

इंटरनेट

मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 2993 (1998): A.C. motor capacitors [ETD 29: Power Capacitors]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE



भारतीय मानक
ए. सी. मोटर कैपीसीटर
(दूसरा पुनरीक्षण)

Indian Standard
A. C. MOTOR CAPACITORS
(*Second Revision*)

ICS 31.060.70

© BIS 1998

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

NATIONAL FOREWORD

This Indian Standard which is identical with IEC 252 (1993) 'A. C. Motor capacitors' issued by the International Electrotechnical Commission was adopted by the Bureau of Indian Standards on the recommendation of the Power Capacitors Sectional Committee (ET 29) and approval of the Electrotechnical Division Council.

The text of the IEC Standard has been approved as suitable for publication as Indian Standard without deviations. This standard supersedes the contents of its earlier edition IS 2993 : 1975 and constitutes its technical revision.

While finalizing this standard, members expressed their concern regarding the poor quality of marking on the capacitors. It was, therefore, decided by the Committee to add the following test after clause 2.6 of the standard for ensuring good quality of marking:

'2.6.1 Compliance to the quality of marking shall be checked by inspection after rubbing the marking for 15 s with a piece of cotton cloth soaked in water. The test shall be repeated with further piece of cloth, soaked in petroleum spirit.'

In the adopted standard, certain terminology and conventions are not identical to those used in Indian Standards. Attention is specially drawn to the following:

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker while in Indian standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted are listed below along with their degree of equivalence:

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 68-2-1 : 1990 Environmental testing — Part 2 : Tests — Test A : Cold test	IS 9000 (Part 2/Sec 2 to 4) : 1977	Equivalent
IEC 68-2-3 : 1969 Environmental testing — Part 2 : Tests — Test Ca : Damp heat, steady state	IS 9000 (Part 4) : 1979	do
IEC 68-2-6 : 1982 Environmental testing — Part 2 : Tests — Test Fc and guidance : Vibration (Sinusoidal)	IS 9000 (Part 8) : 1981	do
IEC 68-2-20 : 1979 Environmental testing — Part 2 : Tests — Test T: Soldering	IS 9000 (Part 18/Sec 1 to 3) : 1981	do

(Continued on third cover)

CONTENTS

	Page
SECTION 1: GENERAL	
Clause	
1.1 Scope and object	3
1.2 Normative references	4
1.3 Definitions	4
1.4 Service conditions	7
1.5 Preferred tolerances on capacitance	8
SECTION 2: QUALITY REQUIREMENTS AND TESTS	
2.1 Test requirements	8
2.2 Nature of tests	8
2.3 Type tests	9
2.4 Routine tests	11
2.5 Tangent of loss angle	11
2.6 Visual examination	11
2.7 Voltage test between terminals	11
2.8 Voltage test between terminals and case	13
2.9 Capacitance measurement	13
2.10 Check of dimensions	13
2.11 Mechanical tests	13
2.12 Sealing test	16
2.13 Endurance test	16
2.14 Damp-heat test	19
2.15 Self-healing test	19
2.16 Destruction test	20
SECTION 3: OVERLOADS	
3.1 Permissible overloads	23
SECTION 4: SAFETY REQUIREMENTS	
4.1 Creepage distances and clearances	24
4.2 Terminals and connecting cables	24
4.3 Earth connections	24
4.4 Discharge devices	25
SECTION 5: RATINGS	
5.1 Marking	26

SECTION 6: GUIDE FOR INSTALLATION AND OPERATION

6.1 General 26

6.2 Choice of rated voltage 27

6.3 Checking capacitor temperature 27

6.4 Checking transients 28

6.5 Leakage current 28

Annex A – Test voltage 29

Indian Standard
A. C. MOTOR CAPACITORS
(*Second Revision*)
SECTION 1: GENERAL

1.1 Scope and object

This International Standard applies to motor capacitors intended for connection to windings of asynchronous motors supplied from a single-phase system having a frequency up to and including 100 Hz, and to capacitors to be connected to three-phase asynchronous motors so that these motors may be supplied from a single-phase system.

This standard covers impregnated or unimpregnated capacitors having a dielectric of paper, plastic film, or a combination of both, either metallized or with metal-foil electrodes, with rated voltages up to and including 660 V.

Electrolytic motor start capacitors will be covered by IEC 252-2 which is under consideration.

NOTE – The following are excluded from this standard:

- Shunt capacitors of the self-healing type for a.c. power systems of up to and including 1 000 V nominal voltage. (IEC 831-1)
- Shunt capacitors of non self-healing type for a.c. power systems of up to and including 1 000 V nominal voltage. (IEC 931-1)
- Shunt capacitors for a.c. power systems having a nominal voltage above 1 000 V. (IEC 871-1)

- Capacitors for induction heat-generating plants, operating at frequencies between 40 Hz and 24 000 Hz (IEC 110: Recommendation for capacitors for inductive heat generating plants operating at frequencies between 40 Hz and 24 000 Hz).

- Series capacitors (IEC 143: Series capacitors for power systems).
- Coupling capacitors and capacitor dividers (IEC 358: Coupling capacitors and capacitor dividers).

- Capacitors to be used in power electronic circuits (IEC 1071-1: Power electronic capacitors).

- Small a.c. capacitors to be used for fluorescent and discharge lamps (IEC 566: Capacitors for use in tubular fluorescent and other discharge lamp circuits).

- Capacitors for suppression of radio interference (IEC publication under consideration).
- Capacitors intended to be used in various types of electrical equipment and thus considered as components.
- Capacitors intended for use with d.c. voltage superimposed on a.c. voltage.

The object of this standard is:

- a) to formulate uniform rules regarding performance, testing and rating;
- b) to formulate specific safety rules;
- c) to provide a guide for installation and operation.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 68-2-1: 1990, *Environmental testing. Part 2: Tests – Test A: Cold*

IEC 68-2-3: 1969, *Environmental testing. Part 2: Tests – Test Ca: Damp heat, steady state*

IEC 68-2-6: 1982, *Environmental testing. Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*

IEC 68-2-20: 1979, *Environmental testing, Part 2: Tests – Test T: Soldering*

IEC 68-2-21: 1983, *Environmental testing. Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 529: 1989, *Degrees of protection provided by enclosures (IP Code).*

1.3 Definitions

For the purposes of this International Standard, the following definitions apply:

1.3.1 motor running capacitor: A power capacitor which, when used in conjunction with an auxiliary winding of a motor, assists the motor to start and improves the torque under running conditions.

NOTE - The running capacitor is usually connected permanently to the motor winding and remains in circuit throughout the running period of the motor. During the starting period, if it is in parallel with the starting capacitor, it helps to start the motor.

1.3.2 motor starting capacitor: A power capacitor which provides a leading current to an auxiliary winding of a motor and which is switched out of circuit once the motor is running.

1.3.3 metal foil capacitor: A capacitor, the electrodes of which consist of metal foils or strips separated by a dielectric.

1.3.4 metallized capacitor: A capacitor, in which the electrodes consist of a metallic deposit on the dielectric.

1.3.5 self-healing capacitor: A capacitor, the electrical properties of which, after local breakdown of the dielectric, are rapidly and essentially self restored.

1.3.6 discharge device of a capacitor: A device which may be incorporated in a capacitor, capable of reducing the voltage between the terminals effectively to zero, within a given time, after the capacitor has been disconnected from a network.

1.3.7 continuous operation: Operation with no time limit within the normal life of the capacitor.

1.3.8 Intermittent operation: Operation in which periods with the capacitor energized are followed by intervals during which the capacitor is unenergized.

1.3.9 starting operation: A special type of intermittent operation in which the capacitor is energized for only a very short period while the motor is accelerating to rated speed.

1.3.10 rated duty cycle: A rated value indicating the type of intermittent or starting duty for which a capacitor is suitable. It is specified by the duty cycle duration, in minutes, and the percentage of the time during which the capacitor is energized.

1.3.11 duty cycle duration: Total time of one energized and one unenergized interval during the intermittent operation.

1.3.12 relative operation time: The percentage of the cycle duration in which the capacitor is energized.

1.3.13 capacitor for continuous and intermittent operation: A capacitor designed to operate at one voltage when in continuous operation and at a different (usually higher) voltage when in intermittent operation.

1.3.14 class of operation: The minimum total life for which the capacitor has been designed at rated duty, voltage, temperature and frequency.

Class A - 30 000 h

Class B - 10 000 h

Class C - 3 000 h

Class D - 1 000 h

These classes of operation are intended to represent a true failure rate not exceeding 3 % during the life of the product.

A capacitor may have more than one class with corresponding voltages.

1.3.15 minimum permissible capacitor operating temperature: The minimum permissible temperature on the outside of the case at the moment of switching on the capacitor.

1.3.16 maximum permissible capacitor operating temperature (t_c): The maximum permissible temperature of the hottest area of the outside of the capacitor case during operation.

1.3.17 rated voltage of a capacitor (U_N): The r.m.s. value of the alternating voltage for which the capacitor has been designed.

1.3.18 maximum voltage (only for motor starting capacitors): The maximum r.m.s. voltage permissible at the starting capacitor terminals between the point of starting and the instant at which the switch disconnects the capacitor.

1.3.19 rated frequency of a capacitor (f_N): The highest frequency for which the capacitor has been designed.

1.3.20 rated capacitance of a capacitor (C_N): The capacitance value for which the capacitor has been designed.

1.3.21 rated current of a capacitor (I_N): The r.m.s. value of the alternating current at the rated voltage and frequency.

1.3.22 rated output of a capacitor (Q_N): The reactive power derived from the rated values of capacitance, frequency and voltage (or current).

1.3.23 capacitor losses: The active power dissipated by a capacitor.

NOTE - Unless otherwise stated, the capacitor losses will be understood to include losses in fuses and discharge resistors forming an integral part of the capacitor.

1.3.24 tangent of loss angle (tan delta) of a capacitor: The ratio between the equivalent series resistance and the capacitive reactance of a capacitor at specified sinusoidal alternating voltage and frequency.

1.3.25 capacitive leakage current (only for capacitors with a metal case): The current flowing through a conductor connecting the metallic case to earth, when the capacitor is energized from an a.c. supply system with an earthed neutral.

1.3.26 type of capacitor: Capacitors are considered to be of the same type when of similar constructional form, the same constructional technology, same rated voltage, same climatic category and same kind of operation. Capacitors of the same type can differ only in rated capacitance and size. Minor differences between terminations and mounting devices are permitted.

NOTE - The same construction includes, for example, the same dielectric material, dielectric thickness and type of case (metal or plastic).

1.3.27 model of capacitor: Capacitors are considered to be of the same model when they are of the same construction and have the same functional and dimensional characteristics within the tolerance limits and are consequently interchangeable.

1.3.28 class of safety protection: The degree of safety protection identified by one of three codes to be marked on the capacitor.

(P2) Indicates that the capacitor type has been designed to fail in the open-circuit mode only and is protected against fire or shock hazard. Compliance is verified by the test described in clause 2.16.

- (P1) Indicates that the capacitor type may fail in the open-circuit or short-circuit mode and is protected against fire or shock hazard. Compliance is verified by the test described in clause 2.16.
- (P0) Indicates that the capacitor type has no specific failure protection.

1.4 Service conditions

1.4.1 Normal service conditions

This standard gives requirements for capacitors intended for use under the following conditions:

a) Altitude

Not exceeding 2 000 m.

b) Residual voltage at energization

Not to exceed 10 % rated voltage (clause 4.4, note).

c) Pollution

Capacitors included in the scope of this standard are designed for operation in lightly polluted atmospheres.

NOTE - The IEC has not yet established a definition for "lightly polluted". When this definition is established by the IEC it will be incorporated in this standard.

d) Operating temperature

Between $-40\text{ }^{\circ}\text{C}$ and $+100\text{ }^{\circ}\text{C}$ (see 1.3.15 and 1.3.16).

The preferred minimum and maximum permissible capacitor operating temperatures are as follows:

Minimum temperatures: $-40\text{ }^{\circ}\text{C}$, $-25\text{ }^{\circ}\text{C}$, $-10\text{ }^{\circ}\text{C}$ and $0\text{ }^{\circ}\text{C}$

Maximum temperatures: $55\text{ }^{\circ}\text{C}$, $70\text{ }^{\circ}\text{C}$, $85\text{ }^{\circ}\text{C}$ and $100\text{ }^{\circ}\text{C}$.

Capacitors shall be suitable for transport and storage at temperatures down to $-25\text{ }^{\circ}\text{C}$, or the minimum operating temperature, whichever is the lower, without adverse effect on their quality.

e) Damp heat severity

Between 4 days and 56 days. The preferred severity is 21 days.

(According to IEC 68-2-3. The damp heat severity shall be selected from the values indicated by IEC 68-2-3, i.e.: 4 days, 10 days, 21 days and 56 days.)

Capacitors are classified in climatic categories defined by the minimum and maximum permissible capacitor operating temperatures and damp heat severity; i.e. 10/70/21 indicates that the minimum and the maximum permissible capacitor operating temperatures are $-10\text{ }^{\circ}\text{C}$ and $70\text{ }^{\circ}\text{C}$ and the damp heat severity is 21 days.

1.5 Preferred tolerances on capacitance

Preferred tolerances are: $\pm 5\%$, $\pm 10\%$ and $\pm 15\%$.

Asymmetric tolerances are permitted but no tolerance shall exceed 15 %.

SECTION 2: QUALITY REQUIREMENTS AND TESTS

2.1 Test requirements

2.1.1 *General*

This section gives the test requirements for capacitors.

2.1.2 *Test conditions*

Unless otherwise specified for a particular test or measurement, the temperature of the capacitor dielectric shall be in the range $+15\text{ }^{\circ}\text{C}$ to $35\text{ }^{\circ}\text{C}$ range and shall be recorded.

If corrections are necessary, the reference temperature shall be $+20\text{ }^{\circ}\text{C}$.

NOTE - It may be assumed that the dielectric temperature is the same as the ambient temperature, provided that the capacitor has been left in an unenergized state at this ambient temperature for an adequate period, depending on the size of the capacitor.

2.2 Nature of tests

The tests specified are of two sorts:

- a) type tests;
- b) routine tests.

2.2.1 *Type tests*

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 are carried out by the manufacturer and/or the test-authority if there is need for an approval.

These tests may be carried out under the supervision of a proper authority which will issue a certified record and/or type approval.

2.2.2 *Routine tests*

Routine tests shall be carried out by the manufacturer on every capacitor before delivery. If the purchaser so requests, he shall be supplied with a certificate stating that routine tests have been carried out.

2.3 Type tests

2.3.1 Test procedure

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

Capacitors forming the sample shall have successfully passed the routine tests indicated in 2.4.1.

Each test group shall contain as near as possible, equal numbers of capacitors of the highest capacitance and the lowest capacitance in the range.

The manufacturer shall provide data on the ratio of capacitance per outer total surface area of the case of each capacitance value in the range.

The capacitor with the maximum capacitance per unit surface area shall also be tested if this ratio exceeds that of the maximum capacitance value in the range by 10 % or more.

Similarly, the capacitor with the minimum capacitance per unit area shall also be tested if the ratio is less than that of the minimum capacitance value in the range by 10 % or more.

"Area" denotes total outer surface area of the capacitor case with the exception of small protrusions, terminals and fixing studs.

2.3.2 Extent of qualification

2.3.2.1 A type test on a sample consisting of a single model qualifies only the model tested. When the type test is performed on two models of the same type, and of different rated capacitance value, selected under the rules of 2.3.1, the qualification is valid for all models of the same type having rated capacitance between the two tested values.

2.3.2.2 The qualification tests carried out successfully on a capacitor model having a certain capacitance tolerance are valid also for capacitors of the same model but having different capacitance tolerances.

2.3.2.3 Occasionally, in current practice, capacitors are requested with a capacitance tolerance that is not symmetrical with respect to the rated capacitance value.

When a type test is carried out successfully on a capacitor model having a symmetrical capacitance tolerance, the relevant qualification is valid also for capacitors of the same model having a non-symmetrical capacitance tolerance provided that the total range of non-symmetrical tolerance is less than or equal to that of the tested capacitor model.

Table 1 – Type test schedule

Group	Tests	Clause and subclause	Number of samples to be inspected (Note 1)	Number of failures allowed in first test	Number of failures allowed in retest (Note 2)
1	Visual examination Check markings Check of dimensions Mechanical tests (excluding soldering) Sealing tests (if applicable)	2.6 5.1 2.10 2.11 2.12	8 [4]	1 (Note 3)	0
2	Endurance test	2.13	42 [21]	2 (Note 4)	0
3	Soldering (if applicable) Damp heat test Voltage test between terminals Voltage test between terminals and case	2.11.2 2.14 2.7 2.8	12 [6]	1 (Note 3)	0
4	Self-healing test (if applicable)	2.15	20 [10]	1 (Note 3)	0
5	Destruction test (if marked on the capacitor)	2.16	20 [10] 10 [5]	1 (Note 5)	0
<p>NOTES</p> <p>1 Number of samples specified allows for retest if required. The number in square brackets indicates the actual number required for the test.</p> <p>2 A capacitor which fails on more than one test is counted as one defective capacitor.</p> <p>3 For groups 1, 3 and 4, a retest is allowed with 1 failure. No failures are allowed in these retests.</p> <p>4 For group 2 no retest is required with 0 or 1 failure. With two failures a retest is required with no failure allowed in this retest.</p> <p>5 For group 5 see clause 2.16 which allows a retest under special conditions in the event of one failure.</p>					

When the number of defects for each group and the total number of defective capacitors do not exceed the figures indicated in table 1, the capacitor model shall be deemed to comply with this standard.

When a capacitor is designed to operate under two or more different conditions (rated voltages, classes, rated duty cycles etc.), the following tests shall be performed, once only, at the highest test voltage:

- a) Voltage test between terminals (clause 2.7);

- b) Voltage test between terminals and case (clause 2.8);
- c) Self-healing test (clause 2.15).

The endurance test shall be performed for every voltage rating and under every operating condition marked on the capacitor. The number of samples to be inspected shall be calculated accordingly.

2.4 Routine tests

2.4.1 Test procedure

Capacitors shall be subjected to the following tests in the stated order:

- a) Sealing test, if applicable (clause 2.12);
- b) Voltage test between terminals (clause 2.7);
- c) Voltage test between terminals and case (clause 2.8);
- d) Visual examination (clause 2.6);
- e) Capacitance measurement (clause 2.9);
- f) Tangent of loss angle (clause 2.5).

2.5 Tangent of loss angle

The tangent of loss angle limit and measuring frequency shall be defined by the manufacturer.

2.6 Visual examination

The condition, workmanship, marking and finish shall be satisfactory. The marking shall be legible during the life of the capacitor.

2.7 Voltage test between terminals

In type tests, capacitors shall be subjected to an a.c. voltage test as specified in table 2a or table 2b. The test shall be carried out with a substantially sinusoidal voltage at the rated frequency. The test may be carried out at 50 Hz or 60 Hz.

A higher frequency may be used at the manufacturer's discretion.

IMPORTANT NOTE

All European countries and countries not specifically named below, require tests to be carried out in accordance with Table 2a.

Canada, Japan and USA require that tests are carried out in accordance with Table 2b.

Table 2a – Test voltages

Type of operation	Type of capacitor	Ratio of test voltage to rated voltage a.c.	Type test time s
Continuous	Non-self-healing capacitor	2,15	60
	Self-healing capacitor	2,0	60
Intermittent	Non-self-healing capacitor	1,6	60
	Self-healing capacitor	1,4	60
Intermittent duty cycle $\leq 3 / \leq 2$ % (Motor start)	Self-healing capacitor	1,3	60

For routine tests, the test time in table 2a may be reduced from 60 s to 2 s.

Table 2b – Test voltages

Type of operation	Type of capacitor	Ratio of test voltage to rated voltage a.c.	Type test time s
Continuous	Non-self-healing capacitor	2,15	10
	Self-healing capacitor	1,75	10
Intermittent	Non-self-healing capacitor	1,6	10
	Self-healing capacitor	1,4	10
Intermittent duty cycle $\leq 3 / \leq 2$ % (Motor start)	Self-healing capacitor	1,3	10

For routine tests, the test time in table 2b may be reduced from 10 s to 1 s.

No flashover or permanent breakdown shall occur. For metallized capacitors self-healing may occur.

When the capacitor comprises more than one section, each section shall be tested independently in accordance with the above tables.

NOTE - The duty cycle $\leq 3 / \leq 2$ % refers to capacitors suitable for starting purposes only.

2.8 Voltage test between terminals and case

Capacitors shall be capable of withstanding without breakdown, for 60 s, a test between terminals (joined together) and the case, with a substantially sinusoidal a.c. voltage of a frequency as near as possible to the rated frequency and of the following r.m.s. value:

twice the rated voltage +1 000 V but not less than 2 000 V.

If the capacitor case is of insulating material, in type tests the test voltage shall be applied between the terminals and the metal mountings, if any, or between the terminals and a metal foil wrapped tightly round the surface of the case. In routine tests the test voltage shall be applied between the terminals and a metal part, if any.

No routine test is required if the case is made entirely of insulating material.

During the test, no dielectric breakdown or flashover shall occur.

For routine tests, the duration may be reduced from 60 s to 2 s for countries using table 2a in clause 2.7 or 1 s for countries using table 2b in clause 2.7.

2.9 Capacitance measurement

The capacitance shall be measured using a method which excludes errors due to harmonics.

The precision of measurement shall be better than 5 % of the total tolerance band. For type tests the absolute precision shall be 0,2 % maximum.

Type and routine testing shall be carried out at between 0,9 and 1,1 times the rated voltage and at the rated frequency.

Other measuring voltages and frequencies are permitted if it can be demonstrated that the capacitance measured does not deviate from the true value by more than 0,2 %.

2.10 Check of dimensions

Dimensions of the case, of the terminals and of the fixing arrangements shall comply with those indicated in the drawing, taking tolerances into account.

In addition, minimum creepage distances and clearances indicated in table 5 shall be checked.

2.11 Mechanical tests

These tests shall be carried out in conformity with the relevant test in IEC 68.

These tests are:

- Robustness of terminations: Test U, IEC 68-2-21;
- Soldering : Test T, IEC 68-2-20;
- Vibration (sinusoidal) : Test Fc, IEC 68-2-6.

2.11.1 *Robustness of terminations*

The capacitor shall be subjected to Test Ua, Ub, Uc and Ud of IEC 68-2-21, as applicable.

2.11.1.1 *Test Ua - Tensile*

The load to be applied shall be:

for all types of terminations: 20 N.

For external wire terminations the cross sectional area shall be at least 0,5 mm².

2.11.1.2 *Test Ub - Bending (half of the terminations)*

This test shall be carried out only on wire terminations. Two consecutive bends shall be applied.

2.11.1.3 *Test Uc - Torsion (other half of the terminations)*

This test shall be carried out only on wire terminations. Two successive rotations of 180° shall be applied.

2.11.1.4 *Test Ud - Torque (screw terminals)*

This test shall be carried out on threaded terminations.

The nuts or screws shall be tightened to the torque specified in table 3 and loosened again. The torque shall be applied gradually. The screw material shall have adequate resistance against stress cracking.

Table 3

Thread diameter		Torque N.m
mm	in	
2,6	—	0,4
3,0	1/8	0,5
3,5	9/64	0,8
4,0	5/32	1,2
5,0	3/16	1,8
5,5	7/32	2,2
6,0	1/4	2,5
8	5/16	5
10	3/8	7
12	1/2	12

2.11.1.5 *Visual examination*

After each of these tests the capacitors shall be visually examined. There shall be no visible damage.

2.11.2 *Soldering*

This test shall be carried out only when terminals are designed for connection by soldering.

The capacitor shall then be subjected to Test T of IEC 68-2-20 either using the solder bath method or the solder globule method.

When neither the solder bath method nor the solder globule method is applicable, the soldering iron test shall be used, with soldering iron size A.

Before and after the test the capacitance of the capacitor shall be measured by the method laid down in clause 2.9. No perceivable capacitance change is permitted.

When the test procedures have been carried out the capacitors shall be visually examined. There shall be no visible damage.

2.11.3 *Vibration*

The capacitors shall be subjected to Test Fc of IEC 68-2-6 using a mounting system similar to that which is to be used in practice. The severity of the test shall be as follows:

$f = 10 \text{ Hz to } 55 \text{ Hz}$

$a = \pm 0,35 \text{ mm}$

Test duration per axis = 10 frequency cycles (3 axes offset from each other by 90°),
1 octave per minute.

Before and after the test, the capacitance of the capacitors shall be measured by the method laid down in clause 2.9. No perceivable capacitance change is permitted.

After the test, the capacitor shall be subjected to the voltage test between terminals and case according to clause 2.8. No dielectric breakdown or flashover shall occur.

When all the test procedures have been carried out, the capacitors shall be visually examined. There shall be no visible damage.

2.11.4 *Fixing bolt or stud (if fitted)*

Fixing threaded bolts and attachments to the capacitor body shall have adequate resistance to ageing deterioration in service.

The durability of the fixing bolt or stud shall be checked on four of the samples tested in clause 2.13 (endurance test) by the following method:

Four of the capacitors shall be mounted on a fixing plate in the endurance test chamber. The thickness of the fixing plate shall be $1,5 \text{ mm} \pm 0,1 \text{ mm}$ and the diameter of the hole shall be the base bolt diameter $+0,5 \text{ mm to } +1,0 \text{ mm}$.

Prior to commencement of the endurance test, torque values specified in table 3 are to be applied. On completion of the endurance test, a torque figure of one half the appropriate value specified in table 3 is to be applied.

No failures are permitted.

2.12 Sealing test

This test is not required if the manufacturer certifies that capacitors do not contain substances that are liquid at $t_c + 10$ °C.

The capacitor shall be mounted in a position most likely to reveal leakage at a temperature 10 °C \pm 2 °C higher than the maximum permissible capacitor operating temperature for a time sufficient for all parts of the capacitor to reach this temperature.

The capacitor shall be maintained at this temperature for a further hour before cooling.

No leakage shall occur.

If the capacitor is intended to be supplied with a terminal cover the sealing test should preferably be carried out before fastening the cover. The cover shall be fastened in such a manner that the sealing is not impaired.

After the sealing test, capacitors shall be inspected for liquid leakage and distorted case.

Liquids are allowed to wet the surface but not to form droplets.

2.13 Endurance test

This test is intended to prove the suitability of the capacitor design for the class of operation specified by the manufacturer.

For capacitors fitted with base bolts, refer also to clause 2.11.

The method indicated below is intended to ensure that the capacitor case temperature is as close as possible to the maximum permissible capacitor operating temperature.

2.13.1 *Testing in air with forced circulation*

The capacitors shall be mounted in a test chamber in which the temperature of the air is constant within a tolerance of ± 2 °C.

The air in the test chamber shall be continuously agitated but not so vigorously as to cause undue cooling of the capacitors. The capacitors under test shall not be subjected to direct radiation from any heating elements in the chamber.

The sensitive element of the thermostat regulating the air temperature of the chamber shall be well within the stream of heated circulating air.

NOTE - Heating of the air may take place in a separate chamber, from which the air can be admitted to the capacitor test chamber through a valve allowing good distribution of heated air over the capacitors.

The capacitors are mounted in a position most favourable to the leakage of impregnant or filling material.

The distance between cylindrical capacitors shall not be less than their diameter, and the distance between rectangular capacitors shall not be less than twice the shorter side of their base.

The temperature sensitive element of a temperature recording instrument shall be attached half way up the side of the case of the capacitor with the lowest value of tangent of loss angle.

The thermostat shall be set to $(t_c - 15\text{ }^\circ\text{C})$, and capacitors are then energized according to the appropriate voltage and test cycle (see also annex A). During the first 24 h, the difference between t_c and the indication of the temperature recording instrument shall be noted, and adjustments made to ensure the temperature of each capacitor case is at $t_c \pm 2\text{ }^\circ\text{C}$. The test is then continued to the end of the appropriate time without further adjustment of the thermostat, the time being measured from the first energization of the capacitors.

NOTE - It is recommended that each test capacitor is individually protected by a circuit breaker or fuse.

2.13.2 *Endurance test procedure*

2.13.2.1 *Continuous and intermittent duty capacitors*

Capacitors intended for continuous and intermittent duty shall be tested according to the appropriate class indicated in table 4.

Table 4 – Endurance test conditions

Life expectancy	30 000 h (Class A)	10 000 h (Class B)	3 000 h (Class C)	1 000 h (Class D)
Capacitors intended for continuous duty and relative operating time $\geq 25\%$	6 000 h @ $1,25 U_N$ continuous or 3 000 h @ $1,35 U_N$ continuous	2 000 h @ $1,25 U_N$ continuous or 1 000 h @ $1,35 U_N$ continuous	600 h @ $1,25 U_N$ continuous	200 h $1,25 U_N$ continuous
Capacitors intended for intermittent operation with relative operating time $< 25\%$	Energization time 6 000 h @ $1,15 U_N$ Maximum "on" time 50 % of cycle	Energization time 2 000 h @ $1,15 U_N$ Maximum "on" time 50 % of cycle	Energization time 600 h @ $1,15 U_N$ Maximum "on" time 50 % of cycle	Energization time 200 h @ $1,15 U_N$ Maximum "on" time 50 % of cycle
Permitted capacitance change	3 %	3 %	3 %	3 %

Life expectancy classes over 30 000 h are permitted by using the calculation:

Test duration = 10 % of life at $1,35 U_N$ and 20 % of life at $1,25 U_N$.

For intermittent rating, the duty cycle shall be in accordance with the marking on the capacitor. In order to reduce the test time, the duty cycle may be increased by 50 % at the discretion of the manufacturer.

The test times given in table 4 refer to periods of actual energization.

2.13.2.2 Motor start capacitors

The test is to be carried out according to the marking of the capacitor.

If no details are provided by the manufacturer, intermittent operation with 3 s energized duration and 3 min unenergized duration is assumed.

The total duration of the test shall be 1 000 h which includes both energized and unenergized periods.

The energized test voltage shall be $1,15 U_N$. Maximum permitted capacitance change shall be 3 %.

2.13.3 Conditions of compliance

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

No leak should be apparent which forms droplets within 10 min when kept at upper temperature limit in the most unfavourable position.

At the end of the test, the capacitors shall cool down freely to the ambient temperature and the capacitance shall then be measured (clause 2.9).

Intermediate test measurements are permitted.

2.14 Damp-heat test

Capacitance shall be measured before the test (see clause 2.9).

This test shall be carried out in accordance with IEC 68-2-3.


The severity indicated in the marking shall be employed. No voltage shall be applied to the samples and no measurement shall be taken during the test.

After the damp-heat period, the capacitors shall be stored under standard atmospheric conditions for recovery for not less than 1 h and not more than 2 h. Immediately after recovery, the capacitance shall be measured in accordance with clause 2.9.

Capacitance change shall be less than 0,5 % after the test.

2.15 Self-healing test

Self-healing capacitors shall have adequate self-healing properties. Compliance is checked by the following test.

This test shall be applied only to capacitors marked  or SH.

The capacitors shall be subjected to the test described in clause 2.7 for the test time indicated in the appropriate table.

If fewer than five self-healing breakdowns (clearings) occur during this time, the voltage shall be increased at a rate of not more than 200 V per minute until five clearings have occurred since the beginning of the test or until the voltage has reached a maximum of $3,5 U_N$ for continuously rated capacitors or $2,0 U_N$ for intermittent or motor start capacitors.

The voltage shall then be decreased to 0,8 times the voltage at which the fifth clearing occurred or 0,8 times the maximum voltage and maintained for 10 s. One additional clearing in each capacitor shall be permitted during this period.

The capacitors shall be deemed to have passed the test if they meet both of the following requirements:

- a) Change of capacitance is $< 0,5 \%$
- b) RC value is ≥ 100 s.

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

2.16 Destruction test

This test is optional.

A capacitor type which becomes open-circuit following this test shall be marked (P2). A capacitor type which may become either open or short-circuit following this test shall be marked (P1).

NOTE - The short-circuit failure mode is only permitted for capacitors marked (P1). Capacitors not subjected to this test shall be marked (P0).

2.16.1 Test specimens

The test is to be carried out on 10 samples, with a similar specimen of 10 samples held in reserve for possible retest. Half the test specimens (5) shall have passed the test according to 2.4.1. The remaining five capacitors shall have passed the endurance test described in clause 2.13 (group 2).

2.16.2 Test apparatus

2.16.2.1 Test apparatus for d.c. conditioning

Apparatus for carrying out the d.c. conditioning is shown in figure 1. The d.c. source shall be capable of delivering an open-circuit voltage equivalent to $10 U_N$ and have a sustained short-circuit capability greater than 50 mA.

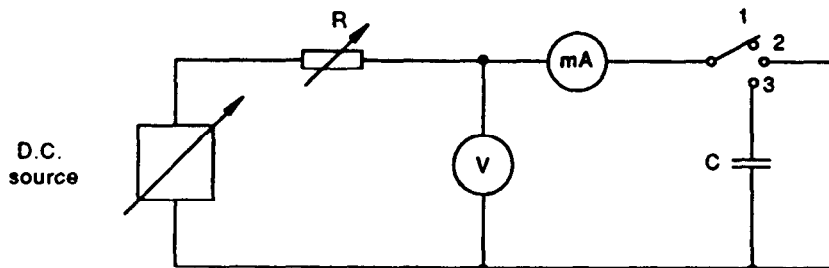


Figure 1

The d.c. source is adjusted to provide an open-circuit voltage equivalent to $10 U_N$ with the switch in position 1.

A variable resistor R is adjusted to provide a current of 50 mA with the switch in position 2.

D.C. voltage is applied to the test capacitor with the switch in position 3.

2.16.2.2 Test apparatus for a.c. destruction test

- The instantaneous short-circuit current of the a.c. supply shall be at least 300 A.
- A 25 A slow-blow fuse and adjustable inductance (L), shall be inserted between the a.c. source and the capacitor (see figure 2).

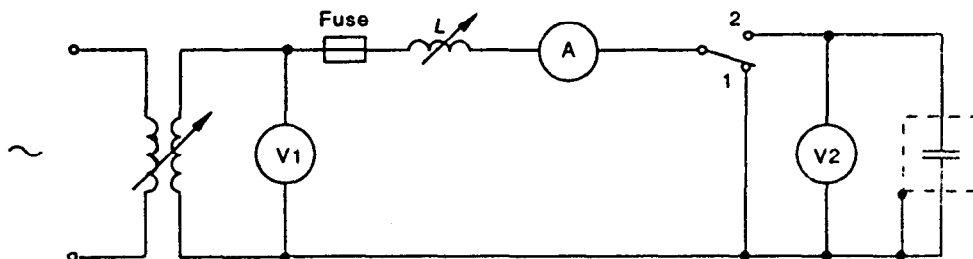


Figure 2

The inductor shall be so adjusted that, with the switch in position 1 and a voltage of $1,3 U_N$ applied across the voltmeter V1, a current equal to 1,3 times the capacitor rated current (I_N) flows.

The capacitor is energized with the switch in position 2.

NOTE - The variable inductor L in figure 2 may be replaced by the arrangement shown in figure 3 whereby T2 is a fixed ratio transformer and L_f is a fixed inductor. A variable ratio transformer T1 is used to adjust the inductive current.

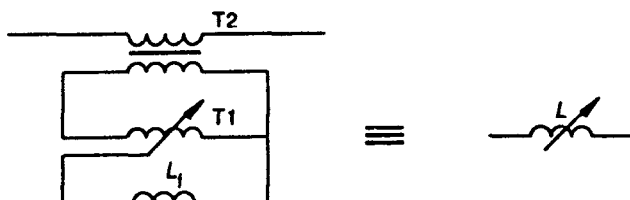


Figure 3

2.16.3 Test procedure

The test shall be conducted in four stages:

- preparation and pre-conditioning,
- d.c. conditioning,
- a.c. destruction test,
- evaluation of the failure.

2.16.3.1 Preparation and pre-conditioning

All the test specimens shall be prepared and pre-conditioned as follows:

The capacitors shall be wrapped closely with cheese-cloth and mounted within an "air circulating" test chamber at $t_c + 10$ °C. The temperature deviation shall not exceed ± 2 °C. In preparation for the destruction test, the specimens shall have rated voltage (U_N) applied for 2 h at $t_c + 10$ °C. No open-circuit or short-circuit capacitors are permitted.

2.16.3.2 *D.C. conditioning*

Five capacitors that have passed the endurance test (group 2) shall be pre-heated to a temperature of $t_c + 10$ °C before d.c. conditioning. The remaining five capacitors, having passed the test in 2.4.1 shall be tested at room temperature.

The voltage of a d.c. source (figure 1) shall be raised from zero to a maximum of $10 U_N$ at a rate of approximately 200 V per minute until a short-circuit occurs or $10 U_N$ has been reached.

Capacitors shall be removed from d.c. conditioning when the voltage indicated on the voltmeter is zero or $10 U_N$ has been reached and maintained for a period of 5 min or other period as defined by the manufacturer.

2.16.3.3 *A.C. destruction test*

With the capacitors maintained at the d.c. conditioning temperature they shall then have applied an a.c. voltage of $1,3 U_N$.

If the capacitor clears (becomes operative) or becomes open-circuit, the voltage shall be maintained for 5 min.

If the capacitor becomes short-circuit, then the test shall be maintained for 8 h. If the capacitor is still operative after 5 min then the d.c. conditioning shall be repeated.

2.16.4 *Evaluation of the failure*

After completion of the test, the cheese-cloth shall not have burnt on any test specimen; however, it may be discoloured by escaping substances

Each capacitor shall meet the following:

- a) escaping liquid material may wet the outer surface of the capacitor, but not fall away in drops;
- b) internal live parts shall not be accessible to the standard test finger (see figure 1 of IEC 529);
- c) burning or scorching of the cheese-cloth shall not be evident, since this would indicate that flames or fiery particles have been emitted from the openings;
- d) the capacitor shall withstand the test of clause 2.8 with the voltage being reduced to 0,8 times the value indicated.

The test is concluded when 10 capacitors have become inoperative.

If one of the test specimens does not satisfy the criteria according to a) or d) above, the test may be repeated once on a further 10 samples. However, all capacitors shall pass the repeat test.

If more than one capacitor does not satisfy the criteria according to a) or d) then, the test shall be regarded as failed. All capacitors must satisfy the requirements of b) and c).

For capacitors with a metal case, this shall be connected to one pole of the voltage source. If a distinction can be made between the capacitor terminals, the group shall be sub divided into two sub-groups. The first sub-group shall have terminal A connected to the case, the second sub-group shall have terminal B connected to the case.

SECTION 3: OVERLOADS

3.1 Permissible overloads

3.1.1 *Maximum permissible voltage*

Irrespective of their type of operation, metal-foil and metallized capacitors shall be suitable for operation under abnormal conditions for prolonged periods at an r.m.s. voltage between terminals not exceeding 1,10 times the rated voltage, excluding transients caused by switching the capacitors in and out of circuit (clauses 6.2, 6.3 and 6.5) but including the effects of harmonics and supply voltage variations.

3.1.2 *Maximum permissible current*

Capacitors shall be suitable for operation at an r.m.s. current not exceeding 1,30 times the current which occurs at rated sinusoidal voltage and rated frequency excluding transients.

Taking into account the capacitance tolerance, the maximum permissible current can be up to 1,30 times the rated current increased in proportion to the actual capacitance value compared with the rated capacitance value.

3.1.3 *Maximum permissible reactive output*

The overload resulting from operation at voltage and current exceeding the rated values (though within the limits indicated in 3.1.1 and 3.1.2) shall not exceed 1,35 times the rated output.

Taking into account the capacitance tolerance the maximum permissible output can be up to 1,35 times the rated output increased in proportion to the actual capacitance value compared with the rated capacitance value.

NOTE - It should be noted that operation of capacitors with overload, even within the limit indicated above, may adversely affect the life duration of these capacitors.

3.1.4 *Permissible extension of the duty cycle*

Capacitors shall be suitable for operation:

- a) with a relative operation time not exceeding the rated operation time;
- b) with an absolute operation time not exceeding the product of the rated relative operation time and the rated cycle duration.

The cycle duration may be extended without limit provided the permissible operation time is not exceeded.

SECTION 4: SAFETY REQUIREMENTS

4.1 Creepage distances and clearances

The creepage distances over external surfaces of terminal insulation and the clearances between the exterior parts of terminal connections or between such live parts and the metal case of the capacitor, if any, shall be not less than the minimum values given in table 5.

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.

The requirements for specific applications shall be satisfied.

The contribution to the creepage distances 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 calculating the total air path.

Creepage distances are distances in air, measured along the surface of insulating material.


4.2 Terminals and connecting cables

Terminals and undetachable connecting cables shall have a conductor cross-section which can safely carry the current of the capacitor and shall have sufficient mechanical strength. The minimum cross-sectional area of the conductor shall be 0,5 mm². Insulated cables shall conform to the voltage and-temperature ratings of the capacitor.

Manufacturers shall provide evidence that the cable supplied with the capacitor shall adequately carry the current over the full capacitance/temperature/voltage range specified.

4.3 Earth connections

If the metal case of the capacitor is intended to be connected to earth or to a neutral conductor, means shall be provided to enable an effective connection to be made. This may be achieved by supplying the capacitor in an unpainted metal case or by provision of an earth terminal, an earth conductor, or a metal bracket with sound electrical connection to the case.

Whichever the type of connection used, it must be clearly marked by the symbol  as the earth connection.

When the metal case is provided with a threaded stud and the capacitor is securely fixed to the metal frame by means of this stud without interposed insulating material and the frame is securely connected to earth, the stud shall be considered as an effective connection to earth.

Table 5 – Minimum creepage distances and clearances

Rated voltage	Up to and including 24 V mm	Above 24 V up to and including 250 V mm	Above 250 V up to and including 500 V mm	Above 500 V up to and including 1 000 V mm
Creepage distances				
1. Between live parts of different polarity	2	3 (2)	5	6
2. 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
Clearances				
3. Between live parts of different polarity	2	3 (2)	5	6
4. 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
5. Between live parts and a flat supporting surface or a loose metal cover, if any, if the construction does not ensure that the values under item 4 above are maintained under the most unfavourable conditions	2	6	10	12
<p>NOTE – The values in brackets apply to creepage distances and clearances protected against dirt. For permanently sealed-off or compound-filled cases, creepage distances and clearances are not checked.</p> <p>* For glass or other insulation with equivalent tracking qualities.</p>				

4.4 Discharge devices

In many cases discharge devices are not required; namely, when the capacitor is connected permanently to the motor winding, or when placed in an inaccessible position.

When a discharge device is specified, it must reduce the voltage at the terminals from the peak of the rated voltage to a value of 50 V or less in the time of 1 min from the moment the capacitor is switched off.

NOTE - A discharge device may sometimes be specified, not for safety reasons, but to prevent electrical overstress on the capacitor. This may occur when a disconnected capacitor still charged is reconnected across another capacitor of different polarity.

SECTION 5: RATINGS

5.1 Marking



The following information shall be marked on the capacitor:

- 1) Manufacturer's name, abbreviated name or trade mark.
- 2) Manufacturer's type designation.
- 3) Rated capacitance (C_N) in microfarads and tolerance as a percentage.
- 4) Rated voltage (U_N) in volts.

When the capacitor is intended for both continuous and intermittent operation (see 1.3.13) different voltages shall be given.

- 5) Rated duty cycle, e.g. 10/50 % (see 1.3.10) if the capacitor is not intended for continuous operation.

When the capacitor is intended for both types of operation, the duty cycle shall be marked next to the voltage applicable for intermittent operation.

- 6) Rated frequency f_N in hertz, if other than 50 Hz.
- 7) Climatic category, e.g. 25/85/21 (see 1.4.1).
- 8) Date of manufacture (a code may be used).
- 9)  or SH for self-healing capacitors.
- 10) Discharge device, if any, shall be written out in full or indicated by the symbol 
- 11) Class of safety protection for example, P0, P1, P2.
- 12) Approval marks.
- 13) Filling material. Reference to liquid used (not needed for dry capacitors).
- 14) Class of operation or life duration. To be positioned adjacent to the voltage.
- 15) Specification (Standard) number.

SECTION 6: GUIDE FOR INSTALLATION AND OPERATION

6.1 General

Unlike most electrical apparatus, motor capacitors are not connected to power systems as independent apparatus. In each case, the capacitor is connected in series with an inductive winding on the motor and may also be in physical contact with the motor or other apparatus. The characteristics of the motor and such other apparatus exert a strong influence on the operating conditions of the capacitors.

The most important influences on motor capacitors are the following:

- where a motor capacitor is connected in series with the auxiliary winding of a single-phase induction motor, the voltage at the terminals of the capacitor at operating speed is generally considerably higher than the mains voltage;
- when in physical contact with the motor, the capacitor is not only stressed by vibration of the motor but also by the heat transferred from the energized windings and the active iron. Also, other sources of heat such as the heating of an electric washing machine may raise the temperature of the capacitor.

Most capacitor motors, and consequently the capacitors also, are switched on and off frequently. In switching tests, it has been found that high transients often occur at the terminals of both the running and starting capacitors. To withstand these transients, care should be exercised in the choice of the rated voltage of the capacitor, so that its maximum allowable voltage is not exceeded.

6.2 Choice of rated voltage

6.2.1 *Measurements of working voltage*

With maximum mains voltage, motor inductance and capacitance (taking into account tolerances and motor loads for worst conditions), the voltage across the capacitor shall not exceed 10 % above the capacitor rated voltage.

6.2.2 *Influence of capacitance*

Apart from the supply system voltage and the inductive coupling between the main winding and the auxiliary winding of the capacitor motor, the voltage at the terminals of the capacitor depends on the value of the capacitance itself, especially when the capacitor and the auxiliary winding operate near the resonance point. This fact should be taken into account when choosing the rated voltage of the capacitor and due attention should also be paid to the maximum permissible motor current.

In choosing the rated voltage of the capacitor, due attention should be paid to the voltage measurements specified in 6.2.1, to the possible variation in the mains voltage and to the effect of the capacitance tolerance.

6.3 Checking capacitor temperature

6.3.1 *Choice of maximum permissible capacitor operating temperature*

Since many factors influence the temperature conditions of motor capacitors, which cannot easily be calculated beforehand (heat radiation and heat conduction from the motor, high ambient temperature, bad cooling conditions; etc.), the user should check the capacitor operating temperature in association with the apparatus into which the capacitor is built. During this test, the most unfavourable permissible conditions of operation applicable to the apparatus should be attained. Under these conditions, the capacitor temperature

should be measured. The rated maximum permissible capacitor operating temperature should be not less than the highest temperature measured during this test.

Before changing the capacitor type, this test shall be repeated.

6.3.2 *Choice of minimum permissible capacitor operating temperature*

The rated minimum permissible capacitor operating temperature shall not be higher than the lowest ambient temperature at which the capacitor may be operated.

6.4 Checking transients

Under certain conditions of switching motors on or off, or the switching of starting capacitors across run capacitors, high current surges or transient over-voltages may occur. To prevent premature capacitor failure, the user shall establish by appropriate tests, that maximum ratings of the capacitor are not exceeded.

In some circumstances it may be necessary to add resistance to reduce the peak current to within the capacitor's design ratings.

6.5 Leakage current

Capacitive leakage current is not normally significant for motor applications. However, where the application requires low leakage to earth, this should be specifically requested by the user.

Annex A
(normative)

Test voltage

Voltage tests are carried out with an a.c. source as specified in the relevant clause. The source shall be adequate to maintain, over any specified test period, the test voltage required, subject to a tolerance of $\pm 2,5$ %, but ± 2 % for the endurance test.

A.C. voltage tests are made using a 50 Hz or 60 Hz frequency, as appropriate, the voltage waveform of which is sufficiently free from harmonics as to ensure that, when applied to the capacitor, the resulting current does not exceed the value corresponding to a sinusoidal voltage waveform by more than 10 %.

(Continued from second cover)

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 68-2-21 : 1983 Environmental testing — Part 2 : Tests — Test U: Robustness of terminations and integral mounting devices	IS 9000 (Part 19/Sec 1 to 5) : 1986	Equivalent
IEC 529 : 1989 Degrees of protection provided by enclosures (IP Code)	IS 12063 : 1987	do

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.

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 or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc : No. ET 29 (5004).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 323 01 31, 323 94 02, 323 33 75

Telegrams: Manaksanstha
(Common to
all offices)

Regional Offices:

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002

Telephone

{ 323 76 17
323 38 41

Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola
CALCUTTA 700054

{ 337 84 99, 337 85 61
337 86 26, 337 86 62

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022

{ 60 38 43
60 20 25

Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600113

{ 235 02 16, 235 04 42
235 15 19, 235 23 15

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
MUMBAI 400093

{ 832 92 95, 832 78 58
832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR.
COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR.
KANPUR. LUCKNOW. NAGPUR. PATNA. PUNE. THIRUVANANTHAPURAM.