IEC 60143-3

Edition 2.0 2015-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Series capacitors for power systems –
Part 3: Internal fuses

Condensateurs série destinés à être installés sur des réseaux –
Partie 3: Fusibles internes

IEC 60143-3:2015-06(en-fr)

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 It also gives information on projects, replaced and withdrawn publications.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 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 60 000 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.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
Plus de 60 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 60143-3

Edition 2.0 2015-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Series capacitors for power systems – Part 3: Internal fuses

Condensateurs série destinés à être installés sur des réseaux – Partie 3: Fusibles internes

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 31.060.70

ISBN 978-2-8322-2715-2

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SERIES CAPACITORS FOR POWER SYSTEMS –

Part 3: Internal fuses

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.

International Standard IEC 60143-3 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This second edition cancels and replaces the first edition published in 1998. This edition constitutes a technical revision.

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

The test procedure has been largely simplified.

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

FDIS	Report on voting
33/577/FDIS	33/579/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 60143 series, published under the general title *Series capacitors for power systems*, 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 website 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.

SERIES CAPACITORS FOR POWER SYSTEMS –

Part 3: Internal fuses

1 Scope

This part of IEC 60143 applies to internal fuses designed to isolate faulty capacitor elements, to allow operation of the remaining parts of that capacitor unit and the bank in which the capacitor unit is connected. Such fuses are not a substitute for a switching device such as a circuit-breaker, or for external protection of the capacitor bank, or any part thereof.

The object of this part of IEC 60143 is:

– to formulate requirements regarding performance and testing;

– to provide a guide for coordination of fuse and bank protection.

NOTE External fuses for series capacitors are treated in IEC 60143-1:2004, Annex A: "Test requirements and application guide for external fuses and units to be externally fused".

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 60143-1:2004, *Series capacitors for power systems – Part 1: General*

IEC 60143-2:2012, *Series capacitors for power systems – Part 2: Protective equipment for series capacitor banks*

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60143-1 and IEC 60143-2, as well as the following, apply.

3.1
rated voltage of a capacitor element U_{Ne}
r.m.s. value of the alternating voltage for which the capacitor element has been designed

4 Performance requirements

4.1 General

The fuse is connected in series with the element(s) which the fuse is intended to isolate if the element(s) becomes faulty. The range of currents and voltages for the fuse is therefore dependent on the capacitor design, and in some cases also on the design of the bank in which the fuse is connected.

The operation of an internal fuse is in general determined by one or both of the two following factors:

– the discharge energy from elements or units connected in parallel with the faulty element or unit;

– the power-frequency fault current.

4.2 Disconnecting requirements

The fuse shall enable the faulty element to be disconnected when electrical breakdown of elements occurs in a voltage range, in which u_1 is the lowest, and u_2 is the highest (instantaneous) value of the voltage between the terminals of the unit at the instant of fault.

The recommended values for u_1 and u_2 are the following:

$u_1 = 0{,}5\ \sqrt{2}\ U_N$

$u_2 = \sqrt{2}\ U_{lim}$

For u_1, other values can be agreed upon between purchaser and manufacturer.

The u_2 value is of a transient nature.

The u_1 and u_2 values above are based on the voltage that may normally occur across the capacitor unit terminals at the instant of electrical breakdown of the element.

The purchaser shall specify if the u_1 value differs from the stated one. If so, the value stated in 3.2.3.1 shall be changed accordingly.

The u_2 value cannot be exceeded due to the overvoltage protector. A voltage lower than the u_1 value can occur in service, but breakdowns are unlikely to take place under these conditions.

4.3 Withstand requirements

4.3.1 After operation, the gap in the blown fuse shall withstand full element voltage, plus any unbalance voltage due to fuse action, and any short-time transient overvoltages normally experienced during the life of the capacitor.

4.3.2 Throughout the life of the capacitor, the fuse shall be capable of carrying continuously a current equal to or greater than the rated capacitor unit current (including harmonics if applicable), divided by the number of parallel fused paths. In addition, the fuse shall withstand the working currents given in 7.1 and 10.3 of IEC 60143-1:2004.

4.3.3 The fuses shall be capable of withstanding the high-amplitude, high-frequency discharge currents due to operation of the overvoltage protector and/or the bypass switch, expected during the life of the capacitor.

4.3.4 The fuse connected to the undamaged element(s) shall be able to carry the discharge currents due to the breakdown of element(s).

4.3.5 The fuse shall be able to carry the currents due to short-circuit faults on the bank external to the unit(s) occurring within the voltage range in accordance with 2.2.

4.3.6 The fuse shall be capable of withstanding the high-amplitude, high-frequency discharge current that will arise as a consequence of a flashover to platform fault or a varistor failure.

5 Tests

5.1 Routine tests

5.1.1 General

The fuses shall be able to withstand all routine tests of the capacitor unit in accordance with IEC 60143-1.

5.1.2 Discharge test

Capacitors having internal fuses shall be subjected to one short-circuit discharge test, from a d.c. voltage of 1,7 U_N (= 1,2 × $\sqrt{2}$ × U_N), through a gap situated as closely as possible to the capacitor, without any additional impedance in the circuit.

The capacitance shall be measured before and after the discharge test. The difference between the two measurements shall be less than an amount corresponding to one internal fuse operation.

The discharge test may be made before or after the voltage test between terminals (see 5.5 of IEC 60143-1:2004). However, if it is made after the voltage test between terminals, a capacitance measurement at rated voltage shall be made afterwards to detect fuse operation. It is permitted that a d.c. charging voltage be generated by initially energizing with an a.c. voltage of 1,7 U_N peak value and disconnecting at a current zero. The capacitor is then immediately discharged from this peak value. Alternatively, if the capacitor is disconnected at a slightly higher voltage than 1,7 U_N, the discharge may be delayed until the discharge resistor reduces the voltage to 1,7 U_N.

5.2 Type tests

5.2.1 General

The fuses shall be able to withstand all type tests of the capacitor unit(s) in accordance with IEC 60143-1.

The unit(s) shall have passed all routine tests stated in IEC 60143-1.

The disconnecting test on fuses (see 3.2.3) shall be performed either on one complete capacitor unit or, at the choice of the manufacturer, on two units, one unit being tested at the lower voltage limit, and one unit at the upper voltage limit, in accordance with 3.2.3.1.

NOTE Due to testing, measuring and safety circumstances, it may be necessary to make some modifications to the unit(s) under test; for example those indicated in Annex A. See also the different test methods given in Annex A.

Type tests are considered valid if they are performed on capacitor(s) of a design identical with that of the capacitor offered, or on a capacitor(s) of a design that does not differ from it in any way that might affect the properties to be checked by the type tests.

5.2.2 Discharge test on fuses

The fuses shall be subjected to the discharge test stated in 5.13 of IEC 60143-1:2004.

To prove that the fuses have not operated, a capacitance measurement shall be made before and after the test. A measuring method shall be used that is sufficiently sensitive to detect the capacitance change caused by one blown fuse.

5.2.3 Disconnecting test on fuses

5.2.3.1 Test procedures

The disconnecting test on fuses shall be performed at the lower a.c. test voltage of 0,5 × U_N, and at the upper a.c. test voltage of 1,1 × U_{lim}, where 1,1 is a test factor. The tests may be performed on two different units, one for each level.

NOTE 1 For the upper a.c. test voltage, the discharge energy of parallel elements will normally blow the fuse, whereas at the lower a.c. test voltage, a power-frequency current is normally required to blow the fuse.

Certain test methods are indicated in Annex A.

If the test is carried out with d.c., the test voltage shall be $\sqrt{2}$ times the corresponding a.c. test voltage.

NOTE 2 Normally the dielectric would only withstand a voltage of 2.5 U_N for a very limited period of time. Therefore a test with d.c. is in most cases to be preferred.

NOTE 3 If the test is carried out with a.c., the triggering of the element failure with a voltage peak will not be necessary for the test at the lower voltage limit.

NOTE 4 The voltage u_2 stated in 2.2 is the maximum voltage that the unit can be exposed to during service. However the disconnecting test is performed at 1,1 times that voltage.

5.2.3.2 Capacitance measurement

After the test, the capacitance shall be measured to prove that the fuse(s) has (have) blown.

A measuring method shall be used that is sufficiently sensitive to detect the capacitance change caused by one blown fuse.

5.2.3.3 Inspection of the unit

No significant deformation of the container shall be apparent.

After opening the container, a check shall be made to ensure that at lower and upper voltage limit:

a) no severe deformation of sound fuses is apparent;

b) no more than one additional fuse (or one-tenth of fused elements directly in parallel) has been damaged (see Note 1 of Clause A.1).

NOTE 1 A small amount of blackening of the impregnant will not affect the quality of the capacitor.

NOTE 2 Dangerous trapped charges may be present on elements disconnected either by operated fuses or by damage to their connections. All elements will be discharged with great care.

5.2.4 Voltage test after opening the container

A d.c. test voltage equal to 1,7 × U_{lim} shall be applied for 10 s across the broken-down element and the gap in its blown fuse. During the test, the gap shall be in the impregnant.

No breakdown over the fuse gap or between any part of the fuse and any other part of the unit is allowed.

The test can be replaced by an a.c. test before opening of the unit. The test voltage between the terminals is calculated using the capacitance ratio such that the voltage across the breakdown element and the gap in its blown fuse is the value given in 3.2.4, divided by $\sqrt{2}$.

Annex A
(normative)

Test procedures for the disconnecting test on internal fuses

A.1 General

The test procedure described in A.2 or an alternative method agreed upon between the manufacturer and the purchaser, shall be used.

If no agreement has been reached, the choice is left to the manufacturer: see also the note in 3.2.1.

The capacitor voltage and current shall be recorded during the test to verify that the fuse has disconnected correctly.

To verify the current-limiting behaviour of the fuses when tested at the upper voltage limit, the voltage drop, excluding transient, across the blown fuse shall not exceed 30 %.

If the fuse does not fulfil this requirement, precautions shall be taken to make certain that the parallel stored energy and the power-frequency fault current available from the system are representative of service conditions. A test shall then be made to demonstrate the satisfactory operation of the fuse.

At the upper voltage limit, one additional fuse (or one-tenth of the fused elements directly in parallel) connected to a sound element(s) is allowed to be damaged.

The test voltage should be maintained some seconds after a breakdown, to ensure that the fuse has disconnected correctly, unaided by disconnection of the power supply.

Precautions should be taken when performing this test against the possible explosion of a capacitor unit and the explosive projection of the nail.

Coordination of the element failure with an a.c. voltage peak is not necessary for the test at the lower voltage limit.

A.2 Test procedure – Mechanical puncture of the element

Mechanical puncture of the element is made by a nail, which is forced into the element through an opening in the container. The test voltage may be d.c. or a.c., the choice being left to the manufacturer.

If an a.c. voltage is used (at the high disconnection voltage u2), capacitor current shall be recorded during the test and the timing of the puncture shall be made, to ascertain that the breakdown is triggered to take place at the instant of the peak of the a.c. test voltage, or very close to it.

NOTE 1 Puncture of only one element cannot be guaranteed.

NOTE 2 In order to limit the possibility of a flashover to the container along the nail, or through the hole caused by the nail, the punctures will be performed in the elements connected, permanently or during the test, to the container.

NOTE 3 DC voltage is especially suitable for capacitors having all elements in parallel.