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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Power capacitors – Low-voltage power factor correction banks

Condensateurs de puissance – Batteries de compensation du facteur de puissance basse tension

IEC 61921:2017-06(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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.
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International Standard IEC 61921 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This second edition cancels and replaces the first edition published in 2003. It constitutes a technical revision.

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

- numerous changes regarding verification methods to align with IEC 61439-1;
- modification of marking;
- add routine verification of rated output;
- new Annex D with guidance on methods for temperature rise verification;
- update of normative references;
- general editorial review.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
33/607/FDIS	33/611/RVD

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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.

POWER CAPACITORS – LOW-VOLTAGE POWER FACTOR CORRECTION BANKS

1 Scope

This International Standard is applicable to low-voltage AC shunt capacitor banks intended to be used for power factor correction purposes, possibly equipped with a built-in switchgear and controlgear apparatus capable of connecting to or disconnecting from the mains part(s) of the bank with the aim to correct its power factor.

Low-voltage power factor correction banks if not otherwise indicated hereinafter and where applicable comply with the requirements of IEC 61439-1 and IEC 61439-2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61439-1:2011, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61439-2:2011, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

IEC 60831-1:2014, *Shunt power capacitors of the self-healing type for AC 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 60931-1:1996, *Shunt power capacitors of the non-self-healing type for AC 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 61642:1997, *Industrial AC networks affected by harmonics – Application of filters and shunt capacitors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61439-1, IEC 61439-2, IEC 60831-1 and IEC 60931-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
Low-voltage AC capacitor bank or power factor correction bank
Combination of one or more low-voltage capacitor units together with associated switching devices and control, measuring, signalling, protective, regulating equipment, etc., completely

assembled under the responsibility of the assembly manufacturer with all the internal electrical and mechanical interconnections and structural parts

Note 1 to entry: The capacitor bank can be fixed, manually switched or automatically controlled through the use of a power factor controller.

Note 2 to entry: The components of switchgear and controlgear of the automatic bank may be electromechanical or electronic.

3.2
step of capacitor bank
combination of one or more capacitor units switched together through a single switch with possible detuned reactors, connecting wires, and associated switchgear and controlgear apparatus

3.3
automatic reactive power controller
device designed to calculate the reactive power absorbed by the load connected to the power line and to control the switching on and off of the steps of the automatic bank, in order to compensate for the reactive power

Note 1 to entry: The reactive power is normally calculated at the fundamental frequency.

Note 2 to entry: The controller may be “built-in” or “free-standing”.

Note 3 to entry: The controller generally performs functions of measurement / monitoring of power, controlling (of capacitor steps) and protection (of capacitor bank).

3.4
transient inrush current I_t
transient overcurrent of high amplitude and frequency that may occur when a capacitor is switched on, the amplitude and frequency being determined by factors such as the short-circuit impedance of the supply, the amount of energized capacitance switched in parallel and the instant of the switching

3.5
rated reactive power Q_N (of a capacitor bank)
total reactive power of a capacitor bank at the rated frequency and voltage, calculated by the total impedance of the bank including reactors, if any

3.6
maximum permissible current
value of current declared by the manufacturer which can be present continuously in the capacitor bank, used for installation and protection settings

4 Marking of a capacitor bank

The following minimum information shall be given by the manufacturer on a rating plate to be fixed on the capacitor bank.

1) Manufacturer’s name or trademark.
2) Identification number or type designation.
3) Date of manufacture, in clear or code form.
4) Rated reactive power, Q_N in kilovars (kvar).
5) Rated voltage, U_N in volts (V).
6) Rated frequency, f_N in hertz (Hz).
7) Reference to the IEC 61921 standard and its year of publication.

The following information must also be given by the manufacturer, on the rating plate or on instruction sheet.

8) Rating of steps, in kvar.
9) Value of series reactor if any (or reactance ratio in % or tuning frequency).
10) Minimum and maximum ambient temperatures in degrees Celsius (°C).
11) Degree of protection of enclosure.
12) Location type: indoor or outdoor.
13) Rated short time withstand current (I_{cw}).
14) Rated conditional short-circuit current (I_{cc}), if applicable.
15) Maximum permissible current.
16) Rated insulation voltage(U_i).
17) Rated impulse withstand voltage (U_{imp}).

5 Service conditions

See relevant clauses of IEC 61439-1 and IEC 61439-2.

6 Guide for design, installation, operation and safety

6.1 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 a capacitance in a system might 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.

6.2 Design

6.2.1 Choice of rated voltage

The rated voltage of the capacitor bank 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. The service voltage is the actual voltage level experienced by the capacitor bank even if it does not respect the normal tolerances on the rated voltage.

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 capacitor banks, since their performance and life may be adversely affected by an undue increase of the voltage across the capacitor dielectric.

If no information to the contrary is agreed between the manufacturer and the customer, the service voltage shall be assumed as equal to the rated voltage of the network with applicable tolerances.

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

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. Exception will be during temperature rise test of the design verification.

NOTE 1 An excessive safety margin in the choice of the rated voltage of the capacitor units has to be avoided, because this would result in a decrease of reactive power output when compared with the rated reactive power output.

NOTE 2 See IEC 60831-1 concerning maximum permissible voltage.

6.2.2 Switching and overload protection

Capacitor overload capacities are given in IEC 60831-1 and in IEC 60931-1. These limits are however larger than the ones applicable for the banks. The switching and protective devices and the connections shall be designed to carry continuously a current of at least 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.

The switching and protective devices and the connections shall also 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 bank or a step is switched in parallel with others that are already energized. Care should be taken not to exceed the maximum permissible switching current of capacitors and switching devices.

Some of the techniques used to reduce the switching transient include use of series reactors, use of capacitor duty contactors with pre-charging resistors or solid state switches. When consideration of electrodynamic and thermal stresses runs the risk of leading to excessive dimensions, special precautions, such as those mentioned in IEC 60831-1 for the purpose of protection against overcurrents, should be taken.

In certain cases, for example when the banks are automatically controlled, repeated switching operations may occur at relatively short intervals of time. Switching and protection devices should be selected to withstand these conditions.

It is recommended that capacitors be protected against overcurrent by means of suitable overcurrent devices when the current exceeds the permissible limit specified in IEC 60831-1 and IEC 60931-1. Fuses do not generally provide suitable overcurrent protection.

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.

6.3 Installation and operation

6.3.1 Electrical environment

6.3.1.1 Harmonics

The connection of a capacitor bank onto a system containing harmonics may reduce its life time. The damaging effects of harmonics can be mitigated by the use of a suitable detuning reactor in series with each capacitor step.

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

More detailed information can be found in IEC 61642.

6.3.1.2 Switching overvoltages

Switching overvoltages internally generated due to the operation of the capacitor bank should be avoided or minimized. Such switching overvoltages if any shall not exceed the limits prescribed in the IEC 60831-1 or IEC 60931-1. If switching components are selected which are specifically recommended for capacitor applications, the problem should not arise. Nevertheless, equipment does deteriorate with time and worn contacts should be replaced during regular maintenance checks.

6.3.2 Secondary effects of the capacitor bank

6.3.2.1 Harmonic distortion

A capacitor bank when connected onto a system where harmonics are being generated will generally increase the amplitude of the harmonics, unless a well suited detuning reactor is placed in series with each capacitor step.

The increase in harmonics will not only affect the life of the capacitors but could cause problems with other electric and electronic equipment in the system.

6.3.2.2 Attenuation of injected ripple control signal

Ripple control signals are provided by electricity authorities for the control and switching of off-peak loads (e.g. hot water heaters, street lighting, etc).

A capacitor bank may cause significant decrease of the ripple control signal. This can be prevented by increasing the impedance at the frequency of that signal by connecting rejection or blocking circuits in series to the capacitors units.

6.3.3 Overvoltages

IEC 60831-1 and IEC 60931-1 specify overvoltage factors.

With the manufacturer’s agreement, the overvoltage factor may be increased.

6.3.4 Overload currents

Before ordering a capacitor bank, consideration should be given to checking the conditions in the system at the place of installation (for instance, presence of harmonic distortion, or use of ripple control frequencies).

Capacitors should never be operated with currents exceeding the maximum value specified in IEC 60831-1 or IEC 60931-1.

6.4 Safety

6.4.1 Discharging devices

6.4.1.1 General

Each capacitor bank or step shall be provided with means for discharging the capacitors (as for IEC 60831-1 or IEC 60931-1) after disconnection from the network.

The specified discharging times may be met by applying either internal (incorporated) discharge resistors on each capacitor or external discharge devices rated for the entire capacitor equipment.

Before touching any live parts, allow at least 5 min for the bank to self-discharge and then short-circuit each capacitor terminal together and ground.

6.4.1.2 Internal resistors

Internal resistors are generally built into the individual capacitors. They are designed to ensure the discharge of each capacitor and therefore the whole bank. In a bank with several sections of capacitors in series, the residual voltage on the bank terminal is equal to the sum of the residual voltage in each section.

6.4.1.3 External discharge devices

External discharge devices may be used. Each device should be adapted to the conditions existing at the site of erection of the equipment and have suitable clearance, creepage path and insulation level. If the capacitors have no internal discharge resistors, there shall be no switching device between the capacitor and the discharge device.

Discharge reactors may be used, connected directly in parallel with the capacitor steps. Usually, two reactors are connected line-to-line across two phases because of economic reasons. Under operating conditions, only the magnetizing current flows in the reactor. When the capacitor equipment is switched off, all the energy stored circulates through the coil in a few seconds. Most of the energy is dissipated in the reactor. The number of discharges per unit of time should be restricted so that no overheating of the discharge reactor occurs.

Windings of transformers or motors may be considered as suitable impedances as well as the primary of voltage transformers.

6.4.2 Discharging after disconnection

A disconnected capacitor installation should completely self-discharge no matter where the discharge device is located, be it directly at each capacitor or at the connecting terminals of the equipment.

However, a capacitor installation comprising series connections and star connections, which have undergone puncturing or internal or external arcing, may not be discharged completely through discharge devices connected to the terminals of the capacitor installation. Although there is no voltage measurable at the equipment terminals, dangerous amounts of stored energy may exist in the bank. These so-called “trapped charges” may persist over a period of several months and can only be discharged by individual discharging of each section of the bank.

It is important to note that a discharging device is not a substitute for short-circuiting the capacitor terminals together and to ground before and during handling.