

## UV ballasts enter electronic age

Constant-current output designs offer greater efficiency.

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All ultraviolet (UV) systems have basic “core” components, including the UV lamp, reactor vessel, power source and peripheral components, such as UV monitors, temperature probes, solenoid valves, etc.

A UV manufacturer can design most of these components to work as a stand-alone design or incorporate the individual components into a total system. The challenge is to provide a system that will function in a country with a somewhat unstable power network equally as well as in a country with a very stable power network, such as exists in North America.

Traditionally, manufacturers have used simple electromagnetic devices, or ballasts as they are commonly referred to. These devices incorporate electrical wires wound around a ferrite core. The numbers of windings determine the output current delivered to the lamp. The ballast also incorporates a starter to physically generate enough starting voltage to vaporize the mercury enclosed inside the low-pressure UV lamps. This sounds relatively simple, and in fact is, as long as both the input voltage and input frequency remain constant.

The problem is that many regions around the world have extremely unstable power grids with both fluctuating voltage and frequency. To deliver the optimum UV output, a typical, low pressure UV lamp operates at an output current of 425 mA (other lamp types may operate at 185 mA or 800 mA).

If the lamp operates at less than 425mA, then the system produces less UV output and consequently less UV dose. Conversely, if the lamp is overdriven at an output above 425mA, critical ballast and lamp failure will occur.

### **Magnetic ballasts and power fluctuations**

Although the cost of a magnetic ballast is relatively low, its use in the design of UV systems offers many obstacles. Ultraviolet lamps offer their optimum output at a temperature of 40 degrees Celsius (104 degrees Fahrenheit). If the temperature rises above this optimum, the resistance of the lamp changes, altering the

voltage and current supplied by the ballast. The result is lower UV output and ultimately a lower UV dose. In low-temperature situations, the lamp may experience difficulty in starting.

In order for manufacturers to offer a variety of models with different flow rates, it is necessary to use UV lamps of varying lengths. As you vary the length of the lamp, you vary the voltage that the lamp requires to operate.

To provide a system incorporating a magnetic ballast, the windings contained within that ballast must be matched exactly to provide the proper voltage and current to the lamp. This translates into the need for a single ballast for each lamp at a specific voltage and a specific frequency.

As voltage and frequency vary tremendously (voltages do vary even in North America), many different ballasts would be required to provide the optimum output under each unique circumstance. When the incoming voltage is high, the lamp is overdriven and runs hot. The more it is overdriven, the hotter it gets, resulting in premature ballast and/or lamp failure.

What happens when a system using a G36T6L lamp designed to operate on an input voltage of 115 volts suddenly receives 105 volts during a “brown out” condition? The results of this would be lower lamp current, resulting in a system that never reaches the prescribed UV dose. In an ideal situation, for a magnetic ballast to function as designed, the output flow would need to vary based upon the input voltage and frequency.

Frequency, or the electrical “cycles,” can cause even more disastrous results with magnetic ballasts. Input frequency variations as little as  $\pm 3$  hertz can cause ballast and/or lamp failures. Even though many countries claim to have “clean” power, variations do exist and magnetic devices are sometimes not flexible enough to adequately perform consistently in the field.

### **The electronic age**

In an effort to provide customers with the best possible components for their UV systems, the exploration of electronic solid-state ballasts began in the early 1990s. An electronic ballast incorporates a series of transistors, filter capacitors and transformers. The ballast takes the AC input and converts it to DC, eliminating the effects of frequency variations.

The capacitors store this energy and modulate the electrical output. The ballast then converts this DC back to AC and delivers this current back to the lamp. If properly designed, the results of this device are a ballast that operates at extremely cool temperatures and operates over a wide voltage and frequency range.

These electronic ballasts proved to be a vast improvement over traditional magnetic ballasts; however, these designs did not address the issue of regulating the output current. Even in these new electronic ballasts, the lower the voltage delivered to the lamp, the lower the output current and the lower the UV dose delivered to the water.

In the late 1990s, electronic ballasts were designed that would operate over a wide range of input voltages, be frequency-independent, operate over a wide range of UV lamps and operate the UV lamps at their optimum operating parameters to maximize UV output and lamp life.

Most of the electronic ballasts in use today are modified versions of ballasts used in the lighting industry. These new constant current output ballasts were specifically designed for use in UV systems. By using overrated components and good thermal management, the reduced heat buildup offers substantially longer component life and trouble-free operation. The unique stress-free mechanical interface to the ballast's aluminum housing allows for maximum heat dissipation of the power semiconductors.

The useful life of a UV lamp is largely determined by the crest factor performance of the ballast driving the lamp. The open-loop, current-control circuitry of these new electronic ballasts compensates for crest factor degradation caused by aging of the filter capacitors.

In a standard electronic ballast, the crest factor is degraded by the amount of AC ripple voltage on the DC voltage supplied to the inverter circuit. As the filter capacitors age, this ripple voltage of the DC supply will increase, therefore degrading the crest factor performance of the ballast.

In an effort to comply with European and North American certification protocols, these new electronic ballasts offer full filtering capabilities for both electromagnetic interference and radio frequency interference.

The output current of the constant-output current ballast remains constant at 425 mA throughout the entire input voltage range of 100 to 260 volts.

Traditional electronic ballasts may function over the same range; however, their output current does not remain constant and does not operate the lamp properly as the voltage is varied.

Efficiency is a measure of how effectively a ballast converts the incoming power to the power demands of the UV lamp. A typical magnetic ballast may operate at <50 percent efficiency. Electronic ballasts can operate over a wide range of efficiencies.

Properly designed electronic ballasts should exceed 90-percent efficiency. This is especially important for UV disinfection since the UV system is designed to be operated on a continuous basis. Inefficient ballasts waste energy and cost more to operate. This wasted energy shows up as heat. A ballast that runs hot is wasting energy. The constant-output current ballasts run cool, resulting in little energy waste.

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