Lighting: Metal Halide Ballasts

Like other discharge light sources, high-intensity discharge (HID) metal halide lamps require a ballast to limit current to the electrodes. Ballasts also provide the correct voltage for starting and restarting, and they adjust current to maintain light color and intensity over time. All ballasts suffer internal losses—ranging from 5 to 90 percent of the lamp wattage—that should be included in any calculation of potential savings, especially when switching from nonballasted sources such as incandescent lamps. Two main types of ballasts are now available: the newer electronic ballasts and the more common magnetic ones.

What Are the Options?

Magnetic Ballasts.

Up until a few years ago, magnetic ballasts were the only option for HID light sources, and they are still the type that is most often used. The most common type of magnetic ballast sold today is the constant-wattage autotransformer, which effectively regulates lamp power to minimize flicker and unexpected shutoffs if the line voltage varies. Composed mainly of magnetic coils, these ballasts often include a capacitor in the circuitry to improve power factor. Magnetic ballasts generally have internal losses of at least 10 percent of the lamp wattage—and the percentage is even higher for lower-wattage lamps. Manufacturers produce magnetic ballasts capable of working with lamps of up to 1,500 watts (W).

Electronic Ballasts

Electronic ballasts are a relatively new offering, and they are now available for lamps of up to 450 W. They use switching electronics and small high-frequency inductors, rather than large line-frequency ones, to control current and voltage to the lamp. Though costly, electronic ballasts offer a host of benefits over their magnetic counterparts, including higher efficiency, better dimming capabilities, better light quality, and shorter warm-up times.

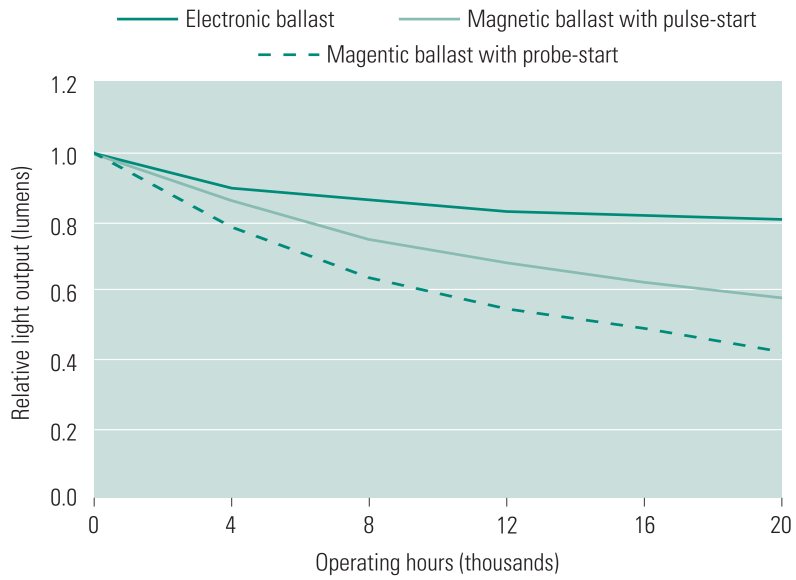
Efficiency. Electronic ballasts for HID lamps consume about 60 percent less power than their magnetic equivalents—a typical electronic ballast for a 400-W lamp uses 15 to 30 W, compared with 50 to 60 W for a magnetic unit.

Light output. Metal halide lamps are notorious for the color variability of their light output, but lamps operated by electronic metal halide ballasts provide more stable output than lamps operated by magnetic ballasts. That’s because the electronic ballasts reduce the variability of the voltage supplied to the lamp.

The light output of lamps driven by electronic ballasts also degrades more slowly over time, resulting in greater light output at the mean and end of the lamp’s life (see **Figure 1**). This in turn enables systems with electronic ballasts to use fewer fixtures, or lower-wattage lamps, to provide the same output as systems with magnetic ballasts.

Figure 1: Electronic ballasts improve lumen maintenance

Lamp output degrades more slowly with electronic ballasts than with magnetic ballasts. Output declines more rapidly on probe-start metal halide lamps operating on magnetic ballasts.



Source: Platts; data from Advance Transformer

Dimming capability. Electronic ballasts can be made continuously dimmable, down to about 50 percent of full output power. This characteristic makes them more amenable to daylight harvesting than magnetic ballasts, which, at best, offer step-dimming down to one or two lower levels. Step-dimming to 50 percent of maximum light output is common in warehouses and other irregularly occupied building spaces. Electronic ballasts also have greater dimming efficiency than magnetic ones. A magnetic ballast step-dimmed to 50 percent of maximum light output typically consumes 65 percent of full power, whereas the ratio of light output to power input for an electronic ballast is nearly one-to-one. However, dimming any HID lamp, even with an electronic ballast, may lead to significant color-shifting, seriously limiting this capability in areas where color is of concern.

Warm-up and restrike times. Metal halide lamps take several minutes to warm up to full output and several minutes to cool down and restart once they go out (either intentionally or due to a power failure). With electronic ballasts, warm-up times are significantly shortened for both quartz and ceramic lamps, but restrike times (the time it takes for a lamp to cool down and restart after a momentary outage) are only shortened for quartz lamps (see **Table 1**). None of the times is shortened to the point where metal halide lamps can be used with on/off controls.

Table 1: Warm-up and restrike times for metal halide lamps

Electronic ballasts have shortened warm-up and restrike times for pulse-start metal halide lamps. The ranges of values account for differences in ballast starting techniques, fixture heat dissipation, lamp type (coated or clear, open or enclosed rating), lamp age, and whether or not there is a hot restrike capability.

Lamp/ballast type	Warm-up time (minutes)	Restrike time (minutes)
Probe-start MH, magnetic ballast	4–5	10–20
Pulse-start MH, magnetic ballast	2–3	3–5
CMH, magnetic ballast	2–3	10–20+
Quartz pulse-start MH with electronic ballast	1–3	2–4
CMH with electronic ballast	1–3	10–20+

Notes: CMH = ceramic metal halide; MH = metal halide.

Source: Platts; data from Stan Walerczyk

Noise. Magnetic ballasts produce noise because the metal laminations within them vibrate as the magnetic field changes at the line frequency of 60 times per second. Electronic ballast products are available that operate at both high and low frequencies, but operation is silent because the ballasts don't have laminations to vibrate. This quality is important in areas such as libraries, concert halls, and retail shops.

Light flicker. Some electronic ballasts for metal halide lamps operate at much higher frequencies than the 60 hertz (Hz) of magnetic ballasts. This high-frequency operation eliminates the flicker that can accompany line-frequency operation and can cause headaches or otherwise affect a room's occupants. High-frequency electronic ballasts also eliminate the stroboscopic effect. Although other types of lamp flicker are just annoying, the stroboscopic effect can be dangerous. When circular saws, drill presses, and other machinery operate at a certain speed, the stroboscopic effect from magnetic ballasts can cause the machines to appear as if they are not operating. Other electronic ballasts operate at lower frequencies (75 Hz for one product), but they have a square wave design that also eliminates flicker.

Reduced stock variety. The use of dimming electronic ballasts allows a facility to minimize the different types of lamps and ballasts it must keep on hand—making inventory tracking easier and eliminating the risk that the wrong lamp would be installed. For example, instead of having to purchase, stock, and replace 250-, 320-, and 400-W pulse-start metal halide lamps and ballasts, a facility can stock just 400-W lamps and use dimming electronic ballasts to get the right light levels. This also enables the facility to take advantage of the 400-W lamps' longer life—20,000 hours versus just 15,000 hours for 250-W lamps.

Longer lamp life. Ballast manufacturers report that pulse-start metal halide lamp life may be increased by about 25 percent through the use of electronic ballasts. This effect is plausible, because electronic ballasts provide more-precise control of current and therefore place less stress on electrodes when a lamp is started. But as of yet, no independent confirmations of increased lamp life have been made, and it may take some time for manufacturers to verify longer lamp life. Meanwhile, when trying to estimate the life of a lamp operating with a particular electronic ballast, use data from a lamp manufacturer rather than from a ballast manufacturer.

Cost. Incremental costs for electronic ballasts have been running $60 to $150 above the $30 cost of magnetic pulse-start metal halide ballasts. However, electronic ballasts have reasonable simple-payback periods over magnetic ballasts based on efficiency and lumen depreciation alone (see **Table 2**).

Table 2: Cost comparison—electronic versus magnetic ballasts

Systems with electronic ballasts currently cost significantly more than those with magnetic ballasts. However, energy savings can lead to a reasonable payback, depending on the application.

	Pulse-start lamp with magnetic ballast	Pulse-start lamp with electronic ballast
Lamp power (watts)	400	400
Ballast power (watts)	60	15
Initial output (lumens)	43,000	43,000
Lumen maintenance	0.65	0.70
End-of-life output (lumens)	27,950	30,100
Number of fixtures	100	93
Total output (lumens)	2,795,000	2,799,300
Annual operating time (hours)	6,000	6,000
Annual cost of electricity [a] ($)	22,080	18,526
Annual savings ($)	NA	3,554
Equipment cost/fixture ($)	135	335
Total equipment cost ($)	13,500	31,155
Cost difference ($)	NA	17,655
Simple payback (years)	NA	5

Notes: NA = not applicable.
a. Assumes energy cost of $0.08 per kilowatt-hour.

Source: Platts

How to Make the Best Choice?

Electronic ballasts for HID light sources offer various benefits over magnetic ballasts: greater efficiency, greater light and color stability, lower lumen depreciation, better dimming options, faster warm-up and restrike times, less noise, elimination of flicker, and longer lamp life. However, they do carry a higher cost. To determine if electronic ballasts are a cost-effective solution, conduct a cost analysis that considers these five ballast/lamp parameters: ballast power, lumen maintenance (a measure of lamp light depreciation over time), lamp life, and end-of-life output. Other factors include the operational hours in a year, the cost of electricity, and the cost of the ballasts.

When choosing a particular electronic ballast, make sure that it is compatible with the lamp and that the ballast's rated operating temperature falls into a range in which the ballast is expected to operate. Also, because electronic ballasts are a relatively new technology, there have been some reliability questions—look for manufacturers with a good track record.

What's on the Horizon?

Although electronic ballasts are more expensive than magnetic ballasts, the incremental cost of electronic ballasts should drop and reliability should improve as sales volumes increase and manufacturers introduce new products and gain more experience.

Newer, more-capable wireless systems, some of which are available today, may broaden the wireless lighting market considerably if costs can be reduced. Due to their enhanced dimming properties, electronic ballasts may one day be controlled via wireless controllers, providing an opportunity to enhance an existing electronic ballast system with daylighting capabilities. These newer wireless systems should begin to appear on the market in 2006.