IEC 60831-1

Edition 3.0 2014-02
REDLINE VERSION

INTERNATIONAL STANDARD

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

colour inside

Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V –
Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

IEC 60831-1:2014-02 RLV(EN)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2014 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 14 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 55 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

IEC 60831-1

Edition 3.0 2014-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE RM

ICS 29.120.99, 31.060.70

ISBN 978-2-8322-1429-9

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 5

~~SECTION 1: GENERAL~~

1 Scope ~~and object~~ 7
2 Normative references 8
3 Terms and definitions 8
4 Service conditions 12
4.1 Normal service conditions 12
4.2 Unusual service conditions 13

~~SECTION 2: QUALITY REQUIREMENTS AND TESTS~~

5 Test requirements 13
5.1 General 13
5.2 Test conditions 13
6 Classification of tests 13
6.1 Routine tests 13
6.2 Type tests 14
6.3 Acceptance tests 14
7 Capacitance measurement and output calculation 15
7.1 Measuring procedure 15
7.2 Capacitance tolerances 15
8 Measurement of the tangent of the loss angle (tan δ) of the capacitor 15
8.1 Measuring procedure 15
8.2 Loss requirements 16
9 Voltage tests between terminals 16
9.1 Routine test 16
9.2 Type test 16
10 Voltage tests between terminals and container 16
10.1 Routine test 16
10.2 Type test 17
11 Test of internal discharge device 17
12 Sealing test 18
13 Thermal stability test 18
14 Measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature 19
14.1 Measuring procedure 19
14.2 Requirements 19
15 Lightning impulse voltage test between terminals and container 20
16 Discharge test 20
17 Ageing test 21
18 Self-healing test 21
19 Destruction test 21

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

~~SECTION 3: OVERLOADS~~

20 Maximum permissible voltage 21
20.1 Long-duration voltages 21
20.2 Switching voltages 21
21 Maximum permissible current 22

~~SECTION 4: SAFETY REQUIREMENTS~~

22 Discharge device 22
23 Container connections 22
24 Protection of the environment 22
25 Other safety requirements 23

~~SECTION 5: MARKINGS~~

26 Marking of the unit 23
26.1 Rating plate 23
26.2 Standardized connection symbols 24
26.3 Warning plate 24
27 Marking of the bank 24
27.1 Instruction sheet or rating plate 24
27.2 Warning plate 24

~~SECTION 6: GUIDE FOR INSTALLATION AND OPERATION~~

28 General 24
29 Choice of the rated voltage 25
30 Operating temperature 26
30.1 General 26
30.2 Installation 26
30.3 High ambient air temperature 26
30.4 Evaluation of losses 26
31 Special service conditions 26
32 Overvoltages 27
33 Overload currents 28
34 Switching and protective devices and connections 28
35 Choice of creepage distance 29
36 Capacitors connected to systems with audio-frequency remote control 29
37 Electromagnetic compatibility (EMC) 30
37.1 Emission 30
37.2 Immunity 30
37.2.1 General 30
37.2.2 Low-frequency disturbances 30
37.2.3 Conducted transients and high-frequency disturbances 30
37.2.4 Electrostatic discharges 30
37.2.5 Magnetic disturbances 30
37.2.6 Electromagnetic disturbances 31

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Annex A (normative) Additional definitions, requirements and tests for power filter capacitors 32
A.1 Terms and definitions 32
A.2 Quality requirements and tests 32
A.2.1 Capacitance tolerance 32
A.2.2 Voltage test between terminals (see Clause 9) 33
A.2.3 Thermal stability test (see Clause 13) 33
A.3 Overloads – Maximum permissible current (see Clause 21) 33
A.4 Markings – Instruction sheet or rating plate (see 27.1) 33
A.5 Guide for installation and operation – Choice of the rated voltage (see Clause 29) 33
Annex B (informative) Formulae for capacitors and installations 34
B.1 Computation of the output of three-phase capacitors from three single-phase capacitance measurements 34
B.2 Resonance frequency 34
B.3 Voltage rise 34
B.4 Inrush transient current 35
B.4.1 Switching in of single capacitor 35
B.4.2 Switching of capacitors in parallel with energized capacitor(s) 35
B.4.3 Discharge resistance in single-phase units or in one-phase or polyphase units 35
Bibliography 37

Figure B.1 – k values depending on the method of connection of the resistors with the capacitor units 36

Table 1 – Letter symbols for upper limit of temperature range 12
Table 2 – Ambient air temperature for the thermal stability test 18
Table 3 – Admissible voltage levels in service 21

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SHUNT POWER CAPACITORS OF THE SELF-HEALING TYPE FOR A.C. SYSTEMS HAVING A RATED VOLTAGE UP TO AND INCLUDING 1 000 V –

Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60831-1 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This third edition cancels and replaces the second edition published in 1996 and Amendment 1:2002. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Updating of the normative references;
b) Test conditions have been clarified;
c) Thermal stability test has been clarified;
d) Maximum permissible voltage and current have been clarified;
e) The protection of the environment has been amended with safety concerns and plastic quality requirements.

The text of this standard is based on the following documents:

FDIS	Report on voting
33/543/FDIS	33/550/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60831 series, published under the general title *Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including, 1 000 V* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of May 2014 have been included in this copy.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

SHUNT POWER CAPACITORS OF THE SELF-HEALING TYPE FOR A.C. SYSTEMS HAVING A RATED VOLTAGE UP TO AND INCLUDING 1 000 V –

Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

~~Section 1: General~~

1 Scope ~~and object~~

This part of the IEC 60831 series is applicable to both capacitor units and capacitor banks intended to be used, particularly, for power-factor correction of a.c. power systems having a rated voltage up to and including 1 000 V and frequencies of 15 Hz to 60 Hz.

This part of IEC 60831 also applies to capacitors intended for use in power filter circuits. Additional definitions, requirements, and tests for power filter capacitors are given in Annex A.

The following capacitors are excluded from this part of IEC 60831:

– Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1 000 V (IEC 60931-1, -2 and -3).

– Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V (IEC 60871-1, -2, -3 and -4).

– Capacitors for inductive heat-generating plants operating at frequencies between 40 Hz and 24 000 Hz (IEC 60110-1 and -2).

– Series capacitors (IEC60143-1, -2, -3 and -4).

– ~~Capacitors for motor applications and the like~~ AC motor capacitors (IEC 60252-1 and -2).

– Coupling capacitors and capacitor dividers (IEC 60358-1).

– Capacitors ~~to be used in~~ for power electronic circuits (IEC 61071).

– Small a.c. capacitors to be used for fluorescent and discharge lamps (IEC 61048 and IEC 61049).

– Capacitors for suppression of radio interference (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 the a.c. voltage.

Accessories such as insulators, switches, instrument transformers, fuses, etc., should be in accordance with the relevant IEC standards and are not covered by the scope of this part of IEC 60831.

The object of this part of IEC 60831 is to:

a) formulate uniform rules regarding performances, testing and rating;

b) formulate specific safety rules;

c) provide a guide for installation and operation.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60050(436):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 436: Power capacitors*~~

IEC 60060-1:~~1989~~2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

~~IEC 60110:1973, *Recommendation for capacitors for inductive heat generating plants operating at frequencies between 40 and 24 000 Hz*~~

~~IEC 60143:1992, *Series capacitors for power systems*~~

~~IEC 60252:1993, *A.C. motor capacitors*~~

IEC 60269-1:~~1986~~2006, *Low-voltage fuses – Part 1: General requirements*

~~IEC 60358:1990, *Coupling capacitors and capacitor dividers*~~

IEC 60695-2-12:2010, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 60831-2:~~1995~~2013, *Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V – Part 2: Ageing test, self-healing test and destruction test*

~~IEC 60871-1:1987, *Shunt capacitors for a.c. power systems having a rated voltage above 1000 V** – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation~~

~~IEC 60931-1:1996, *Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation*~~

~~IEC 60931-3:1996, *Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V – Part 3: Internal fuses*~~

IEC 61000-2-2:~~1990~~2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC 61000-4-1:~~1992~~2006, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – ~~Overview of immunity tests. Basic EMC publication~~ Overview of IEC 61000-4 series*

~~IEC 61048:1991, *Capacitors for use in tubular fluorescent and other discharge lamp circuits – General and safety requirements*~~

~~IEC 61049:1991, *Capacitors for use in tubular fluorescent and other discharge lamp circuits – Performance requirements*~~

~~IEC 61071-1:1993, *Power electronic capacitors – Part 1: General*~~

_____

~~* According to Amendment 1 (1991).~~

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
capacitor element
element
device consisting essentially of two electrodes separated by a dielectric

[SOURCE: IEC 60050-436:1990, 436-01-03]

3.2
capacitor unit
unit
assembly of one or more capacitor elements in the same container with terminals brought out

[SOURCE: IEC 60050-436:1990, 436-01-04]

3.3
self-healing capacitor
capacitor of which the electrical properties, after local breakdown of the dielectric, are rapidly and essentially restored

[SOURCE: IEC 60050-436:1990, 436-03-12]

3.4
capacitor bank
bank
number of capacitor units connected so as to act together

[SOURCE: IEC 60050-436:1990, 436-01-06]

3.5
capacitor
generic term, encompassing the notions of capacitor unit and capacitor bank

Note 1 to entry: In this part of IEC 60831, 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.

3.6
capacitor installation
one or more capacitor banks and their accessories

[SOURCE: IEC 60050-436:1990, 436-01-07]

3.7
discharge device of a capacitor
device which may be incorporated in a capacitor, capable of reducing the voltage between the terminals practically to zero, within a given time, after the capacitor has been disconnected from a network

[SOURCE: IEC 60050-436:1990, 436-03-15, modified ("intended to reduce … value" has been replaced by "capable of reducing … zero")]

3.8
internal fuse of a capacitor
fuse connected inside a capacitor unit, in series with an element or a group of elements

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

[SOURCE: IEC 60050-436:1990, 436-03-16]

3.9
overpressure disconnector for a capacitor
disconnecting device designed to switch off the capacitor in the case of abnormal increase of the internal pressure

[SOURCE: IEC 60050-436:1990, 436-03-17, modified ("to interrupt ... in the event" has been replaced by "to switch off ... in the case")]

3.10
overtemperature disconnector for a capacitor
disconnecting device designed to switch off the capacitor in the case of abnormal increase of the internal temperature

3.11
line terminal
terminal intended for connection to a line conductor of a network

Note 1 to entry: In polyphase capacitors, a terminal intended to be connected to the neutral conductor is not considered to be a line terminal.

[SOURCE: IEC 60050-436:1990, 436-03-01]

3.12
rated capacitance of a capacitor
C_N
capacitance value for which the capacitor has been designed

[SOURCE: IEC 60050-436:1990, 436-01-12, modified (symbol C_N added and "the r.m.s. value of the alternating current" has been replaced by "capacitance value")]

3.13
rated output of a capacitor
Q_N
reactive power derived from the rated values of capacitance, frequency and voltage

[SOURCE: IEC 60050-436:1990, 436-01-16, modified (symbol Q_N added and "for which the capacitor has been designed" has been replaced by "derived ... voltage")]

3.14
rated voltage of a capacitor
U_N
r.m.s. value of the alternating voltage for which the capacitor has been designed

Note 1 to entry: In the case of capacitors consisting of one or more separate circuits (such as single-phase units intended for use in polyphase connection, or polyphase units with separate circuits), U_N refers to the rated voltage of each circuit.

For polyphase capacitors with internal electrical connections between the phases, and for polyphase capacitor banks, U_N refers to the phase-to-phase voltage.

[SOURCE: IEC 60050-436:1990, 436-01-15]

3.15
rated frequency of a capacitor
f_N
frequency for which the capacitor has been designed

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

[SOURCE: IEC 60050-436:1990, 436-01-14]

3.16
rated current of a capacitor
I_N
r.m.s. value of the alternating current for which the capacitor has been designed

[SOURCE: IEC 60050-436:1990, 436-01-13]

3.17
capacitor losses
active power dissipated in the capacitor

Note 1 to entry: All loss-producing components should be included, for example:

– for a unit, losses from dielectric, internal fuses, internal discharge resistor, connections, etc.;
– for a bank, losses from units, external fuses, busbars, discharge and damping reactors, etc.

[SOURCE: IEC 60050-436:1990, 436-04-10]

3.18
tangent of the loss angle of a capacitor
tan δ
ratio between the equivalent series resistance and the capacitive reactance of the capacitor at specified sinusoidal alternating voltage and frequency

[SOURCE: IEC 60050-436:1990, 436-04-11]

3.19
maximum permissible a.c. voltage of a capacitor
maximum r.m.s. alternating voltage which the capacitor can sustain for a given time in specified conditions

[SOURCE: IEC 60050-436:1990, 436-04-07]

3.20
maximum permissible a.c. current of a capacitor
maximum r.m.s. alternating current which the capacitor can sustain for a given time in specified conditions

[SOURCE: IEC 60050-436:1990, 436-04-09]

3.21
ambient air temperature
temperature of the air at the proposed location of the capacitor

3.22
cooling air temperature
temperature of the cooling air measured at the hottest position in the bank, under steady-state conditions, midway between two units

Note 1 to entry: If only one unit is involved, it is the temperature measured at a point approximately 0,1 m away from the capacitor container and at two-thirds of the height from its base.

3.23
steady-state condition
thermal equilibrium attained by the capacitor at constant output and at constant ambient air temperature

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

3.24
residual voltage
voltage remaining on the terminals of a capacitor at a certain time following disconnection

4 Service conditions

4.1 Normal service conditions

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

a) Residual voltage at energization

Not to exceed 10 % rated voltage (Clause 22, Clause 32, and Annex B).

b) Altitude

Not exceeding 2 000 m.

c) Ambient air temperature categories

Capacitors are classified in temperature categories, each category being specified by a number followed by a letter. The number represents the lowest ambient air temperature at which the capacitor may operate.

The letters represent upper limits of temperature variation ranges, having maximum values specified in Table 1. The temperature categories cover the temperature range of –50 °C to +55 °C.

The lowest ambient air temperature at which the capacitor may be operated should be chosen from the five preferred values +5 °C, –5 °C, –25 °C, –40 °C, –50 °C.

For indoor use, a lower limit of –5 °C is normally applicable.

Table 1 is based on service conditions in which the capacitor does not influence the ambient air temperature (for example outdoor installations).

Table 1 – Letter symbols for upper limit of temperature range

Symbol	Ambient temperature °C		
	Maximum	Highest mean over any period of	
		24 h	1 year
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

NOTE 1 The temperature values according to Table 1 can be found in the meteorological temperature table covering the installation site.

NOTE 2 Higher temperature values than those indicated in Table 1 can be considered in special applications by mutual agreement between manufacturer and purchaser. In that case, the temperature category should be indicated by the combination of minimum and maximum temperature values, for example, –40/60.

If the capacitor influences the air temperature, the ventilation and/or choice of capacitor shall be such that the Table 1 limits are maintained. The cooling air temperature in such an installation shall not exceed the temperature limits of Table 1 by more than 5 °C.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Any combination of minimum and maximum values can be chosen for the standard temperature category of a capacitor, for example –40/A or –5/C.

Preferred temperature categories are:

–40/A, –25/A, –5/A and –5/C.

4.2 Unusual service conditions

Unless otherwise agreed between manufacturer and purchaser, this standard does not apply to capacitors, the service conditions of which, in general, are incompatible with the requirements of the present standard.

~~Section 2: Quality requirements and tests~~

5 Test requirements

5.1 General

Clause 5 gives the test requirements for capacitor units and, when specified, for capacitor elements.

Supporting insulators, switches, instrument transformers, fuses, etc, shall be in accordance with relevant IEC standards.

5.2 Test conditions

Unless otherwise specified for a particular test or measurement, the temperature of the capacitor dielectric at the start of the test shall be in the range of +5 °C to +35 °C.

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 constant ambient temperature for an adequate period. ~~When a correction has to be applied, the reference temperature to be used is +20 °C, unless otherwise agreed between the manufacturer and the purchaser.~~

The a.c. tests and measurements shall be carried out at a frequency of 50 Hz or 60 Hz independent of the rated frequency of the capacitor, if not otherwise specified.

Capacitors having a rated frequency below 50 Hz shall be tested and measured at 50 Hz or 60 Hz, if not otherwise specified.

6 Classification of tests

~~The tests are classified as:~~

6.1 Routine tests

The following tests are routine tests. For details, reference should be made to the relevant clauses or subclauses:

a) capacitance measurement and output calculation (see Clause 7);

b) measurement of the tangent of the loss angle (tan δ) of the capacitor (see Clause 8);

c) voltage test between terminals (see 9.1);

d) voltage test between terminals and container (see 10.1);

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

e) test of the internal discharge device (see Clause 11);

f) sealing test (see Clause 12).

Routine tests shall have been carried out by the manufacturer on every capacitor before delivery. If the purchaser so requests, he shall be supplied with a certificate detailing the results of such tests.

In general, the indicated sequence of the tests is not mandatory.

6.2 Type tests

The following tests are type tests. For details, reference should be made to the relevant clauses or subclauses:

a) thermal stability test (see Clause 13);

b) measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature (see Clause 14);

c) voltage test between terminals (see 9.2);

d) voltage test between terminals and container (see 10.2);

e) lightning impulse voltage test between terminals and container (see Clause 15);

f) discharge test (see Clause 16);

g) ageing test (see Clause 17);

h) self-healing test (see Clause 18);

i) destruction test (see Clause 19).

Type tests are carried out in order to ascertain that, as regards design, size, materials and construction, the capacitor complies with the specified characteristics and operation requirements detailed in this standard.

Unless otherwise specified, every capacitor sample to which the type test is applied shall first have withstood satisfactorily the application of all the routine tests.

The type tests shall have been carried out by the manufacturer, and the purchaser shall, on request, be supplied with a certificate detailing the results of such tests.

The successful completion of each type test is also valid for units having the same rated voltage and lower output, provided that they do not differ in any way that may influence the properties to be checked by the test. It is not essential that all type tests be carried out on the same capacitor sample.

The number of samples for the type test shall be subjected to agreement between the manufacturer and user.

6.3 Acceptance tests

Some or all of the routine and/or type tests may be repeated by the manufacturer in connection with any contract by agreement with the purchaser. The kind of tests, the number of samples that may be subjected to such repeated tests, and the acceptance criteria shall be subject to agreement between manufacturer and purchaser, and shall be stated in the contract.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

7 Capacitance measurement and output calculation

7.1 Measuring procedure

The capacitance shall be measured at the voltage and at the frequency chosen by the manufacturer. The method used shall not include errors due to harmonics, or to accessories external to the capacitor to be measured, such as reactors and blocking circuits in the measuring circuit. The accuracy of the measuring method and the correlation with the values measured at rated voltage and frequency shall be given.

The capacitance measurement shall be carried out after the voltage test between terminals (see Clause 9).

Measurement at a voltage between 0,9 and 1,1 times the rated voltage, and at a frequency between 0,8 and 1,2 times the rated frequency, shall be performed on the capacitor previously used for the thermal stability test (see Clause 13), the ageing test (see Clause 17), and the self-healing test (see Clause 18~~ before these tests~~), and could be performed on other capacitors at the request of the purchaser in agreement with the manufacturer.

7.2 Capacitance tolerances

The capacitance shall not differ from the rated capacitance by more than

–5 % to +~~15~~10 % for units and banks up to 100 kvar;

~~0 –~~5 % to +~~10~~5 % for units and banks above 100 kvar.

The capacitance value is that measured under the conditions of 7.1.

In three-phase units, the ratio of maximum to minimum value of the capacitance measured between any two-line terminals shall not exceed 1,08.

NOTE A formula for the calculation of the output of a three-phase capacitor from a single-phase capacitance measurement is given in Annex B.

8 Measurement of the tangent of the loss angle (tan δ) of the capacitor

8.1 Measuring procedure

The capacitor losses (or tan δ) shall be measured at the voltage and at the frequency chosen by the manufacturer. The method used shall not include errors due to harmonics, or to accessories external to the capacitor to be measured, such as reactors and blocking circuits in the measuring circuit. The accuracy of the measuring method and the correlation with the values measured at the rated voltage and frequency shall be given.

The measurement of the capacitor losses shall be carried out after the voltage test between terminals (see Clause 9).

Measurement at a voltage between 0,9 and 1,1 times the rated voltage, and at a frequency between 0,8 and 1,2 times the rated frequency shall be performed on the capacitor before the thermal stability test (see Clause 13), and may be performed on other capacitors upon request of the purchaser in agreement with the manufacturer.

~~NOTE 1~~ When testing a large number of capacitors, statistical sampling may be used for measuring tan δ. The statistical sampling plan should be by agreement between manufacturer and purchaser.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

~~NOTE 2~~ The tan δ value of certain types of dielectric is a function of the energization time before the measurement. In that case, test voltage and energization time should be by agreement between manufacturer and purchaser.

8.2 Loss requirements

The value of tan δ, measured in accordance with 8.1, shall not exceed the value declared by the manufacturer for the temperature and voltage of the test, or the value agreed upon between manufacturer and purchaser.

9 Voltage tests between terminals

9.1 Routine test

Each capacitor shall be subjected to an a.c. test at U_t = 2,15 U_N for a minimum time of 2 s.

The a.c. test shall be carried out with a substantially sinusoidal voltage at a frequency between 15 Hz and 100 Hz, and preferably as near as possible to the rated frequency.

During the test, no permanent puncture or flashover shall occur. ~~Self-~~healing breakdowns are permitted.

When the unit is composed of a number of elements, or a group of elements connected in parallel, and which are tested separately, it is not necessary to repeat the test on the unit.

~~NOTE 1~~ For polyphase capacitors, the test voltages should be adjusted as appropriate.

NOTE ~~2~~ Operation of internal element fuses is permitted, provided the capacitance tolerances are still met and that not more than two fuses have operated per unit. ~~>~~

9.2 Type test

Each capacitor shall be subjected to an a.c. test at U_t = 2,15 U_N for 10 s.

The a.c. test shall be carried out with a substantially sinusoidal voltage.

During the test, no permanent puncture or flashover shall occur. Self-healing breakdowns are permitted.

~~NOTE 1~~ For polyphase capacitors, the test voltages should be adjusted as appropriate.

NOTE ~~2~~ Operation of internal element fuses is permitted, provided capacitance tolerances are still met, and that not more than two fuses have operated per unit.

10 Voltage tests between terminals and container

10.1 Routine test

Units having all terminals insulated from the container shall be subjected to an a.c. voltage applied between the terminals (joined together) and the container. ~~If the rated voltage of the capacitor is U_N ≤660 V, the voltage to be applied is 3 kV for 10 s or 3,6 kV for a minimum time of 2 s. If the rated voltage of the capacitor is U_N >660 V, the voltage to be applied is 6 kV for 10 s or 7,2 kV for a minimum time of 2 s.~~ The voltage to be applied is 2 U_N + 2 kV or 3 kV, whichever is the higher, for 10 s or 20 % higher for a minimum time of 2 s.

If the units are intended to be connected directly to the aerial power line and by agreement between the manufacturer and the user, the test shall be performed with a voltage of 6 kV.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

During the test, neither puncture nor flashover shall occur.

The test shall be performed, even if, in service, one of the terminals is intended to be connected to the container.

Three-phase units having separate phase capacitance can be tested with respect to the container with all the terminals joined together. Units having one terminal permanently connected to the container shall not be subjected to this test.

When the unit container consists of insulating material, this test shall be omitted.

If a capacitor has separate phases or sections, a test of the insulation between phases or sections shall be made at the same voltage value as for the terminals-to-container test.

10.2 Type test

Units having all terminals insulated from the container shall be subjected to a test according to 10.1 for a duration of 1 min ~~with a voltage of 3 kV if the rated voltage of the capacitor is U_N ≤660 V or with a voltage of 6 kV if U_N >660 V~~.

The test on units having one terminal permanently connected to the container shall be limited to the bushing(s) and container (without elements) or to a fully insulated unit with identical internal insulation.

If the capacitor container is of insulating material, the test voltage shall be applied between the terminals and a metal foil wrapped closely round the surface of the container.

The test shall be made under dry conditions for indoor units, and with artificial rain (see IEC 60060-1) for units to be used outdoors.

During the test, neither puncture nor flashover shall occur.

~~NOTE 1~~ Units intended for outdoor installation may be subjected to a dry test only.

The manufacturer should in such a case supply a separate type test report showing that the bushing with enclosure, if used, will withstand the wet test voltage.

NOTE ~~2~~ For filter capacitors, the voltage appearing at the capacitor terminals is always higher than the network voltage.

For filter capacitors, and provided the arithmetic sum of the r.m.s values of the harmonic voltages does not exceed 0,5 times the nominal network voltage, the test voltage between terminals and container refers to the nominal network voltage to which the filter is connected (and not to the voltage appearing at the capacitor terminals).

If the factor of 0,5 times is exceeded, then the ~~normal rule should apply, that is the~~ test voltage between terminals and container refers to the rated voltage of the capacitor.

11 Test of internal discharge device

The resistance of the internal discharge device, if any, shall be checked either by a resistance measurement or by measuring the self-discharging rate (see Clause 22). The choice of the method is left to the manufacturer.

The test shall be made after the voltage tests of Clause 9.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

12 Sealing test

The unit (in non-painted state) shall be exposed to a test that will effectively detect any leak of the container and bushing(s). The test procedure is left to the manufacturer, who shall describe the test method concerned.

If no procedure is stated by the manufacturer, the following test procedure shall apply:

Unenergized capacitor units shall be heated throughout so that all parts reach a temperature not lower than 20 °C above the maximum value in Table 1 corresponding to the capacitor symbol, and shall be maintained at this temperature for 2 h. No leakage shall occur.

It is recommended that a suitable indicator is used.

NOTE If the capacitor contains no liquid materials at the test temperature, the test may be omitted as a routine test.

13 Thermal stability test

The capacitor unit subjected to the test shall be placed between two other units of the same rating which shall be energized at the same voltage as the test capacitor. Alternatively, two dummy capacitors each containing resistors may be used. The dissipation in the resistors shall be adjusted to a value so that the container temperatures of the dummy capacitors near the top opposing faces are equal to, or greater than, those of the test capacitor. The separation between the units shall be equal to~~, or less than,~~ normal spacings as specified by manufacturer's instructions.

The assembly shall be placed in still air (without forced air ventilation) in a heated enclosure in the most unfavourable thermal position according to the manufacturer's instructions for mounting on site. The ambient air temperature shall be maintained at or above the appropriate temperature shown in Table 2. It shall be checked by means of a thermometer having a thermal time constant of approximately 1 h.

The ambient air thermometer should be shielded so that it is subjected to the minimum possible thermal radiation from the three energized samples.

Table 2 – Ambient air temperature for the thermal stability test

Symbol	Ambient air temperature °C
A	40
B	45
C	50
D	55

After all parts of the capacitor have attained the temperature of the ambient air, the capacitor shall be subjected for a period of at least 48 h to an a.c. voltage of substantially sinusoidal form. The magnitude of the voltage throughout the last 24 h of the test shall be adjusted to give a calculated output, using the measured capacitance (see 7.1), of at least 1,44 times its rated output.

~~During the last six hours, the temperature of the container near the top shall be measured at least four times. Throughout this period of 6 h, the temperature rise shall not increase by more than 1 °C. Should a greater change be observed, the test may be continued until the above requirement is satisfied for four consecutive measurements during a 6 h period.~~

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

The test will stop in one of the following two conditions:

– For a period of 6 h, the temperature of the container measured at 2/3 of the height from the bottom (excluding terminals) shall not increase by more than 1 °C. In this case, the test is considered as positive.

– If the temperature increases of three successive periods of 6 h do not decrease in magnitude. In this case, the test is considered as having failed.

At the end of the stability test, the difference between the measured temperature of the container and the ambient air temperature shall be recorded.

Before and after the test the capacitance shall be measured (see 7.1) within the standard temperature range for testing (see 5.2), and these two measurements shall be corrected to the same dielectric temperature. No change of capacitance greater than 2 % shall be apparent from these measurements.

A measurement of the tangent of the loss angle (tan δ) shall be made before and after the thermal stability test, at a temperature of ~~approximately 20°C~~ 25°C ± 5°C.

The value of the second measurement of the tangent of the loss angle shall be not greater than that of the first by more than 2×10^{-4}.

When interpreting the results of the measurements, two factors shall be taken into account:

– the repeatability of the measurements;

– the fact that internal change in the dielectric may cause a small change of capacitance, without the puncture of any element of the capacitor, or the blowing of an internal fuse having occurred.

~~NOTE 1~~ When checking whether the capacitor losses or temperature conditions are satisfied, fluctuations of voltage, frequency and ambient air temperature during the test should be taken into account. For this reason, it is advisable to plot these parameters and the tangent of the loss angle and the temperature rise as a function of time.

~~NOTE 2~~ Units intended for 60 Hz installation may be tested at 50 Hz and units intended for 50 Hz may be tested at 60 Hz provided that the specified output is applied. For units rated below 50 Hz, the test conditions should be agreed between purchaser and manufacturer.

NOTE ~~3~~ For polyphase units, two possibilities are allowed:

– use of a three-phase source;

– modification of the internal connections in order to have only one phase with the same output.

14 Measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature

14.1 Measuring procedure

The capacitor losses (tan δ) shall be measured at the end of the thermal stability test (see Clause 13). The measuring voltage shall be that of the thermal stability test.

14.2 Requirements

The value of tan δ, measured in accordance with 14.1, shall not exceed the value declared by the manufacturer for the temperature and voltage of the test, or the value agreed upon between manufacturer and purchaser.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

15 Lightning impulse voltage test between terminals and container

Only units having all terminals insulated from the container ~~and intended for exposed installations~~ shall be subjected to this test.

The impulse test shall be performed with a wave of 1,2/50 μs to 5/50 μs having a peak value of 8 kV if the rated voltage of the capacitor is $U_N \leq 690$ V or having a peak value of 12 kV if $U_N > 690$ V.

~~Unless otherwise agreed between manufacturer and purchaser,~~ If the units are intended to be connected directly to exposed installations such as overhead lines and by agreement between the manufacturer and the user, the impulse test shall be performed with a wave of 1,2/50 μs to 5/50 μs having a peak value of 15 kV if the rated voltage of the capacitor is $U_N \leq$ ~~660~~690 V or having a peak value of 25 kV if $U_N >$ ~~660~~690 V.

Three impulses of positive polarity followed by three impulses of negative polarity shall be applied between the terminals joined together and the container.

After the change of polarity, it is permissible to apply some impulses of lower amplitude before the application of the test impulses.

The absence of failure during the test shall be verified by ~~a cathode ray~~ an oscillograph, which is used to record the voltage and to check the wave shape.

If the capacitor container is of insulating material, the test voltage shall be applied between the terminals and a metal foil wrapped closely round the surface of the container.

NOTE Partial discharge in the insulation to the container may be indicated by the modification of the waveshapes between the different impulses.

16 Discharge test

The unit shall be charged by means of d.c. and then discharged through a gap situated as close as possible to the capacitor.

It shall be subjected to five such discharges within 10 min.

The test voltage shall be equal to 2 U_N.

Within 5 min after this test, the unit shall be subjected to a voltage test between terminals (see 9.1).

The capacitance shall be measured before the discharge test and after the voltage test. The measurements shall not differ by an amount corresponding either to the breakdown of an element, or to the blowing of an internal fuse, or by more than 2 %.

For polyphase units, the test shall be carried out in the following manner:

– In the case of units with three-phase delta connection, two terminals shall be short-circuited and the test carried out between the third terminal and the short-circuited terminals at 2 U_N.

– In the case of units with three-phase star connection, the test shall be carried out between two terminals with the third terminal left unconnected. The test voltage shall be 4 $U_N/\sqrt{3}$ to achieve the same test voltage across the elements.

If the first peak of the test current exceeds the value of 200 I_N (r.m.s.), it may be kept at this limit by means of an external coil.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

17 Ageing test

The requirements for this test are given in IEC 60831-2.

18 Self-healing test

The requirements for this test are given in IEC 60831-2.

19 Destruction test

The requirements for this test are given in IEC 60831-2.

~~Section 3: Overloads~~

20 Maximum permissible voltage

20.1 Long-duration voltages

Capacitor units shall be suitable for operation at voltage levels according to Table 3 (see also Clauses 29 and 32).

Table 3 – Admissible voltage levels in service

Type	Voltage factor × U_N r.m.s.	Maximum duration	Observations
Power frequency	1,00	Continuous	Highest average value during any period of capacitor energization. For energization periods less than 24 h, exceptions apply as indicated below (see Clause 29).
Power frequency	1,10	8 h in every 24 h	System voltage regulation and fluctuations.
Power frequency	1,15	30 min in every 24 h	System voltage regulation and fluctuations.
Power frequency	1,20	5 min	Voltage rise at light load (see Clause 29).
Power frequency	1,30	1 min	
Power frequency plus harmonics	So that the current does not exceed the value given in clause 21 (see also Clauses 33 and 34).		

~~The amplitude of the overvoltages that may be tolerated without significant deterioration of the capacitor depends on their duration, the number of applications, and the capacitor temperature (see clause 29).~~ 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. It is assumed that the overvoltages given in Table 3 and having a value higher than 1,15 U_N occur 200 times in the life of the capacitor.

20.2 Switching voltages

The switching of a capacitor bank by a restrike-free circuit breaker usually causes a transient overvoltage, the first peak of which does not exceed 2 √2 times the applied voltage (r.m.s. value) for a maximum duration of 1/2 cycle.

About 5 000 switching operations per year are acceptable under these conditions, taking into account the fact that some of them may take place when the internal temperature of the capacitors is less than 0 °C, but is within the temperature category. (The associated peak transient overcurrent may reach 100 times the value I_N (see Clause 33)).

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

In the case of capacitors that are switched more frequently, the values of the overvoltage amplitude and duration and the transient overcurrent shall be limited to lower levels (see Clause 34).

These limitations and/or reductions shall be agreed between manufacturer and purchaser.

21 Maximum permissible current

Capacitor units shall be suitable for continuous operation at an r.m.s. line current of 1,3 times the current that occurs at rated sinusoidal voltage and rated frequency, excluding transients. Taking into account the capacitance tolerances of ~~1,15~~ 1,1 C_N, the maximum current can reach ~~1,5~~ 1,43 I_N.

These overcurrent factors are intended to take into account the combined effects of harmonics, overvoltages and capacitance tolerance according to 20.1.

~~Section 4: Safety requirements~~

22 Discharge device

Each capacitor unit and/or bank shall be provided with a means for discharging each unit in 3 min to 75 V or less, from an initial peak voltage of $\sqrt{2}$ times the rated voltage U_N.

There shall be no switch, fuse cut-out, or any other isolating device between the capacitor unit and this discharge device.

A discharge device is not a substitute for short-circuiting the capacitor terminals together and to earth before handling.

~~NOTE 1~~ Capacitors connected directly and permanently to other electrical equipment providing a discharge path should be considered properly discharged, provided that the circuit characteristics are such as to ensure the discharge of the capacitor within the time specified above.

~~NOTE 2~~ Attention is drawn to the fact that in some countries smaller discharge times and voltages are required. In that event, the purchaser should inform the manufacturer.

~~NOTE 3~~ Discharge circuits should have adequate current-carrying capacity to discharge the capacitor from the peak of the 1,3 U_N overvoltage according to Clause 20.

~~NOTE 5~~ Since the residual voltage at energization should not exceed 10 % of the rated voltage (see 4.1), discharge resistors with lower resistance or additional switched discharge devices may be needed, if the capacitors are automatically controlled.

NOTE ~~4~~ A formula for the calculation of the discharge resistance is given in Annex B.

23 Container connections

To enable the potential of the metal container of the capacitor to be fixed, and to be able to carry the fault current in the event of a breakdown to the container, the metallic container shall be provided with a connection capable of carrying the fault current.

24 Protection of the environment

When capacitors are impregnated with products that shall not be dispersed into the environment, the necessary precautions shall be taken. In some countries, there exist legal

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

requirements in this respect (see 26.3). The units and the bank shall be labelled accordingly, if so required.

Products of combustion of the terminals shall be environmentally acceptable. Self-extinguishing materials with a minimum Glow-Wire Flammability Index (GWFI) of 750 °C shall be used for the terminals (see IEC 60695-2-12).

25 Other safety requirements

The purchaser shall specify at the time of enquiry any special requirements with regard to the safety regulations that apply to the country in which the capacitor is to be installed.

~~Section 5: Markings~~

26 Marking of the unit

26.1 Rating plate

The following information shall be marked indelibly, either directly or by means of a plate, on each capacitor unit:

a) Manufacturer.

b) Identification number and manufacturing year.

(The year may be a part of the identification number or be in code form)

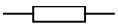
c) Rated output Q_N in kilovars (kvar).

For three-phase units, the total output shall be given (see Annex B).

d) Rated voltage U_N in volts (V).

e) Rated frequency f_N in hertz (Hz).

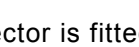
f) Temperature category.

g) Discharge device, if internal, shall be indicated by wording or by the symbol  or by the rated resistance in kilohms (kΩ) or megohms (MΩ).

h) Reference of self-healing design: "SH" or  or "self-healing".

i) Connection symbol.

(All capacitors, except single-phase units having one capacitance only, shall have their connection indicated. For standardized connection symbols, see 26.2).

j) Internal fuses, if included, shall be indicated by wording or by the symbol  .

k) Indication for the overpressure or thermal disconnector, if such disconnector is fitted.

l) Insulation level U_i in kilovolts (kV). (Only for units having all terminals insulated from the container).

The insulation level shall be marked by means of two numbers separated by a stroke, the first number giving the r.m.s. value of the power frequency test voltage, in kilovolts, and the second number giving the peak value of the lightning impulse test voltage, in kilovolts (for example 3/15 kV).

For units having one terminal permanently connected to the container, and ~~units for non-exposed installation and~~ not tested according to Clause 15, this information should be 3/- kV.

m) Reference to IEC 60831-1 (plus year of issue of the edition).

In the case of filter capacitors, a reference to Annex A shall be made.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

~~NOTE 1~~ For small units, which are permanently connected together by the manufacturer or the manufacturer's representative to form a bank or a large unit, certain of the above items may be deleted. This bigger bank or unit should in this case carry a complete rating plate.

~~NOTE 2~~ A warning notice should be included as follows: "Warning: wait 5 minutes after isolating supply before handling".

The purchaser should specify any additional marking requirement.

26.2 Standardized connection symbols

The type of connection shall be indicated either by letters or by the following symbols:

D or  = delta

Y or  = star

YN or  = star, neutral brought out

III or  = three sections without interconnections.

26.3 Warning plate

When capacitors are impregnated with products that shall not be dispersed into the environment (see Clause 24), the capacitor shall carry markings in accordance with the laws or regulations in force in the user's country, the onus being on the user to inform the manufacturer of such laws or regulations.

27 Marking of the bank

27.1 Instruction sheet or rating plate

The following minimum information shall be given by the manufacturer in an instruction sheet, or alternatively, on request of the purchaser, on a rating plate:

a) Manufacturer.

b) Rated output Q_N in kilovars (kvar).

(Total output to be given.)

c) Rated voltage U_N in volts (V).

d) Connection symbol.

(For standardized connection symbols, see 26.2. The connection symbol may be part of a simplified connection diagram.)

e) Minimum time required between disconnection and reclosure of the bank.

f) Weight in kilograms (kg).

NOTE The choice between a rating plate and an instruction sheet is left to the purchaser.

27.2 Warning plate

Subclause 26.3 is also valid for the bank.

~~Section 6: Guide for installation and operation~~

28 General

Unlike most electrical apparatus, shunt capacitors, whenever energized, operate continuously at full load, or at loads that deviate from this value only as a result of voltage and frequency variations.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Overstressing and overheating shorten the life of a capacitor, and therefore the operating conditions (that is, temperature, voltage and current) should be strictly controlled.

It should be noted that the introduction of concentrated capacitance in a system may produce unsatisfactory operating conditions (for example amplification of harmonics, self-excitation of machines, overvoltage due to switching, unsatisfactory working of audio-frequency remote-control apparatus, etc.).

Because of the different types of capacitors and the many factors involved, it is not possible to cover, by simple rules, installation and operation in all possible cases. The following information is given with regard to the more important points to be considered. In addition, the instructions of the manufacturer and the power supply authorities shall be followed, especially those concerning the switching of capacitors when the network is under light load conditions.

29 Choice of the rated voltage

The rated voltage of the capacitor shall be at least equal to the service voltage of the network to which the capacitor is to be connected, account being taken of the influence of the presence of the capacitor itself.

In certain networks, a considerable difference may exist between the service and rated voltage of the network, details of which should be furnished by the purchaser, so that due allowance can be made by the manufacturer. This is of importance for capacitors, since their performance and life may be adversely affected by an undue increase of the voltage across the capacitor dielectric.

Where circuit elements are inserted in series with the capacitor to reduce the effects of harmonics, etc., the resultant increase in the voltage at the capacitor terminals above the service voltage of the network necessitates a corresponding increase in the rated voltage of the capacitor.

If no information to the contrary is available, the service voltage shall be assumed as equal to the rated (or declared) voltage of the network.

When determining the voltage to be expected on the capacitor terminals, the following considerations shall be taken into account:

a) shunt-connected capacitors may cause a voltage rise from the source to the point where they are located (see Annex B); this voltage rise may be greater due to the presence of harmonics. Capacitors are therefore liable to operate at a higher voltage than that measured before connecting the capacitors;

b) the voltage on the capacitor terminals may be particularly high at times of light load conditions (see Annex B); in such cases, some or all of the capacitors should be switched out of circuit in order to prevent overstressing of the capacitors and undue voltage increase in the network.

Only in case of emergency should capacitors be operated at maximum permissible voltage and maximum ambient temperature simultaneously, and then only for short periods of time.

NOTE 1 An excessive safety margin in the choice of the rated voltage U_N should be avoided, because this would result in a decrease of output when compared with the rated output.

NOTE 2 See Clause 20 concerning maximum permissible voltage.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

30 Operating temperature

30.1 General

Attention should be paid to the operating temperature of the capacitor, because this has a great influence on its life. In this respect, the temperature of the hot spot is a determining factor, but it is difficult to measure this temperature in practical operation.

Temperature in excess of the upper limit accelerates electrochemical degradation of the dielectric.

30.2 Installation

Capacitors shall be so placed that there is adequate dissipation by convection and radiation of the heat produced by the capacitor losses.

The ventilation of the operating room and the arrangement of the capacitor units shall provide good air circulation around each unit. This is of special importance for units mounted in rows one above the other.

The temperature of capacitors subjected to radiation from the sun or from any high-temperature surface will be increased. Depending on the cooling air temperature, the intensity of the cooling and the intensity and duration of the radiation, it may be necessary to opt for one of the following remedies:

– to protect the capacitors from radiation;

– to choose a capacitor designed for a higher ambient air temperature (for example, category –5/B instead of –5/A, which is otherwise suitably designed);

– to employ capacitors with rated voltage higher than that laid down in Clause 29.

Capacitors installed at high altitude (more than 2 000 m) will be subjected to decreased heat dissipation, which shall be considered when determining the output of the units (see item e), Clause 31).

30.3 High ambient air temperature

Symbol C capacitors are suitable for the majority of applications under tropical conditions. In some locations, however, the ambient temperature may be such that a symbol D capacitor is required. The latter may also be needed for those cases where the capacitors are frequently subjected to the radiation of the sun for several hours (for example in desert areas), even though the ambient temperature is not excessive (see 30.2).

In exceptional cases, the maximum ambient temperature may be higher than 55 °C, or the daily average higher than 45 °C. Where it is impossible to increase the cooling conditions, capacitors of special design shall be used.

30.4 Evaluation of losses

If losses are to be evaluated, all accessories producing losses, such as external fuses, reactors, etc., shall be included in the calculation of total bank losses.

31 Special service conditions

Apart from the conditions prevailing at both limits of the temperature category (see 30.1), the most important conditions, which the manufacturer shall be informed about, are the following:

a) *High relative humidity*

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

It may be necessary to use insulators of special design. Attention is drawn to the possibility of external fuses being shunted by a deposit of moisture on their surfaces.

b) *Rapid mould growth*

Mould growth does not develop on metals, ceramic materials and some kinds of paints and lacquers. For other materials, mould growth may develop in humid places, especially where dust, etc., can settle.

The use of fungicidal products may improve the behaviour of these materials, but such products do not retain their poisoning property for more than a certain period.

c) *Corrosive atmosphere*

Corrosive atmosphere is found in industrial and coastal areas. It should be noted that in climates of higher temperature the effects of such atmospheres may be more severe than in temperate climates. Highly corrosive atmosphere may be present even in indoor installations.

d) *Pollution*

When capacitors are mounted in a location with a high degree of pollution, special precautions shall be taken.

e) *Altitude exceeding 2 000 m*

Capacitors used at altitudes exceeding 2 000 m are subject to special conditions. The choice of the type should be made by agreement between purchaser and manufacturer.

32 Overvoltages

Clause 20 specifies overvoltage factors.

With the manufacturer's agreement, the overvoltage factor may be increased if the estimated number of overvoltages is lower, or if the temperature conditions are less severe. These power frequency overvoltage limits are valid, provided that transient overvoltages are not superposed on them. The peak voltage shall not exceed $\sqrt{2}$ times the given r.m.s. value.

Capacitors that are liable to be subjected to high overvoltages due to lightning should be adequately protected. If lightning arresters are used, they should be located as near as possible to the capacitors.

Special arresters may be required to take care of the discharge current from the capacitor, especially from large banks.

When a capacitor is permanently connected to a motor, difficulties may arise after disconnecting the motor from the supply. The motor, while still revolving, may act as a generator by self-excitation and may give rise to voltages considerably in excess of the system voltage.

This, however, can usually be prevented by ensuring that the capacitor current is less than the magnetizing current of the motor; a value of about 90 % is suggested. As a precaution, live parts of a motor to which a capacitor is permanently connected should not be touched before the motor stops.

NOTE 1 The maintained voltage due to self-excitation after the machine is switched off is particularly dangerous for induction generators and for motors with a braking system intended to be operated by loss of voltage (for example lift motors).

NOTE 2 In the case where the motor stops immediately after having been disconnected from the supply, the compensation may exceed 90 %.

When a capacitor is connected to a motor associated with a star-delta starter, the arrangement should be such that no overvoltage can occur during the operation of the starter.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

33 Overload currents

Capacitors should never be operated with currents exceeding the maximum value specified in Clause 21.

Overload currents may be caused either by excessive voltage at the fundamental frequency, or by harmonics, or both. The chief sources of harmonics are rectifiers, power electronics, and saturated transformer cores.

If the voltage rise at times of light load is increased by capacitors, the saturation of transformer cores may be considerable. In this case, harmonics of abnormal magnitude are produced, one of which may be amplified by resonance between the transformer and capacitor. This is a further reason for recommending the disconnection of capacitors at times of light load, as referred to in item b), Clause 29.

If the capacitor current exceeds the maximum value specified in Clause 21, while the voltage is within the permissible limit of 1,10 U_N specified in Clause 20, the predominant harmonic should be determined in order to find the best remedy.

The following remedies should be considered:

a) moving some or all of the capacitors to other parts of the system;

b) connection of a reactor in series with the capacitor, to lower the resonant frequency of the circuit to a value below that of the disturbing harmonic;

c) increase of the capacitance value when the capacitor is connected close to power semiconductors.

The voltage waveform and the network characteristics should be determined before and after installing the capacitor. When sources of harmonics such as large semiconductors are present, special care should be taken.

Transient overcurrents of high amplitude and frequency may occur when capacitors are switched into circuit. Such transient effects are to be expected when a section of a capacitor bank is switched in parallel with other sections that are already energized (see Annex B).

It may be necessary to reduce these transient overcurrents to acceptable values in relation to the capacitor and to the equipment by switching on the capacitors through a resistor (resistance switching), or by the insertion of reactors in the supply circuit to each section of the bank.

If the capacitors are provided with fuses, the peak value of the overcurrents due to switching operations shall be limited to a maximum of 100 I_N (r.m.s. value).

34 Switching and protective devices and connections

The switching and protective devices and the connections shall be designed to carry continuously a current of 1,3 times the current that would be obtained with a sinusoidal voltage of an r.m.s. value equal to the rated voltage at the rated frequency. As the capacitor may have a capacitance equal to ~~1,15~~ 1,1 times the value corresponding to its rated output (see 7.2), this current may have a maximum value of 1,3 × ~~1,15~~ 1,1 times the rated current.

Moreover, harmonic components, if present, may have a greater heating effect than the corresponding fundamental component, due to skin effect.

The switching and protective devices and the connections shall be capable of withstanding the electrodynamic and thermal stresses caused by the transient overcurrents of high amplitude and frequency that may occur when switching on.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Such transients are to be expected when a capacitor (unit or bank) is switched in parallel with other capacitor(s) that are already energized. It is common practice to increase the inductance of the connections in order to reduce the switching current, although this increases the total losses. Care should be taken not to exceed the maximum permissible switching current.

When consideration of the electrodynamic and thermal stresses would lead to excessive dimensions, special precautions, such as those mentioned in Clause 33 for the purpose of protection against overcurrents, should be taken.

~~NOTE 1~~ In certain cases, for example when the capacitors are automatically controlled, repeated switching operations may occur at relatively short intervals of time. Switchgear and fuses should be selected to withstand these conditions (see ~~note 5 of~~ Clause 22).

~~NOTE 2~~ Breakers connected to the same busbar which is also connected to a bank of capacitors may be subjected to special stress in the event of switching on a short-circuit.

~~NOTE 3~~ Breakers for switching of parallel banks shall be able to withstand the inrush current (amplitude and frequency) resulting when one bank is connected to a busbar to which other bank(s) are already connected.

It is recommended that capacitors be protected against overcurrent by means of suitable overcurrent relays, which are adjusted to operate the circuit-breakers when the current exceeds the permissible limit specified in Clause 21. Fuses do not generally provide suitable overcurrent protection.

~~NOTE~~ Depending on the design of the capacitors, their capacitance will vary more or less with temperature.

Attention should be paid to the fact that the capacitance may change rapidly after the energization of cold capacitors. This may cause needless functioning of the protective equipment.

If iron-cored reactors are used, attention should be paid to possible saturation and overheating of the core by harmonics.

Any bad contacts in capacitor circuits may give rise to arcing, causing high-frequency oscillations that may overheat and overstress the capacitors. Regular inspection of all capacitor equipment contacts is therefore recommended.

35 Choice of creepage distance

No requirement at present.

36 Capacitors connected to systems with audio-frequency remote control

The impedance of capacitors at audio-frequencies is very low. When they are connected to systems having audio-frequency remote control, overloading of the remote control transmitter and unsatisfactory working may, therefore, result.

There are various methods of avoiding these deficiencies. The choice of the best method should be made by agreement between all parties concerned.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

37 Electromagnetic compatibility (EMC)

37.1 Emission

Under normal service conditions, power capacitors according to this standard do not produce any electromagnetic disturbances. Therefore, the requirements for electromagnetic emissions are deemed to be satisfied, and no verification by test is necessary.

~~NOTE 1~~ Self-healing breakdowns are considered to create no electromagnetic emission because their effect is short-circuited by the parallel capacitance.

~~NOTE 2~~ Due to the decreasing impedance of capacitors with frequency, measures should be taken to avoid inadmissible influence on ripple control systems.

~~NOTE 3~~ When using capacitors and inductances in a network which is loaded with harmonic voltages or currents, care should be taken because the harmonics may be amplified.

37.2 Immunity

37.2.1 General

Power capacitors are provided for an EMC environment in residential, commercial, and light-industrial locations (being supplied directly at low voltage from the public mains) as well as in industrial locations (being part of a non-public low voltage industrial network).

Under normal service conditions, the following immunity requirements and tests are considered to be relevant:

37.2.2 Low-frequency disturbances

Capacitors shall be suitable for continuous operation in the presence of harmonics and interharmonics within the limits required in Clauses 2 and 3 of IEC 61000-2-2. A verification by test is not necessary.

NOTE To stay within the requirements of Clauses 20 and 21, it is common to use inductances in series with the capacitors.

37.2.3 Conducted transients and high-frequency disturbances

The high capacitance of power capacitors absorbs conducted transients and high-frequency disturbances without harmful effect. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

37.2.4 Electrostatic discharges

Power capacitors are not sensitive to electrostatic discharges. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

37.2.5 Magnetic disturbances

Power capacitors are not sensitive to magnetic disturbances. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

37.2.6 Electromagnetic disturbances

Power capacitors are not sensitive to electromagnetic disturbances. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Annex A
(normative)

Additional definitions, requirements and tests for power filter capacitors

When the following clauses are added to the text of this standard, the standard will apply to ~~bypass~~ filter capacitors (see Clause 1).

A.1 Terms and definitions

A.1.1
band-pass and high-pass filter capacitor
filter capacitor
capacitor (or capacitor bank) that, when connected with other components, such as reactor(s) and resistor(s), gives a low impedance for one or more harmonic currents

A.1.2
rated voltage (see 3.14)
U_N
arithmetic sum of the r.m.s. voltages arising from the fundamental and harmonic frequencies~~, or the voltage calculated from rated output (see A.1.3) and capacitor reactance at rated frequency, whichever value is the greater.~~

A.1.3
rated output (see 3.13)
Q_N
arithmetic sum of output generated by the fundamental frequency and by the harmonics

A.1.4
rated current (see 3.16)
I_N
square root of the sum of the squared values of the rated currents at the fundamental and harmonic frequencies

Note 1 to entry: For accessories such as busbars, etc., the r.m.s. value for all currents should be considered.

A.2 Quality requirements and tests

A.2.1 Capacitance tolerance

For filter capacitors, especially for band-pass filters, symmetrical tolerances are recommended for both units and banks.

Standard units have non-symmetrical tolerance bands (see 7.2). This fact shall be taken into account when determining the capacitance value and tolerances.

~~NOTE~~ When determining the bank tolerances in a filter capacitor, the following factors should be considered:

– tolerances of the associated equipment, especially the reactor(s);
– fundamental frequency variations in the network to which the filter capacitor is connected;
– capacitance variation due to ambient temperature and load;
– the allowed capacitance variation for short periods during, for example, warming up, or unusual service conditions;
– capacitance variation due to an internal protection operation, if any.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

A.2.2 Voltage test between terminals (see Clause 9)

AC test.

For filter capacitors:

~~$U_t = 2{,}15\ U_i + 1{,}5\ U_H$~~

$U_t = 2{,}15\ U_N$

where

~~U_i is the r.m.s. voltage at the fundamental frequency;~~

~~U_H is the arithmetic sum of the r.m.s. values of the harmonic voltages.~~

U_N is the rated voltage defined for the filter capacitors.

A.2.3 Thermal stability test (see Clause 13)

If for filter capacitors 1,44 Q_N is lower than the output determined for 1,1 U_N at fundamental frequency, the latter test voltage shall be used in the thermal stability test.

A.3 Overloads – Maximum permissible current (see Clause 21)

For filter capacitors, the maximum permissible current shall be agreed between purchaser and manufacturer.

A.4 Markings – Instruction sheet or rating plate (see 27.1)

For filter capacitors, the tuned harmonic frequency shall preferably be marked after the rated frequency, for example:

50 Hz + 250 Hz (narrow band-pass filter)

50 Hz + 550/650 Hz (broad band-pass filter)

50 Hz + ≥ 750 Hz (high-pass filter).

A.5 Guide for installation and operation – Choice of the rated voltage (see Clause 29)

A reactor in series with the filter capacitor will cause voltage rise on the capacitor terminals at the fundamental frequency voltage.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Annex B
(informative)

Formulae for capacitors and installations

B.1 Computation of the output of three-phase capacitors from three single-phase capacitance measurements

The capacitances measured between any two-line terminals of a three-phase capacitor of either delta or star connection are denoted as C_a, C_b, and C_c. If the symmetry requirements laid down in 7.2 are fulfilled, the output Q of the capacitor can be computed with sufficient accuracy from the formula:

~~$Q = (C_a + C_b + C_c)\ \omega\ U_N^2 \times 10^{-12}$~~

$$Q = \frac{2}{3}\left(C_a + C_b + C_c\right)\omega\, U_{N^2} \times 10^{-12}$$

where

C_a, C_b and C_c are expressed in microfarads (μF);

U_N is expressed in volts (V);

Q is expressed in megavars (Mvar).

B.2 Resonance frequency

A capacitor will be in resonance with a harmonic in accordance with the following equation in which n is an integer:

$$n = \sqrt{\frac{S}{Q}}$$

where

S is the short-circuit power (MVA) where the capacitor is to be installed;

Q is expressed in megavars (Mvar);

n is the harmonic number: that is, the ratio between the resonant harmonic (Hz) and the network frequency (Hz).

B.3 Voltage rise

Connection of a shunt capacitor will cause the steady-state voltage rise given by the following expression:

$$\frac{\Delta U}{U} \approx \frac{Q}{S}$$

where

ΔU is the voltage rise in volts (V);

U is the voltage before connection of the capacitor (V);

S is the short-circuit power (MVA) where the capacitor is to be installed;

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Q is expressed in megavars (Mvar).

B.4 Inrush transient current

B.4.1 Switching in of single capacitor

$$\hat{I}_S \approx I_N \sqrt{\frac{2S}{Q}}$$

where

$\hat{I}_S$ is the peak of inrush capacitor current in amperes (A);

I_N is the rated capacitor current (r.m.s.) in amperes (A);

S is the short-circuit power (MVA) where the capacitor is to be installed;

Q is expressed in megavars (Mvar).

B.4.2 Switching of capacitors in parallel with energized capacitor(s)

$$\hat{I}_S = \frac{U\sqrt{2}}{\sqrt{X_C X_L}}$$

$$f_S = f_N \sqrt{\frac{X_C}{X_L}}$$

where

$\hat{I}_S$ is the peak of inrush capacitor current in amperes (A);

U is the phase-to-earth voltage in volts (V);

X_C is the series-connected capacitive reactances per phase in ohms (Ω);

X_L is the inductive reactance per phase between the banks in ohms (Ω);

f_S is the frequency of the inrush current in hertz (Hz);

f_N is the rated frequency in hertz (Hz).

B.4.3 Discharge resistance in single-phase units or in one-phase or polyphase units

$$R \leq \frac{t}{k \times C \times \ln\left(\frac{U_N\sqrt{2}}{U_R}\right)}$$

where

t is the time for discharge from $U_N\sqrt{2}$ to U_R in seconds (s);

R equals discharge resistance in megohms (MΩ)

C is the rated capacitance in microfarads (μF) per phase;

U_N is the rated voltage of unit in volts (V);

U_R is the permissible residual voltage in volts (V) (see Clause 22 for limits of t and U_R);

k is the coefficient depending on the method of connection of the resistors to the capacitor units (see Figure B.1).

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

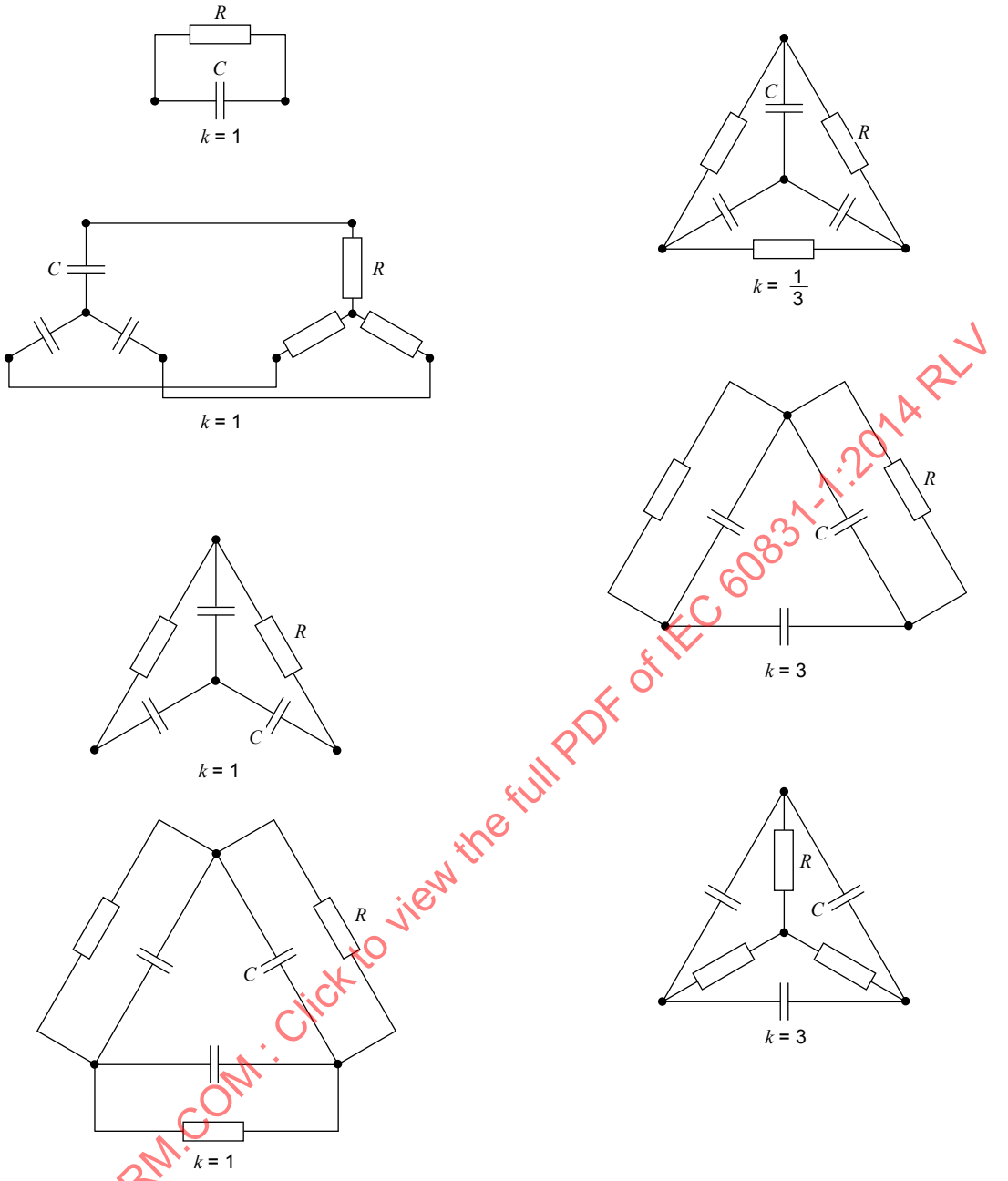


Figure B.1 – k values depending on the method of connection of the resistors with the capacitor units

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Bibliography

[1] IEC 60273:1990, *Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1 000 V*

[2] IEEE Std 824-1994, *IEEE Standard for Series Capacitors in Power Systems*

[3] IEEE Paper PE-009PRD (09-2000), *Considerations for the Application of Series Capacitors to Radial Power Distribution Circuits. Series Capacitor Working Group of the IEEE Capacitor Subcommittee*

[4] ANSI C29.9:1983, *American National Standard for Wet-Process Porcelain Insulators (Apparatus, Post type)*

[5] IEC 60050-436:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 436: Power capacitors*

[6] IEC 60050-601:1985, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*

[7] IEC 60050-604:1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*

[8] IEC 60060-2:1994, *High-voltage test techniques – Part 2: Measuring systems*

[9] IEC 60721-2-6:1990, *Classification of environmental conditions – Part 2-6: Environmental conditions appearing in nature. Earthquake, vibration and shock*

[10] IEC 60110-1:1998, *Power capacitors for induction heating installations – Part 1: General*

[11] Series capacitors (IEC60143 Part 1, Part 2, Part 3 and Part 4)

[12] IEC 60252-1:2001, *AC motor capacitors – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation*

[13] IEC 60358-1, *Coupling capacitors and capacitor dividers*

[14] IEC 60996:1989, *Method for verifying accuracy of tan delta measurements applicable to capacitors*

[15] IEC 61048:1991, *Auxiliaries for lamps – Capacitors for use in tubular fluorescent and other discharge lamp circuits – General and safety requirements*

[16] IEC 61049:1991, *Capacitors for use in tubular fluorescent and other discharge lamp circuits – Performance requirements*

[17] IEC 61071 (all parts), *Power electronic capacitors*

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

IEC 60831-1

Edition 3.0 2014-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V –
Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

Condensateurs shunt de puissance autoregénérateurs pour réseaux à courant alternatif de tension assignée inférieure ou égale à 1 000 V –
Partie 1: Généralités – Caractéristiques fonctionnelles, essais et valeurs assignées – Règles de sécurité – Guide d'installation et d'exploitation

IEC 60831-1:2014-02(EN-FR)

CONTENTS

FOREWORD 5
1 Scope 7
2 Normative references 8
3 Terms and definitions 8
4 Service conditions 11
4.1 Normal service conditions 11
4.2 Unusual service conditions 12
5 Test requirements 12
5.1 General 12
5.2 Test conditions 13
6 Classification of tests 13
6.1 Routine tests 13
6.2 Type tests 13
6.3 Acceptance tests 14
7 Capacitance measurement and output calculation 14
7.1 Measuring procedure 14
7.2 Capacitance tolerances 14
8 Measurement of the tangent of the loss angle (tan δ) of the capacitor 15
8.1 Measuring procedure 15
8.2 Loss requirements 15
9 Voltage tests between terminals 15
9.1 Routine test 15
9.2 Type test 15
10 Voltage tests between terminals and container 16
10.1 Routine test 16
10.2 Type test 16
11 Test of internal discharge device 17
12 Sealing test 17
13 Thermal stability test 17
14 Measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature 19
14.1 Measuring procedure 19
14.2 Requirements 19
15 Lightning impulse voltage test between terminals and container 19
16 Discharge test 19
17 Ageing test 20
18 Self-healing test 20
19 Destruction test 20
20 Maximum permissible voltage 20
20.1 Long-duration voltages 20
20.2 Switching voltages 21
21 Maximum permissible current 21
22 Discharge device 21
23 Container connections 22

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

24 Protection of the environment 22
25 Other safety requirements 22
26 Marking of the unit 22
26.1 Rating plate 22
26.2 Standardized connection symbols 23
26.3 Warning plate 23
27 Marking of the bank 23
27.1 Instruction sheet or rating plate 23
27.2 Warning plate 23
28 General 24
29 Choice of the rated voltage 24
30 Operating temperature 25
30.1 General 25
30.2 Installation 25
30.3 High ambient air temperature 25
30.4 Evaluation of losses 25
31 Special service conditions 26
32 Overvoltages 26
33 Overload currents 27
34 Switching and protective devices and connections 27
35 Choice of creepage distance 28
36 Capacitors connected to systems with audio-frequency remote control 29
37 Electromagnetic compatibility (EMC) 29
37.1 Emission 29
37.2 Immunity 29
37.2.1 General 29
37.2.2 Low-frequency disturbances 29
37.2.3 Conducted transients and high-frequency disturbances 29
37.2.4 Electrostatic discharges 29
37.2.5 Magnetic disturbances 30
37.2.6 Electromagnetic disturbances 30
Annex A (normative) Additional definitions, requirements and tests for power filter capacitors 31
A.1 Terms and definitions 31
A.2 Quality requirements and tests 31
A.2.1 Capacitance tolerance 31
A.2.2 Voltage test between terminals (see Clause 9) 32
A.2.3 Thermal stability test (see Clause 13) 32
A.3 Overloads – Maximum permissible current (see Clause 21) 32
A.4 Markings – Instruction sheet or rating plate (see 27.1) 32
A.5 Guide for installation and operation – Choice of the rated voltage (see Clause 29) 32
Annex B (informative) Formulae for capacitors and installations 33
B.1 Computation of the output of three-phase capacitors from three single-phase capacitance measurements 33
B.2 Resonance frequency 33
B.3 Voltage rise 33

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

B.4 Inrush transient current 34
B.4.1 Switching in of single capacitor 34
B.4.2 Switching of capacitors in parallel with energized capacitor(s) 34
B.4.3 Discharge resistance in single-phase units or in one-phase or polyphase units 34
Bibliography 36

Figure B.1 – k values depending on the method of connection of the resistors with the capacitor units 35

Table 1 – Letter symbols for upper limit of temperature range 12
Table 2 – Ambient air temperature for the thermal stability test 18
Table 3 – Admissible voltage levels in service 20

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SHUNT POWER CAPACITORS OF THE SELF-HEALING TYPE FOR A.C. SYSTEMS HAVING A RATED VOLTAGE UP TO AND INCLUDING 1 000 V –

Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

International Standard IEC 60831-1 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This third edition cancels and replaces the second edition published in 1996 and Amendment 1:2002. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Updating of the normative references;
b) Test conditions have been clarified;
c) Thermal stability test has been clarified;
d) Maximum permissible voltage and current have been clarified;

e) The protection of the environment has been amended with safety concerns and plastic quality requirements.

The text of this standard is based on the following documents:

FDIS	Report on voting
33/543/FDIS	33/550/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60831 series, published under the general title *Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including, 1 000 V* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of May 2014 have been included in this copy.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

SHUNT POWER CAPACITORS OF THE SELF-HEALING TYPE FOR A.C. SYSTEMS HAVING A RATED VOLTAGE UP TO AND INCLUDING 1 000 V –

Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation

1 Scope

This part of the IEC 60831 series is applicable to both capacitor units and capacitor banks intended to be used, particularly, for power-factor correction of a.c. power systems having a rated voltage up to and including 1 000 V and frequencies of 15 Hz to 60 Hz.

This part of IEC 60831 also applies to capacitors intended for use in power filter circuits. Additional definitions, requirements, and tests for power filter capacitors are given in Annex A.

The following capacitors are excluded from this part of IEC 60831:

– Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1 000 V (IEC 60931-, -2 and -3).

– Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V (IEC 60871-1, -2, -3 and -4).

– Capacitors for inductive heat-generating plants operating at frequencies between 40 Hz and 24 000 Hz (IEC 60110-1 and -2)

– Series capacitors (IEC60143-1, -2, -3 and -4)

– AC motor capacitors (IEC 60252-1 and -2)

– Coupling capacitors and capacitor dividers (IEC 60358-1)

– Capacitors for power electronic circuits (IEC 61071).

– Small a.c. capacitors to be used for fluorescent and discharge lamps (IEC 61048 and IEC 61049).

– Capacitors for suppression of radio interference (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 the a.c. voltage.

Accessories such as insulators, switches, instrument transformers, fuses, etc., should be in accordance with the relevant IEC standards and are not covered by the scope of this part of IEC 60831.

The object of this part of IEC 60831 is to:

a) formulate uniform rules regarding performances, testing and rating;

b) formulate specific safety rules;

c) provide a guide for installation and operation.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements*

IEC 60831-2:2013, *Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V – Part 2: Ageing test, self-healing test and destruction test*

IEC 60695-2-12:2010, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC 61000-4-1:2006, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – Overview of IEC 61000-4 series*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
capacitor element
element
device consisting essentially of two electrodes separated by a dielectric

[SOURCE: IEC 60050-436:1990, 436-01-03]

3.2
capacitor unit
unit
assembly of one or more capacitor elements in the same container with terminals brought out

[SOURCE: IEC 60050-436:1990, 436-01-04]

3.3
self-healing capacitor
capacitor of which the electrical properties, after local breakdown of the dielectric, are rapidly and essentially restored

[SOURCE: IEC 60050-436:1990, 436-03-12]

3.4
capacitor bank
bank
number of capacitor units connected so as to act together

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

[SOURCE: IEC 60050-436:1990, 436-01-06]

3.5
capacitor
generic term, encompassing the notions of capacitor unit and capacitor bank

Note 1 to entry: In this part of IEC 60831, 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.

3.6
capacitor installation
one or more capacitor banks and their accessories

[SOURCE: IEC 60050-436:1990, 436-01-07]

3.7
discharge device of a capacitor
device which may be incorporated in a capacitor, capable of reducing the voltage between the terminals practically to zero, within a given time, after the capacitor has been disconnected from a network

[SOURCE: IEC 60050-436:1990, 436-03-15, modified ("intended to reduce ... value" has been replaced by "capable of reducing ... zero")]

3.8
internal fuse of a capacitor
fuse connected inside a capacitor unit, in series with an element or a group of elements

[SOURCE: IEC 60050-436:1990, 436-03-16]

3.9
overpressure disconnector for a capacitor
disconnecting device designed to switch off the capacitor in the case of abnormal increase of the internal pressure

[SOURCE: IEC 60050-436:1990, 436-03-17, modified ("to interrupt ... in the event" has been replaced by "to switch off ... in the case")]

3.10
overtemperature disconnector for a capacitor
disconnecting device designed to switch off the capacitor in the case of abnormal increase of the internal temperature

3.11
line terminal
terminal intended for connection to a line conductor of a network

Note 1 to entry: In polyphase capacitors, a terminal intended to be connected to the neutral conductor is not considered to be a line terminal.

[SOURCE: IEC 60050-436:1990, 436-03-01]

3.12
rated capacitance of a capacitor
C_N
capacitance value for which the capacitor has been designed

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

[SOURCE: IEC 60050-436:1990, 436-01-12, modified (symbol C_N added and "the r.m.s. value of the alternating current" has been replaced by "capacitance value")]

3.13
rated output of a capacitor
Q_N
reactive power derived from the rated values of capacitance, frequency and voltage

[SOURCE: IEC 60050-436:1990, 436-01-16, modified (symbol Q_N added and "for which the capacitor has been designed" has been replaced by "derived … voltage")]

3.14
rated voltage of a capacitor
U_N
r.m.s. value of the alternating voltage for which the capacitor has been designed

Note 1 to entry: In the case of capacitors consisting of one or more separate circuits (such as single-phase units intended for use in polyphase connection, or polyphase units with separate circuits), U_N refers to the rated voltage of each circuit.

For polyphase capacitors with internal electrical connections between the phases, and for polyphase capacitor banks, U_N refers to the phase-to-phase voltage.

[SOURCE: IEC 60050-436:1990, 436-01-15]

3.15
rated frequency of a capacitor
f_N
frequency for which the capacitor has been designed

[SOURCE: IEC 60050-436:1990, 436-01-14]

3.16
rated current of a capacitor
I_N
r.m.s. value of the alternating current for which the capacitor has been designed

[SOURCE: IEC 60050-436:1990, 436-01-13]

3.17
capacitor losses
active power dissipated in the capacitor

Note 1 to entry: All loss-producing components should be included, for example:

– for a unit, losses from dielectric, internal fuses, internal discharge resistor, connections, etc.;
– for a bank, losses from units, external fuses, busbars, discharge and damping reactors, etc.

[SOURCE: IEC 60050-436:1990, 436-04-10]

3.18
tangent of the loss angle of a capacitor
tan δ
ratio between the equivalent series resistance and the capacitive reactance of the capacitor at specified sinusoidal alternating voltage and frequency

[SOURCE: IEC 60050-436:1990, 436-04-11]

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

3.19
maximum permissible a.c. voltage of a capacitor
maximum r.m.s. alternating voltage which the capacitor can sustain for a given time in specified conditions

[SOURCE: IEC 60050-436:1990, 436-04-07]

3.20
maximum permissible a.c. current of a capacitor
maximum r.m.s. alternating current which the capacitor can sustain for a given time in specified conditions

[SOURCE: IEC 60050-436:1990, 436-04-09]

3.21
ambient air temperature
temperature of the air at the proposed location of the capacitor

3.22
cooling air temperature
temperature of the cooling air measured at the hottest position in the bank, under steady-state conditions, midway between two units

Note 1 to entry: If only one unit is involved, it is the temperature measured at a point approximately 0,1 m away from the capacitor container and at two-thirds of the height from its base.

3.23
steady-state condition
thermal equilibrium attained by the capacitor at constant output and at constant ambient air temperature

3.24
residual voltage
voltage remaining on the terminals of a capacitor at a certain time following disconnection

4 Service conditions

4.1 Normal service conditions

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

a) Residual voltage at energization

Not to exceed 10 % rated voltage (Clause 22, Clause 32, and Annex B).

b) Altitude

Not exceeding 2 000 m.

c) Ambient air temperature categories

Capacitors are classified in temperature categories, each category being specified by a number followed by a letter. The number represents the lowest ambient air temperature at which the capacitor may operate.

The letters represent upper limits of temperature variation ranges, having maximum values specified in Table 1. The temperature categories cover the temperature range of –50 °C to +55 °C.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

The lowest ambient air temperature at which the capacitor may be operated should be chosen from the five preferred values +5 °C, –5 °C, –25 °C, –40 °C, –50 °C.

For indoor use, a lower limit of –5 °C is normally applicable.

Table 1 is based on service conditions in which the capacitor does not influence the ambient air temperature (for example outdoor installations).

Table 1 – Letter symbols for upper limit of temperature range

Symbol	Ambient temperature °C		
	Maximum	Highest mean over any period of	
		24 h	1 year
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

NOTE 1 The temperature values according to Table 1 can be found in the meteorological temperature table covering the installation site.

NOTE 2 Higher temperature values than those indicated in Table 1 can be considered in special applications by mutual agreement between manufacturer and purchaser. In that case, the temperature category should be indicated by the combination of minimum and maximum temperature values, for example, –40/60.

If the capacitor influences the air temperature, the ventilation and/or choice of capacitor shall be such that the Table 1 limits are maintained. The cooling air temperature in such an installation shall not exceed the temperature limits of Table 1 by more than 5 °C.

Any combination of minimum and maximum values can be chosen for the standard temperature category of a capacitor, for example –40/A or –5/C.

Preferred temperature categories are:

–40/A, –25/A, –5/A and –5/C.

4.2 Unusual service conditions

Unless otherwise agreed between manufacturer and purchaser, this standard does not apply to capacitors, the service conditions of which, in general, are incompatible with the requirements of the present standard.

5 Test requirements

5.1 General

Clause 5 gives the test requirements for capacitor units and, when specified, for capacitor elements.

Supporting insulators, switches, instrument transformers, fuses, etc, shall be in accordance with relevant IEC standards.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

5.2 Test conditions

Unless otherwise specified for a particular test or measurement, the temperature of the capacitor dielectric at the start of the test shall be in the range of +5 °C to +35 °C.

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 constant ambient temperature for an adequate period.

The a.c. tests and measurements shall be carried out at a frequency of 50 Hz or 60 Hz independent of the rated frequency of the capacitor, if not otherwise specified.

Capacitors having a rated frequency below 50 Hz shall be tested and measured at 50 Hz or 60 Hz, if not otherwise specified.

6 Classification of tests

6.1 Routine tests

The following tests are routine tests. For details, reference should be made to the relevant clauses or subclauses:

a) capacitance measurement and output calculation (see Clause 7);
b) measurement of the tangent of the loss angle (tan δ) of the capacitor (see Clause 8);
c) voltage test between terminals (see 9.1);
d) voltage test between terminals and container (see 10.1);
e) test of the internal discharge device (see Clause 11);
f) sealing test (see Clause 12).

Routine tests shall have been carried out by the manufacturer on every capacitor before delivery. If the purchaser so requests, he shall be supplied with a certificate detailing the results of such tests.

In general, the indicated sequence of the tests is not mandatory.

6.2 Type tests

The following tests are type tests. For details, reference should be made to the relevant clauses or subclauses:

a) thermal stability test (see Clause 13);
b) measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature (see Clause 14);
c) voltage test between terminals (see 9.2);
d) voltage test between terminals and container (see 10.2);
e) lightning impulse voltage test between terminals and container (see Clause 15);
f) discharge test (see Clause 16);
g) ageing test (see Clause 17);
h) self-healing test (see Clause 18);
i) destruction test (see Clause 19).

Type tests are carried out in order to ascertain that, as regards design, size, materials and construction, the capacitor complies with the specified characteristics and operation requirements detailed in this standard.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Unless otherwise specified, every capacitor sample to which the type test is applied shall first have withstood satisfactorily the application of all the routine tests.

The type tests shall have been carried out by the manufacturer, and the purchaser shall, on request, be supplied with a certificate detailing the results of such tests.

The successful completion of each type test is also valid for units having the same rated voltage and lower output, provided that they do not differ in any way that may influence the properties to be checked by the test. It is not essential that all type tests be carried out on the same capacitor sample.

The number of samples for the type test shall be subjected to agreement between the manufacturer and user.

6.3 Acceptance tests

Some or all of the routine and/or type tests may be repeated by the manufacturer in connection with any contract by agreement with the purchaser. The kind of tests, the number of samples that may be subjected to such repeated tests, and the acceptance criteria shall be subject to agreement between manufacturer and purchaser, and shall be stated in the contract.

7 Capacitance measurement and output calculation

7.1 Measuring procedure

The capacitance shall be measured at the voltage and at the frequency chosen by the manufacturer. The method used shall not include errors due to harmonics, or to accessories external to the capacitor to be measured, such as reactors and blocking circuits in the measuring circuit. The accuracy of the measuring method and the correlation with the values measured at rated voltage and frequency shall be given.

The capacitance measurement shall be carried out after the voltage test between terminals (see Clause 9).

Measurement at a voltage between 0,9 and 1,1 times the rated voltage, and at a frequency between 0,8 and 1,2 times the rated frequency, shall be performed on the capacitor previously used for the thermal stability test (see Clause 13), the ageing test (see Clause 17), and the self-healing test (see Clause 18), and could be performed on other capacitors at the request of the purchaser in agreement with the manufacturer.

7.2 Capacitance tolerances

The capacitance shall not differ from the rated capacitance by more than

–5 % to +10 % for units and banks up to 100 kvar;

–5 % to +5 % for units and banks above 100 kvar.

The capacitance value is that measured under the conditions of 7.1.

In three-phase units, the ratio of maximum to minimum value of the capacitance measured between any two-line terminals shall not exceed 1,08.

NOTE A formula for the calculation of the output of a three-phase capacitor from a single-phase capacitance measurement is given in Annex B.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

8 Measurement of the tangent of the loss angle (tan δ) of the capacitor

8.1 Measuring procedure

The capacitor losses (or tan δ) shall be measured at the voltage and at the frequency chosen by the manufacturer. The method used shall not include errors due to harmonics, or to accessories external to the capacitor to be measured, such as reactors and blocking circuits in the measuring circuit. The accuracy of the measuring method and the correlation with the values measured at the rated voltage and frequency shall be given.

The measurement of the capacitor losses shall be carried out after the voltage test between terminals (see Clause 9).

Measurement at a voltage between 0,9 and 1,1 times the rated voltage, and at a frequency between 0,8 and 1,2 times the rated frequency shall be performed on the capacitor before the thermal stability test (see Clause 13), and may be performed on other capacitors upon request of the purchaser in agreement with the manufacturer.

When testing a large number of capacitors, statistical sampling may be used for measuring tan δ. The statistical sampling plan should be by agreement between manufacturer and purchaser.

The tan δ value of certain types of dielectric is a function of the energization time before the measurement. In that case, test voltage and energization time should be by agreement between manufacturer and purchaser.

8.2 Loss requirements

The value of tan δ, measured in accordance with 8.1, shall not exceed the value declared by the manufacturer for the temperature and voltage of the test, or the value agreed upon between manufacturer and purchaser.

9 Voltage tests between terminals

9.1 Routine test

Each capacitor shall be subjected to an a.c. test at U_t = 2,15 U_N for a minimum time of 2 s.

The a.c. test shall be carried out with a substantially sinusoidal voltage at a frequency between 15 Hz and 100 Hz, and preferably as near as possible to the rated frequency.

During the test, no permanent puncture or flashover shall occur. Self-healing breakdowns are permitted.

When the unit is composed of a number of elements, or a group of elements connected in parallel, and which are tested separately, it is not necessary to repeat the test on the unit.

For polyphase capacitors, the test voltages should be adjusted as appropriate.

NOTE Operation of internal element fuses is permitted, provided the capacitance tolerances are still met and that not more than two fuses have operated per unit.

9.2 Type test

Each capacitor shall be subjected to an a.c. test at U_t = 2,15 U_N for 10 s.

The a.c. test shall be carried out with a substantially sinusoidal voltage.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

During the test, no permanent puncture or flashover shall occur. Self-healing breakdowns are permitted.

For polyphase capacitors, the test voltages should be adjusted as appropriate.

NOTE Operation of internal element fuses is permitted, provided capacitance tolerances are still met, and that not more than two fuses have operated per unit.

10 Voltage tests between terminals and container

10.1 Routine test

Units having all terminals insulated from the container shall be subjected to an a.c. voltage applied between the terminals (joined together) and the container. The voltage to be applied is 2 U_N + 2 kV or 3 kV, whichever is the higher, for 10 s or 20 % higher for a minimum time of 2 s.

If the units are intended to be connected directly to the aerial power line and by agreement between the manufacturer and the user, the test shall be performed with a voltage of 6 kV.

During the test, neither puncture nor flashover shall occur.

The test shall be performed, even if, in service, one of the terminals is intended to be connected to the container.

Three-phase units having separate phase capacitance can be tested with respect to the container with all the terminals joined together. Units having one terminal permanently connected to the container shall not be subjected to this test.

When the unit container consists of insulating material, this test shall be omitted.

If a capacitor has separate phases or sections, a test of the insulation between phases or sections shall be made at the same voltage value as for the terminals-to-container test.

10.2 Type test

Units having all terminals insulated from the container shall be subjected to a test according to 10.1 for a duration of 1 min.

The test on units having one terminal permanently connected to the container shall be limited to the bushing(s) and container (without elements) or to a fully insulated unit with identical internal insulation.

If the capacitor container is of insulating material, the test voltage shall be applied between the terminals and a metal foil wrapped closely round the surface of the container.

The test shall be made under dry conditions for indoor units, and with artificial rain (see IEC 60060-1) for units to be used outdoors.

During the test, neither puncture nor flashover shall occur.

Units intended for outdoor installation may be subjected to a dry test only.

The manufacturer should in such a case supply a separate type test report showing that the bushing with enclosure, if used, will withstand the wet test voltage.

NOTE For filter capacitors, the voltage appearing at the capacitor terminals is always higher than the network voltage.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

For filter capacitors, and provided the arithmetic sum of the r.m.s values of the harmonic voltages does not exceed 0,5 times the nominal network voltage, the test voltage between terminals and container refers to the nominal network voltage to which the filter is connected (and not to the voltage appearing at the capacitor terminals).

If the factor of 0,5 times is exceeded, then the test voltage between terminals and container refers to the rated voltage of the capacitor.

11 Test of internal discharge device

The resistance of the internal discharge device, if any, shall be checked either by a resistance measurement or by measuring the self-discharging rate (see Clause 22). The choice of the method is left to the manufacturer.

The test shall be made after the voltage tests of Clause 9.

12 Sealing test

The unit (in non-painted state) shall be exposed to a test that will effectively detect any leak of the container and bushing(s). The test procedure is left to the manufacturer, who shall describe the test method concerned.

If no procedure is stated by the manufacturer, the following test procedure shall apply:

Unenergized capacitor units shall be heated throughout so that all parts reach a temperature not lower than 20 °C above the maximum value in Table 1 corresponding to the capacitor symbol, and shall be maintained at this temperature for 2 h. No leakage shall occur.

It is recommended that a suitable indicator is used.

NOTE If the capacitor contains no liquid materials at the test temperature, the test may be omitted as a routine test.

13 Thermal stability test

The capacitor unit subjected to the test shall be placed between two other units of the same rating which shall be energized at the same voltage as the test capacitor. Alternatively, two dummy capacitors each containing resistors may be used. The dissipation in the resistors shall be adjusted to a value so that the container temperatures of the dummy capacitors near the top opposing faces are equal to, or greater than, those of the test capacitor. The separation between the units shall be equal to normal spacings as specified by manufacturer's instructions.

The assembly shall be placed in still air (without forced air ventilation) in a heated enclosure in the most unfavourable thermal position according to the manufacturer's instructions for mounting on site. The ambient air temperature shall be maintained at or above the appropriate temperature shown in Table 2. It shall be checked by means of a thermometer having a thermal time constant of approximately 1 h.

The ambient air thermometer should be shielded so that it is subjected to the minimum possible thermal radiation from the three energized samples.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Table 2 – Ambient air temperature for the thermal stability test

Symbol	Ambient air temperature °C
A	40
B	45
C	50
D	55

After all parts of the capacitor have attained the temperature of the ambient air, the capacitor shall be subjected for a period of at least 48 h to an a.c. voltage of substantially sinusoidal form. The magnitude of the voltage throughout the last 24 h of the test shall be adjusted to give a calculated output, using the measured capacitance (see 7.1), of at least 1,44 times its rated output.

The test will stop in one of the following two conditions:

– For a period of 6 h, the temperature of the container measured at 2/3 of the height from the bottom (excluding terminals) shall not increase by more than 1 °C. In this case, the test is considered as positive.
– If the temperature increases of three successive periods of 6 h do not decrease in magnitude. In this case, the test is considered as having failed.

At the end of the stability test, the difference between the measured temperature of the container and the ambient air temperature shall be recorded.

Before and after the test the capacitance shall be measured (see 7.1) within the standard temperature range for testing (see 5.2), and these two measurements shall be corrected to the same dielectric temperature. No change of capacitance greater than 2 % shall be apparent from these measurements.

A measurement of the tangent of the loss angle (tan δ) shall be made before and after the thermal stability test, at a temperature of 25°C ± 5°C.

The value of the second measurement of the tangent of the loss angle shall be not greater than that of the first by more than 2×10^{-4}.

When interpreting the results of the measurements, two factors shall be taken into account:

– the repeatability of the measurements;
– the fact that internal change in the dielectric may cause a small change of capacitance, without the puncture of any element of the capacitor, or the blowing of an internal fuse having occurred.

When checking whether the capacitor losses or temperature conditions are satisfied, fluctuations of voltage, frequency and ambient air temperature during the test should be taken into account. For this reason, it is advisable to plot these parameters and the tangent of the loss angle and the temperature rise as a function of time.

Units intended for 60 Hz installation may be tested at 50 Hz and units intended for 50 Hz may be tested at 60 Hz provided that the specified output is applied. For units rated below 50 Hz, the test conditions should be agreed between purchaser and manufacturer.

NOTE For polyphase units, two possibilities are allowed:

– use of a three-phase source;

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

– modification of the internal connections in order to have only one phase with the same output.

14 Measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature

14.1 Measuring procedure

The capacitor losses (tan δ) shall be measured at the end of the thermal stability test (see Clause 13). The measuring voltage shall be that of the thermal stability test.

14.2 Requirements

The value of tan δ, measured in accordance with 14.1, shall not exceed the value declared by the manufacturer for the temperature and voltage of the test, or the value agreed upon between manufacturer and purchaser.

15 Lightning impulse voltage test between terminals and container

Only units having all terminals insulated from the container shall be subjected to this test.

The impulse test shall be performed with a wave of 1,2/50 μs to 5/50 μs having a peak value of 8 kV if the rated voltage of the capacitor is $U_N \leq 690$ V or having a peak value of 12 kV if $U_N > 690$ V.

If the units are intended to be connected directly to exposed installations such as overhead lines and by agreement between the manufacturer and the user, the impulse test shall be performed with a wave of 1,2/50 μs to 5/50 μs having a peak value of 15 kV if the rated voltage of the capacitor is $U_N \leq 690$ V or having a peak value of 25 kV if $U_N > 690$ V.

Three impulses of positive polarity followed by three impulses of negative polarity shall be applied between the terminals joined together and the container.

After the change of polarity, it is permissible to apply some impulses of lower amplitude before the application of the test impulses.

The absence of failure during the test shall be verified by an oscillograph, which is used to record the voltage and to check the wave shape.

If the capacitor container is of insulating material, the test voltage shall be applied between the terminals and a metal foil wrapped closely round the surface of the container.

NOTE Partial discharge in the insulation to the container may be indicated by the modification of the waveshapes between the different impulses.

16 Discharge test

The unit shall be charged by means of d.c. and then discharged through a gap situated as close as possible to the capacitor.

It shall be subjected to five such discharges within 10 min.

The test voltage shall be equal to 2 U_N.

Within 5 min after this test, the unit shall be subjected to a voltage test between terminals (see 9.1).

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

The capacitance shall be measured before the discharge test and after the voltage test. The measurements shall not differ by an amount corresponding either to the breakdown of an element, or to the blowing of an internal fuse, or by more than 2 %.

For polyphase units, the test shall be carried out in the following manner:

– In the case of units with three-phase delta connection, two terminals shall be short-circuited and the test carried out between the third terminal and the short-circuited terminals at 2 U_N.
– In the case of units with three-phase star connection, the test shall be carried out between two terminals with the third terminal left unconnected. The test voltage shall be 4 $U_N/\sqrt{3}$ to achieve the same test voltage across the elements.

If the first peak of the test current exceeds the value of 200 I_N (r.m.s.), it may be kept at this limit by means of an external coil.

17 Ageing test

The requirements for this test are given in IEC 60831-2.

18 Self-healing test

The requirements for this test are given in IEC 60831-2.

19 Destruction test

The requirements for this test are given in IEC 60831-2.

20 Maximum permissible voltage

20.1 Long-duration voltages

Capacitor units shall be suitable for operation at voltage levels according to Table 3 (see also Clauses 29 and 32).

Table 3 – Admissible voltage levels in service

Type	Voltage factor × U_N r.m.s.	Maximum duration	Observations
Power frequency	1,00	Continuous	Highest average value during any period of capacitor energization. For energization periods less than 24 h, exceptions apply as indicated below (see Clause 29).
Power frequency	1,10	8 h in every 24 h	System voltage regulation and fluctuations.
Power frequency	1,15	30 min in every 24 h	System voltage regulation and fluctuations.
Power frequency	1,20	5 min	Voltage rise at light load (see Clause 29).
Power frequency	1,30	1 min	
Power frequency plus harmonics	So that the current does not exceed the value given in clause 21 (see also Clauses 33 and 34).		

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. It is assumed that the

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

overvoltages given in Table 3 and having a value higher than 1,15 U_N occur 200 times in the life of the capacitor.

20.2 Switching voltages

The switching of a capacitor bank by a restrike-free circuit breaker usually causes a transient overvoltage, the first peak of which does not exceed 2 √2 times the applied voltage (r.m.s. value) for a maximum duration of 1/2 cycle.

About 5 000 switching operations per year are acceptable under these conditions, taking into account the fact that some of them may take place when the internal temperature of the capacitors is less than 0 °C, but is within the temperature category. (The associated peak transient overcurrent may reach 100 times the value I_N (see Clause 33)).

In the case of capacitors that are switched more frequently, the values of the overvoltage amplitude and duration and the transient overcurrent shall be limited to lower levels (see Clause 34).

These limitations and/or reductions shall be agreed between manufacturer and purchaser.

21 Maximum permissible current

Capacitor units shall be suitable for continuous operation at an r.m.s. line current of 1,3 times the current that occurs at rated sinusoidal voltage and rated frequency, excluding transients. Taking into account the capacitance tolerances of 1,1 C_N, the maximum current can reach 1,43 I_N.

These overcurrent factors are intended to take into account the combined effects of harmonics, overvoltages and capacitance tolerance according to 20.1.

22 Discharge device

Each capacitor unit and/or bank shall be provided with a means for discharging each unit in 3 min to 75 V or less, from an initial peak voltage of √2 times the rated voltage U_N.

There shall be no switch, fuse cut-out, or any other isolating device between the capacitor unit and this discharge device.

A discharge device is not a substitute for short-circuiting the capacitor terminals together and to earth before handling.

Capacitors connected directly and permanently to other electrical equipment providing a discharge path should be considered properly discharged, provided that the circuit characteristics are such as to ensure the discharge of the capacitor within the time specified above.

Attention is drawn to the fact that in some countries smaller discharge times and voltages are required. In that event, the purchaser should inform the manufacturer.

Discharge circuits should have adequate current-carrying capacity to discharge the capacitor from the peak of the 1,3 U_N overvoltage according to Clause 20.

Since the residual voltage at energization should not exceed 10 % of the rated voltage (see 4.1), discharge resistors with lower resistance or additional switched discharge devices may be needed, if the capacitors are automatically controlled.

NOTE A formula for the calculation of the discharge resistance is given in Annex B.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

23 Container connections

To enable the potential of the metal container of the capacitor to be fixed, and to be able to carry the fault current in the event of a breakdown to the container, the metallic container shall be provided with a connection capable of carrying the fault current.

24 Protection of the environment

When capacitors are impregnated with products that shall not be dispersed into the environment, the necessary precautions shall be taken. In some countries, there exist legal requirements in this respect (see 26.3). The units and the bank shall be labelled accordingly, if so required.

Products of combustion of the terminals shall be environmentally acceptable. Self-extinguishing materials with a minimum Glow-Wire Flammability Index (GWFI) of 750 °C shall be used for the terminals (see IEC 60695-2-12).

25 Other safety requirements

The purchaser shall specify at the time of enquiry any special requirements with regard to the safety regulations that apply to the country in which the capacitor is to be installed.

26 Marking of the unit

26.1 Rating plate

The following information shall be marked indelibly, either directly or by means of a plate, on each capacitor unit:

a) Manufacturer.

b) Identification number and manufacturing year.

(The year may be a part of the identification number or be in code form)

c) Rated output Q_N in kilovars (kvar).

For three-phase units, the total output shall be given (see Annex B).

d) Rated voltage U_N in volts (V).

e) Rated frequency f_N in hertz (Hz).

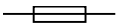
f) Temperature category.

g) Discharge device, if internal, shall be indicated by wording or by the symbol or by the rated resistance in kilohms (kΩ) or megohms (MΩ).

h) Reference of self-healing design: "SH" or  or "self-healing".

i) Connection symbol.

(All capacitors, except single-phase units having one capacitance only, shall have their connection indicated. For standardized connection symbols, see 26.2).

j) Internal fuses, if included, shall be indicated by wording or by the symbol  .

k) Indication for the overpressure or thermal disconnector, if such disconnector is fitted.

l) Insulation level U_i in kilovolts (kV). (Only for units having all terminals insulated from the container).

The insulation level shall be marked by means of two numbers separated by a stroke, the first number giving the r.m.s. value of the power frequency test voltage, in kilovolts,

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

and the second number giving the peak value of the lightning impulse test voltage, in kilovolts (for example 3/15 kV).

For units having one terminal permanently connected to the container, and not tested according to Clause 15, this information should be 3/- kV.

m) Reference to IEC 60831-1 (plus year of issue of the edition).

In the case of filter capacitors, a reference to Annex A shall be made.

For small units, which are permanently connected together by the manufacturer or the manufacturer's representative to form a bank or a large unit, certain of the above items may be deleted. This bigger bank or unit should in this case carry a complete rating plate.

A warning notice should be included as follows: "Warning: wait 5 minutes after isolating supply before handling".

The purchaser should specify any additional marking requirement.

26.2 Standardized connection symbols

The type of connection shall be indicated either by letters or by the following symbols:

D or  = delta

Y or  = star

YN or  = star, neutral brought out

III or  = three sections without interconnections.

26.3 Warning plate

When capacitors are impregnated with products that shall not be dispersed into the environment (see Clause 24), the capacitor shall carry markings in accordance with the laws or regulations in force in the user's country, the onus being on the user to inform the manufacturer of such laws or regulations.

27 Marking of the bank

27.1 Instruction sheet or rating plate

The following minimum information shall be given by the manufacturer in an instruction sheet, or alternatively, on request of the purchaser, on a rating plate:

a) Manufacturer.

b) Rated output Q_N in kilovars (kvar).

(Total output to be given.)

c) Rated voltage U_N in volts (V).

d) Connection symbol.

(For standardized connection symbols, see 26.2. The connection symbol may be part of a simplified connection diagram.)

e) Minimum time required between disconnection and reclosure of the bank.

f) Weight in kilograms (kg).

NOTE The choice between a rating plate and an instruction sheet is left to the purchaser.

27.2 Warning plate

Subclause 26.3 is also valid for the bank.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

28 General

Unlike most electrical apparatus, shunt capacitors, whenever energized, operate continuously at full load, or at loads that deviate from this value only as a result of voltage and frequency variations.

Overstressing and overheating shorten the life of a capacitor, and therefore the operating conditions (that is, temperature, voltage and current) should be strictly controlled.

It should be noted that the introduction of concentrated capacitance in a system may produce unsatisfactory operating conditions (for example amplification of harmonics, self-excitation of machines, overvoltage due to switching, unsatisfactory working of audio-frequency remote-control apparatus, etc.).

Because of the different types of capacitors and the many factors involved, it is not possible to cover, by simple rules, installation and operation in all possible cases. The following information is given with regard to the more important points to be considered. In addition, the instructions of the manufacturer and the power supply authorities shall be followed, especially those concerning the switching of capacitors when the network is under light load conditions.

29 Choice of the rated voltage

The rated voltage of the capacitor shall be at least equal to the service voltage of the network to which the capacitor is to be connected, account being taken of the influence of the presence of the capacitor itself.

In certain networks, a considerable difference may exist between the service and rated voltage of the network, details of which should be furnished by the purchaser, so that due allowance can be made by the manufacturer. This is of importance for capacitors, since their performance and life may be adversely affected by an undue increase of the voltage across the capacitor dielectric.

Where circuit elements are inserted in series with the capacitor to reduce the effects of harmonics, etc., the resultant increase in the voltage at the capacitor terminals above the service voltage of the network necessitates a corresponding increase in the rated voltage of the capacitor.

If no information to the contrary is available, the service voltage shall be assumed as equal to the rated (or declared) voltage of the network.

When determining the voltage to be expected on the capacitor terminals, the following considerations shall be taken into account:

a) shunt-connected capacitors may cause a voltage rise from the source to the point where they are located (see Annex B); this voltage rise may be greater due to the presence of harmonics. Capacitors are therefore liable to operate at a higher voltage than that measured before connecting the capacitors;

b) the voltage on the capacitor terminals may be particularly high at times of light load conditions (see Annex B); in such cases, some or all of the capacitors should be switched out of circuit in order to prevent overstressing of the capacitors and undue voltage increase in the network.

Only in case of emergency should capacitors be operated at maximum permissible voltage and maximum ambient temperature simultaneously, and then only for short periods of time.

An excessive safety margin in the choice of the rated voltage U_N should be avoided, because this would result in a decrease of output when compared with the rated output.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

NOTE See Clause 20 concerning maximum permissible voltage.

30 Operating temperature

30.1 General

Attention should be paid to the operating temperature of the capacitor, because this has a great influence on its life. In this respect, the temperature of the hot spot is a determining factor, but it is difficult to measure this temperature in practical operation.

Temperature in excess of the upper limit accelerates electrochemical degradation of the dielectric.

30.2 Installation

Capacitors shall be so placed that there is adequate dissipation by convection and radiation of the heat produced by the capacitor losses.

The ventilation of the operating room and the arrangement of the capacitor units shall provide good air circulation around each unit. This is of special importance for units mounted in rows one above the other.

The temperature of capacitors subjected to radiation from the sun or from any high-temperature surface will be increased. Depending on the cooling air temperature, the intensity of the cooling and the intensity and duration of the radiation, it may be necessary to opt for one of the following remedies:

– to protect the capacitors from radiation;
– to choose a capacitor designed for a higher ambient air temperature (for example, category –5/B instead of –5/A, which is otherwise suitably designed);
– to employ capacitors with rated voltage higher than that laid down in Clause 29.

Capacitors installed at high altitude (more than 2 000 m) will be subjected to decreased heat dissipation, which shall be considered when determining the output of the units (see item e), Clause 31).

30.3 High ambient air temperature

Symbol C capacitors are suitable for the majority of applications under tropical conditions. In some locations, however, the ambient temperature may be such that a symbol D capacitor is required. The latter may also be needed for those cases where the capacitors are frequently subjected to the radiation of the sun for several hours (for example in desert areas), even though the ambient temperature is not excessive (see 30.2).

In exceptional cases, the maximum ambient temperature may be higher than 55 °C, or the daily average higher than 45 °C. Where it is impossible to increase the cooling conditions, capacitors of special design shall be used.

30.4 Evaluation of losses

If losses are to be evaluated, all accessories producing losses, such as external fuses, reactors, etc., shall be included in the calculation of total bank losses.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

31 Special service conditions

Apart from the conditions prevailing at both limits of the temperature category (see 30.1), the most important conditions, which the manufacturer shall be informed about, are the following:

a) *High relative humidity*

It may be necessary to use insulators of special design. Attention is drawn to the possibility of external fuses being shunted by a deposit of moisture on their surfaces.

b) *Rapid mould growth*

Mould growth does not develop on metals, ceramic materials and some kinds of paints and lacquers. For other materials, mould growth may develop in humid places, especially where dust, etc., can settle.

The use of fungicidal products may improve the behaviour of these materials, but such products do not retain their poisoning property for more than a certain period.

c) *Corrosive atmosphere*

Corrosive atmosphere is found in industrial and coastal areas. It should be noted that in climates of higher temperature the effects of such atmospheres may be more severe than in temperate climates. Highly corrosive atmosphere may be present even in indoor installations.

d) *Pollution*

When capacitors are mounted in a location with a high degree of pollution, special precautions shall be taken.

e) *Altitude exceeding 2 000 m*

Capacitors used at altitudes exceeding 2 000 m are subject to special conditions. The choice of the type should be made by agreement between purchaser and manufacturer.

32 Overvoltages

Clause 20 specifies overvoltage factors.

With the manufacturer's agreement, the overvoltage factor may be increased if the estimated number of overvoltages is lower, or if the temperature conditions are less severe. These power frequency overvoltage limits are valid, provided that transient overvoltages are not superposed on them. The peak voltage shall not exceed $\sqrt{2}$ times the given r.m.s. value.

Capacitors that are liable to be subjected to high overvoltages due to lightning should be adequately protected. If lightning arresters are used, they should be located as near as possible to the capacitors.

Special arresters may be required to take care of the discharge current from the capacitor, especially from large banks.

When a capacitor is permanently connected to a motor, difficulties may arise after disconnecting the motor from the supply. The motor, while still revolving, may act as a generator by self-excitation and may give rise to voltages considerably in excess of the system voltage.

This, however, can usually be prevented by ensuring that the capacitor current is less than the magnetizing current of the motor; a value of about 90 % is suggested. As a precaution, live parts of a motor to which a capacitor is permanently connected should not be touched before the motor stops.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

NOTE 1 The maintained voltage due to self-excitation after the machine is switched off is particularly dangerous for induction generators and for motors with a braking system intended to be operated by loss of voltage (for example lift motors).

NOTE 2 In the case where the motor stops immediately after having been disconnected from the supply, the compensation may exceed 90 %.

When a capacitor is connected to a motor associated with a star-delta starter, the arrangement should be such that no overvoltage can occur during the operation of the starter.

33 Overload currents

Capacitors should never be operated with currents exceeding the maximum value specified in Clause 21.

Overload currents may be caused either by excessive voltage at the fundamental frequency, or by harmonics, or both. The chief sources of harmonics are rectifiers, power electronics, and saturated transformer cores.

If the voltage rise at times of light load is increased by capacitors, the saturation of transformer cores may be considerable. In this case, harmonics of abnormal magnitude are produced, one of which may be amplified by resonance between the transformer and capacitor. This is a further reason for recommending the disconnection of capacitors at times of light load, as referred to in item b), Clause 29.

If the capacitor current exceeds the maximum value specified in Clause 21, while the voltage is within the permissible limit of 1,10 U_N specified in Clause 20, the predominant harmonic should be determined in order to find the best remedy.

The following remedies should be considered:

a) moving some or all of the capacitors to other parts of the system;

b) connection of a reactor in series with the capacitor, to lower the resonant frequency of the circuit to a value below that of the disturbing harmonic;

c) increase of the capacitance value when the capacitor is connected close to power semiconductors.

The voltage waveform and the network characteristics should be determined before and after installing the capacitor. When sources of harmonics such as large semiconductors are present, special care should be taken.

Transient overcurrents of high amplitude and frequency may occur when capacitors are switched into circuit. Such transient effects are to be expected when a section of a capacitor bank is switched in parallel with other sections that are already energized (see Annex B).

It may be necessary to reduce these transient overcurrents to acceptable values in relation to the capacitor and to the equipment by switching on the capacitors through a resistor (resistance switching), or by the insertion of reactors in the supply circuit to each section of the bank.

If the capacitors are provided with fuses, the peak value of the overcurrents due to switching operations shall be limited to a maximum of 100 I_N (r.m.s. value).

34 Switching and protective devices and connections

The switching and protective devices and the connections shall be designed to carry continuously a current of 1,3 times the current that would be obtained with a sinusoidal

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

voltage of an r.m.s. value equal to the rated voltage at the rated frequency. As the capacitor may have a capacitance equal to 1,1 times the value corresponding to its rated output (see 7.2), this current may have a maximum value of 1,3 × 1,1 times the rated current.

Moreover, harmonic components, if present, may have a greater heating effect than the corresponding fundamental component, due to skin effect.

The switching and protective devices and the connections shall be capable of withstanding the electrodynamic and thermal stresses caused by the transient overcurrents of high amplitude and frequency that may occur when switching on.

Such transients are to be expected when a capacitor (unit or bank) is switched in parallel with other capacitor(s) that are already energized. It is common practice to increase the inductance of the connections in order to reduce the switching current, although this increases the total losses. Care should be taken not to exceed the maximum permissible switching current.

When consideration of the electrodynamic and thermal stresses would lead to excessive dimensions, special precautions, such as those mentioned in Clause 33 for the purpose of protection against overcurrents, should be taken.

In certain cases, for example when the capacitors are automatically controlled, repeated switching operations may occur at relatively short intervals of time. Switchgear and fuses should be selected to withstand these conditions (see Clause 22).

Breakers connected to the same busbar which is also connected to a bank of capacitors may be subjected to special stress in the event of switching on a short-circuit.

Breakers for switching of parallel banks shall be able to withstand the inrush current (amplitude and frequency) resulting when one bank is connected to a busbar to which other bank(s) are already connected.

It is recommended that capacitors be protected against overcurrent by means of suitable overcurrent relays, which are adjusted to operate the circuit-breakers when the current exceeds the permissible limit specified in Clause 21. Fuses do not generally provide suitable overcurrent protection.

Depending on the design of the capacitors, their capacitance will vary more or less with temperature.

Attention should be paid to the fact that the capacitance may change rapidly after the energization of cold capacitors. This may cause needless functioning of the protective equipment.

If iron-cored reactors are used, attention should be paid to possible saturation and overheating of the core by harmonics.

Any bad contacts in capacitor circuits may give rise to arcing, causing high-frequency oscillations that may overheat and overstress the capacitors. Regular inspection of all capacitor equipment contacts is therefore recommended.

35 Choice of creepage distance

No requirement at present.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

36 Capacitors connected to systems with audio-frequency remote control

The impedance of capacitors at audio-frequencies is very low. When they are connected to systems having audio-frequency remote control, overloading of the remote control transmitter and unsatisfactory working may, therefore, result.

There are various methods of avoiding these deficiencies. The choice of the best method should be made by agreement between all parties concerned.

37 Electromagnetic compatibility (EMC)

37.1 Emission

Under normal service conditions, power capacitors according to this standard do not produce any electromagnetic disturbances. Therefore, the requirements for electromagnetic emissions are deemed to be satisfied, and no verification by test is necessary.

Self-healing breakdowns are considered to create no electromagnetic emission because their effect is short-circuited by the parallel capacitance.

Due to the decreasing impedance of capacitors with frequency, measures should be taken to avoid inadmissible influence on ripple control systems.

When using capacitors and inductances in a network which is loaded with harmonic voltages or currents, care should be taken because the harmonics may be amplified.

37.2 Immunity

37.2.1 General

Power capacitors are provided for an EMC environment in residential, commercial, and light-industrial locations (being supplied directly at low voltage from the public mains) as well as in industrial locations (being part of a non-public low voltage industrial network).

Under normal service conditions, the following immunity requirements and tests are considered to be relevant:

37.2.2 Low-frequency disturbances

Capacitors shall be suitable for continuous operation in the presence of harmonics and interharmonics within the limits required in Clauses 2 and 3 of IEC 61000-2-2. A verification by test is not necessary.

NOTE To stay within the requirements of Clauses 20 and 21, it is common to use inductances in series with the capacitors.

37.2.3 Conducted transients and high-frequency disturbances

The high capacitance of power capacitors absorbs conducted transients and high-frequency disturbances without harmful effect. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

37.2.4 Electrostatic discharges

Power capacitors are not sensitive to electrostatic discharges. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

37.2.5 Magnetic disturbances

Power capacitors are not sensitive to magnetic disturbances. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

37.2.6 Electromagnetic disturbances

Power capacitors are not sensitive to electromagnetic disturbances. A severity level not exceeding level 3, as per IEC 61000-4-1, is deemed to be fulfilled and a verification by test is not necessary.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Annex A
(normative)

Additional definitions, requirements and tests for power filter capacitors

When the following clauses are added to the text of this standard, the standard will apply to filter capacitors (see Clause 1).

A.1 Terms and definitions

A.1.1
band-pass and high-pass filter capacitor
filter capacitor
capacitor (or capacitor bank) that, when connected with other components, such as reactor(s) and resistor(s), gives a low impedance for one or more harmonic currents

A.1.2
rated voltage (see 3.14)
U_N
arithmetic sum of the r.m.s. voltages arising from the fundamental and harmonic frequencies

A.1.3
rated output (see 3.13)
Q_N
arithmetic sum of output generated by the fundamental frequency and by the harmonics

A.1.4
rated current (see 3.16)
I_N
square root of the sum of the squared values of the rated currents at the fundamental and harmonic frequencies

Note 1 to entry: For accessories such as busbars, etc., the r.m.s. value for all currents should be considered.

A.2 Quality requirements and tests

A.2.1 Capacitance tolerance

For filter capacitors, especially for band-pass filters, symmetrical tolerances are recommended for both units and banks.

Standard units have non-symmetrical tolerance bands (see 7.2). This fact shall be taken into account when determining the capacitance value and tolerances.

When determining the bank tolerances in a filter capacitor, the following factors should be considered:

– tolerances of the associated equipment, especially the reactor(s);
– fundamental frequency variations in the network to which the filter capacitor is connected;
– capacitance variation due to ambient temperature and load;
– the allowed capacitance variation for short periods during, for example, warming up, or unusual service conditions;
– capacitance variation due to an internal protection operation, if any.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

A.2.2 Voltage test between terminals (see Clause 9)

AC test.

For filter capacitors:

$$U_t = 2{,}15\ U_N$$

where

U_N is the rated voltage defined for the filter capacitors.

A.2.3 Thermal stability test (see Clause 13)

If for filter capacitors 1,44 Q_N is lower than the output determined for 1,1 U_N at fundamental frequency, the latter test voltage shall be used in the thermal stability test.

A.3 Overloads – Maximum permissible current (see Clause 21)

For filter capacitors, the maximum permissible current shall be agreed between purchaser and manufacturer.

A.4 Markings – Instruction sheet or rating plate (see 27.1)

For filter capacitors, the tuned harmonic frequency shall preferably be marked after the rated frequency, for example:

50 Hz + 250 Hz (narrow band-pass filter)

50 Hz + 550/650 Hz (broad band-pass filter)

50 Hz + ≥ 750 Hz (high-pass filter).

A.5 Guide for installation and operation – Choice of the rated voltage (see Clause 29)

A reactor in series with the filter capacitor will cause voltage rise on the capacitor terminals at the fundamental frequency voltage.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Annex B
(informative)

Formulae for capacitors and installations

B.1 Computation of the output of three-phase capacitors from three single-phase capacitance measurements

The capacitances measured between any two-line terminals of a three-phase capacitor of either delta or star connection are denoted as C_a, C_b, and C_c. If the symmetry requirements laid down in 7.2 are fulfilled, the output Q of the capacitor can be computed with sufficient accuracy from the formula:

$$Q = \frac{2}{3}\left(C_a + C_b + C_c\right)\omega U_{N^2} \times 10^{-12}$$

where

C_a, C_b and C_c are expressed in microfarads (μF);

U_N is expressed in volts (V);

Q is expressed in megavars (Mvar).

B.2 Resonance frequency

A capacitor will be in resonance with a harmonic in accordance with the following equation in which n is an integer:

$$n = \sqrt{\frac{S}{Q}}$$

where

S is the short-circuit power (MVA) where the capacitor is to be installed;

Q is expressed in megavars (Mvar);

n is the harmonic number: that is, the ratio between the resonant harmonic (Hz) and the network frequency (Hz).

B.3 Voltage rise

Connection of a shunt capacitor will cause the steady-state voltage rise given by the following expression:

$$\frac{\Delta U}{U} \approx \frac{Q}{S}$$

where

ΔU is the voltage rise in volts (V);

U is the voltage before connection of the capacitor (V);

S is the short-circuit power (MVA) where the capacitor is to be installed;

Q is expressed in megavars (Mvar).

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

B.4 Inrush transient current

B.4.1 Switching in of single capacitor

$$\hat{I}_S \approx I_N \sqrt{\frac{2S}{Q}}$$

where

$\hat{I}_S$ is the peak of inrush capacitor current in amperes (A);

I_N is the rated capacitor current (r.m.s.) in amperes (A);

S is the short-circuit power (MVA) where the capacitor is to be installed;

Q is expressed in megavars (Mvar).

B.4.2 Switching of capacitors in parallel with energized capacitor(s)

$$\hat{I}_S = \frac{U\sqrt{2}}{\sqrt{X_C X_L}}$$

$$f_S = f_N \sqrt{\frac{X_C}{X_L}}$$

where

$\hat{I}_S$ is the peak of inrush capacitor current in amperes (A);

U is the phase-to-earth voltage in volts (V);

X_C is the series-connected capacitive reactances per phase in ohms (Ω);

X_L is the inductive reactance per phase between the banks in ohms (Ω);

f_S is the frequency of the inrush current in hertz (Hz);

f_N is the rated frequency in hertz (Hz).

B.4.3 Discharge resistance in single-phase units or in one-phase or polyphase units

$$R \leq \frac{t}{k \times C \times \ln\left(\frac{U_N\sqrt{2}}{U_R}\right)}$$

where

t is the time for discharge from $U_N\sqrt{2}$ to U_R in seconds (s);

R equals discharge resistance in megohms (MΩ)

C is the rated capacitance in microfarads (μF) per phase;

U_N is the rated voltage of unit in volts (V);

U_R is the permissible residual voltage in volts (V) (see Clause 22 for limits of t and U_R);

k is the coefficient depending on the method of connection of the resistors to the capacitor units (see Figure B.1).

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

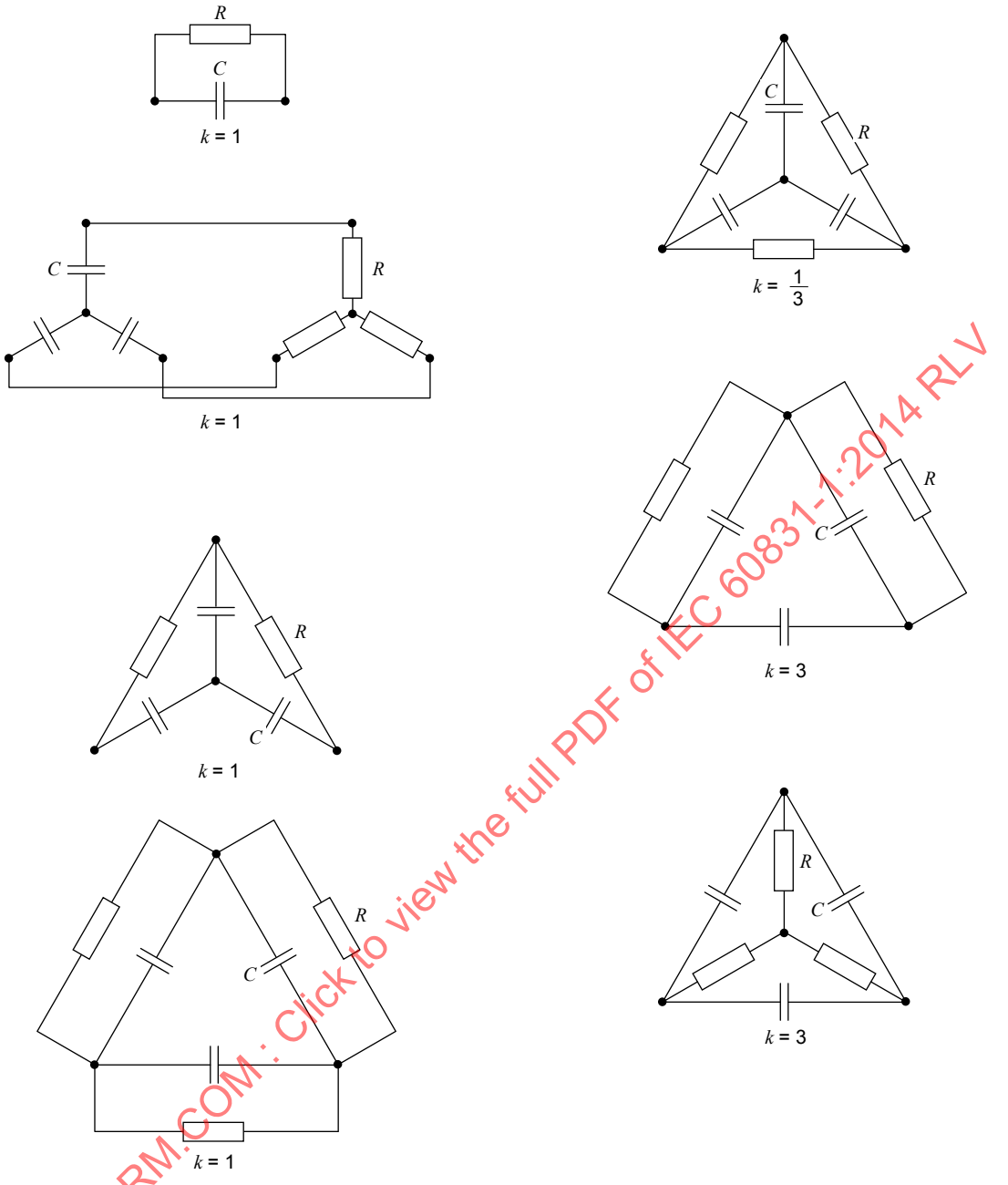


Figure B.1 – k values depending on the method of connection of the resistors with the capacitor units

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Bibliography

[1] IEC 60273:1990, *Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1 000 V*

[2] IEEE Std 824-1994, *IEEE Standard for Series Capacitors in Power Systems*

[3] IEEE Paper PE-009PRD (09-2000), *Considerations for the Application of Series Capacitors to Radial Power Distribution Circuits. Series Capacitor Working Group of the IEEE Capacitor Subcommittee*

[4] ANSI C29.9:1983, *American National Standard for Wet-Process Porcelain Insulators (Apparatus, Post type)*

[5] IEC 60050-436:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 436: Power capacitors*

[6] IEC 60050-601:1985, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*

[7] IEC 60050-604:1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*

[8] IEC 60060-2:1994, *High-voltage test techniques – Part 2: Measuring systems*

[9] IEC 60721-2-6:1990, *Classification of environmental conditions – Part 2-6: Environmental conditions appearing in nature. Earthquake, vibration and shock*

[10] IEC 60110-1:1998, *Power capacitors for induction heating installations – Part 1: General*

[11] Series capacitors (IEC60143 Part 1, Part 2, Part 3 and Part 4)

[12] IEC 60252-1:2001, *AC motor capacitors – Part 1: General – Performance, testing and rating – Safety requirements – Guide for installation and operation*

[13] IEC 60358-1, *Coupling capacitors and capacitor dividers*

[14] IEC 60996:1989, *Method for verifying accuracy of tan delta measurements applicable to capacitors*

[15] IEC 61048:1991, *Auxiliaries for lamps – Capacitors for use in tubular fluorescent and other discharge lamp circuits – General and safety requirements*

[16] IEC 61049:1991, *Capacitors for use in tubular fluorescent and other discharge lamp circuits – Performance requirements*

[17] IEC 61071 (all parts), *Power electronic capacitors*

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

SOMMAIRE

AVANT-PROPOS 41
1 Domaine d'application 43
2 Références normatives 44
3 Termes et définitions 44
4 Conditions de service 47
4.1 Conditions normales de service 47
4.2 Conditions de service inhabituelles 48
5 Exigences relatives aux essais 49
5.1 Généralités 49
5.2 Conditions d'essais 49
6 Classification des essais 49
6.1 Essais individuels 49
6.2 Essais de type 49
6.3 Essais d'acceptation 50
7 Mesure de la capacité et calcul de la puissance 50
7.1 Modalités de mesure 50
7.2 Tolérances sur la capacité 51
8 Mesure de la tangente de l'angle de pertes (tan δ) du condensateur 51
8.1 Modalités de mesure 51
8.2 Exigences concernant les pertes 51
9 Essais diélectriques entre bornes 51
9.1 Essai individuel 51
9.2 Essai de type 52
10 Essais diélectriques entre bornes et cuve 52
10.1 Essai individuel 52
10.2 Essai de type 53
11 Essai du dispositif interne de décharge 53
12 Essai d'étanchéité 53
13 Essai de stabilité thermique 54
14 Mesure de la tangente de l'angle de pertes (tan δ) du condensateur à température élevée 55
14.1 Modalités de mesure 55
14.2 Exigences 55
15 Essai diélectrique en choc de foudre entre bornes et cuve 55
16 Essai de décharge 56
17 Essai de vieillissement 56
18 Essai d'autorégénération 56
19 Essai de destruction 57
20 Tension maximale admissible 57
20.1 Tensions de longue durée 57
20.2 Surtensions de manœuvre 57
21 Courant maximal admissible 58
22 Dispositif de décharge 58
23 Connexions à l'enveloppe 58

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

24 Protection de l'environnement 58
25 Autres exigences de sécurité 59
26 Marquage du condensateur unitaire 59
26.1 Plaque signalétique 59
26.2 Symboles de couplage normalisés 60
26.3 Plaque d'avertissement 60
27 Marquage des batteries 60
27.1 Notice d'instruction ou plaque signalétique 60
27.2 Plaque d'avertissement 60
28 Généralités 60
29 Choix de la tension assignée 61
30 Température de service 62
30.1 Généralités 62
30.2 Conditions d'installation 62
30.3 Température élevée de l'air ambiant 62
30.4 Evaluation des pertes 62
31 Conditions spéciales de service 63
32 Surtension 63
33 Courants de surcharge 64
34 Appareils de coupure et de protection et raccordement 65
35 Choix des lignes de fuite 66
36 Condensateurs raccordés à des réseaux pourvus de télécommande à fréquence acoustique 66
37 Compatibilité électromagnétique (CEM) 66
37.1 Emission 66
37.2 Immunité 66
37.2.1 Généralités 66
37.2.2 Perturbations à basse fréquence 67
37.2.3 Perturbations transitoires conduites et perturbations à haute fréquence 67
37.2.4 Décharges électrostatiques 67
37.2.5 Perturbations magnétiques 67
37.2.6 Perturbations électromagnétiques 67
Annexe A (normative) Définitions, exigences et essais supplémentaires concernant les condensateurs de puissance pour filtrage en courants forts 68
A.1 Termes et définitions 68
A.2 Exigences de qualité et essais 68
A.2.1 Tolérances sur la capacité 68
A.2.2 Essai diélectrique entre bornes (voir Article 9) 69
A.2.3 Essai de stabilité thermique (voir Article 13) 69
A.3 Surcharges – Courant maximal admissible (voir Article 21) 69
A.4 Marquages – Notice d'instructions ou plaque signalétique (voir 27.1) 69
A.5 Guide d'installation et d'exploitation – Choix de la tension assignée (voir Article 29) 69
Annexe B (informative) Formules pour les condensateurs et les installations 70
B.1 Calcul de la puissance de condensateurs triphasés à partir de trois mesures de capacité monophasées 70
B.2 Fréquence de résonance 70

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

B.3 Elévation de tension 70
B.4 Courant d'appel transitoire 71
B.4.1 Mise sous tension d'un seul condensateur 71
B.4.2 Enclenchement de condensateurs en parallèle avec un/des condensateur(s) sous tension 71
B.4.3 Résistance de décharge dans un condensateur monophasé ou dans une phase de condensateurs polyphasés 71
Bibliographie 73

Figure B.1 – Valeurs du coefficient k dépendant du mode de connexion des résistances avec les condensateurs unitaires 72

Tableau 1 – Symboles littéraux de la limite supérieure de la plage de température 48
Tableau 2 – Température de l'air ambiant pour l'essai de stabilité thermique 54
Tableau 3 – Niveaux de tension admissibles en service 57

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

CONDENSATEURS SHUNT DE PUISSANCE AUTOREGÉNÉRATEURS POUR RÉSEAUX À COURANT ALTERNATIF DE TENSION ASSIGNÉE INFÉRIEURE OU ÉGALE À 1 000 V –

Partie 1: Généralités – Caractéristiques fonctionnelles, essais et valeurs assignées – Règles de sécurité – Guide d'installation et d'exploitation

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (CEI) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de la CEI). La CEI a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, la CEI – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de la CEI"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec la CEI, participent également aux travaux. La CEI collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de la CEI concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de la CEI intéressés sont représentés dans chaque comité d'études.
3) Les Publications de la CEI se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de la CEI. Tous les efforts raisonnables sont entrepris afin que la CEI s'assure de l'exactitude du contenu technique de ses publications; la CEI ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de la CEI s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de la CEI dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de la CEI et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) La CEI elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de la CEI. La CEI n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à la CEI, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de la CEI, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de la CEI ou de toute autre Publication de la CEI, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de la CEI peuvent faire l'objet de droits de brevet. La CEI ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale CEI 60831-1 a été établie par le comité d'études 33 de la CEI: Condensateurs de puissance et leurs applications.

Cette troisième édition annule et remplace la seconde édition parue en 1996 et l'Amendement 1:2002. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) mise à jour des références normatives;

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

b) clarification des conditions d'essai;

c) clarification de l'essai de stabilité thermique;

d) clarification de la tension maximale et du courant maximal autorisés;

e) modification des mesures de sécurité et des exigences en matière de qualité du plastique pour la protection de l'environnement.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
33/543/FDIS	33/550/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/CEI, Partie 2.

Une liste de toutes les parties de la série CEI 60831, publiées sous le titre général *Condensateurs shunt de puissance autorégénérateurs pour réseaux à courant alternatif de tension assignée inférieure ou égale à 1 000 V*, peut être consultée sur le site web de la CEI.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de la CEI sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

Le contenu du corrigendum de mai 2014 a été pris en considération dans cet exemplaire.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

CONDENSATEURS SHUNT DE PUISSANCE AUTOREGÉNÉRATEURS POUR RÉSEAUX À COURANT ALTERNATIF DE TENSION ASSIGNÉE INFÉRIEURE OU ÉGALE À 1 000 V –

Partie 1: Généralités – Caractéristiques fonctionnelles, essais et valeurs assignées – Règles de sécurité – Guide d'installation et d'exploitation

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

1 Domaine d'application

La présente partie de la série CEI 60831 s'applique aux condensateurs unitaires et aux batteries de condensateurs autorégénérateurs destinés plus particulièrement à la correction du facteur de puissance des réseaux à courant alternatif de tension assignée inférieure ou égale à 1 000 V et de fréquence comprise entre 15 Hz et 60 Hz.

Cette partie de la CEI 60831 s'applique également aux condensateurs destinés à être utilisés dans des circuits de filtrage. Les définitions, les exigences et les essais complémentaires pour les condensateurs de filtrage en courants forts sont indiqués dans l'Annexe A.

Les condensateurs suivants sont exclus de cette partie de la CEI 60831:

– Condensateurs shunt de puissance non autorégénérateurs destinés à être installés sur des réseaux à courant alternatif de tension assignée inférieure ou égale à 1 000 V (CEI 60931-1, -2 et -3).
– Condensateurs shunt de puissance destinés à être installés sur des réseaux à courant alternatif de tension assignée supérieure à 1 000 V (CEI 60871-1, -2, -3 et -4).
– Condensateurs destinés à des installations de génération de chaleur par induction, soumis à des fréquences comprises entre 40 Hz et 24 000 Hz (CEI 60110-1 et -2).
– Condensateurs série (CEI 60143-1, -2, -3 et -4).
– Condensateurs des moteurs à courant alternatif (CEI 60252-1 et -2).
– Condensateurs de couplage et diviseurs capacitifs (CEI 60358-1).
– Condensateurs destinés aux circuits électroniques de puissance (CEI 61071).
– Petits condensateurs à courant alternatif destinés aux lampes à fluorescence et à décharge (CEI 61048 et CEI 61049).
– Condensateurs d'antiparasitage (à l'étude).
– Condensateurs conçus pour être utilisés dans différents types d'équipements électriques et considérés de ce fait comme des composants.
– Condensateurs destinés à être utilisés sous tension continue superposée à la tension alternative.

Il convient que les accessoires tels que les isolateurs, les interrupteurs, les transformateurs de mesure, les fusibles, etc., soient conformes aux normes particulières de la CEI; ils ne sont pas couverts par le domaine d'application de la présente partie de la CEI 60831.

La présente partie de la CEI 60831 a pour objet:

a) de formuler des règles uniformes pour les performances, les essais et les caractéristiques assignées;
b) de formuler des règles spécifiques de sécurité;
c) de fournir un guide pour l'installation et l'utilisation.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

CEI 60060-1:2010, *Technique des essais à haute tension – Partie 1: Définitions et exigences générales*

CEI 60269-1:2006, *Fusibles basse tension – Partie 1: Exigences générales*

CEI 60831-2:2013, *Condensateurs shunt de puissance autorégénérateurs destinés à être installés sur des réseaux à courant alternatif de tension assignée inférieure ou égale à 1 000 V – Partie 2: Essais de vieillissement, d'autorégénération et de destruction*

CEI 60695-2-12:2010, *Essais relatifs aux risques du feu – Partie 2-12: Essais au fil incandescent/chauffant – Méthode d'essai d'indice d'inflammabilité au fil incandescent (GWFI) pour matériaux*

CEI 61000-2-2:2002, *Compatibilité électromagnétique (CEM) – Partie 2-2: Environnement – Niveaux de compatibilité pour les perturbations conduites basse fréquence et la transmission des signaux sur les réseaux publics d'alimentation basse tension*

CEI 61000-4-1:2006, *Compatibilité électromagnétique (CEM) – Partie 4-1: Techniques d'essai et de mesure – Vue d'ensemble de la série CEI 61000-4*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

3.1
élément de condensateur
élément
dispositif constitué essentiellement par deux électrodes séparées par un diélectrique

[SOURCE: CEI 60050-436:1990, 436-01-03]

3.2
condensateur unitaire
unité
ensemble d'un ou de plusieurs éléments de condensateurs placés dans une même enveloppe et reliés à des bornes de sortie

[SOURCE: CEI 60050-436:1990, 436-01-04]

3.3
condensateur autorégénérateur
condensateur dont les propriétés électriques sont rapidement et pratiquement rétablies après une perforation locale du diélectrique

[SOURCE: CEI 60050-436:1990, 436-03-12]

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

3.4
batterie de condensateurs
batterie
ensemble de condensateurs unitaires raccordés de façon à agir conjointement

[SOURCE: CEI 60050-436:1990, 436-01-06]

3.5
condensateur
terme général englobant les notions de condensateur unitaire et de batterie de condensateurs

Note 1 à l'article: Dans la présente partie de la CEI 60831, le terme condensateur est utilisé lorsqu'il n'est pas nécessaire de préciser les différentes significations des expressions condensateur unitaire ou batterie de condensateurs.

3.6
installation de condensateurs
une ou plusieurs batteries de condensateurs et leurs accessoires

[SOURCE: CEI 60050-436:1990, 436-01-07]

3.7
dispositif de décharge d'un condensateur
dispositif pouvant être incorporé dans un condensateur et capable de ramener pratiquement à zéro, en un temps spécifié, la tension entre bornes de celui-ci, lorsque le condensateur a été déconnecté du réseau

[SOURCE: CEI 60050-436:1990, 436-03-15, modifié ("destiné à réduire ... condensateur" a été remplacé par "capable de ramener ... celui-ci")]

3.8
coupe-circuit interne d'un condensateur
coupe-circuit monté à l'intérieur d'une unité de condensateur et relié en série avec un élément ou avec un groupe d'éléments

[SOURCE: CEI 60050-436:1990, 436-03-16]

3.9
déconnecteur à surpression d'un condensateur
système de déconnexion prévu pour déconnecter le condensateur en cas d'augmentation anormale de la pression à l'intérieur de l'enveloppe

[SOURCE: CEI 60050-436:1990, 436-03-17, modifié ("à interrompre ... en cas" a été remplacé par "pour déconnecter ... en cas")]

3.10
déconnecteur thermique d'un condensateur
système de déconnexion prévu pour déconnecter le condensateur en cas d'augmentation anormale de la température interne du condensateur

3.11
borne de ligne
borne destinée à être reliée à un conducteur de ligne d'un réseau

Note 1 à l'article: Dans les condensateurs polyphasés, la borne destinée à être connectée au conducteur neutre n'est pas considérée comme une borne de ligne.

[SOURCE: CEI 60050-436:1990, 436-03-01]

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

3.12
capacité assignée d'un condensateur
C_N
valeur de la capacité pour laquelle le condensateur a été conçu

[SOURCE: CEI 60050-436:1990, 436-01-12, modifié (symbole C_N ajouté et "la valeur efficace du courant alternatif" a été remplacé par "la valeur de la capacité")]

3.13
puissance assignée d'un condensateur
Q_N
puissance réactive déduite des valeurs assignées de la capacité, de la fréquence et de la tension

[SOURCE: CEI 60050-436:1990, 436-01-16, modifié (symbole Q_N ajouté et "pour laquelle le condensateur a été conçu" a été remplacé par "déduite ... tension")]

3.14
tension assignée d'un condensateur
U_N
valeur efficace de la tension alternative pour laquelle le condensateur a été conçu

Note 1 à l'article: Dans le cas de condensateurs comprenant un ou plusieurs circuits distincts (par exemple, unités monophasées destinées à être utilisées en montage polyphasé, ou unités polyphasées à circuits séparés), U_N se réfère à la tension assignée de chaque circuit.

Dans le cas de condensateurs polyphasés avec connexions électriques internes entre les phases, et dans le cas de batteries polyphasées de condensateurs, U_N se réfère à la tension entre phases.

[SOURCE: CEI 60050-436:1990, 436-01-15]

3.15
fréquence assignée d'un condensateur
f_N
fréquence pour laquelle le condensateur a été conçu

[SOURCE: CEI 60050-436:1990, 436-01-14]

3.16
courant assigné d'un condensateur
I_N
valeur efficace du courant alternatif pour laquelle le condensateur a été conçu

[SOURCE: CEI 60050-436:1990, 436-01-13]

3.17
pertes d'un condensateur
puissance active dissipée dans le condensateur

Note 1 à l'article: Il convient de prendre en compte tous les composants donnant lieu à des pertes, par exemple:

– pour un condensateur unitaire, les pertes des diélectriques, fusibles internes, résistances de décharge internes, connexions, etc.
– pour une batterie de condensateurs, les pertes des condensateurs unitaires, fusibles externes, jeux de barres, réactances de décharge et d'amortissement, etc.

[SOURCE: CEI 60050-436:1990, 436-04-10]

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

3.18
tangente de l'angle de perte d'un condensateur
tan δ
rapport entre la résistance-série équivalente et la réactance capacitive du condensateur dans des conditions spécifiées de fréquence et de tension alternative sinusoïdale

[SOURCE: CEI 60050-436:1990, 436-04-11]

3.19
tension alternative maximale admissible d'un condensateur
valeur efficace maximale de la tension alternative que le condensateur peut supporter pendant un temps déterminé dans des conditions spécifiées

[SOURCE: CEI 60050-436:1990, 436-04-07]

3.20
courant alternatif maximal admissible d'un condensateur
valeur efficace maximale du courant alternatif que le condensateur peut supporter pendant un temps déterminé dans des conditions spécifiées

[SOURCE: CEI 60050-436:1990, 436-04-09]

3.21
température de l'air ambiant
température de l'air à l'emplacement prévu pour le condensateur

3.22
température de l'air de refroidissement
température de l'air de refroidissement mesurée à l'état stable à l'endroit le plus chaud de la batterie, à mi-distance entre deux unités

Note 1 à l'article: S'il s'agit d'une seule unité, c'est la température mesurée à 0,1 m environ de la cuve du condensateur et aux deux tiers de la hauteur à partir de sa base.

3.23
état stable
équilibre thermique interne atteint par le condensateur dans des conditions constantes de puissance et de température de l'air ambiant

3.24
tension résiduelle
tension restant entre les bornes d'un condensateur un certain temps après la mise hors service

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

4 Conditions de service

4.1 Conditions normales de service

La présente norme donne les exigences relatives aux condensateurs destinés à être utilisés dans les conditions suivantes:

a) Tension résiduelle lors de la mise en service

   Elle ne doit pas être supérieure à 10 % de la tension assignée (voir Article 22, Article 32 et Annexe B).

b) Altitude

   Elle ne doit pas dépasser 2 000 m.

c) Catégories de température de l'air ambiant

Les condensateurs sont classés en catégories de température, chaque catégorie étant repérée par un nombre suivi d'une lettre. Le nombre représente la valeur la plus basse de la température de l'air ambiant à laquelle le condensateur peut fonctionner.

Les lettres représentent les valeurs limites supérieures des plages de variation de la température, dont les valeurs maximales sont spécifiées dans le Tableau 1. Les catégories de température couvrent une plage qui s'étend de –50 °C à +55 °C.

Il convient de choisir la température minimale de l'air ambiant à laquelle le condensateur peut être mis sous tension parmi les cinq valeurs préférentielles +5 °C, –5 °C, –25 °C, –40 °C, –50 °C.

Pour l'utilisation à l'intérieur, la limite inférieure de –5 °C est normalement applicable.

Le Tableau 1 est basé sur des conditions de service dans lesquelles le condensateur n'influence pas la température de l'air ambiant (par exemple, emploi à l'extérieur).

Tableau 1 – Symboles littéraux de la limite supérieure de la plage de température

Symbole	Température de l'air ambiant °C		
	Maximum	Moyenne la plus élevée sur toute période de	
		24 h	1 an
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

NOTE 1 Les valeurs de température du Tableau 1 peuvent être trouvées dans les tableaux météorologiques de température concernant le lieu d'installation.

NOTE 2 Des valeurs de température plus élevées que celles qui sont indiquées au Tableau 1 peuvent être envisagées pour des applications spéciales, par accord mutuel entre le fabricant et l'acheteur. Il convient, dans ce cas, que les catégories de température soient indiquées en combinant les valeurs de température minimale et maximale, par exemple –40/60.

Si le condensateur exerce une influence sur la température de l'air environnant, l'effet de la ventilation et/ou le choix du condensateur doivent permettre de maintenir les valeurs limites du Tableau 1. Dans ce type d'installation, la température de l'air de refroidissement ne doit pas dépasser les limites indiquées dans le Tableau 1 de plus de 5 °C.

Pour définir la catégorie normale de température d'un condensateur, il est possible de choisir n'importe quelle combinaison de valeurs minimale et maximale, par exemple –40/A ou –5/C.

Les catégories de température préférentielles sont les suivantes:

–40/A, –25/A, –5/A et –5/C.

4.2 Conditions de service inhabituelles

Sauf accord différent passé entre le fabricant et l'acheteur, cette norme ne s'applique pas aux condensateurs dont les conditions de service, prises en général, ne sont pas compatibles avec les exigences de la présente norme.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

5 Exigences relatives aux essais

5.1 Généralités

L'Article 5 indique les exigences relatives aux essais des condensateurs unitaires et, lorsque cela est précisé, des éléments des condensateurs.

Les supports isolants, les interrupteurs, les transformateurs de mesure, les fusibles, etc., doivent être conformes aux normes particulières de la CEI.

5.2 Conditions d'essais

Sauf spécification contraire, pour un essai ou une mesure particuliers, la température du diélectrique du condensateur, au début de l'essai, doit être comprise entre +5 °C et +35 °C.

On peut admettre que la température du diélectrique est celle de l'air ambiant, pourvu que le condensateur ait été laissé hors tension à température ambiante constante pendant une durée suffisante.

Les essais et les mesures en courant alternatif doivent être effectués à la fréquence de 50 Hz ou 60 Hz, indépendamment de la fréquence assignée du condensateur, sauf spécification contraire.

Les condensateurs ayant une fréquence assignée inférieure à 50 Hz doivent être soumis à essai et mesurés à 50 Hz ou 60 Hz, sauf spécification contraire.

6 Classification des essais

6.1 Essais individuels

Les essais suivants sont des essais individuels. Pour plus de détails, il convient de se référer aux articles ou paragraphes appropriés:

a) mesure de la capacité et calcul de la puissance (voir Article 7);

b) mesure de la tangente de l'angle de pertes (tan δ) du condensateur (voir Article 8);

c) essai diélectrique entre bornes (voir 9.1);

d) essai diélectrique entre bornes et cuve (voir 10.1);

e) contrôle du dispositif de décharge interne (voir Article 11);

f) essai d'étanchéité (voir Article 12).

Les essais individuels doivent avoir été exécutés par le fabricant sur chaque condensateur avant livraison. Sur demande de l'acheteur, un rapport d'essai doit lui être remis, indiquant de façon détaillée les résultats des essais.

L'ordre dans lequel les essais sont effectués n'est pas obligatoirement celui qui est indiqué ci-dessus.

6.2 Essais de type

Les essais suivants sont des essais de type. Pour plus de détails, il convient de se référer aux articles ou paragraphes appropriés:

a) essai de stabilité thermique (voir Article 13);

b) mesure de la tangente de l'angle de pertes (tan δ) du condensateur à température élevée (voir Article 14);

c) essai diélectrique entre bornes (voir 9.2);

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

d) essai diélectrique entre bornes et cuve (voir 10.2);

e) essai diélectrique en choc de foudre entre bornes et cuve (voir Article 15);

f) essai de décharge (voir Article 16);

g) essai de vieillissement (voir Article 17);

h) essai d'autorégénération (voir Article 18);

i) essai de destruction (voir Article 19).

Les essais de type sont effectués afin de s'assurer que la conception, les dimensions, les matériaux et la construction sont tels que le condensateur satisfait aux caractéristiques spécifiées et aux conditions de fonctionnement précisées par la présente norme.

Sauf spécification contraire, chaque condensateur sur lequel sont effectués les essais de type doit d'abord avoir supporté de façon satisfaisante tous les essais individuels.

Les essais de type doivent avoir été exécutés par le fabricant et un certificat donnant le détail des résultats de ces essais doit être remis à l'acheteur sur sa demande.

Un résultat satisfaisant pour chaque essai de type qualifie les condensateurs ayant la même tension assignée et une puissance assignée inférieure, à condition que ces condensateurs ne présentent aucune différence pouvant affecter les propriétés contrôlées par ces essais. Il n'est pas indispensable que tous les essais de type soient effectués sur le même condensateur.

Le nombre d'échantillons pour l'essai de type doit faire l'objet d'un accord entre le fabricant et l'utilisateur.

6.3 Essais d'acceptation

Les essais individuels et/ou de type, ou certains d'entre eux, peuvent être renouvelés par le fabricant à l'occasion de tout contrat en accord avec l'acheteur. La nature des essais, le nombre d'échantillons pouvant être soumis au renouvellement de tels essais et les critères d'acceptation doivent faire l'objet d'un accord entre le fabricant et l'acheteur, et mention doit en être faite dans le contrat.

7 Mesure de la capacité et calcul de la puissance

7.1 Modalités de mesure

La capacité doit être mesurée à la tension et à la fréquence choisies par le fabricant. La méthode utilisée doit permettre d'éviter les erreurs dues à des harmoniques et aux accessoires extérieurs au condensateur à mesurer, tels que les réactances et circuits de blocage dans le circuit de mesure. La précision de la méthode utilisée ainsi que la corrélation avec les valeurs mesurées à la tension et à la fréquence assignées doivent être indiquées.

La mesure de la capacité doit être effectuée après l'essai diélectrique entre bornes (voir Article 9).

Une mesure à une tension comprise entre 0,9 et 1,1 fois la tension assignée et à une fréquence comprise entre 0,8 et 1,2 fois la fréquence assignée doit être effectuée sur le condensateur avant l'essai de stabilité thermique (voir Article 13), l'essai de vieillissement (voir Article 17), et l'essai d'autorégénération (voir Article 18), et pourrait être effectuée sur d'autres condensateurs sur demande de l'acheteur, en accord avec le fabricant.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

7.2 Tolérances sur la capacité

La capacité ne doit pas s'écarter de la capacité assignée de plus de:

–5 % à +10 % pour les condensateurs unitaires et les batteries jusqu'à 100 kvar;

–5 % à + 5 % pour les condensateurs unitaires et les batteries au-dessus de 100 kvar.

La valeur de la capacité est mesurée dans les conditions spécifiées en 7.1.

Dans les unités triphasées, le rapport entre les valeurs maximale et minimale des capacités, mesurées entre deux bornes de ligne quelconque, ne doit pas dépasser 1,08.

NOTE Une formule pour le calcul de la puissance d'un condensateur triphasé à partir des mesures des capacités monophasées est donnée dans l'Annexe B.

8 Mesure de la tangente de l'angle de pertes (tan δ) du condensateur

8.1 Modalités de mesure

Les pertes du condensateur (ou tan δ) doivent être mesurées à la tension et à la fréquence choisies par le fabricant. La méthode utilisée doit permettre d'éviter les erreurs dues à des harmoniques ou aux accessoires extérieurs au condensateur à mesurer, tels que les réactances et circuits de blocage dans le circuit de mesure. La précision de la méthode utilisée ainsi que la corrélation avec les valeurs mesurées à la tension et à la fréquence assignées doivent être indiquées.

La mesure des pertes du condensateur doit être effectuée après l'essai diélectrique entre bornes (voir Article 9).

Une mesure à une tension comprise entre 0,9 et 1,1 fois la tension assignée et à une fréquence comprise entre 0,8 et 1,2 fois la fréquence assignée doit être effectuée sur le condensateur avant l'essai de stabilité thermique (voir Article 13), et peut être effectuée sur d'autres condensateurs sur demande de l'acheteur, en accord avec le fabricant.

Lorsque l'on essaie un grand nombre de condensateurs, une mesure de tan δ peut être faite selon un plan d'échantillonnage. Il convient que ce dernier fasse l'objet d'un accord entre fabricant et acheteur.

La valeur de tan δ de certains types de diélectriques est fonction de la durée de la mise sous tension précédant la mesure. Dans ce cas, il convient que la tension d'essai et la durée de mise sous tension préalable fassent l'objet d'un accord entre le fabricant et l'acheteur.

8.2 Exigences concernant les pertes

La valeur de tan δ, mesurée conformément à 8.1, ne doit pas dépasser la valeur spécifiée par le fabricant pour la température et la tension de l'essai, ou la valeur fixée par accord entre le fabricant et l'acheteur.

9 Essais diélectriques entre bornes

9.1 Essai individuel

Chaque condensateur doit être soumis à un essai à courant alternatif à U_t = 2,15 U_N, pendant un temps minimal de 2 s.

L'essai à courant alternatif doit être exécuté à une tension pratiquement sinusoïdale et à une fréquence comprise entre 15 Hz et 100 Hz, de préférence la plus rapprochée possible de la fréquence assignée.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV

Pendant l'essai, il ne doit se produire ni perforation permanente ni contournement. Les perforations autorégénérables sont autorisées.

Lorsque le condensateur est composé d'un certain nombre d'éléments, ou d'un groupe d'éléments montés en parallèle, soumis séparément à l'essai, il n'est pas nécessaire de répéter les essais sur ce condensateur unitaire.

Pour les condensateurs polyphasés, il convient d'ajuster convenablement les tensions d'essais.

NOTE Le fonctionnement de fusibles internes est autorisé, à condition que les tolérances sur la capacité soient encore respectées et que deux fusibles au plus aient fonctionné par condensateur.

9.2 Essai de type

Chaque condensateur doit être soumis à un essai à courant alternatif à U_t = 2,15 U_N pendant 10 s.

L'essai doit être exécuté à une tension pratiquement sinusoïdale.

Pendant l'essai, il ne doit se produire ni perforation permanente ni contournement. Les autorégénérations sont autorisées.

Pour les condensateurs polyphasés, il convient d'ajuster convenablement les tensions d'essais.

NOTE Le fonctionnement de fusibles internes est autorisé, à condition que les tolérances sur la capacité soient encore respectées et que deux fusibles au plus aient fonctionné par condensateur.

10 Essais diélectriques entre bornes et cuve

10.1 Essai individuel

Les condensateurs dont toutes les bornes sont isolées de la cuve doivent être soumis à une tension alternative appliquée entre les bornes (raccordées entre elles) et la cuve. La tension minimale à appliquer est de 2 U_N + 2 kV ou de 3 kV, en prenant la plus élevée des deux valeurs, pendant 10 s, ou de 20 % plus élevée pendant une durée minimale de 2 s.

Si les condensateurs sont destinés à être reliés directement à la ligne aérienne d'alimentation, et selon accord entre le fabricant et l'utilisateur, l'essai doit être réalisé avec une tension de 6 kV.

Au cours de l'essai, il ne doit se produire ni perforation ni contournement.

Cet essai doit être effectué même si, en service, l'une des bornes est destinée à être connectée à la cuve.

Les condensateurs triphasés, dont les phases sont indépendantes, peuvent être soumis à essai par rapport à la cuve en raccordant toutes les bornes entre elles. Les condensateurs ayant une borne connectée en permanence à la cuve ne doivent pas être soumis à cet essai.

Lorsque la cuve du condensateur est constituée d'un matériau isolant, cet essai ne doit pas être réalisé.

Si un condensateur a des phases ou sections indépendantes, un essai d'isolement entre ces phases ou sections doit être effectué à la même tension que celle qui est prévue pour l'essai entre bornes et cuve.

IECNORM.COM : Click to view the full PDF of IEC 60831-1:2014 RLV