RATED POWER VERSUS RATED VOLTAGE OF POWER CAPACITORS

Variation of capacitor power with voltage

In certain networks, a considerable difference may exist between the rated and service voltage of the network. It is then common practice to give some allowance in the rated voltage of the capacitor (e.g. 400 V rated voltage of capacitors for a 380 V network), as the performance and life of capacitor may be adversely affected if they work above rated voltage.

The output power of a capacitor connected to a network of lower voltage than its rated voltage will however be reduced, and can be calculated from:

$$Q_{effective} = Q_N \left(\frac{U_{network}}{U_N}\right)^2$$

Where: $Q_{effective}$ = Power of capacitor at $U_{network}$ (kvar)
Q_N = Rated power of capacitor (kvar)
U_N = Rated voltage of capacitor (V)
$U_{network}$ = Voltage of network (V)

For example, a 100 kvar capacitor rated at 400 V will give only about 90 kvar when connected to a 380 V network:

$$\boldsymbol{Q_{effective} = 100\left(\frac{380}{400}\right)^2 = 100 * 0.902 = 90.2\ Kvar}$$

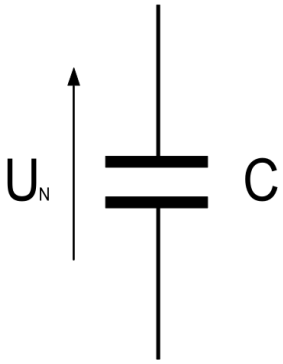
Here below are some examples of capacitors connected to voltages other than their rated voltages, with indication of the output obtained:

Voltage	Power	Voltage	Power	Voltage	Power
400 V	**100 kvar**	**415 V**	**100 kvar**	**440 V**	**100 kvar**
380 V	90.2 kvar	400 V	92.9 kvar	415 V	89.0 kvar
360 V	81.0 kvar	380 V	83.8 kvar	400 V	82.6 kvar
347 V	75.3 kvar	360 V	75.3 kvar	380 V	74.6 kvar

Calculation of capacitor power from capacitance values

The reactive power that a capacitor is able to supply is proportional to its capacitance value and it depends on the voltage and frequency of the network where it is connected. The reactive power can be calculated from:

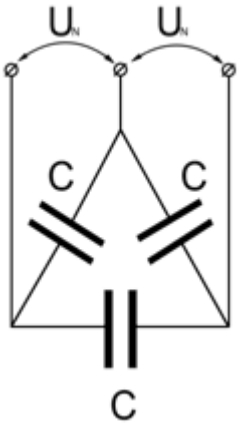
$$Q_N = C\omega U_N^2 * 10^{-9}$$



Where:
Q_N = Rated power of capacitor (kvar)
C = Capacitance (µF)
$\omega = 2 * \omega * f_N$
f_N = Rated frequency (Hz)
U_N = Rated voltage (V)

In the case of a three phase capacitor (delta connected), the reactive power can be calculated from:

$$Q_N = 3C\omega U_N^2 * 10^{-9}$$



Measured (apparent) capacitance of a power capacitor

All the formulae shown above are useful if you already know the value of the internal capacitance C. Usual problem is that you have a capacitor and you want to know or confirm which the output is. You can do that accurately if you have a capacitance meter. These are the steps to follow:

1) **ATTENTION: Before performing any maintenance operation or handling any part of power capacitors, remove all fuses and check that capacitors are discharged.**
Even when banks are disconnected from the mains, capacitors may still be charged. Therefore, after removing the fuses, wait for five minutes and then short circuit them and earth the terminals or outlet cables of each capacitor.

2) With the capacitance meter measure between any two-line terminals of a three phase capacitor (either delta or star connection). You will get three readings C_a, C_b, C_c. These readings are called apparent capacitance.

3) If the phases of the capacitor are reasonably well balanced, the output Q of the capacitor can be calculated with enough accuracy from:

$$Q = \frac{2}{3}(C_a + C_b + C_c)\omega U_N^2 * 10^{-9}$$

Where:
Q = Capacitor output (kvar)
C_a, C_b, C_c = Measured capacitance (µF)
ω = $2 \cdot \pi \cdot f_N$
f_N = Rated frequency (Hz)
U_N= Rated voltage (V)

Following tables give the measured (apparent) capacitance of a three phase capacitor when measured between two line terminals, for different rated voltages and frequencies:

Common tolerances for these values (for capacitors up to 100 kvar) are, according to IEC 831- EN 60831, -5%/+10 %

Table 1: apparent capacitance (µF) of three phase power capacitors at 50 Hz

Q_N (kvar)	Rated voltage of capacitors (V)								
	220	**230**	**240**	**380**	**400**	**415**	**440**	**480**	**500**
5	164	150	138	55	50	46	41	35	32
10	329	301	276	110	99	92	82	69	64
15	493	451	414	165	149	139	123	104	95
20	658	602	553	220	199	185	164	138	127
25	822	752	691	276	249	231	206	173	159
30	986	903	829	331	298	277	247	207	191
35	1151	1053	967	386	348	323	288	242	223
40	1315	1203	1105	441	398	370	329	276	255
50	1644	1504	1382	551	497	462	411	345	318
60	1973	1805	1658	661	597	554	493	414	382
75				827	746	693	617	518	477
80				882	796	739	658	553	509
100				1102	995	924	822	691	637

Table 2: apparent capacitance (µF) of three phase power capacitors at 60 Hz

Q_N (kvar)	Rated voltage of capacitors (V)								
	220	**230**	**240**	**380**	**400**	**415**	**440**	**480**	**500**
5	137	125	115	46	41	39	34	29	27
10	274	251	230	92	83	77	69	58	53
15	411	376	345	138	124	116	103	86	80
20	548	501	461	184	166	154	137	115	106
25	685	627	576	230	207	193	171	144	133
30	822	752	691	276	249	231	206	173	159
35	959	878	806	321	290	270	240	201	186
40	1096	1003	921	367	332	308	274	230	212
50	1370	1254	1151	459	414	385	343	288	265
60	1644	1504	1382	551	497	462	411	345	318
75				689	622	578	514	432	398
80				735	663	616	548	461	424
100				918	829	770	685	576	531