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colour inside

Power capacitors – Low-voltage power factor correction banks

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POWER CAPACITORS – LOW-VOLTAGE POWER FACTOR CORRECTION BANKS

FOREWORD

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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- withdrawn,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.

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**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 ~~shall~~ comply with the requirements of ~~IEC 60439-1 and those of IEC 60439-3~~ 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 60439-1:1999, *Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*~~

~~IEC 60439-3:1990, *Low-voltage switchgear and controlgear assemblies – Part 3: Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use – Distribution boards*~~

IEC 60831-1:~~1996~~ 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 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 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 60439-1,~~ 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: Throughout this standard, the abbreviations "automatic bank" and "assembly" are used for a low-voltage a.c capacitors automatic or non-automatic bank.~~

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
~~**step**~~
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 ~~regulator~~
controller
~~circuit~~ 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" ~~and has usually to be adjusted for each bank before operation~~.

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 ~~an assembly~~ a capacitor bank)
total reactive power of ~~an assembly~~ 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 ~~in an instruction sheet or alternatively, on request of the purchaser,~~ on a rating plate to be fixed on the ~~assembly~~ 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) ~~Short-circuit withstand strength, in amperes (A)~~
   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.

~~**5.2 Choice of components**~~

~~The choice of components of an assembly shall be carried out with careful reference to compliance between their ambient air temperature category and that of the assembly itself.~~

6.2 Design

~~**5.3.1 Power factor correction system enclosed within a main switchboard**~~

~~The equipment needed for the automatic correction of power factor in an installation, including controller, fuses, switching devices, capacitors and reactors (chokes), can be installed as an integral part of the main switchboard.~~

~~This equipment can be also installed in a separate shell of the main board or simply as an added part in the common main switchboard shell.~~

~~**5.3.2 Free standing power factor correction system**~~

~~The equipment is free standing and usually installed adjacent or close to the main switchboard or relevant sub-board. It generally has a main bus bar arrangement of the required fault level to match the adjacent main switchboard or sub-board or the required fault current of that section of the installation.~~

~~This bus bar section is bus barred or cabled back to the main supply of the installation.~~

~~Feeding off this bus bar section is a group of fuses, circuit-breakers or fused switch which are wired to a switching device and then to the capacitor banks.~~

~~**5.3.3 Automatic power factor correction system with remote mounted capacitors**~~

~~All components except for the capacitors are mounted in the control cubicle.~~

~~The capacitors and the required reactors, if any, are mounted on a remote mounting rack. This arrangement is generally used if there is a problem with space requirements or to allow further dissipation of heat.~~

~~It is important to note that power factor component equipment such as fuses, capacitors, reactors, etc. generate a significant amount of heat.~~

~~**5.3.4 Compartmentalization**~~

~~The general arrangement of a power factor correction assembly can be made in sections, which can be arranged in separate compartments or in a single configuration:~~

~~a) bus bar, main connection and/or main isolation;~~

~~b) capacitor bank fuses or circuit-breakers and/or contactors;~~

~~c) reactors for harmonic control purposes;~~

~~d) capacitors;~~

~~e) control fuses, terminals and controller.~~

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 ~~available~~ agreed between the manufacturer and the customer, the service voltage shall be assumed as equal to the rated ~~(or declared)~~ 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 ~~U_N~~ of the capacitor units ~~should~~ 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.

~~**5.3.6 Special service conditions**~~

~~Apart from the conditions prevailing at both limits of the temperature category, the most important conditions about which the manufacturer shall be informed 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 certain kinds of paints or 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 atmosphere might 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. Choice of type of capacitor should be made by agreement between purchaser and manufacturer.

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. It is common practice to increase the inductance of the connections in order to reduce switching current, although this increases the total losses. 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.

NOTE 1 In certain cases, for example when the banks are automatically controlled, repeated switching operations may occur at relatively short intervals of time. Switchgear and fuses Switching and protection devices should be selected to withstand these conditions.

NOTE 2 Switching devices connected to a busbar which is also connected to a bank, may be subjected to special stress in the event of switching on a short-circuit.

NOTE 3 Devices for switching parallel steps and their associated protective equipment should 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 adjustable to operate the switching 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.

NOTE 4 Depending on the design of capacitors, their capacitance will vary more or less with the temperature.If iron-core 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.

5.3.8 International protection designation (IP)

Most panels are installed in main switch rooms or adjacent to main boards: in these conditions, IP20 may be sufficient. Other IP levels should be agreed between manufacturer and purchaser.

Degrees of protection (IP rating) for assemblies to be installed outdoor may be increased up to IP54. Careful consideration is to be paid to the design of the ventilation of the cubicle.

5.3.9 Accessibility of components

The cubicle and equipment shall be arranged so that in the event of a component failure, components can be easily replaced.

The arrangement of cabling to the capacitor(s) should allow easy regular maintenance checks.

6.3 Installation and operation

6.3.1 Electrical environment

6.3.1.1 Harmonics

The connection of PFC (power factor correction) equipment a capacitor bank onto a system containing harmonics may reduce the life of the PFC equipment 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.

5.4.1.2 Voltage spikes

Voltage spikes should be avoided. 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.

5.4.1.3 Load assessment

The decision of where to apply the power factor correction is determined by a number of factors, including cost and available space:

a) determine where the loads with the low power factor are situated: the PFC can be located at these points;

b) generally, it is more practical to locate PFC at the main switchboard, where space is available. In this case, the PFC will correct the power factor of the whole load and maintenance of the PFC is in one location.

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 ~~PFC system~~ capacitor bank

6.3.2.1 Harmonic distortion

~~PFC equipment~~ 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).

~~If the PFC equipment causes significant loss of the audio frequency signal, the impedance to the frequency may be increased by connecting rejection or stopper circuits in series to the capacitors units, which will prevent interference to the frequency injection control system of the electricity authority concerned.~~

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.

~~5.4.2.3 Rise of ambient temperature~~

~~PFC equipment produces heat from the losses developed in capacitors, reactors, resistors, coils, etc. This heat adds to the ambient temperature in the surrounding area. It is important to ensure that adequate ventilation is provided in the operating room in order to maintain good air circulation around the PFC unit.~~

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 ~~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 superimposed on them. The peak voltage shall not exceed $\sqrt{2}$ times the given r.m.s. value.~~

~~Capacitor banks that are liable to be subjected to high overvoltages due to lightning should be adequately protected.~~

6.3.4 Overload currents

Before ordering ~~PFC equipment~~ 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.

~~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 capacitor banks at times of light load.

If the capacitor current exceeds the maximum value specified in IEC 60831-1, while the voltage is within the permissible limit of 1,10 U_N specified in IEC 60831-1, the predominant harmonic should be determined in order to find the best remedy.

The following remedies should be considered:

a) move some or all of the capacitor units to other parts of the system fed by another transformer;
b) connect a reactor in series with the capacitor unit, to lower the resonant frequency of the circuit to a value below that of the disturbing harmonic.

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

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

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

The peak value of the overcurrents due to switching operations shall be limited to a maximum of 100 I_N (r.m.s. value) or to the maximum capability of the contactors, whichever is the smaller.

6.4 Safety

6.4.1 Discharging devices

6.4.1.1 General

Each capacitor bank or step should shall be provided with means for discharging the bank 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 ~~strike distance~~ clearance, creepage path and insulation level. If the capacitors have no internal discharge resistors, there ~~should~~ shall be no ~~isolating~~ switching device between the capacitor ~~bank~~ 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.

6.4.3 Fire hazard in case of failure

Capacitors contain flammable materials, i.e. dielectric film and/or paper, oil, etc. The bank should be arranged with consideration of a possible fire hazard in case of a failure of a component. The two areas to be considered are as follows:

a) Adjacent areas to the capacitors. Normally capacitors are manufactured in metal cans or are installed in a segregated metal section or separated from other components by metal barriers. Power and control cables in these areas should be kept to a minimum and carefully cabled, so as to avoid direct contact to capacitor cases.

b) Adjacent areas around the reactors. Where reactors (chokes and filters) are installed, power and control cables should be kept to a minimum around these components or at least supported away from the laminated steel cores of these components.

6.4.4 Human and property damage

~~The manufacture of the assembly should have components arranged in a manner so that when carrying out maintenance, personnel are not subject to accidental arcing faults. Capacitors with a rating of, say, 50 kvar, will develop quite a heavily interrupting arc if fuses are extracted without first isolating the bank via the controlling device.~~

~~The same will apply if the fuse is inserted while the continuity of the circuit is present.~~

Any maintenance operation shall be undertaken after isolation of the complete capacitor bank (or sections) providing that the safety operations described by IEC 61439-1 are observed. The minimum discharge time as per 6.4.1.1 shall also be observed.

6.4.5 Busbar

~~The bus bar section of power factor assemblies shall withstand, as a minimum, the fault currents of the system at the point where it is intended to be connected. Usually, these assemblies are connected onto a section of the main installation where the fault currents are quite high.~~

~~If the manufacturer specifies a current-limiting device at the connection point of the equipment, the withstand test shall be carried out with this type of device connected in the circuit.~~

For details, refer to IEC 61439-1.

6.4.6 Connection of systems

The bus bar system in these ~~assemblies~~ capacitor banks shall be arranged so that cables or bus bars to be connected and extended to the installation have sufficient area for take-off. If cables are used for this extension, they are usually of a large cross-sectional area and shall be of a suitable size to take the required rated current and fault current of the system.

For details, refer to IEC 61439-1.

~~6 Electromagnetic compatibility~~

~~The relevant clauses of the standards concerning capacitors (see Clause 2, Normative references) apply with the following additions.~~

~~6.1 Emission~~

~~Under normal service conditions, power capacitors do not produce any electromagnetic disturbance. Electromagnetic disturbances can only be generated by assemblies during switching operations (connection or disconnection of steps) and are limited to switching overvoltages, the duration of which is measured in milliseconds. If the controller is regulated so as to limit the number of switching operations to not more than 5/min, the requirements of electromagnetic emission are deemed to be satisfied and no verification is necessary.~~

~~6.2 Immunity~~

~~Assemblies not incorporating electronic equipment are not sensitive to normal electro-magnetic disturbances, and therefore no immunity tests are required.~~

~~6.3 Assemblies incorporating electronic equipment~~

~~Electronic equipment (i.e. the controller) incorporated in assemblies shall comply with the immunity and emission requirements of the relevant IEC standard(s).~~

~~7 Tests~~

~~7.1 Classification of tests~~

~~The tests to verify the characteristics of an assembly include:~~

~~a) type tests (see 7.1.1 and 7.2);~~

b) routine tests (see 7.1.2 and 7.3).

The manufacturer shall, on request, specify the basis for the verifications.

NOTE For verifications and tests to be performed on TTA and PTTA, see IEC 60439-1.

7.1.1 Type tests (see 7.2)

Type tests are intended to verify compliance with the requirements laid down in this standard for a given type of assembly.

Type tests shall be carried out on a sample of an assembly or on parts of assemblies manufactured to the same, or similar design, and under the responsibility of the manufacturer.

Type tests include:

a) verification of temperature-rise limits (see 7.2.1);
b) verification of dielectric properties (see 7.2.2) ;
c) verification of the short-circuit withstand strength (see 7.2.3) ;
d) verification of the effectiveness of the protective circuit (see 7.2.4) ;
e) verification of clearances and creepage distances (see 7.2.5) ;
f) verification of mechanical operation (see 7.2.6) ;
g) verification of the degree of protection (see 7.2.7).

These tests may be carried out in any order and/or on different samples of the same type.

If modifications are made to the components of the assembly, new type tests shall be carried out, but only in so far as such modifications are likely to adversely affect the result of these tests.

7.1.2 Routine tests (see 7.3)

Routine tests are intended to detect faults in materials and workmanship. They shall be carried out on every new assembly after its construction, or on each transport unit (see IEC 60439-1). Another routine test at the place of installation is not required.

Assemblies which are constructed from standardized components not coming from the manufacturer's workshop but making exclusive use of parts and accessories specified or supplied by the manufacturer, shall be routine tested by the firm which has constructed the assembly.

Routine tests include:

a) inspection of the assembly including inspection of wiring and, if necessary, an electrical operation test (see 7.3.1);
b) dielectric test (see 7.3.2);
c) checking of protective measures and of the electrical continuity of the protective circuit (see 7.3.3);
d) verification of insulation resistance (see 7.3.4).

These tests may be carried out in any order.

NOTE The performance of the routine tests at the manufacturer's plant does not relieve the firm installing the assembly from the duty of checking it after transport and installation.

~~7.1.3 Testing of devices and self-contained components incorporated in the assembly~~

~~Type tests and/or routine tests are not required to be carried out on devices and self-contained components incorporated in the assembly when they have been selected in accordance with 5.3.7 and installed in accordance with the instructions of the manufacturer.~~

~~7.2 Type tests~~

~~7.2.1 Verification of temperature-rise limits~~

~~See the relevant clauses of IEC 60439-1 with the following modification:~~

~~The design current shall allow for overcurrents to which capacitors are inherently susceptible, taking special account of the presence of reactors. In the absence of any reactor or other current control device, the design current shall be no less than 1,3 times the rated current.~~

~~When protection or control systems are provided which limit the maximum current, then the test current shall correspond to this maximum current. If no such limiting device is provided, the test current shall be 1,2 times the rated current.~~

~~One (or a combination) of the following methods can obtain the test current level: increase the test voltage, increase the test frequency, increase the capacitor value or superimpose the harmonic current.~~

~~7.2.2 Verification of dielectric properties~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.2.3 Verification of short-circuit withstand strength~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.2.4 Verification of the effectiveness of the protection circuit~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.2.5 Verification of clearances and creepage distances~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.2.6 Verification of mechanical operation~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.2.7 Verification of degree of protection~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.3 Routine tests~~

~~7.3.1 Inspection of the assembly including inspection of wiring and, if necessary, electrical operation test~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.3.2 Dielectric test~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.3.3 Verification of protective measures and of the electrical continuity of the protective circuits~~

~~See the relevant clauses of IEC 60439-1.~~

~~7.3.4 Verification of insulation resistance~~

~~See the relevant clauses of IEC 60439-1.~~

7 Design verification

7.1 General

Design verification is intended to verify compliance with the requirements laid down in this standard for a given type of capacitor bank.

Design verification shall be carried out on a sample of a capacitor bank manufactured to the same, or similar design, and under the responsibility of the manufacturer. (Refer Annex C for definition of similarity of design).

The design verification may be carried out in any order and/or on different samples of the same type.

7.2 Strength of material and parts

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

7.3 Verification of degree of protection of enclosures

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

7.4 Verification of clearances and creepage distances

See the relevant clauses of IEC 61439-1.

7.5 Protection against electric shock and integrity of protective circuits

See the relevant clauses of IEC 61439-1.

7.6 Incorporation of switching devices and components

See the relevant clauses of IEC 61439-1.

7.7 Internal electrical circuits and connections

See the relevant clauses of IEC 61439-1.

7.8 Terminals for external conductors

See the relevant clauses of IEC 61439-1.

7.9 Verification of dielectric properties

For this test, all the electrical equipment of the capacitor bank shall be connected, except those items of apparatus which, according to the relevant specifications, are

– designed for a lower test voltage;

– current-consuming apparatus (e.g. capacitors, windings, measuring instruments, voltage surge suppression devices) in which the application of the test voltage would cause the flow of a current,

shall be disconnected. Such apparatus shall be disconnected at one of their terminals unless they are not designed to withstand the full test voltage, in which case all terminals may be disconnected.

For electromechanically switched capacitor banks, see the relevant clauses of IEC 61439-1 and IEC 61439-2.

For solid state switched capacitor banks, choice of testing method should be made by agreement between purchaser and manufacturer.

7.10 Verification of temperature-rise limits

See the relevant clauses of IEC 61439-1 with the following modifications:

– the test current shall be at least 1,2 times the rated current;

– the calculation method proposed in IEC 61439-1 is not allowed.

In case any system would limit the current to a lower value than 1,2, then the test shall correspond to such limited value.

One (or a combination) of the following methods can obtain the test current level: increase the test voltage, increase the test frequency or increase the capacitor value (see Annex D).

Special service temperature requests by customer can also be tested according to the procedure described in IEC 61439-1.

7.11 Verification of short-circuit withstand strength

See the relevant clauses of IEC 61439-1.

7.12 Electromagnetic compatibility

See the relevant clauses of IEC 61439-1.

7.13 Verification of mechanical operation

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

8 Routine verification

8.1 General

Routine verification is intended to detect faults in materials and workmanship. It shall be carried out on every new capacitor bank after its construction, or on each transport unit (see IEC 61439-1). Another routine verification at the place of installation is not required.

These tests may be carried out in any order, providing that test 8.4 is done first.

8.2 Degree of protection of enclosures

See the relevant clauses of IEC 61439-1.

8.3 Clearances and creepage distances

See the relevant clauses of IEC 61439-1.

8.4 Protection against electric shock and integrity of protective circuits

See the relevant clauses of IEC 61439-1.

8.5 Incorporation of built-in components

See the relevant clauses of IEC 61439-1.

8.6 Internal electrical circuits and connections

See the relevant clauses of IEC 61439-1.

8.7 Terminals for external conductors

See the relevant clauses of IEC 61439-1.

8.8 Mechanical operation

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

8.9 Dielectric properties

For this test, all the electrical equipment of the capacitor bank shall be connected, except those items of apparatus which, according to the relevant specifications, are

– designed for a lower test voltage;
– current-consuming apparatus (e.g. capacitors, windings, measuring instruments, voltage surge suppression devices) in which the application of the test voltage would cause the flow of a current,

shall be disconnected. Such apparatus shall be disconnected at one of their terminals unless they are not designed to withstand the full test voltage, in which case all terminals may be disconnected.

For electromechanically switched capacitor banks, see the relevant clauses of IEC 61439-1.

For solid state switched capacitor banks, choice of testing method should be made by agreement between purchaser and manufacturer.

The alternate method proposed in the IEC 61439-1 (Verification of insulation resistance) is also applicable.

8.10 Wiring, operational performance and function, including verification of rated output

See the relevant clauses of IEC 61439-1.

The verification of the rated output is performed to ascertain the rated reactive power output of capacitor bank at rated voltage and frequency. The test can be performed by two methods.

a) Measurement of net capacitance impedance (considering the series inductance if any) and computed output extrapolated to rated voltage and frequency
b) Measurement of current by application of voltage and extrapolate to rated voltage and frequency

The computed / measured output shall be within the tolerances specified in the IEC 60831-1 or IEC 60931-1.

NOTE The performance of the routine tests at the manufacturer's plant does not relieve the firm installing the capacitor bank from the duty of checking it after transport and installation.

Annex A
(normative)

Minimum and maximum cross-sections of copper conductors suitable for connections

See the relevant annex of IEC ~~60439-1~~ 61439-1.

While selecting the size of copper conductors, the maximum permissible current and its harmonic spectrum shall be considered.

~~Annex B~~
~~(normative)~~

~~Method of calculating the cross-sectional area of protective conductors with regard to thermal stresses due to currents of short-duration~~

~~See the relevant annex of IEC 60439-1.~~

~~Annex C~~
~~(informative)~~

~~Typical examples of assemblies~~

~~See the relevant annex of IEC 60439-1.~~

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 capacitance measured between any two-line terminals of a three-phase capacitor, either delta or star connection, is denoted as C_a, C_b and C_c. If the symmetry requirements laid down in IEC 60831-1 and IEC 60931-1 are fulfilled, the output Q of the capacitor can be computed with sufficient accuracy from the formula:

$$Q = 2/3\ (C_a + C_b + C_c)\quad \omega \quad U_N^2 \quad 10^{-12}$$

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:

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

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 to rise, given by the following expression:

$$\Delta U/U \approx Q/S$$

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).

B.4 Inrush transient current

B.4.1 Switching in of a single capacitor

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

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)

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

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

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 reactance 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

$$R \leq t / [k\ C \ln (U_N \sqrt{2}/U_R)]$$

where

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

R is the discharge resistance in megohms (MΩ);

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

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

U_R is the permissible residual voltage in volts (V) (see IEC 60831-1 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 IEC 60831-1 and IEC 60931-1).

Annex C
(informative)

Definition of similar designs for capacitor bank

Capacitor banks can be considered as similar providing that the mechanical construction and electrical design are similar. For instance, rated power, materials used, clearances, power losses level and distribution, cabinet size, cooling methods should not change from one design to the other.

Banks with similar construction but lower electrical and thermal stresses are automatically qualified by verification of the design of the higher stressed design.

Design parameters that can impact the stresses could include the following items (non-exhaustive list):

– IP degree
– Bus bar and cable current density
– Type of switching device
– Type of reactor (if any)
– Cooling system
– Incoming switching device
– Components position

etc.

Annex D
(informative)

Methods for connecting additional capacitors for performing temperature rise test

Increasing the capacitance value should be done in a way that all the extra losses it is creating affects the internal temperature rise of the capacitor bank.

Some of the possible manner for connection of this additional capacitance is as illustrated in Figure D.1, providing that the layout remains the same.

Configuration (a): Additional capacitor(s) outside the enclosure – Not allowed.

Configuration (b): Complete additional step(s) in parallel with the rated ones inside the enclosure – Not allowed.

Configuration (c): Additional capacitor(s) in parallel with the rated ones inside the enclosure – Allowed.

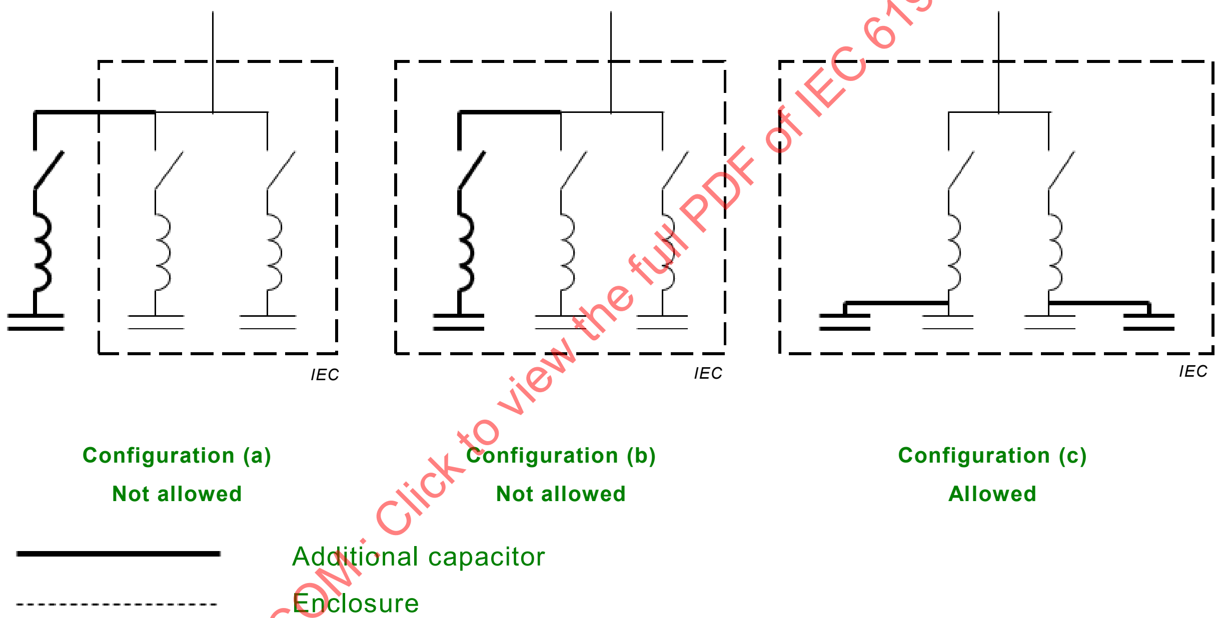

Figure D.1 – Configurations for temperature rise test

Bibliography

~~Additional useful information may be found in the following standards:~~

IEC 60050-436:1990, *International Electrotechnical Vocabulary. Chapter 436: Power capacitors*

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

IEC 60831-2:~~1995~~ 2014, *Shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1 000 V – Part 2: Ageing test, self-healing test and destruction test*

IEC 60931-2:1995, *Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1 000 V – Part 2: Ageing test and destruction test*

IEC 60931-3:1996, *Shunt ~~power~~ capacitors of the non-self-healing type for AC power systems having a rated voltage up to and including 1 000 V – Part 3: Internal fuses*

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 TR 61000-4-1:~~2000~~ 2016, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – Overview of IEC 61000-4 series*

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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)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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POWER CAPACITORS – LOW-VOLTAGE POWER FACTOR CORRECTION BANKS

FOREWORD

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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.

6.4.3 Fire hazard in case of failure

Capacitors contain flammable materials, i.e. dielectric film and/or paper, oil, etc. The bank should be arranged with consideration of a possible fire hazard in case of a failure of a component. The two areas to be considered are as follows:

a) Adjacent areas to the capacitors. Normally capacitors are manufactured in metal cans or are installed in a segregated metal section or separated from other components by metal barriers. Power and control cables in these areas should be kept to a minimum and carefully cabled, so as to avoid direct contact to capacitor cases.

b) Adjacent areas around the reactors. Where reactors (chokes and filters) are installed, power and control cables should be kept to a minimum around these components or at least supported away from the laminated steel cores of these components.

6.4.4 Human and property damage

Any maintenance operation shall be undertaken after isolation of the complete capacitor bank (or sections) providing that the safety operations described by IEC 61439-1 are observed. The minimum discharge time as per 6.4.1.1 shall also be observed.

6.4.5 Busbar

For details, refer to IEC 61439-1.

6.4.6 Connection of systems

The bus bar system in these capacitor banks shall be arranged so that cables or bus bars to be connected and extended to the installation have sufficient area for take-off. If cables are used for this extension, they are usually of a large cross-sectional area and shall be of a suitable size to take the required rated current and fault current of the system.

For details, refer to IEC 61439-1.

7 Design verification

7.1 General

Design verification is intended to verify compliance with the requirements laid down in this standard for a given type of capacitor bank.

Design verification shall be carried out on a sample of a capacitor bank manufactured to the same, or similar design, and under the responsibility of the manufacturer. (Refer Annex C for definition of similarity of design).

The design verification may be carried out in any order and/or on different samples of the same type.

7.2 Strength of material and parts

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

7.3 Verification of degree of protection of enclosures

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

7.4 Verification of clearances and creepage distances

See the relevant clauses of IEC 61439-1.

7.5 Protection against electric shock and integrity of protective circuits

See the relevant clauses of IEC 61439-1.

7.6 Incorporation of switching devices and components

See the relevant clauses of IEC 61439-1.

7.7 Internal electrical circuits and connections

See the relevant clauses of IEC 61439-1.

7.8 Terminals for external conductors

See the relevant clauses of IEC 61439-1.

7.9 Verification of dielectric properties

For this test, all the electrical equipment of the capacitor bank shall be connected, except those items of apparatus which, according to the relevant specifications, are

- designed for a lower test voltage;
- current-consuming apparatus (e.g. capacitors, windings, measuring instruments, voltage surge suppression devices) in which the application of the test voltage would cause the flow of a current,

shall be disconnected. Such apparatus shall be disconnected at one of their terminals unless they are not designed to withstand the full test voltage, in which case all terminals may be disconnected.

For electromechanically switched capacitor banks, see the relevant clauses of IEC 61439-1 and IEC 61439-2.

For solid state switched capacitor banks, choice of testing method should be made by agreement between purchaser and manufacturer.

7.10 Verification of temperature-rise limits

See the relevant clauses of IEC 61439-1 with the following modifications:

- the test current shall be at least 1,2 times the rated current;
- the calculation method proposed in IEC 61439-1 is not allowed.

In case any system would limit the current to a lower value than 1,2, then the test shall correspond to such limited value.

One (or a combination) of the following methods can obtain the test current level: increase the test voltage, increase the test frequency or increase the capacitor value (see Annex D).

Special service temperature requests by customer can also be tested according to the procedure described in IEC 61439-1.

7.11 Verification of short-circuit withstand strength

See the relevant clauses of IEC 61439-1.

7.12 Electromagnetic compatibility

See the relevant clauses of IEC 61439-1.

7.13 Verification of mechanical operation

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

8 Routine verification

8.1 General

Routine verification is intended to detect faults in materials and workmanship. It shall be carried out on every new capacitor bank after its construction, or on each transport unit (see IEC 61439-1). Another routine verification at the place of installation is not required.

These tests may be carried out in any order, providing that test 8.4 is done first.

8.2 Degree of protection of enclosures

See the relevant clauses of IEC 61439-1.

8.3 Clearances and creepage distances

See the relevant clauses of IEC 61439-1.

8.4 Protection against electric shock and integrity of protective circuits

See the relevant clauses of IEC 61439-1.

8.5 Incorporation of built-in components

See the relevant clauses of IEC 61439-1.

8.6 Internal electrical circuits and connections

See the relevant clauses of IEC 61439-1.

8.7 Terminals for external conductors

See the relevant clauses of IEC 61439-1.

8.8 Mechanical operation

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

8.9 Dielectric properties

For this test, all the electrical equipment of the capacitor bank shall be connected, except those items of apparatus which, according to the relevant specifications, are

– designed for a lower test voltage;
– current-consuming apparatus (e.g. capacitors, windings, measuring instruments, voltage surge suppression devices) in which the application of the test voltage would cause the flow of a current,

shall be disconnected. Such apparatus shall be disconnected at one of their terminals unless they are not designed to withstand the full test voltage, in which case all terminals may be disconnected.

For electromechanically switched capacitor banks, see the relevant clauses of IEC 61439-1.

For solid state switched capacitor banks, choice of testing method should be made by agreement between purchaser and manufacturer.

The alternate method proposed in the IEC 61439-1 (Verification of insulation resistance) is also applicable.

8.10 Wiring, operational performance and function, including verification of rated output

See the relevant clauses of IEC 61439-1.

The verification of the rated output is performed to ascertain the rated reactive power output of capacitor bank at rated voltage and frequency. The test can be performed by two methods.

a) Measurement of net capacitance impedance (considering the series inductance if any) and computed output extrapolated to rated voltage and frequency

b) Measurement of current by application of voltage and extrapolate to rated voltage and frequency

The computed / measured output shall be within the tolerances specified in the IEC 60831-1 or IEC 60931-1.

NOTE The performance of the routine tests at the manufacturer's plant does not relieve the firm installing the capacitor bank from the duty of checking it after transport and installation.

Annex A
(normative)

Minimum and maximum cross-sections of copper conductors suitable for connections

See the relevant annex of IEC 61439-1.

While selecting the size of copper conductors, the maximum permissible current and its harmonic spectrum shall be considered.

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 capacitance measured between any two-line terminals of a three-phase capacitor, either delta or star connection, is denoted as C_a, C_b and C_c. If the symmetry requirements laid down in IEC 60831-1 and IEC 60931-1 are fulfilled, the output Q of the capacitor can be computed with sufficient accuracy from the formula:

$$Q = 2/3\ (C_a + C_b + C_c)\quad \omega \quad U_N^2 \quad 10^{-12}$$

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:

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

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 to rise, given by the following expression:

$$\Delta U/U \approx Q/S$$

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).

B.4 Inrush transient current

B.4.1 Switching in of a single capacitor

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

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)

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

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

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 reactance 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

$$R \le t / [k\ C \ln (U_N \sqrt{2}/U_R)]$$

where

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

R is the discharge resistance in megohms (MΩ);

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

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

U_R is the permissible residual voltage in volts (V) (see IEC 60831-1 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 IEC 60831-1 and IEC 60931-1).

Annex C
(informative)

Definition of similar designs for capacitor bank

Capacitor banks can be considered as similar providing that the mechanical construction and electrical design are similar. For instance, rated power, materials used, clearances, power losses level and distribution, cabinet size, cooling methods should not change from one design to the other.

Banks with similar construction but lower electrical and thermal stresses are automatically qualified by verification of the design of the higher stressed design.

Design parameters that can impact the stresses could include the following items (non-exhaustive list):

– IP degree
– Bus bar and cable current density
– Type of switching device
– Type of reactor (if any)
– Cooling system
– Incoming switching device
– Components position

etc.

Annex D
(informative)

Methods for connecting additional capacitors for performing temperature rise test

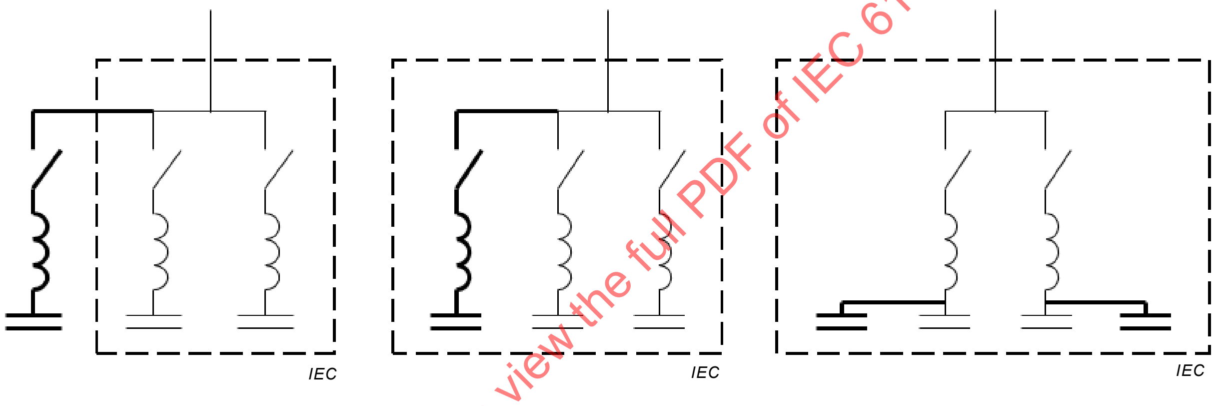
Increasing the capacitance value should be done in a way that all the extra losses it is creating affects the internal temperature rise of the capacitor bank.

Some of the possible manner for connection of this additional capacitance is as illustrated in Figure D.1, providing that the layout remains the same.

Configuration (a): Additional capacitor(s) outside the enclosure – Not allowed.

Configuration (b): Complete additional step(s) in parallel with the rated ones inside the enclosure – Not allowed.

Configuration (c): Additional capacitor(s) in parallel with the rated ones inside the enclosure – Allowed.



Configuration (a) **Not allowed**

Configuration (b) **Not allowed**

Configuration (c) **Allowed**

——— Additional capacitor

- - - - - - Enclosure

Figure D.1 – Configurations for temperature rise test

Bibliography

IEC 60050-436:1990, *International Electrotechnical Vocabulary. Chapter 436: Power capacitors*

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

IEC 60831-2:2014, *Shunt power capacitors of the self-healing type for AC systems having a rated voltage up to and including 1 000 V – Part 2: Ageing test, self-healing test and destruction test*

IEC 60931-2:1995, *Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1 000 V – Part 2: Ageing test and destruction test*

IEC 60931-3:1996, *Shunt capacitors of the non-self-healing type for AC power systems having a rated voltage up to and including 1 000 V – Part 3: Internal fuses*

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 TR 61000-4-1:2016, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – Overview of IEC 61000-4 series*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CONDENSATEURS DE PUISSANCE – BATTERIES DE COMPENSATION DU FACTEUR DE PUISSANCE BASSE TENSION

AVANT-PROPOS

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La Norme internationale IEC 61921 a été établie par le comité d'études 33 de l'IEC: Condensateurs de puissance et leurs applications.

Cette deuxième édition annule et remplace la première édition parue en 2003. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- nombreuses modifications concernant l'alignement des méthodes de vérification sur l'IEC 61439-1;
- modification de marquage;
- ajout d'une vérification individuelle systématique de la puissance assignée;

- nouvelle Annexe D avec préconisations portant sur les méthodes de vérification de l'échauffement;
- actualisation des références normatives;
- révision rédactionnelle générale.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
33/607/FDIS	33/611/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.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

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CONDENSATEURS DE PUISSANCE – BATTERIES DE COMPENSATION DU FACTEUR DE PUISSANCE BASSE TENSION

1 Domaine d'application

La présente Norme internationale s'applique aux batteries de condensateurs shunt à basse tension en courant alternatif destinées à être utilisées pour la compensation du facteur de puissance, ces batteries comportant éventuellement des appareillages de connexion et de commande intégrés capables de mettre sous tension ou hors tension une ou des fractions de l'ensemble afin de compenser le facteur de puissance du réseau.

Sauf indication contraire dans la présente norme et le cas échéant, les batteries de compensation du facteur de puissance basse tension satisfont aux exigences de l'IEC 61439-1 et de l'IEC 61439-2.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. 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).

IEC 61439-1:2011, *Ensembles d'appareillage de basse tension – Partie 1: Règles générales*

IEC 61439-2:2011, *Ensembles d'appareillage à basse tension – Partie 2: Ensembles d'appareillage de puissance*

IEC 60831-1:2014, *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 60931-1:1996, *Condensateurs shunt de puissance non autorégénérateurs pour réseaux à courant alternatif de tension assignée inférieure ou égale à 1000 V – Partie 1: Généralités – Caractéristiques fonctionnelles, essais et valeurs assignées – Règles de sécurité – Guide d'installation et d'exploitation*

IEC 61642:1997, *Réseaux industriels à courant alternatif affectés par les harmoniques – Emploi de filtres et de condensateurs shunt*

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions de l'IEC 61439-1, de l'IEC 61439-2, de l'IEC 60831-1 et de l'IEC 60931-1 ainsi que les suivants, s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
batterie de condensateurs basse tension en courant alternatif ou batterie de compensation du facteur de puissance basse tension
combinaison d'un ou de plusieurs condensateurs unitaires à basse tension avec les appareils de connexion associés et les matériels de commande, de mesure, de signalisation, de protection, de régulation, etc., entièrement assemblés sous la responsabilité du fabricant d'ensembles avec toutes leurs liaisons internes mécaniques et électriques et leurs éléments de construction

Note 1 à l'article: La batterie de condensateurs peut être fixée, connectée manuellement ou commandée automatiquement par un régulateur du facteur de puissance.

Note 2 à l'article: Les composants des appareillages de connexion et de commande de la batterie automatique peuvent être électromécaniques ou électroniques.

3.2
gradin de condensateurs
combinaison d'un ou de plusieurs condensateurs unitaires manœuvrés ensemble par un interrupteur unique avec éventuellement des bobines d'inductance anti-harmoniques, des fils de connexion et des appareillages associés

3.3
régulateur varmétrique
dispositif conçu pour calculer la puissance réactive absorbée par la charge raccordée à l'alimentation de puissance et pour commander la connexion et la déconnexion des gradins de la batterie automatique de façon à compenser la puissance réactive

Note 1 à l'article: La puissance réactive est normalement calculée à la fréquence fondamentale.

Note 2 à l'article: Le régulateur peut être "incorporé" ou "séparé".

Note 3 à l'article: Le régulateur exécute généralement des fonctions de mesure / contrôle de la puissance, de commande (des gradins de condensateurs) et de protection (de la batterie de condensateurs).

3.4
courant d'appel transitoire I_t
surintensité transitoire d'amplitude et de fréquence élevées qui peut apparaître lorsqu'un condensateur est mis sous tension, l'amplitude et la fréquence étant déterminées par des facteurs tels que l'impédance de court-circuit du réseau, l'importance de la capacité en parallèle déjà sous tension et l'instant de connexion

3.5
puissance réactive assignée Q_N (d'une batterie de condensateurs)
puissance réactive totale d'une batterie de condensateurs à la fréquence et à la tension assignées, calculée à partir de l'impédance totale de la batterie en incluant les inductances éventuelles

3.6
courant maximal admissible
valeur de courant déclarée par le fabricant que la batterie de condensateurs peut supporter en permanence et utilisée pour les paramètres d'installation et de protection

4 Marquage d'une batterie de condensateurs

Les informations minimales suivantes doivent être indiquées par le fabricant sur une plaque signalétique à fixer sur la batterie de condensateurs:

1) Nom ou marque de fabrique du fabricant.
2) Numéro d'identification ou désignation du type.
3) Date de fabrication, en clair ou sous forme de code.

4) Puissance réactive assignée, Q_N en kilovars (kvar).
5) Tension assignée, U_N en volts (V).
6) Fréquence assignée, f_N en hertz (Hz).
7) Référence à la norme IEC 61921 et à son année de publication.

Les informations suivantes doivent être également indiquées par le fabricant sur la plaque signalétique ou dans la notice d'instruction.

8) Caractéristiques assignées des gradins, en kvar.
9) Valeur de la bobine d'inductance série lorsqu'elle existe (ou taux de réactance en % ou de fréquence d'accord).
10) Températures ambiantes minimale et maximale en degrés Celsius (°C).
11) Degré de protection de l'enveloppe.
12) Type d'emplacement: intérieur ou extérieur.
13) Courant assigné de courte durée admissible (I_{cw}).
14) Courant assigné de court-circuit conditionnel (I_{cc}), le cas échéant.
15) Courant maximal admissible.
16) Tension assignée d'isolement (U_i).
17) Tension assignée de tenue aux chocs (U_{imp}).

5 Conditions d'emploi

Voir les articles appropriés de l'IEC 61439-1 et de l'IEC 61439-2.

6 Guide de conception, d'installation, d'exploitation et de sécurité

6.1 Généralités

Contrairement à la plupart des appareils électriques, les condensateurs shunt, lorsqu'ils sont en service, fonctionnent en permanence à pleine puissance ou à des puissances qui n'en diffèrent que par suite de variations de la tension et de la fréquence.

Les contraintes et les températures excessives abrègent la durée de vie d'un condensateur et il convient par conséquent de contrôler rigoureusement les conditions de fonctionnement (c'est-à-dire la température, la tension et le courant).

Il convient de noter que l'introduction d'une capacité dans un réseau peut en perturber les conditions de fonctionnement (par exemple, amplification des harmoniques, auto-excitation des machines, surtension de connexion, fonctionnement défectueux des appareils de télécommande à fréquence audio, etc.).

Les différents types de condensateurs et les nombreux facteurs impliqués ne permettent pas de couvrir, par des règles simples, tous les cas possibles d'installation et d'exploitation. Les informations suivantes portent sur les points les plus importants à prendre en considération. En outre, les instructions du fabricant et des distributeurs d'électricité doivent être suivies.

6.2 Conception

6.2.1 Choix de la tension assignée

La tension assignée de la batterie de condensateurs doit être au moins égale à la tension de service du réseau auquel le condensateur doit être raccordé, compte tenu de l'influence de la présence du condensateur lui-même. La tension de service correspond au niveau de tension