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TECHNICAL SPECIFICATION

colour inside

AMENDMENT 1

Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V – Part 2: Endurance testing

IEC TS 60871-2:2014-11/AMD1:2022-03(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SHUNT CAPACITORS FOR AC POWER SYSTEMS HAVING A RATED VOLTAGE ABOVE 1 000 V –

Part 2: Endurance testing

AMENDMENT 1

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Amendment 1 to IEC TS 60871-2:2014 has been prepared by IEC technical committee 33: Power capacitors and their applications.

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

Draft	Report on voting
33/668/DTS	33/671/RVDTS

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

The language used for the development of this Amendment is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications/.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

Add, after Clause 4, the following new text:

5 Element fail safe test for fuseless capacitors

5.1 General

The proof of element fail safe is a design test applicable to fuseless power capacitors, as defined in IEC 60871-1:2014, Clause E.4.

This proof is obtained by means of two separate tests, the low energy test and the high energy test.

The low energy test is aimed to demonstrate that a failure of one capacitive element, caused by a low voltage element failure event at the rated voltage, will result in reliable and secure foil welding on the failed portion of the element without generation of hot spots and persistent release of gas.

The high energy test is aimed to demonstrate that a failure of one or more capacitive elements, caused by the occurrence of an overvoltage on the capacitor bank, will result in reliable and safe behaviour without container rupture or explosion.

The physical location of the fault on the capacitor element is intended to represent the worst possible location under the expected low or high energy level tested. A damage to the insulation of the container is acceptable, provided that it maintains enough insulation in order to remain in service until replacement.

5.2 Test unit

5.2.1 General

Two set-ups of the test unit are possible, as described in 5.2.2 and 5.2.3; the manufacturer shall choose the set-up and manufacture the test unit accordingly.

5.2.2 Set-up of the test unit, first method

The test unit shall be a capacitor unit comparable to the units to be manufactured, as described in Annex A, with the following features:

- The container shall be identical to that used for the units to be manufactured.
- The test unit shall contain a single active element, i.e. electrically connected to the bushings for power supply; the other elements shall be passive, i.e. not electrically connected neither to the active element nor to the bushings.
- The unit may be equipped with some means of shorting the capacitor terminals, such as metallic wires between terminals, for safe handling.
- The position of the tested element shall be located at the top location nearest to the bushing lid.
- The element shall be of the same size to that used for the units to be manufactured.

Each test shall be conducted on a separate test unit, differing for the intentional damage of the active element (as described in 5.2.4 to 5.2.5) but otherwise identical.

5.2.3 Set-up of the test unit, second method

The test unit shall be a capacitor unit comparable to the units to be manufactured, as described in Annex A, with the following features:

- The container shall be identical to that used for the units to be manufactured.
- The test unit shall have full-size active elements, with only one pre-damaged active element identical to those included in the capacitor unit supplied.
- The unit may be equipped with some means of shorting the capacitor terminals, such as metallic wires between terminals, for safe handling.
- The position of the tested element shall be located at the top location nearest to the bushing lid.
- The capacitor units shall be constructed with appropriate resistor values capable to withstand high voltage (see 5.3).

5.2.4 Active element for the low energy test

The insulating films between the two active electrodes of the element for the low energy test shall be mechanically damaged before insertion in the test unit, in order facilitate the element failure during the low energy test.

The mechanical damage shall be located at 5 ± 1 cm from the margin of the element and roughly on the fringe of the element's length as shown in Figure 1. The damage shall be located between five and ten plies from the outermost ply of the element. Two dielectric layers between consecutive metallic foils shall be separately punctured; the punctures should be sufficiently apart in order to avoid shorting the element just at the beginning of the test.

NOTE It is suggested to puncture the layers using a heated nail of about 2 mm in diameter.

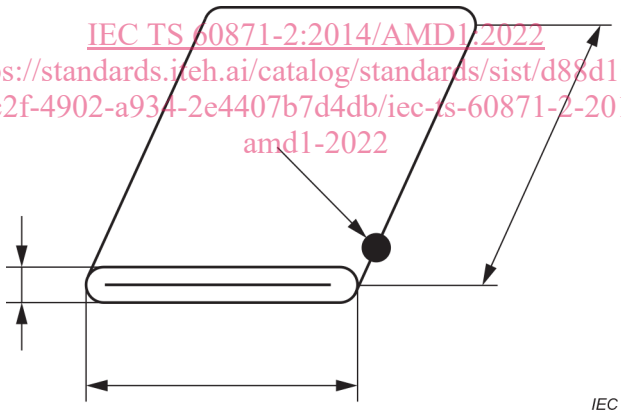

Figure 1 – Puncture location on the active element

5.2.5 Active element for the high energy test

One of the insulating films between the two active electrodes of the active element shall be mechanically damaged during manufacturing in a manner to facilitate the element failure at the time of the tests.

The mechanical damage shall be located at 5 ± 1 cm from the margin of the element and roughly on the fringe of the element's length as shown in Figure 1. The damage shall be located between five and ten plies from the outermost ply of the element. Only one dielectric layer between consecutive metallic foils shall be punctured.

NOTE It is suggested to puncture the layer using a heated nail of about 2 mm in diameter.

5.3 Conditioning of the unit

5.3.1 General

Two methods to prepare the test circuit are possible, as described in 5.3.2 and 5.3.3; the manufacturer shall choose the method and prepare the test circuit accordingly.

5.3.2 Circuit for achieving a failed test unit, first method

The electrical failure of each test unit shall be produced by the discharge of a pre-charged loading capacitor unit in parallel to the test unit. The suggested electric circuit is shown in Figure 2.

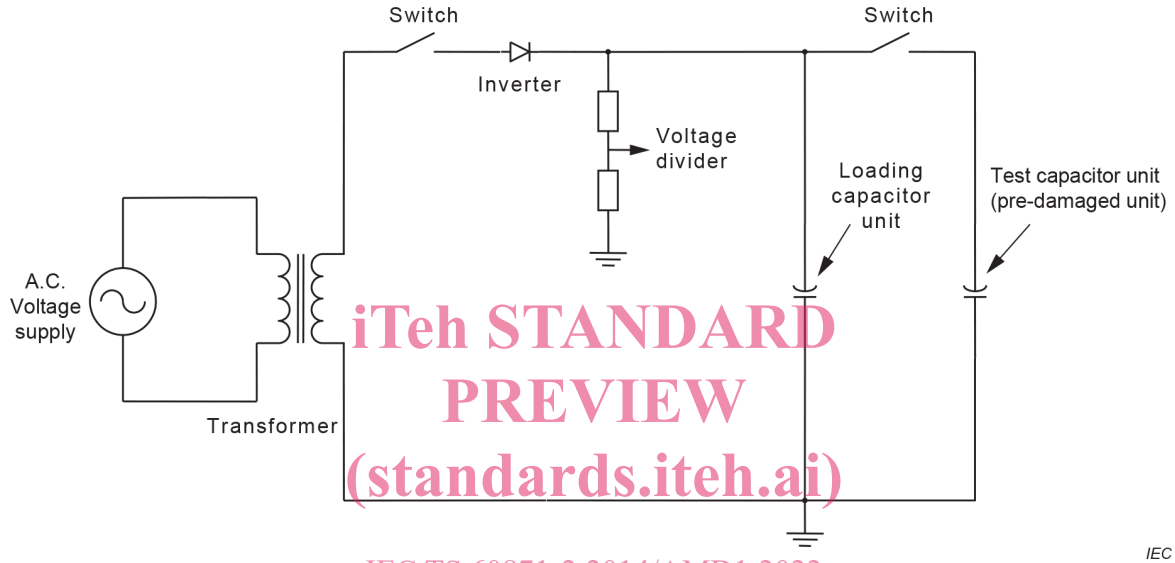

Figure 2 – Electric circuit for conditioning of the units

The discharge into the active element shall be performed by closing the switch in the branch of the test unit, while disconnecting the power supply. Voltage and current shall be recorded during this capacitive discharge to verify that the desired voltage level and the discharge are achieved. Multiple discharges may be necessary for failure to occur. The test unit shall be fully and safely discharged between attempts.

NOTE The use of a shorting stick is suggested, where applicable, in order to shorten the discharge time.

5.3.3 Circuit for achieving a failed test unit, second method

The unit shall be equipped with a modified discharge resistor in order to overheat it to failure. A preheating of the unit at 80 °C for 12 hours with the regular resistor is also possible to achieve a similar result.

NOTE The modified discharge resistor is preferably located near the tested element, in order to focalize the heat to the targeted element and not to the other healthy elements.

The electrical failure of the test units shall be produced by applying and maintaining a DC voltage corresponding to the required energy level for at least 30 minutes or until the element fails.

The applied DC voltage, combined with the heating produced by the modified discharge resistor, should create the proper condition to initiate the element failure. Voltage and current shall be recorded during this attempt to verify that the desired energy level is achieved. Multiple attempts may be necessary for failure to occur. The test units shall be fully discharged between attempts.

For a high energy test unit, a short circuit of the test unit at nominal voltage may be performed between attempts to weaken the tested element, if the attempt exceeds 30 minutes.

5.3.4 Failure of the unit for the low energy test

The failure of the unit for the low energy test is meant to represent the failure of a capacitor element with a low level of stored energy. The loading capacitor shall be pre-charged to a voltage level that does not result in a stored parallel energy higher than the one available to a single element as part of a complete unit when the applied voltage is equal to $0{,}9 \times \sqrt{2} \times U_N$. A tolerance in the range from 0 to +10 % on the test voltage is considered acceptable.

5.3.5 Failure of the unit for the high energy test

The failure of the unit for the high energy test is meant to represent the failure of a capacitor element with a high level of stored energy. The loading capacitor shall be pre-charged to a voltage level that does not result in a stored parallel energy lower than the one available to a single element as part of a complete unit when the applied voltage is equal to $3{,}0 \times \sqrt{2} \times U_N$. A tolerance in the range from -10 % to 0 on the test voltage is considered acceptable.

NOTE The voltage level is chosen to represent a restrike on the circuit breaker during the opening of the capacitor bank.

5.4 Test procedure

5.4.1 General

The following test procedure is applicable for both the low and high energy tests.

5.4.2 Discharge test

A discharge test in accordance with Clause 17 of IEC 60871-1:2014 shall be performed on each of the previously failed test units. The desired discharge current shall be calculated based on the ratio of the number of parallel elements in a complete unit and the total current which would result from discharging that complete unit.

The test unit shall be connected in series with a healthy unit which was previously pre-charged with the DC voltage necessary to obtain the desired discharge current. Figure 3 shows the suggested test setup.

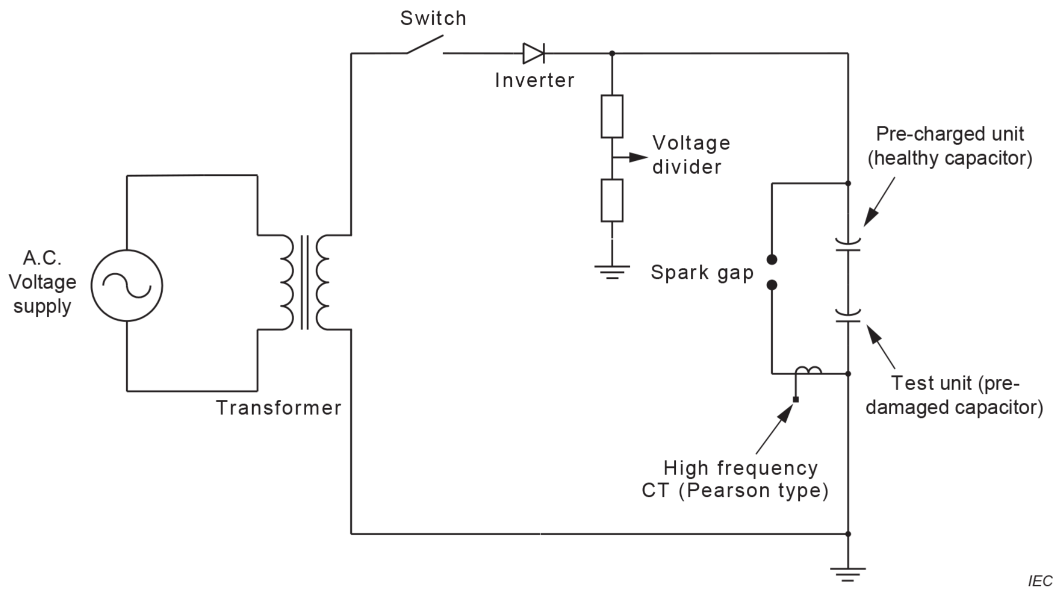

Figure 3 – Electric circuit for the discharge test

5.4.3 Load current test

After subjecting the unit to the discharge test, it shall be placed into a cold chamber at the lowest rated ambient temperature for a period of at least 12 hours. Within five minutes following their removal from the cold chamber, units shall be energized with a current that would circulate if the designed standard unit would have one element shorted at ambient temperature (20 ± 5 °C) and subjected to 1,1 × U_N.

Four temperature sensors shall be placed on the capacitor container, one at the failure location and three at different locations away from the failure.

NOTE It is suggested to place the three sensors near the bottom of the unit.

The test current shall be maintained for a period of 48 hours or until the temperature increase, as measure by the average of the temperature sensors, stabilize to an increase less than 1 K/h for a period of at least five thermal time constants of the unit. Figure 4 shows the suggested test setup.

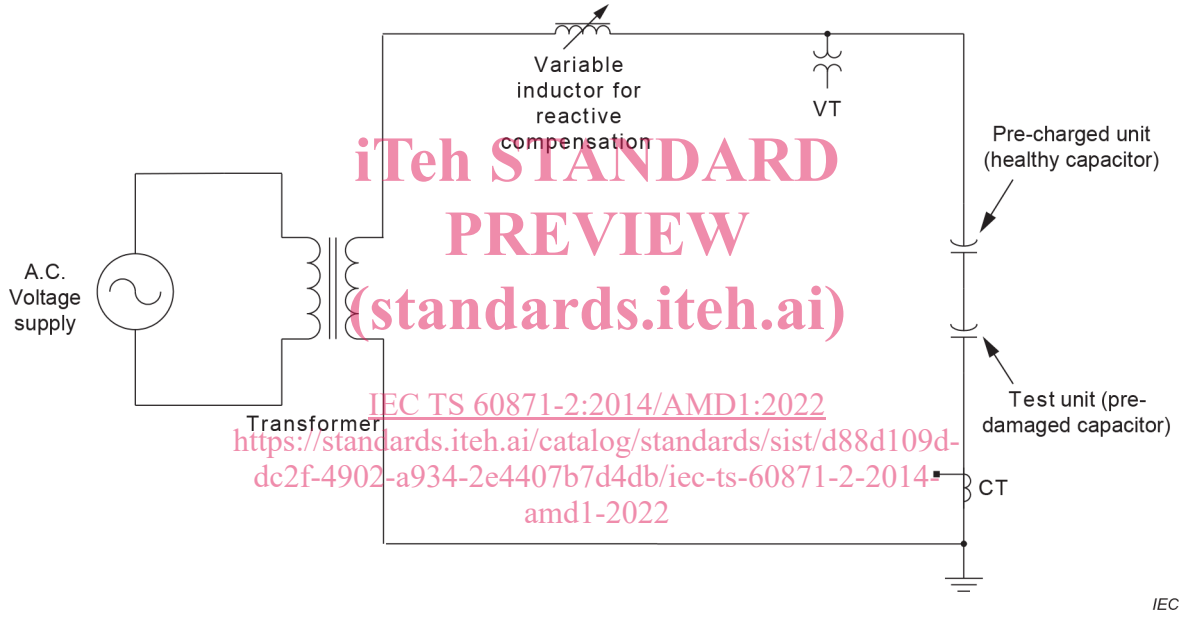

Figure 4 – Electric circuit for the load current test

5.4.4 AC voltage test between terminals and container

The AC voltage test between terminals and container, as described in 15.1 and Clause 18 of IEC 60871-1:2014, shall be performed at 80 % of the test voltage intended for this design, as defined in IEC 60871-1. The duration of the test shall be 60 seconds.

5.5 Success criteria

The test of each unit shall be deemed successful if the following criteria are respected:

a) The discharge test, the load current test and AC voltage test between terminals and container are passed.

b) The container remains sealed; deformations are allowed but no rupture is permitted.

c) The welding of the failed element presents a good electrical and mechanical connection at a visual inspection; burned insulation layers near the location of the punctures are allowed, provided that the units passed the AC voltage test.