Introduction

When capacitors are disconnected from the supply, a DC voltage persists across the terminals of the capacitor unit. Safe handling of capacitor units after de-energisation requires that the stored electric charge in the capacitor unit should be removed to avoid the risk of electric shock to personnel. Any stored charge should be removed gradually — shorting the terminals of a capacitor unit to remove the charge will result in very rapid discharge of a substantial amount of energy that can endanger personnel and result in damage to the capacitor units themselves.

Capacitor units are therefore supplied with a discharge device capable of reducing the voltage between the terminals practically to zero, within a given time, after the capacitor has been disconnected from a network. The question of what this discharge time should be is of interest in this article.

Discharge devices

In practice the discharge device consists of one or more resistors connected across the capacitor terminals. High voltage capacitor units and some low voltage capacitor units have the resistors connected to the terminals inside the capacitor unit before being sealed, while some low voltage capacitor units have discharge resistors connected externally across the terminals.

Most manufacturers adhere to the discharge times nominated in IEC60871-1 or IEEE18 standards. The IEC standard nominates discharge to 75 V within 10 minutes of disconnection and leaves different discharge rates as an option to be specified by individual customers. The IEEE standard nominates discharge to 50 V within 5 minutes of disconnection.

The voltage remaining across a capacitor's terminals is given by:

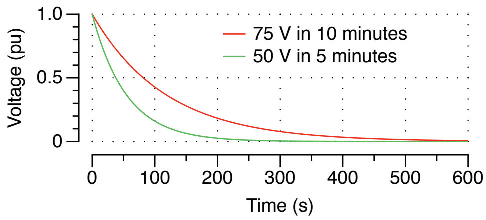
$$U_R = \sqrt{2}U_N e^{-\frac{\tau}{RC}}$$

τ	=	time for discharge from U_N to U_R in seconds
R	=	discharge resistance in ohm
C	=	capacitance in farads
U_N	=	initial AC voltage across the unit, in volts
U_R	=	permissible DC residual voltage, in volts

It is clear that any arbitrary discharge time to any arbitrary residual voltage can be achieved relatively easily by selecting the appropriate discharge resistor.

It is important to understand that access to disconnected equipment with a trapped charge must be prevented (by timed interlocks or by enforced procedure) and that personnel safety is ensured by this delayed access to equipment, irrespective of the rate of discharge specified.

The chart below shows the effect of selecting a discharge time of 10 minutes to 75 V compared with a discharge time of 5 minutes to 50 V.



A shorter discharge time may seem a safer, logical choice when specifying capacitor banks — a lower risk to personnel who need to access the equipment after disconnection.

Side effects

Both discharge rates result in a safe situation – the 75 V discharge curve requires a slightly longer delay before access can be given.

So why was the IEC standard updated to a longer discharge period, or why would any end user specify a discharge to 75 V in 10 minutes? The answer is two-fold:

Improved materials The quicker discharge characteristic dates from an era when materials used in capacitor units were more lossy (paper dielectric) and units generally smaller. Modern units are constructed from material such as polypropylene film that is almost lossless, enabling the construction of capacitor units with much higher power ratings.

Reducing losses An example calculation of I^2R losses in a discharge resistor will illustrate that a 8700 V, 620 kvar unit that will discharge to 75 V in 10 minutes will consume 51 W while it is energised. The same unit with a discharge to 50 V in 5 minutes will consume 110 W, double the losses of the IEC unit.

Higher internal losses will result in higher temperatures with possible long term reduction in life expectancy. An important consideration is the lifetime contribution to greenhouse emissions: a faster-discharge capacitor bank of only twelve of the above units, energised half of the time will over a period of 30 years consume an additional 67 MWh of energy compared to a slower discharge bank, equivalent to driving ten passenger vehicles for one year, or converting 1 700 incandescent lamps to LEDs.

Conclusion

The decision of a shorter discharge time for a capacitor bank may seem safe and harmless. In fact such a decision results in possible long term damage to the the capacitor units, and will always have a significantly higher carbon footprint than the default IEC60871 discharge time.

Optimised Network Equipment Pty Ltd
ABN 56 151 739 374
www.onegrid.com.au

41/ 2 Benson Street Toowong QLD 4066
PO Box 1951 Toowong QLD 4066
info@onegrid.com.au