IS : 1709 - 1984
(Reaffirmed 1995)

Indian Standard

(Reaffirmed 2016)
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SPECIFICATION FOR CAPACITORS FOR ELECTRIC FAN MOTORS

(*First Revision*)

Third Reprint JANUARY 1999

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6

November 1984

AMENDMENT NO. 1 MAY 1986

TO

IS:1709-1984 SPECIFICATION FOR CAPACITORS FOR ELECTRIC FAN MOTORS

(First Revision)

[*Page 6, clause 6.1*(b)] - Substitute the following for the existing matter:

"b) Manufacturer's name or trade-mark and month/year of manufacture."

(ETDC 29)

Printed at Simco Printing Press, Delhi, India

AMENDMENT NO. 2 JULY 1989
TO
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(First Revision)

(*Page* 9, *clause* 7.1.3.3) — Insert the following after this clause:

'NOTE — If the capacitors are identical in design, it shall be sufficient to test the lowest, middle and the highest rating of the capacitance of the capacitor for the purpose of type testing of entire range.'

(ETDC 29)

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AMENDMENT NO. 3 JUNE 2020

TO

IS 1709 : 1984 SPECIFICATION FOR CAPACITORS FOR ELECTRIC FAN MOTORS

(First Revision)

(*Page* 10, *clause* **7.3.2**) — Delete.

(ETD 29)

Publication Unit, BIS, New Delhi, India

Indian Standard

SPECIFICATION FOR CAPACITORS FOR ELECTRIC FAN MOTORS

(First Revision)

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Indian Standard

SPECIFICATION FOR CAPACITORS FOR ELECTRIC FAN MOTORS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 21 June 1984, after the draft finalized by the Power Capacitors Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was first published in 1960 which covered fan capacitors with paper dielectric only. The present revision is undertaken to include capacitors of self-healing type. Other modifications made in this revision are as follows:

a) Dimensions of higher rated capacitors have been included;

b) To suit the actual ambient air temperature, the temperature category has been modified;

c) The climatic tests have been rationalized and tests not required have been eliminated;

d) The additional tests applicable to self-healing type capacitors have been included;

e) The number of samples for type approval have been reduced with modified sequence of tests; and

f) The lot sampling scheme and the criteria for acceptance have been changed.

0.3 Although admittedly the characteristics of fixed capacitors required for electrical appliances similar to fans are the same, the scope of this standard has been limited to fixed capacitors for use with fans only. The dimensions are governed, to a very large extent, by the space available for their locations.

0.4 Cuboidal-shaped containers are required in special cases and are also permitted although cylindrical containers are preferred.

0.5 With the increasing availability of better quality materials and improved techniques of capacitor manufacture, it is likely that the dimensions of a capacitor of a particular capacity may be smaller than those given in this standard. The values recommended in Appendix A

are the maximum dimensions for cylindrical capacitors and there is no restriction to manufacture the capacitors in smaller sizes provided they meet the requirements given in this standard.

0.6 In the preparation of this standard, assistance has been taken from the following publication/document issued by the International Electro technical Commission:

Pub 252 (1975) A.C. motor capacitors.

Doc 33 (Secretariat) 90 Second draft — Shunt capacitors of the self-healing type for ac power systems of up to and including 660 V nominal voltage.

0.7 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.

1. SCOPE

1.1 This standard covers the requirements and methods of test for self-healing and non-self-healing types of fixed capacitors used in single phase ac electric fan motors.

1.2 The recommended dimensions of cylindrical capacitors rated up to 10 μF are specified in Appendix A.

2. TERMINOLOGY

2.0 For the purpose of this standard, the definitions given in **2.1** to **2.16** in addition to those given in IS : 1885 (Part XLII)-1977† shall apply.

2.1 Capacitor Element (or Element) — An indivisible part of a capacitor consisting of electrodes separated by a dielectric.

2.2 Capacitor Unit (or Unit) — An assembly of one or more capacitor elements in a single container with terminals brought out.

2.3 Capacitor — The word 'capacitor' is used when it is not necessary to lay particular stress upon the different meanings of the words ' capacitor unit ' or ' capacitor bank '.

*Rules for rounding off numerical values (*revised*).
†Electrotechnical vocabulary: Part XLII Power capacitors.

2.4 Fixed Capacitor — A capacitor having a constant value of capacitance for given conditions, which cannot be varied by means of any mechanical device.

2.5 Fan Capacitor — A fixed capacitor used for starting of ac single phase fans.

2.6 Self-Healing Capacitor — A capacitor the electrical properties of which after local breakdown of the dielectric are rapidly and essentially restored.

2.7 Rated Voltage — The rms value of the alternating voltage (between terminals) for which the capacitor has been designed.

2.8 Rated Frequency — The frequency of the power system with which the capacitor is designed to operate.

2.9 Rated Capacitance of a Capacitor — The capacitance value for which the capacitor has been designed.

2.10 Capacitor Losses — The active power dissipated by a capacitor.

2.11 Power Factor — The ratio of the active power to the apparent power.

2.12 Tangent of the Loss Angle (tan δ) of the Capacitor — The ratio between the equivalent series resistance and the capacitive reactance of a capacitor at specified sinusoidal alternating voltage and frequency.

2.13 Ambient Air Temperature — The temperature of the surrounding air at the proposed location of the capacitor.

2.14 Routine Tests — Tests carried out on each capacitor to check requirements which are likely to vary during production.

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

2.16 Type Tests — Tests intended to prove the general qualities and design of a given type of capacitor.

3. RATINGS

3.1 Rated Voltage — Unless otherwise specified, the rated voltage of fan capacitors shall be 400 V.

3.2 Rated Frequency — The rated frequency shall be 50 Hz.

3.3 Ambient Air Temperature — The fan capacitors shall be suitable for working at full load under ambient air temperature up to 70°C.

4. PREFERRED CAPACITANCE VALUES

4.1 The following shall be the preferred values of capacitance of the fan capacitors.

1·50, 2·00, 2·25, 2·50, 3·00, 3·50, 4·00, 5·00, 6·00, 8·00 and 10 μF.

4-1.1 *Tolerance on Capacitance* — The fan motor capacitors shall have the capacitance within ± 5 percent of the stated value.

5. MATERIAL, WORKMANSHIP AND FINISH

5.1 Capacitors shall be constructed from the suitable materials for tropical use in accordance with the best prevailing engineering practice and conforming to the relevant Indian Standard Specifications.

5.2 No hygroscopic materials shall be used unless they have been previously rendered moisture-proof.

5.3 The container of the capacitor shall be of metal or non-metal. The capacitor shall be sealed to ensure freedom from ingress of moisture. The container shall preferably be cylindrical in shape (*see* **0.4** also).

5.4 All exposed metal parts likely to be affected by atmospheric conditions shall be painted or otherwise protected to prevent corrosion or rust under normal conditions of use.

5.5 Only non-corrosive flux shall be used unless it can be ensured that corrosive products have been removed. Excess flux and solder particles shall be removed.

5.6 Terminals — The terminations of the fan capacitor shall be either lead, lug or screw type.

5.7 Provision of Earthing — The metal containers of the fan capacitors shall either be fitted with an earthing terminal of adequate size or shall be so constructed that it may be effectively earthed. The earthing terminal, where provided, shall be clearly marked with the symbol 

6. MARKING

6.1 The following shall be legibly marked on the body of the fan capacitors:

a) Reference to this Indian standard — Ref ISS 1709-1984;

b) Manufacturers' name or trade-mark and serial number;

c) Rated voltage;

d) Rated frequency;

e) Rated capacitance;

f) Rated ambient temperature;

g) Type of dielectric, P/PP/MPP/M

where

P = paper,
PP = polypropylene,
MPP = metallized polypropylene,
M = mixed dielectrics; and

h) Reference to self-healing design, for example, SH.

NOTE — In addition to markings on the body of the capacitor, the manufacturer may provide additional information in an enclosed instruction sheet. The rating plate shall bear a reference to this instruction sheet.

6.2 BIS Certification Marking

The product may also be marked with Standard Mark.

6.2.1 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

7. TESTS

7.0 Standard Temperature of Testing — Unless otherwise specified the standard ambient air temperature range for testing shall be 15 to 35°C. If corrections have to be made, the reference temperature shall be 27 ± 2°C.

7.1 Classification

7.1.1 *Routine Tests* — The following shall constitute routine tests which are carried out on each capacitor:

a) Visual examination (*see* **7.2**),

b) Insulation resistance test (*see* **7.3**),

c) Voltage test between terminals (*see* **7.4.1**), and

d) Voltage test between terminals and the container (*see* **7.4.2**).

7.1.2 *Acceptance Tests* — The schedule of acceptance tests shall be as given below:

a) Visual examination (*see* **7.2**),

b) Capacitance measurement (*see* **7.5**),

c) Sealing test (*see* **7.12**),

d) Measurement of tangent of loss angle (*see* **7.6**),

e) Insulation resistance between terminals and container (*see* **7.3.1**)

f) Voltage test between terminals (*see* **7.4.1**),

g) Voltage test between terminals and containers (*see* **7.4.2**), and

h) Capacitance as a function of temperature (*see* **7.13**).

7.1.2.1 *Sampling plan for acceptance tests*— A recommendatory sampling plan for acceptance tests is given in Appendix B.

7.1.2 *Type Tests* — The schedule of type tests shall be as given in Table 1.

7.1.3.1 *Samples and sequence of tests* — For type tests on a capacitor of a single-model, 26 samples are required for self-healing capacitors and 20 samples for non-self-healing capacitors. The units forming the sample shall have successfully passed the routine test indicated in **7.1.1.**

The samples of each model selected for the type tests shall be divided into groups, as indicated in Table 1.

The tests on each group shall be carried out in the order stated in Table 1.

7.1.3.2 *Test certificates* — Type tests are intended to prove the soundness of the design of the capacitor and its suitability for operation under the conditions detailed in this standard. Type tests shall have been carried out by the manufacturer before accepting a contract for the supply of the capacitors, and a certificate detailing the results of such tests shall be supplied to the purchaser at his request. These tests shall have been made upon capacitors of a design identical with that offered or on capacitors of a design that does not differ from that offered to the purchaser in any way that may influence the features to be checked by the type test.

Type tests may be carried out under the supervision of a proper authority, which will issue a certified record and/or type approval. Type approval is a statement to the effect that a particular manufacturer can be considered capable of producing, in reasonable quantities, the capacitors of the type complying with this standard. Some type tests need not be repeated by the manufacturer in connection with any particular contact, except by agreement with the purchaser and when stipulated in the capacitor supply contract.

TABLE 1 SCHEDULE OF TYPE TESTS

(*Clauses* 7.1.3, 7.1.3.1. *and* 7.1.3.3)

GROUP	TEST	CLAUSE REF	NUMBER OF SAMPLES TO BE INSPECTED	NUMBER OF DEFECTIVES ALLOWED FOR EACH GROUP	TOTAL NUMBER OF DEFECTIVES ALLOWED
(1)	(2)	(3)	(4)	(5)	(6)
I.	Visual examination	7·2	4	2	2
	Check of dimensions	1·1, Appendix A			
	Mechanical tests	7·7 to 7·11			
II.	Sealing test	7·12	10	1	
	Capacitance as a function of temperature	7·13			
	Endurance test	7·16			
	Measurement of tangent of loss angle	7·6			
III.	Damp heat	7·15	6	1	
	Insulation resistance between terminals and containers	7·3·1			
	Insulation resistance between terminals (if applicable)	7·3·2			
	Voltage test between terminals	7·4·1			
	Voltage test between terminals and container	7·4·2			
IV.	Self-healing test (if applicable)	7·14	6	1	
	Destruction test (for self-healing type capacitors)	7·17			

7.1.3.3 *Criteria of conformity* — When the number of defectives for each group and the total number of defectives do not exceed the figures indicated in Table 1 the capacitor model shall be deemed to comply with this standard.

7.1.3.4 *Extent of qualification* — A type test on a sample consisting of a single model only qualifies the model tested. When the type test is performed on three models of the same type with the same rated voltage and of lowest, middle/highest rated capacitance value, the qualification is valid for all models of the same type with the same rated voltage and of all rated capacitances included between the lowest and highest tested values.

7.2 Visual Examination — The capacitors shall be visually examined for finish and marking.

7.3 Insulation Resistance

7.3.1 *Insulation Resistance Between Terminals and Container* — The insulation resistance shall be measured at 500 V dc after 30 ± 5 sec of the application of voltage between the terminals connected together and:

a) the outer casing or mounting brackets if these are of metal, or

b) a metal foil tightly surrounding the container if the latter is of insulating metarial.

The value of insulation resistance so measured shall be not less than 100 MΩ.

7.3.2 *Insulation Resistance Between Terminals* — Before the measurement of insulation resistance, the capacitor shall be fully discharged. The insulation resistance shall be measured with a direct voltage of 500 V after 2 min ± 5 sec of electrification. The voltage shall not be applied gradually but shall be applied immediately through the internal resistance of the test apparatus The product of this internal resistance and the rated capacitance under test shall not exceed one second. The value of measured insulation resistance shall be higher than the limit given by the manufacturer.

NOTE — When the capacitor has a discharge resistor, this shall be disconnected before measuring the insulation resistance.

7.4 Voltage Tests

7.4.1 *Voltage Test Between Terminals* — In type tests capacitors shall be subjected to an ac voltage test as specified in Table 2. The test shall be carried out with a substantially sinusoidal voltage at a frequency as near as possible to the rated frequency.

7.4.1.1 In routine test, instead of alternating current, direct current may be used, leaving the choice to the manufacturer. In the event of a dc test the expression for arriving at test voltage is indicated in Table 2.

7.4.1.2 For metal foil and metallized non-self healing capacitors, no dielectric breakdown shall occur; for self healing capacitors, no permanent breakdown shall occur.

NOTE — For routine tests, the test time of 10 seconds may be reduced to 2 seconds provided the test voltage is increased by 10 percent.

TABLE 2 VOLTAGE TEST

(*Clauses* 7.4.1 *and* 7.4.1.1)

Kind of Capacitor	Ratio of Test Voltage to Rated Voltage		Test Time
	ac	dc	Seconds
(1)	(2)	(3)	(4)
Non-self healing	2·15	$\sqrt{2} \times 2{\cdot}15$	10
Self healing	1·5	$\sqrt{2} \times 1{\cdot}5$	10

7.4.2 *Voltage Test Between Terminals and Container* — Capacitors shall be subjected for 10 sec to a test between terminals (joined together) and the container, with a substantially sinusoidal ac voltage of a frequency as near as possible to the rated frequency and of twice rated voltage + 1 000 V, but not less than 2 000 V rms value.

7.4.2.1 If the capacitor container is of insulating material, the test voltage shall be applied between the terminals and the metal mountings, if any, or a metal foil wrapped tightly around the surface of the container. During the test, no dielectric breakdown or flashover shall occur.

NOTE — For routine test, the duration may be reduced from 10 seconds to 2 seconds if the test voltage is increased by 10 percent.

7.5 *Capacitance Measurement Test* — The capacitance shall be measured at a frequency as nearly as possible to 50 Hz. The measuring method shall be such as not to introduce an error greater than 1 percent of the tolerance permitted on the capacitance value. The applied voltage for testing shall not exceed 20 percent of the rated voltage of the capacitor.

7.5.1 The measured value of capacitance shall not deviate from the rated value by more than 5 percent.

7.6 *Measurement of Tangent of Loss Angle* — The tangent of loss angle ($\tan\delta$) of the capacitor shall be determined by means of a Schering Bridge or any other method capable of giving sufficiently accurate results. For metal-foil paper capacitors and metallized paper capacitors, the measuring inaccuracy in tangent of loss angle ($\tan\delta$) shall not exceed 0·000 2. The measurement shall be carried out at the rated voltage and frequency. The value of the tangent of loss angle determined by the test shall not exceed by more 10 percent of the value agreed between the

manufacturer and the purchaser. However the maximum value of the tangent of loss angle shall not exceed the values given below:

Self-healing type:	
a) Metallized paper	0·006
b) Metallized polypropylene	0·002
Non-self healing type	0·005

7.7 *Test for Robustness of the Termination* — The body of the capacitor shall be clamped vertically with the terminations downward and a weight of 2 kg shall be suspended freely from each one of them in turn for a period of 10 sec. There shall be no damage to the capacitor or termination after this loading.

7.8 *Test for Flexibility of Lead Terminations*

7.8.1 Each termination shall withstand two consecutive bends as specified in **7.8.2** and **7.8.3** without damage to the capactior.

7.8.2 A load of one kilogram shall be freely suspended from each of the terminations of the capacitor in turn in the direction of the axis of the terminations, the body of the capacitor being held vertically with the terminations downward so that the terminations are in their normal position relative to the body of the capacitor. The body of the capacitor shall then be inclined, reasonably slowly, so as to bend the terminations through 90° and returned to normal, the entire action taking place in one vertical place. Bending through an angle of 90° and back shall be defined as one bend.

7.8.3 Where the terminations are so designed that they are weaker in one place than in others, they shall be tested in the weakest direction, or several tests each on a separate sample shall be made. Consecutive bends shall be in opposite directions.

7.9 *Test for Flexibility of Soldering Tags*

7.9.1 Soldering tags shall withstand two consecutive cycles of bending as specified in **7.9.2** without damage to the capacitor.

7.9.2 A load of one kilogram shall be applied to each soldering tag at right angle to the flat face of the terminal having the bigger area by attaching the load to each tag at the point where the termination would be normally made. The load should be applied first in one direction and then in the opposite direction. This operation shall be considered as one cycle of operation.

7.10 Test for Screw Terminals — There shall be no damage to the capacitor when a torque as specified below is applied to the nuts and

screws of threaded terminations:

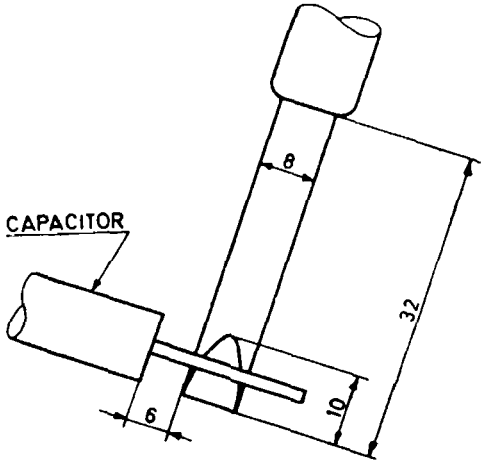
Nominal Diameter of screw, mm				*Torque*, Nm
Up to and including			2·8	0·4
Over 2·8 up to and including			3·0	0·5
,, 3·0	,,	,,	3·2	0·6
,, 3·2	,,	,,	3·6	0·8
,, 3·6	,,	,,	4·1	1·2
,, 4·1	,,	,,	4·7	1·8
,, 4·7	,,	,,	5·3	2·0
,, 5·3	,,	,,	6·0	2·5

7.11 Soldering Test

7.11.1 Each solderable termination shall be readily wetted by molten solder.

7.11.2 The capacitor shall not suffer any damage when the specified soldering iron (*see* **7.11.3**) is applied to the termination for 15 sec.

7.11.3 For lead terminations, the soldering iron shall be applied in the manner indicated in **Fig.** 1.



All dimensions in millimetres.

FIG. 1 ARRANGEMENT FOR SOLDERING TEST

7.11.4 For tag type of terminations, the soldering iron shall be applied in such a way that it does not touch the seals on the capacitor. In either case, the termination or tag shall be tinned, using the solder specified in **7.11.6** during the first two seconds of application of the iron.

7.11.5 The bit of the soldering iron used for this test shall be smooth, clean and properly tinned and it shall be at a temperature of 300 to 350°C. It shall be of the form and size indicated in Fig. 1.

7.11.6 The solder used shall contain 60 percent tin and 40 percent lead with a non-activated resin core and shall have a diameter of approximately 2 mm.

7.12 Sealing Test

7.12.1 After degreasing, the capacitors shall be stored in a position most likely to reveal leakage at a temperature 5°C higher than the maximum permissible capacitor operating temperature of 80°C for a time sufficient for all parts of the capacitor to reach this temperature. As routine test the capacitor shall be maintained at this temperature for 1 hour before cooling.

7.12.2 When the test is used as a type test, the total heating and cooling cycle time shall be 8 hour. The temperature shall be increased uniformly till the capacitor attains the highest temperature. Maintain the capacitor at the highest temperature for one hour and then reduce the temperature uniformly. No leakage shall occur.

NOTE — If the manufacturer can certify that the capacitor contains no materials that are liquid at the sealing test temperature, then the test may be omitted as a routine test.

7.13 Capacitance as a Function of Temperature

7.13.1 This test is performed only when expressly required by the purchaser. The capacitance shall be measured in accordance with the method specified in **7.5** but at temperature equal to the limits of the rated temperature range of the capacitor and also at 27 ± 5°C. Before measurement, the samples shall be stored in a chamber with constant temperature equal to the limit temperature until they have attained this temperature throughout in the whole of the interior.

7.13.2 The change of capacitance at limit temperatures as compared to the value measured at a temperature of 27°C ± 5°C shall not exceed 5 percent corresponding to its value at 70°C and 3 percent corresponding to 0°C.

NOTE — While taking measurement at 0°C, it is permissible to carry out this measurement in the range from 0°C to 5°C.

7.14 Self Healing Test (for Self-Healing Capacitors Only)

7.14.1 Before the test, the capacitance shall be measured (*see* **7.5**). The capacitor shall be subjected for 10 seconds to an ac voltage of 1·5 times the rated voltage between terminals. If fewer than five breakdowns occur

during this time, the voltage shall be increased slowly until five breakdowns have occurred since the beginning of the test, or until the voltage has reached 3·5 times the rated voltage. After this, the voltage shall be decreased to 0·8 times the initial value (that is 1·24 times the rated voltage) and maintained for 10 seconds. No breakdown is permitted after decrease of voltage.

7.14.2 If only one or no breakdown has occurred since beginning of the test when the voltage has reached 3·5 times the rated voltage, the test shall be repeated on another identical capacitor.

7.14.3 Before and after the test, the capacitance (*see* **7.5**) shall be measured. A change not greater than 0·3 percent in its value shall be allowed.

NOTE — Self healing breakdowns during the test may be detected by an oscillosope or by accoustic or high frequency test methods. Special attention shall be given to the sensitivity of the instrument used.

7.15 Damp Heat Test

7.15.1 *General* — The capacitors shall be subjected to the damp heat test (long-term exposure). This test is intended to determine the suitability of a capacitor for use under conditions of high relative humidity and to observe the effects of such high humidity when combined with wide temperature variations.

7.15.2 *Test Chamber* — The chamber used for this test shall be capable of maintaining the temperature in any region, where the capacitors can be placed, at 40 ± 2°C and relative humidity between 90 to 95 percent. The air in the chamber shall be circulated and the chamber shall be so designed that no mist or dust or condensed water can directly reach the capacitors.

7.15.3 *Conditioning* — The capacitors shall be placed in the test chamber (*see* **7.15.2**) and subjected to the conditioning for 21 days. No test voltage shall be applied to the capacitors and no measurement during the conditioning period is made.

7.15.4 *Requirements* — After the damp heat period the capacitors shall be stored under standard atmospheric conditions for recovery not less than 1 hour and not more than 2 hours. After the recovery, the test for capacitance and tangent of the loss angle shall be carried out. The maximum permitted variation of capacitance compared to the value measured before the test and the maximum permitted individual values of the tangent of the loss angle shall be as follows:

	Metal-Foil and Metallized Capacitor
Maximum capacitance variation	5 percent
Maximum value of the tangent of the loss angle	Same limits as given in **7.6**

In some particular applications for metal foil and metallized capacitors, a maximum capacitance variation smaller than 5 percent may be requested. In these cases, the maximum variation shall be agreed between manufacturer and the purchaser.

7.16 Endurance Test — This test is intended to prove the suitability of the design of the capacitors when subjected to the most severe conditions compatible with this standard. The two test methods described (*see* **7.16.2** and **7.16.3**) are intended to ensure that the capacitor container temperature is as close as possible to the maximum permissible capacitor operating temperature.

7.16.1 *Methods* — Either of two alternative methods given in **7.16.2** and **7.16.3** of obtaining the test temperature are valid, the choice of the method used being left to the manufacturer. The two test methods are considered equivalent.

7.16.2 *Testing in a Liquid Bath* — The capacitors are immersed in a container filled with a liquid which by additional heating is kept at the maximum permissible capacitor operating temperature during the whole test. This temperature is maintained with a permissible change of $\pm$ 2°C. Care shall be taken that the temperature in the neighbourhood of all samples is within these limits.

NOTE — Where the terminal insulation or the insulation of the cable permanently attached to the capacitor is of material that might be damaged by the heating liquid, it is permissible for the capacitors to be positioned in such a manner that these terminals or cables are kept above the surface of the liquid.

7.16.3 *Testing in Forced-Circulated Air* — The capacitors are mounted in an enclosure in which heated air is circulated with an air velocity not less than 2 m/s such that temperature variations at different points of the enclosure shall not exceed $\pm$2°C. Heating of the air shall take place in a separate enclosure and the air shall be admitted in the capacitor enclosure through a valve allowing the best possible distribution of heated air on all capacitors. No heating shall take place through radiation. The sensitive element of the thermostat regulating the temperature in the capacitor enclosure should be placed well within the stream of the forced air circulating in the enclosure. The capacitors shall be placed in a vertical position with the terminals upright. When many capacitors are tested together they shall be placed with sufficient clearance between them. Their distance shall be not less than their diameter if they are cylindrical, nor less than twice the shorter side of their base, if the base is rectangular. After placing the capacitors in their unheated enclosure the thermostat shall be set at a temperature 10°C less than the relevant maximum permissible capacitor operating temperature. Of the 10 capacitors to be tested, that with the lowest loss angle shall be selected and the temperature recording instrument shall be placed against the side of the case three-fourths of the way up.

7.16.3.1 Then, without energizing the capacitors, the enclosure shall be brought to thermal stability which shall be deemed to have been reached when the container temperature of the selected capacitor shall have reached the stated temperature with a tolerance of ± 2°C.

7.16.4 *Test Performance* — Before the test, the capacitance and tangent of loss angle shall be measured (*see* **7.5** and **7.6**).

7.16.4.1 The capacitors shall be then energized at the stated voltage. After 24 h, the difference between the maximum permissible operating temperature of the capacitor and the maximum value of temperature recorded on the container shall be calculated. Then the thermostat shall be set again at a variation equal to the difference and with the same sign. After this the test shall be carried on for the prescribed duration without further modifications of the setting of the thermostat. The test time is computed from the moment of energization.

7.16.4.2 In both the methods, the following test conditions shall be used:

Test time	500 h
Ratio of test voltage to rated voltage	1·25
Test ferquency	Rated frequency
Kind of operation	Rated duty cycle

7.16.4.3 During the test no permanent breakdown, interruption or flashover shall occur.

7.16.4.4 At the end of the test, the capacitors shall cool freely down to the ambient temperature. The capacitance and tangent of loss angle shall be measured (*see* **7.5** and **7.6**).

7.16.4.5 The maximum permitted variation of capacitance compared to the value measured before the test, and the maximum permitted individual values of the tangent of the loss angle shall be as follows:

Final Measurements	
Maximum capacitance variation	5 percent
Maximum value of tangent of loss angle	Same limits as given in **7.6**

In some particular application for metal foil and metallized capacitors a maximum capacitance variation smaller than 5 percent may be requested. In these cases the maximum variation shall be agreed between the manufacturer and the purchaser.

7.17 Destruction Test (for Self-Healing Type Capacitors Only)

7.17.1 The test shall be carried out on 6 capacitors which had passed the routine tests (*see* **7.1**) and self-healing test (*see* **7.14**).

7.17.2 The capacitors shall be mounted in an oven prescribed in Appendix C and then heated throughout to a temperature of 10°C above 70°C their rated maximum temperature.

7.17.3 The capacitors, while still in the oven at the same 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 the rated voltage and the circuit shown in Fig. 2.

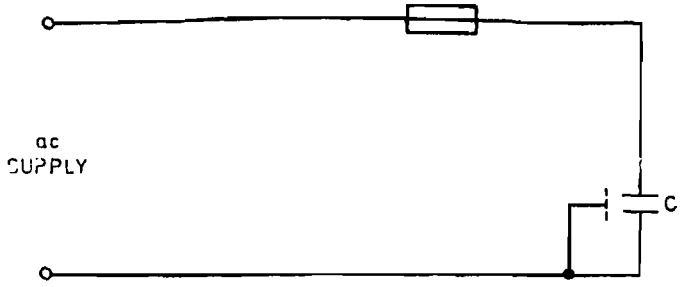


FIG. 2 DESTRUCTION TEST CIRCUIT

7.17.4 The rated current of the fuse shall be 20 A or 10 times the current corresponding to the rating of the capacitors, whichever is 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 greater.

7.17.5 The voltage shall be increased to 1·4 times the rated voltage and maintained for 1 hour. It shall then be increased in steps of 20 percent of the rated voltage at the end of every hour until it has reached twice the rated voltage. This value shall also be maintained for 1 hour.

7.17.6 Switch off and then during each of four subsequent 24-hour cycles, the capacitors shall be energized at twice the rated voltage for 8 hour. The temperature of the oven shall be maintained throughout each cycle at the original temperature.

7.17.7 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.

7.17.8 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.

7.17.9 If the next interruption is caused by the action of the fuse, the same procedure as before shall be repeated until both replacement fuses operated.

7.17.10 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.

7.17.11 The capacitors shall then be allowed to cool to room temperature after which they shall be subjected to the test prescribed in **7.4.2**, the test voltage, however, being reduced to 500 V.

7.17.12 The one or two failures, which according to **7.1.3.3** do not merit rejection shall not be of such a nature that there is a risk of fire.

7.17.13 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.

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

7.17.15 Table 3 summarizes the requirements of the destrution test.

TABLE 3 SUMMARY OF DESTRUCTION TEST FOR SELF-HEALING CAPACITORS

i)	Number of samples	6
ii)	Samples heated to	80°C
iii)	AC test voltage applied to (oven temperature maintained at 80°C)	1·4 *Un* for 1 h Then 1·6 *Un* for 1 h Then 1·8 *Un* for 1 h Then 2·0 *Un* for 1 h Switch off. Then 2 *Un* for an 8 h period each in four cycles of 24 h.
	where *Un* is the rated voltage between terminals.	
iv)	Criteria of acceptance	A capacitor is considered to have passed destruction test if: a) the current through it has not been interrupted by the delayed action test circuit fuse or by any internal fuse; b) the current through it has been interrupted without any harmful effects occurring; c) three delayed action test circuit fuses have cleared without any harmful effects occurring; d) 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 e) the test prescribed in **7.4.2** is passed at the end of the test, voltage being reduced to 500 V

APPENDIX A

(*Clause* 1.2)

DIMENSIONS OF CONTAINERS FOR CAPACITORS

A-1. The recommended maximum dimensions for cylinderical containers of capacitors are:

Capacitor Rating, μF	*Dimensions*, mm	
	Diameter *Max*	Length *Max*
Up to 2·25	40	75
2·50 to 4·00	45	75
1·50 to 10·00	65	115

A-2. The dimensions of cubodial-shaped capacitors shall be agreed between the manufacturer and the users (*see* **0.4**).

APPENDIX B

(*Clause* 7.1.2.1)

RECOMMENDED SAMPLING PLAN

B-1. LOT

B-1.1 In a consignment, all the capacitors of the same capacity and rating manufactured in the same factory under similar conditions of production shall be grouped together to constitute a lot.

B-1.2 The number of capacitors to be selected from each lot shall depend upon the size of the lot and shall be in accordance with col 1 and 2 of Table 4.

B-1.2.1 These capacitors shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* may be followed.

B-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

B-2.1 All the capacitors selected in the first sample at random according to col 1 and 3 of Table 4 shall be subjected to the acceptance tests. A capacitor failing to satisfy any of the acceptance tests shall be termed as ' defective '. The lot shall be considered as conforming to the

*Methods of random sampling.

requirements of acceptance tests if the number of defectives found in the first sample is less than or equal to the acceptance number (*see* col 4). If the number of defectives is greater than or equal to the corresponding rejection number (*see* col 5), the lot shall be considered as not conforming to the requirements and therefore, shall be rejected. If the number of defectives is greater than the acceptance number but less than the rejection number, a second sample of the same size as the first sample, shall be taken to determine the conformity or otherwise of the lot. The number of defectives found in the first and second samples shall be combined and if the combined number of defectives is less than or equal to the corresponding acceptance number of the second sample, the lot shall be declared as conforming to the requirements; otherwise not.

TABLE 4 SAMPLE SIZE AND ACCEPTANCE NUMBER

(*Clauses* B-1.2 *and* B-2.1)

Lot Size	Stage of Sampling	Sample Size	Acceptance Number	Rejection Number
(1)	(2)	(3)	(4)	(5)
Up to 50	First	5	0	2
	Second	5	1	2
51 to 100	First	8	0	2
	Second	8	1	2
101 to 150	First	13	0	2
	Second	13	1	2
151 to 300	First	20	0	3
	Second	20	3	4
301 to 500	First	32	1	4
	Second	32	4	5
501 to 1 000	First	50	2	5
	Second	50	6	7
1 001 and above	First	80	3	7
	Second	80	8	9

APPENDIX C

(*Clause* 7.17.2)

OVEN FOR DESTRUCTION TEST

C-1. CAPACITOR ARRANGEMENT

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

C-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 ± 2°C to ensure that the air in the oven is continuously agitated, but not so vigorously as to cause undue cooling of the capacitors.

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

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

C-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. Clear space between capacitors in all horizontal directions shall not be less than 50 mm, and the capacitors shall occupy not 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.

C-1.6 Where the use of metallic shelves or racks is 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.

C-2. VERIFICATION OF OVEN TEMPERATURE DISTRIBUTION

C-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 capacitors during this preliminary test.

C-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 well-spaced wires of diameter 0·3 mm, *Max*, to minimize heat losses.

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

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