COMAR CONDENSATORI S.p.A
Via del Lavoro, 80 – Loc. Crespellano
40053 VALSAMOGGIA (BOLOGNA)
Tel. +39 / 051 / 733.383 - Fax. +39 / 051 / 733.620

Titolo: **Check and Replacement of PFC Capacitors**

Livello: **BASIC + EXPERT**

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Autore: Engineering Department of COMAR Condensatori SPA

1 Summary

The measures to be carried out to check the condition of PFC capacitors and their replacement - if they are out of service - are described below.

Check the condition of the capacitors

Basic level

Required instrumentation: current clamp.
The checks described below (in par. 2.1) can be performed:

- On the equipment as a whole (with the front door closed), manually activating each single bank of capacitors;
- On each single bank of capacitors (equipment with open door), when all the capacitor banks are inserted and are unable to supply the reactive power necessary for power factor correction;

⚠ In this case, only trained personnel qualified to operate on live electrical panels can perform the checks.

Expert level

Required instrumentation: capacitance meter. The checks described below (in par. 2.2) must be performed with the electrical panel disconnected from the mains.

Capacitor replacement

Required instrumentation:

- M12 nut wrench;
- Flathead screwdriver.

2 Capacitor condition check

2.1 Basic level

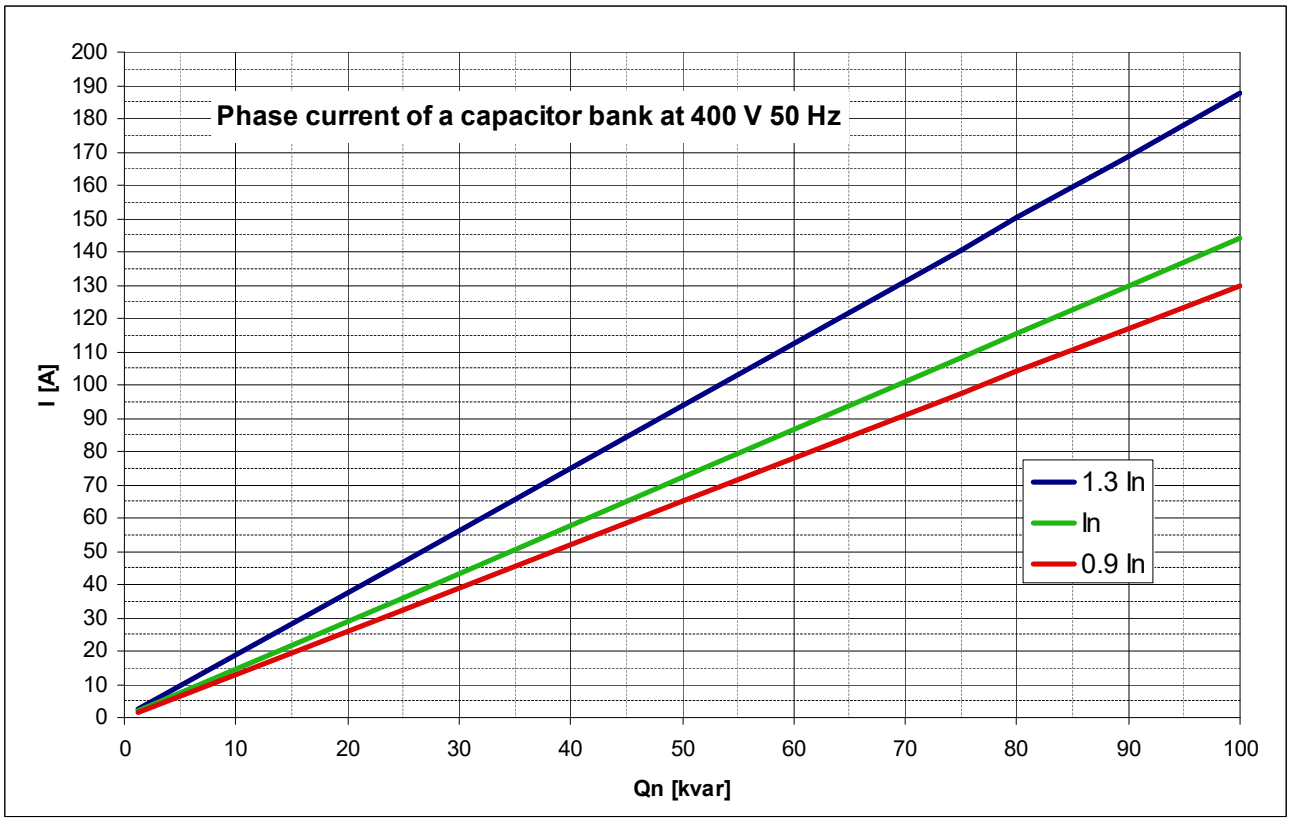
Measure the current that circulates in each single phase with a current clamp and follow the criteria indicated in par.2.1.3.

2.1.1 Formula for calculating the current circulating in a three-phase capacitor bank

$$I_n = \frac{Q_n}{\sqrt{3} \cdot U_{line}}$$

Where:
In – rated phase current at the fundamental frequency circulating in the capacitor bank
Qn – rated power of the capacitor bank
Uline – measured line voltage

2.1.2 Graph for the calculation of the current circulating in a three-phase capacitor bank



For values greater than 100 kvar, apply the proportionality formula.

2.1.3 Evaluation criterion for the conditions of a bank of capacitors

The measured RMS current must normally be between these two values:

$$0.9 \cdot I_n \leq I \leq 1.3 \cdot I_n$$

The lower limit defines the loss of capacitance of the capacitor, caused by its aging.
The upper limit delimits the maximum level of harmonics acceptable to the capacitor, it cannot exceed 30% of the nominal current at the fundamental frequency.

If the measured current, on one or more phases, is too low, then the capacitors must be replaced. If the measured current, on one or more phases, is too high:

- For appliances without series inductances - the current harmonic level (THDi) is too high for the equipment, it is advisable to replace the equipment with one having the series inductances
- For equipment with series inductances - the level of the harmonics in voltage (THDu) is too high for the equipment, it is advisable to replace the equipment with one having the series inductances that bear a higher value.

2.2 Expert level

Measure the capacity of each individual bank of capacitors with a capacitance meter and follow the criteria indicated in par. 2.2.3.

If the capacitor bank is connected in delta with the contactor connected internally to the triangle, to perform the measurement you can proceed in one of the following ways:

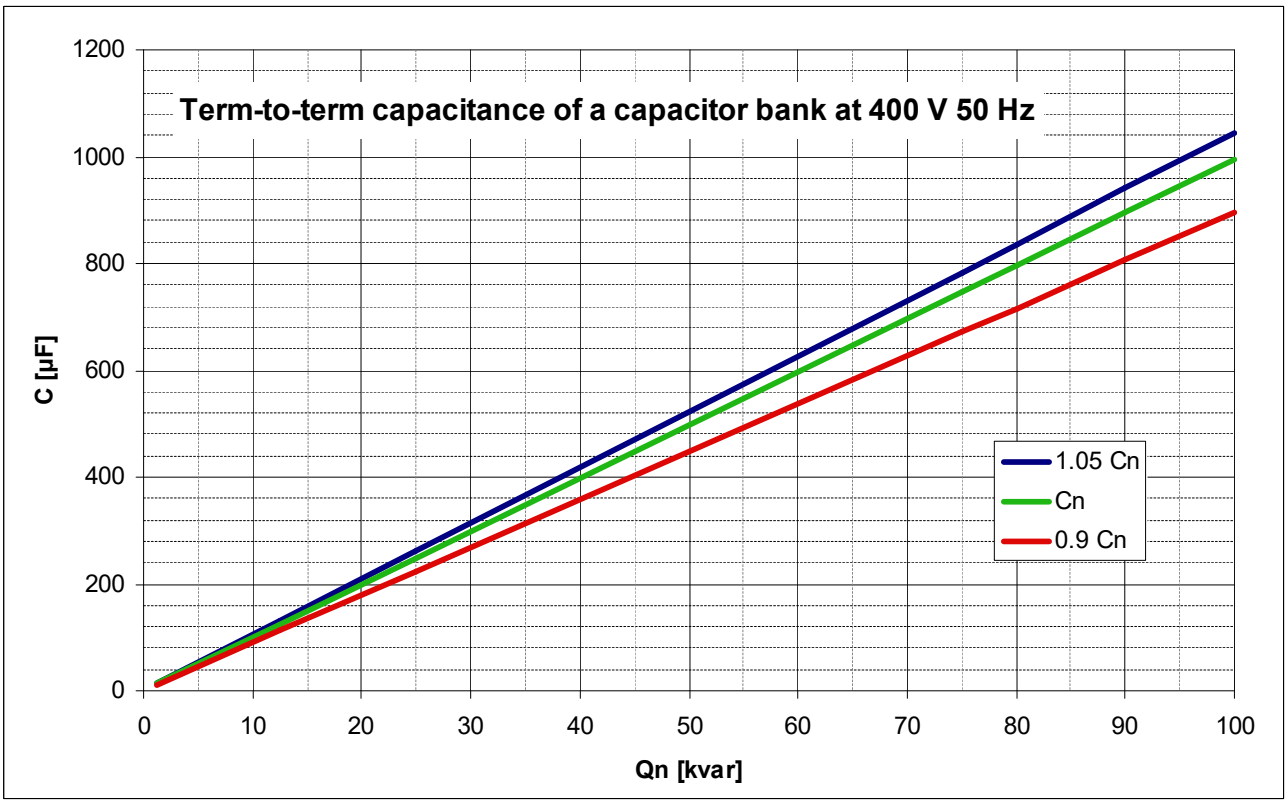
- Manually force the closure of the contactor and apply the criterion described in par. 2.2.3 (see also what described in par. 2.2.1 or 2.2.2)
- Measure each individual capacitor individually and apply what described in par. 2.2.4.

2.2.1 Formula for calculating the capacitance between the terminals of a three-phase capacitor bank

$$C_{nm} = \frac{Q_n}{2\pi \cdot f_n \cdot U_{line}^2} \cdot \frac{1}{2}$$

Where:
Cnm – nominal capacity measurable between two terminals of the capacitor bank
Qn – nominal power of the capacitor bank
Uline – measured line voltage
fn – nominal line frequency

2.2.2 Graph for calculating the capacitance between the terminals of a three-phase capacitor bank



For values greater than 100 kvar, apply the proportionality formula.

2.2.3 Evaluation criterion for the conditions of a bank of capacitors

The measured capacitance Cm on each pair of terminals must normally be between these two values:

$$0.9 \cdot C_{nm} \leq C_m \leq 1.05 \cdot C_{nm}$$

The limits are due to the tolerances of the capacitor production process.
The lower limit also limits the capacity loss of the capacitor bank, caused by its aging. Exceeding the upper limit may also indicate damage to the capacitor bank.

If one of the limits is exceeded, replace all the capacitors that are part of the capacitor bank.

Before connecting the capacitance meter to a capacitor bank, check that the capacitor bank is completely discharged. If it had already been connected to the discharge resistor it is sufficient to wait 3 min and then short-circuit the terminals of the capacitor bank with a copper wire stripped at the ends for safety.

2.2.4 Single-phase capacitor measurement

The measured capacitance Cm on each pair of terminals must normally be between these two values:

$$0.9 \cdot C_n \leq C_m \leq 1.05 \cdot C_n$$

Where:
Cn - nominal capacity indicated on the identification plate of the capacitor

The limits are due to the tolerances of the capacitor production process.
The lower limit also limits the loss of capacitance of the capacitor, caused by its aging.
Exceeding the upper limit may also indicate damage to the capacitor.

⚠ When a capacitor is found outside the limits, it is advisable to replace all the capacitors that belong to the same capacitor bank.

⚠ Before connecting the capacitance meter to a capacitor, check that the capacitor is completely discharged. If it had already been connected to the discharge resistance (for example from 270 kΩ in parallel) it is sufficient to wait 3 min and then short-circuit the capacitor terminals with a screwdriver for safety.

3 Replacing the Capacitors

⚠ Before touching the capacitor terminals with your hands, make sure that:
- if the discharge resistance is still connected to the capacitor, 3 minutes have elapsed since the capacitor was disconnected from the mains
- if the discharge resistance is not connected, as damaged, discharge the capacitor with a similar resistance, or with an insulated copper wire, stripped to the ends

If an out of order capacitor is found, it is advisable to replace all the capacitors belonging to the same bank.

If the verification - carried out according to the suggestions described in par. 2 - shows that the conditions of a capacitor bank are out of the indicated limits, replace all the capacitors of that capacitor bank.

When a capacitor is replaced, it is also advisable to replace its discharge resistance, connected in parallel.

Also check the status of the female Faston connectors. If they have oxidation, or if the insertion and disconnection are too easy (ie the clamping force of the male element is poor), also replace the 6.3mm female Faston connectors, better if equipped with a mechanical tooth against accidental extractions.

The cable section to be crimped is normally 2.5 mm².

Keep the existing Faston covers, to guarantee the identification of the phases.