All Lighting Capacitors are Not Created Equal

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Hi-Bay Lighting

Hi-bay lighting is very common in community, commercial, and industrial applications – often a large group of many Metal Halide (or similar) lamps, mounted at considerable height, to shine down onto the ground. An example is the lighting for sports fields – the lamps are mounted at the top of a pole. These units range in wattage from 500W to 2500W, and can be either 230V or 400V. Typically, they require a ballast reactor, which can be mounted at the base of the lighting tower. Whilst this provides great lighting, it is widely accepted and acknowledged by lighting suppliers that these units have very poor power quality. They operate at very low power factors, and produce significant levels of harmonic distortion (voltage and current), particularly during their warm up cycle which can last 20 to 30 minutes. To mitigate this low power factor, the lighting manufacturer installs capacitors. This document is a technical overview of the requirements for power factor correction with Hi-Bay lights as fitted to stadiums, warehouses, carparks, etc.

Capacitor Placement

Power quality is a complicated subject with many variables. Whilst adding capacitors is a postive step, there are other factors that need to be considered. One of these is the physical positioning of the capacitors. Most lighting manufacturers place the capacitors at the base of the tower, alongside the ballast choke, a device that can safely operate at well over 100°C. Unfortunately, heat is the biggest enemy of capacitors – when they are operated at over approximately 45°C, their life expectancy is severely reduced, and they cannot safely operate over about 85°C at all. It follows that capacitors should be protected from these temperatures, and the first step to do this is to ensure they are located some distance from the chokes. In larger power factor correction systems, capacitors have a constant flow of the coolest air available forced over their surface; something that is never seen in lighting.

Class of Capacitor

When capacitors are designed, they are designed to comply with the relevant IEC specification. This specification defines the following four classes:

Class A	30,000 hours expected lifetime
Class B	10,000 hours expected lifetime
Class C	3,000 hours expected lifetime
Class D	1,000 hours expected lifetime

These tests are done under ideal conditions of ambient temperature, frequency, voltage, harmonic levels, and capacitor can temperature of 30,000 hours. This is a statistically calculated number and any premature failures are statistically compared to the overall population of capacitors installed. The reality is that no capacitors are ever operated within these ideal conditions, and therefore seldom achieve the expected lifetime. Despite this, the classes can still be used to compare capacitors and manufacturers, and thereby select the capacitors that have the best chance of a long life.

In addition to these four classes, there are also different methods as to how the capacitor behaves if/when it does fail. Plastic case capacitors are typically potted with a resin and contain no safety disconnect unit internally, and no case earth (as they are polymeric). If the capacitor starts to melt internally, for whatever reason, it cannot fail to earth and trip an earth leakage device, and it cannot disconnect itself from the supply because it does not have an over pressure safety disconnect unit. Unfortunately, the capacitor will just continue to melt, strangely self-limiting the current, avoiding blown fuses, and run the risk of catching on fire. Early polypropylene plastic cased capacitors did not use flame resistant potting compound, and only some of the modern capacitors have corrected this.

In comparison, metal cased capacitors are filled with soft resin, polyurethane, inert gas, or vegetable oil, and usually include an over pressure disconnect unit. While these capacitors are safer, sometimes the overheating and resulting capacitor failure is so quick and so violent that the safety mechanism does not operate fast enough or early enough to prevent the can rupturing, which significantly increases the chance of fire.

Is there a problem?

Regrettably, yes. In past years, a large number of lighting units have been supplied with plastic case capacitors, and then mounted directly adjacent to the ballast choke. It is the opinion of kVArCorrect Ltd. that all of these capacitors should be removed on the basis of fire risk mitigation.

Nowadays, many of the lights are supplied with oil or soft resin filled metal cased capacitors, with an internal safety disconnect unit. While this is an obvious improvement over the plastic case capacitors, it is sadly not enough to reduce the fire risk to an acceptable level. Further explanation of the four classes is required to understand the problems.

The four classes defined above related to lifetime hours as specified by IEC Standard 60252-1. There is also a DIN Standard that specifies operating temperatures for the capacitors, and together, it can be seen that the four classes correspond to temperature as well as lifetime hours, as follows:

Class A	30,000 hours expected lifetime,	maximum capacitor temperature of 45^{o}C
Class B	10,000 hours expected lifetime,	maximum capacitor temperature of 50^{o}C
Class C	3,000 hours expected lifetime,	maximum capacitor temperature of 55^{o}C
Class D	1,000 hours expected lifetime,	maximum capacitor temperature of 60^{o}C

Given that during the first 20-30 minutes of the light's operation the harmonics are significantly higher than the longer term running conditions, the capacitors will be running significantly warmer during this time. This is particularly the case in the centre of the capacitor where heat caused by harmonics is generated. Because of this, a realistic core temperature during this start up time is much nearer to the Class D end of the scale; i.e.: projected capacitor life is down around the 1,000 hours level. It follows that lights that are turned on and off more often than lights that are allowed to remain on for long periods will have a shorter lifespan, often considerably shorter.

What is the solution?

Aside from the plastic case capacitors that should be changed, it is commonplace to fit metal case motor capacitors or general purpose lighting capacitors to these units – as opposed to power factor correction capacitors. Almost without fail, these capacitors conform to the IEC/DIN Standards, meaning that the very best life expected, when run in the unrealistic "ideal" conditions, is only 30,000 hours. There are capacitors readily available with life expectancy of 100,000 hours – these are called Low Voltage Single Phase Power Factor Correction capacitors. These capacitors have a different design from motor and lighting capacitors, and are manufactured to much tighter parameters and quality standards. Often they are of similar size to lighting capacitors, and are only slightly more costly.

Summary

There is a very real fire risk in hi-bay lighting. Currently, there is an abundance of hi-bay lightig with plastic case capacitors, motor capacitors, or general lighting capacitors installed, often immediately next to the ballast choke. The heat produced by harmonics, the choke, and general start up strain, is the biggest killer of capacitors. The best, and safest, capacitors to be used in hi-bay lights are Low Voltage Single Phase Power Factor Correction capacitors. Using these capacitors will raise the service life of the unit above 2 years, and mitigate the fire risk.

About the Author

The opinions expressed here are the researched views of Allan Ramson, General Manager, kVArCorrect Ltd. All claims have been substantiated by testing and observations from the Australasian market between 2007 and 2017. Having been associated with the design, manufacture and supply of many thousands of power factor capacitors and over 500 power factor systems, kVArCorrect are confident that they will recommend the correct capacitor for the application.

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