.

**5.14.2** The capacitors shall be mounted in an oven as described in Appendix D and then heated throughout to a temperature of  $10^{\circ}\text{C}$  above its rated maximum temperature.

**5.14.3** The capacitors, while still in the oven at the suitable temperature as previously, shall then be energized for 1 hour, in series with a time lag fuse using an ac voltage of  $1.3 \times U_n$  and the circuit shown in Fig. 2.

**5.14.4** The rated current of the fuse shall be 20 A or 10 times the current corresponding to the rating of the capacitor, whichever is the greater. The test voltage supply shall be capable of passing a fault current of 300 A or 10 times the rated current of the fuse whichever is the greater.

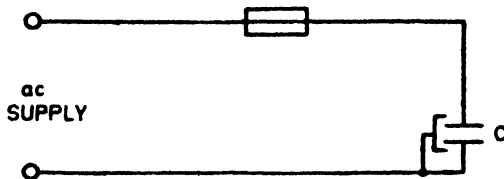


FIG. 2 DESTRUCTION TEST CIRCUIT

**5.14.5** The voltage shall be increased to  $1.4 U_n$  and maintained for 1 hour. It shall then be increased in steps of 20 percent  $U_n$  at the end of every hour until it has reached  $2 U_n$ . This value shall also be maintained for 1 hour.

**5.14.6** During each of four subsequent 24 hour cycles, the capacitors shall be energized at  $2 U_n$  for 8 hours. The temperature of the oven shall be maintained throughout each cycle at the original temperature.

**5.14.7** If during this treatment, the current through any capacitor is interrupted either by an internal open circuit or by the operation of the external fuse, a check shall be made, by renewing the fuse twice, to ascertain that, if the interruption has been caused by the operation of the external fuse, the internal short circuit is stable.

**5.14.8** If both replacement fuses operate the test on that capacitor shall be ended. If only one of the replacement fuses operates the test shall be continued, as previously, until the current is again interrupted.

**5.14.9** If the next interruption is caused by the action of the fuse the same procedure as before shall be repeated until both replacement fuses fail.

**5.14.10** At the conclusion of the test, the enclosure of each capacitor shall be intact but escaping materials may be allowed to wet the surface of the capacitor provided they do not form drops.

**5.14.11** The capacitors shall then be allowed to cool to room temperature after which they shall be subjected to the test prescribed in 5.7, the test voltage however, being reduced by 500 V.

**5.14.12** The one or two failures, which according to 5.1 do not lead to immediate rejection, shall not be of such a nature that there has been a risk of fire.

**5.14.13** A suitable method of checking whether there has been a risk of fire, is to enclose the capacitor in gauze (cheese cloth). Burning or scorching of the gauze is then considered as a criterion of failure.

**5.14.14** If a repeat test has to be made the same distribution of samples shall be used as for the first test.

**5.14.15** Figure 1 illustrates the procedure in respect of sample quantities used during the endurance and destruction tests (see 5.13 and 5.14).

**5.14.16** Table 4 summarizes the requirements of the destruction test (see 5.14).

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**TABLE 4 SUMMARY OF DESTRUCTION TEST FOR  
SELF-HEALING CAPACITORS**

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1.	Number of samples	10
2.	Samples heated to dc voltage applied	$t_c + 10^\circ\text{C}$
3.	AC test voltage applied (oven temperature maintained at $t_c + 10^\circ\text{C}$ )	Then, $1.4 U_n$ for 1 h $1.6 U_n$ for 1 h $1.8 U_n$ for 1 h $2.0 U_n$ for 1 h  Switch off. Then, $2 U_n$ for an 8 hour period each 24 hours for another 96 hours.
4.	Criteria of acceptance	A capacitor is considered to have passed the destruction test if: <ol style="list-style-type: none"> <li>the current through it has not been interrupted by the delayed action test circuit fuse or by any internal fuse; or</li> <li>the current through it has been interrupted without any harmful effects occurring; or</li> <li>three delayed action test circuit fuses have cleared without any harmful effects occurring; or</li> <li>the enclosure is intact at the end of the test. (Escaping materials are allowed to wet the surface of the enclosure provided drops do not form); and</li> <li>the test prescribed in 5.7 is passed at the end of the test. Voltage is reduced by 500 V.</li> </ol>

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**APPENDIX A**( *Clauses 3.7 and 5.9* )**DISCHARGE RESISTORS**

**A-1.** The value of discharge resistors may be calculated by the following formula:

$$U_0 e^{-60/C'R'} = 50$$

where

$U_0$  = peak voltage to which the capacitor can be charged  
(namely,  $1.1 \times 1.414 \times$  rated voltage),

$e$  = base of Napierian logarithms,

$C'$  = maximum value of the capacitance of the capacitor  
(  $\mu\text{F}$  ),

$R'$  = maximum value of the resistance of the discharge  
resistor (  $\text{M}\Omega$  ).

The above formula may be simplified to:

$$C'R' = \frac{60}{(2.303 \log_{10} U_n) - 3.47}$$

where

$U_n$  = capacitor rated voltage.

If typical voltage ratings are inserted in this formula the results in Table 5 shall be obtained.

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**TABLE 5 NOMINAL VALUE OF DISCHARGE RESISTOR**

RATED VOLTAGE OF CAPACITOR	NOMINAL RESISTANCE, $R^*$
(1)	(2)
	$\text{M}\Omega$
240 V	$< 22.60/C$
250 V	$< 22.15/C$
300 V	$< 20.34/C$
380 V	$< 18.40/C$
440 V	$< 17.36/C$

\* $R$  is the nominal resistance in  $\text{M}\Omega$  and  $C$  the nominal capacitance in  $\mu\text{F}$ .

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Table 5 takes into account the resistance tolerance of +20 percent and a capacitance tolerance of +10 percent.

Provided the actual resistance value is less than the value given by these formulae, the capacitor shall be discharged sufficiently rapidly. To avoid excessive heat generation in the resistor, its value shall not be made any smaller than necessary.

## **A P P E N D I X   B**

*( Clause 5.1.2 )*

### **TEST VOLTAGE**

**B-1.** Voltage tests, except discharge resistor tests, shall be carried out with either an ac or dc source as specified in the relevant clauses. The source shall be adequate to maintain, over any specified test period, the test voltage required, subject to a tolerance of  $\pm 2.5$  percent.

**B-2.** AC tests shall be made using a 50 Hz supply, the voltage waveform of which shall be sufficiently free from harmonics as to ensure that when applied to the capacitor, the resulting current shall not exceed the value corresponding to a sinusoidal voltage waveform by more than 10 percent.

**B-3.** If desired, discharge resistors may be disconnected during voltage tests.

## **A P P E N D I X   C**

*( Clause 5.2.1 )*

### **SAMPLING PROCEDURE**

#### **C-1. LOT**

**C-1.1** In any consignment, all the capacitors of the same type manufactured by the same factory during the same period shall be grouped together to constitute a lot.

**C-1.2** From each lot, a certain number of capacitors ( as specified in Table 6 ) shall be selected at random and subjected to acceptance tests specified in 5.2.

**C-2. CRITERION FOR CONFORMITY**

**C-2.1** The actual number of capacitors to be selected from a lot shall be in accordance with Table 6. In this table,  $N_1$  is the size of the first sample. If the number of failures found in this sample is less than or equal to  $C_1$ , the lot shall be accepted. If the number of failures is equal to or greater than  $C_2$  the lot shall be rejected. If the number of failures is between  $C_1$  and  $C_2$  further sample of  $N_2$  capacitors shall be taken and subjected to all acceptance tests. If the number of failures in the two samples combined is less than  $C_2$ , the lot shall be accepted; otherwise it shall be rejected.

NOTE — The plan recommended under C-2 assures that lots with defectives 4 percent or less would be accepted most of the time and lots with defectives 30 percent or more would be rejected most of the time. The exact consumer risk depends on the lot size and it would be minimum when the lot size is maximum.

**TABLE 6 SAMPLING PLAN***( Clauses C-1.2 and C-2.1 )*

BATCH SIZE	$N_1$	$N_2$	$N_1 + N_2$	$C_1$	$C_2$
(1)	(2)	(3)	(4)	(5)	(6)
51 to 100	10	20	30	0	3
101 „ 200	13	26	39	0	5
201 „ 300	20	40	60	1	5
301 „ 500	25	50	75	1	6
501 „ 800	35	70	105	2	7
801 „ 1 300	50	100	150	3	10
1 301 „ 3 200	75	150	225	5	12

**APPENDIX D***( Clauses 5.13.1 and 5.14.2 )***ENDURANCE TEST****D-1. CAPACITOR ARRANGEMENT**

**D-1.1** The temperature in the oven shall be controlled by a temperature sensing device suitably located in the working space.

**D-1.2** In addition, care shall be taken to ensure that the conditions prevailing at any point in the working space of the oven are homogeneous with a tolerance of  $\pm 2^\circ\text{C}$ . Therefore, the air in the oven shall be continuously agitated, but not so vigorously as to cause undue cooling of the capacitors.

**D-1.3** The capacitors under test shall not be subjected to direct radiation from any heating elements in the oven.

**D-1.4** Care shall be taken that any heat dissipation from the capacitors under test shall not appreciably influence conditions within the oven.

**D-1.5** In order to ensure this, the capacitors shall preferably be placed or mounted on non-metallic shelves or racks which shall be designed so that they do not obstruct the convection. The clear spacing between capacitor in all horizontal directions shall not be less than 50 mm, and the capacitor shall not occupy more than 25 percent of the horizontal cross-sectional area of the oven. If two layers of capacitors are employed, the vertical clear space between them shall be at least 100 mm, and the capacitors in the two layers shall be staggered horizontally.

**D-1.6** Where the use of metallic shelves or racks shall be unavoidable, a thermally insulating plate shall be inserted between the capacitors and the shelf or rack in such a manner as will not obstruct the flow of convection air currents over the surface of the capacitors.

## **D-2. VERIFICATION OF OVEN TEMPERATURE DISTRIBUTION**

**D-2.1** In order to verify the suitability of the heating arrangements of the test oven, and the proper disposition of the capacitors and their supports, it is desirable to make a preliminary test of the oven using similar capacitors to those which are going to be tested. Voltage shall not be applied to the capacitors during this preliminary test.

**D-2.2** For this test a set of capacitors shall be mounted in position with each capacitor having at least two calibrated fine-wire thermocouples attached to it on opposite sides of, and towards opposite ends of its casing. The connections from these thermocouples shall be brought out of the oven by means of very thin (0.3 mm diameter or less) and well spaced wires to minimize heat losses.

**D-2.3** After the oven has been maintained at approximately the specified test temperature for not less than 3 hours, the surface temperature distribution on each capacitor shall not show differences of more than 2°C. In addition, the average surface temperatures of the capacitors shall be within 2°C of each other.

## **D-3. TEST PROCEDURE**

**D-3.1** The test capacitors shall be mounted as described in D-1 and subjected to 84 cycles of heating and cooling, one cycle of which is described as follows.

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**D-3.2** The first period of the cycle shall be of 6 hours and the loading of the oven shall be such that the temperature of the air surrounding and in the immediate neighbourhood of the capacitors rises to within 5°C of the maximum rated temperature of the capacitors as marked on their container, within the first half hour from switching on, and remains within 2°C of this maximum rated temperature during the last 4 hours of the 6-hour period. During the whole of the heating period of 6 hours the capacitors shall have applied to them the ac test voltage specified.

**D-3.3** At the end of the 6-hour heating period, the applied voltage shall be switched off and the capacitors shall be subjected to forced cooling to 30°C or less, without removal from the test enclosures. The forced air cooling shall be such that the air temperature surrounding and in the immediate neighbourhood of the capacitors is reduced to below 30°C before the end of a 2-hour period, which then completes one cycle.

**D-3.4** Immediately, at the end of the colling period, the heating and voltage shall be reapplied, and the test cycle repeated without interruption for the number of cycles specified.

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