

Mounting and Maintenance Instruction for Power Capacitors

1. Safety notes

The installation shall only be made by adequately trained personnel and in compliance with the safety regulations and rules applicable at the site of application. The VDE and IEC standards quoted when placing the order apply for the production, testing and operation of the capacitors unless other prerequisites were demanded by the customer. For detailed data with regard to protective engineering concerning HV capacitors, refer to IEC 871-3. The capacitors shall be mounted in such a way as to exclude any danger for people by providing earth connection according to the rules, by placing warning plates in the appropriate positions and by taking precautions to protect against accidental contact.

Correctly dimensioned, mounted and maintained capacitors have a service life above average. If, however, the instructions are not observed, the below stated damages may occur:

High voltage – a cause of danger:

Before works are carried out on a capacitor or a capacitor bank, the equipment must be inactive and the following safety rules shall be observed:

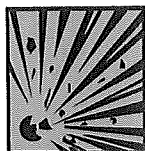
- | | | |
|--------------------------------|---------------------|------------------|
| 1. Switch off entire system | 3. Discharge | 5. Short-circuit |
| 2. Secure against reactivation | 4. Connect to earth | |



Attention: The integration of a discharge device does not replace the previously stated safety notes!

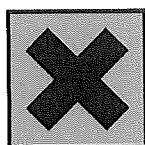
Danger of fire or explosion:

Even if monitoring and safety devices are installed, overloading or a major electrical defect may destroy the casing and/or the bushings. Another consequence of this may be the inflammation of the capacitor's combustible component parts. When selecting the site of erection of the capacitor, the applicable fire protection instructions shall be taken into account (adequate safety distance, securing of escape routes).



Danger of leakage of impregnating agent:

If the impregnating agent is leaking, the safety rules referring to the type of impregnating agent indicated on the rating plate (refer "Oil No.") are to be observed. Relevant advice is given in the correlated safety data sheet. Dry capacitors are marked with the term "dry" on their rating plates.



Danger during fault clearing of defective equipment:

When the capacitors have been subject to overloading, a considerable build-up of pressure may occur in the capacitor casing; therefore the capacitor unit should be allowed to cool down before works are started at it. The possibility of the internal discharge resistors having been interrupted and thus having become ineffective and of the casing insulation and the internal interconnection having both been damaged, has to be taken into account as well.

2. Transport:

The capacitors are shipped ex works in sturdy packing. Upon receipt, each consignment shall be checked for its proper condition. Transport devices shall be attached to the lifting lugs, to the lateral transport angles or to the bottom fixings of the capacitor only. Under no circumstances may the electrical connections and bushings be utilized for transportation purposes. Damages due to transport are excluded from the manufacturer's liability. Any damage having occurred during transport shall be reported to the forwarder at once for damage adjustment. The forwarder will have to make the official statement on the facts, which will be required as evidence for damage adjustment by the transport insurance company.

3. Installation and putting into operation:

The rules effective at the site of installation for mounting a power installation shall be observed (e.g. EN 50179 and/or VDE 0101). The rated values and the internal connection shown on the rating plate, data sheet or the order shall be checked for their suitability for the respective case of application. Partial ratings are marked or numbered on the cover next to the bushings and shown on a second rating plate. The operating voltage of the capacitors shall not exceed the capacitors' rated voltage. For admissible short-term overloading, refer to the applicable standard (e.g. IEC 60871-1), unless missing in the data sheet.

Short-circuit connections (for discharging) shall be removed before putting the capacitor equipment into operation!

All current-carrying connections shall be as flexible as possible and feature an adequate cross-sectional area. The capacitors' bushings must not be subject to any tensile, compressive or bending stress by the connecting lines. For frequencies > 500 Hz, only non-magnetic screwing material shall be applied. Current-carrying water lines, which are lead outside in an isolated manner, require hose lines of adequate length without metallic armour. Their length is to be determined according to the electric conductance of the water and the voltage to earth.

Starting torques for current-carrying screw-connections in accordance with DIN 46 200; specifications in the dimension sheets or on the plates mounted next to the bolts take priority and shall be complied with:

M6 = 3 Nm

M10 = 10 Nm

M16 = 30 Nm

M8 = 6 Nm

M12 = 15.5 Nm

The connections shall be mechanically sound and safe against coming loose and shall be retightened after approximately four weeks of operation. Stress on the welds by sliding the casing on the floor or on the carrier framework, etc. may cause leakages. Scratches on the varnish are to be repaired immediately in order to avoid underfilm corrosion. In locations where the capacitors are subject to heavy mechanical vibrations, each capacitor unit or the entire capacitor bank shall be assembled on a vibration cushioned base. The capacitors are designed for horizontal or vertical mounting at the narrow end.

For switching the air-cooled power capacitors, only **switchgear without restriking** may be used. Restriking causes high transient overvoltages and may lead to a sudden failure of the capacitors. Non-observance of these stipulations leads to exclusion of the manufacturer's liability. Protective capacitors for overvoltage serve to reduce transient voltage pikes and feature an increased overvoltage proofness in contrast to power capacitors.

4. Cooling:

4.1 Air-cooled capacitors:

Static power capacitors generate heat during operation. When observing both the maximum cooling air temperature and the minimum spacing, natural convection will guarantee sufficient cooling. We recommend a distance of >35 mm between the casings' broad ends or to the adjoining casing parts.

The temperature category is indicated on the rating plate. This value must not be exceeded at any spot within the capacitor, even in terrace or cabinet constructions. The manufacturer's liability does not apply to capacitors failing because the permissible ambient temperature has been exceeded.

Temperature categories in accordance with IEC 60871-1:

Ambient temperature in °C			
Symbol	Max. temperature	Maximum average temperature over a period of	
		24 hours	1 year
A	40	30	20
B	45	35	25
C	50	40	30
D	55	45	35

4.2. Water-cooled capacitors:

The power loss occurring during operation shall be dissipated by means of the cooling water. The quantity of cooling water indicated in l/min on the rating plate constitutes the minimum amount required for sites at altitudes up to 1000 m above sea level, and a warm-up by maximum 5K will then take place. The maximum outlet temperature and the limiting temperatures of the ambient air as specified on the rating plate must be met. The heating cartridges fitted in the outer casing are provided for control purposes in case of damage and must not be removed.

The cooling water system shall be equipped with filters to protect against contamination and it shall not contain any chemical impurities which would attack copper. The water channel system shall be designed in a way as to avoid damage due to corrosion caused by the metals' electrolytic voltage series. The maximum pressure in the cooling system must not exceed 8 bar. If capacitors are equipped with monitoring devices (thermostat, pressure switch, etc.), the control line required for this shall be placed at a sufficient distance from the busbar system and shall be included in the facility monitoring programme.

5. Earthing and discharging:


Earthing of the casing or frames shall be effected at the spot marked



As with deliveries of individual capacitors, the site of installation is unknown, the customer has to ensure protection against accidental contact of facilities with live casings and fit them with warning signs. Rules effective at the site of installation shall be observed.



After disconnection from the source of supply, the capacitors shall be discharged in order to avoid endangering the maintenance personnel and parts of the equipment. Every capacitor equipment shall, therefore, be firmly connected to a discharge device unless it is directly connected to another electrical device which serves as a discharging circuit.

The rating plate of capacitors with incorporated discharge resistors show the symbol  or the letters "EW" [*Entladewiderstand = discharge resistor*]. The discharge duration is rated in accordance with the instruction indicated on the capacitor's rating plate.

A reconnection of the capacitor equipment to the supply is only permissible after the residual voltage has dropped to less than 10% of the rated voltage.

6. Operation and maintenance

At regular intervals, the capacitors shall be subject to visual inspection for leakage and overheating at the terminals and in case of a heavily polluted environment, the bushings shall be cleaned. Switchgear shall be maintained in accordance with the manufacturer's mounting and maintenance instructions. Leaky capacitors shall be returned to the factory or to our customer service stations for inspection and repair.

6.1. Air-cooled capacitors:

At adequate intervals, the operator of the equipment shall check the cooling air conditions and change the filter mats in the event of room ventilation if necessary.

6.2. Water-cooled capacitors:

Ensure that the specified cooling water quantity flows through each capacitor. In case of irregular outlet quantities, a pressure-reduction valve has to be installed, and the water channel system shall be checked for potential inclusion of air. If capacitors are not monitored by thermostats, the temperature of the outflowing cooling water of all parallel lines should be measured during trial operation of the equipment after the first, second and third hour. The permissible maximum temperature must not be exceeded. Monitoring equipment, such as pressure switches and flow control devices, should be checked by a momentary cut-off of the water supply.

Approximately every three months, the operator of the equipment shall check the cooling water supply and the appropriate monitoring equipment. The flow rate and the run-off temperature established in these checks are to be recorded. Bottom settlings in the cooling water system shall be removed by flushing them out.

If water-cooled capacitors are switched off during frost periods, appropriate measures should be taken to prevent line breakage due to freezing (empty the water cooling system, use antifreeze agent, heat the room where the equipment is mounted).

7. Monitoring devices:



The choice of monitoring and protection devices depends on the characteristics of both the network and the capacitor bank and has to be made for each individual case of application. The operation of the capacitor batteries is not permitted without a correctly dimensioned unbalance monitoring system or current-limiting fuses and can lead to serious consequential damages as well as danger to the personnel.

7.1. Pressure switch (optional):

Via a pressure sensor, the internal pressure is monitored in a capacitor. If the stipulated limiting value is exceeded, a signal contact (change-over contact) initiates the disconnection of the electrical supply to the capacitor. Such an early disconnection from the source of supply, after an internal breakdown, can stop the gas evolution in the capacitor before the casing bursts. In connection with current-limiting fuses, the bursting of the casing can be prevented with high probability.

7.1.1. Fields of application:

The pressure switch can be used for all capacitor casings which are earthed or live with a maximum of up to 500V to earth, if the capacitor can be disconnected from the source of supply via a series-connected tripping device. Pressure switches are especially suitable for monitoring individual capacitors and small capacitor banks where purely electrical protection systems, such as unbalance monitoring or phase comparison protection, are not economical as means of protection.

7.1.2. Range of protection:

The protection device covers faults within the range of limited fault currents:

- ☐ Partial breakdown in earthed medium voltage capacitors with gas evolution at the spot of breakdown with simultaneous limitation of the fault current due to partial capacitances connected in series.
- ☐ Medium frequency capacitors being operated in equipment of low short-circuit power.
- ☐ All types of self-healing capacitors where, owing to their constructional features, the short-circuit current is limited in case of a breakdown.

7.1.3. Supplementary protective devices required:

In order to provide a complete protection for equipment with high short-circuit power, a blow-out fuse featuring an adequate breaking capacity with current-limiting characteristic has to be provided in addition to the electric contact-breaking device. With rated safety current values up to 200A, the bursting of the casing is avoided with high probability. The combined protection of motors/generators and compensating capacitors with the same fuse has to be strictly avoided, as with self-excitation the short-circuit power from the kinetic energy of large machines could cause the bursting of the capacitor, even though it has been disconnected from the source of supply. Circuit breakers are not suitable because of their long breaking time.

7.2. Unbalance protection (optional):

In equipment with unbalance monitoring, the signal relays are to be set according to the limiting values calculated by the manufacturer. When exceeding the tripping value, the capacitor battery has to be switched off immediately. For a safe operation, a short circuit current monitoring is required in addition to the unbalance monitoring.

8. Clearance of trouble:

When monitoring devices have tripped, it should be checked whether the switching-off is due to electrical or thermal overloading. If the damage occurred in the capacitor zone, an external inspection of the switchgear, the terminals and the capacitor casings shall be carried out observing all safety rules (see 1.). If there are no external changes, it is then necessary to check the capacitance of the units by means of a capacitance meter. We suggest to replace capacitors with a capacitance deviation of more than 5% from the capacitance value at the time of delivery.

As not all damages can be detected via a capacitance meter, it is also recommended to carry out a dielectric test with 75% of the new test value between terminals and between terminals and casing before putting it into operation again.

9. Return shipment of capacitors:

When returned, capacitors must be transported in a standing position with the bushings upwards. The packing shall be marked accordingly. Leaking capacitors shall be made leakproof or packed in a liquid-tight manner. Replacement units should be requisitioned giving both the data on the rating plate and the capacitor number. Capacitors which have been opened by the purchaser are exempt from the guarantee.

Capacitors for return from customers at home and abroad should be addressed to:

Maschinenfabrik Reinhausen GmbH
Rachelstraße / Tor 2
D - 93059 Regensburg
Germany
(with specification of purchase order no. Q9XXXX)

10. Disposal:

Since all static power capacitors are impregnated with a liquid agent or potted depending on the type of capacitor (see 1.3.), they have to be disposed of under proper supervision at the end of their service lives. For the disposal of capacitors impregnated with liquid agent in particular, the risk of leaking oil and thus groundwater pollution has to be considered. Local guidelines concerning pollution control have to be observed.

11. Table of impregnating agents:

Oil No.	Impregnating agent	Oil No.	Impregnating agent
3	Rizinus	9	Jarylec C101
7	Mixoflex	dry	Casting resin