

Energy Efficient Fluorescent Ballasts

A Pacific Energy Center Factsheet

Introduction

Recent advances in fluorescent lamp ballast technology offer improved performance and increased energy efficiency. Use of these ballasts is an excellent energy-saving strategy that should not be overlooked by anyone interested in reducing operating costs.

Technology Description

All gas discharge lamps, including fluorescent lamps, require a ballast to operate. The ballast provides a high initial voltage to initiate the discharge, then rapidly limits the lamp current to safely sustain operation. (Lamp manufacturers specify lamp electrical input characteristics (lamp current, starting voltage, current crest factor, etc.) required to achieve rated lamp life and lumen output specifications. Similarly, the American National Standards Institute (ANSI) publishes recommended lamp input specifications for all ANSI-type lamps. Manufacturers usually design ballasts to optimally operate a unique lamp type. Some ballasts, however, will adequately operate more than one type of lamp, although the resulting lamp starting characteristics, light output, and operating life may differ from the lamp's optimum performance.

Ballast Types

There are three primary types of ballasts, classified based on the kinds of electrical components used to build the ballast.

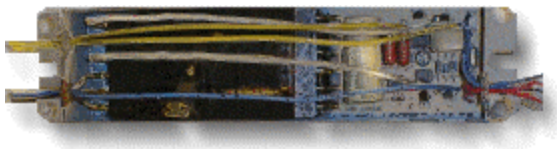


Figure 1. Typical Magnetic Fluorescent Ballast

Magnetic Ballasts consist of a transformer and a capacitor encased in an insulating material. In 1990, U.S. energy standards required that standard magnetic ballasts no longer be sold, although these older ballasts still make up the majority of fluorescent ballast installations. Magnetic ballasts sold after 1990 bear the designation “energy-saving,” and are about eight percent more efficient than older ballasts. The lamp operating frequency is 60 HZ, the same as the input frequency.



Figure 2. Typical Heater Cutout Fluorescent Ballast

Heater Cutout (Hybrid) Ballasts are similar to magnetic ballasts but include an electronic circuit that removes the voltage to the electrode heaters in rapid-start lamps once the lamps are operating. By eliminating the power consumption normally used to heat the electrodes, these ballasts consume about 20 percent less power than standard magnetic energy-efficient ballasts. Lumen output is reduced about 12 percent.



Figure 3. Typical Electronic Fluorescent Ballast

Electronic Ballasts use a variety of electronic components to convert the lamp operating frequency from 60Hz to 20-40 kHz. The high frequency operation reduces internal losses in the lamp and conserves energy.

Start-up Circuitry

Ballasts can also be classified on the basis of the circuitry employed in lamp start-up.

In Preheat start-up, lamp electrodes are heated prior to initiating the discharge. A “starter switch” closes, permitting a current to flow through each electrode. The starter switch rapidly cools down, opening the switch, and triggering the supply voltage across the arc tube, initiating the discharge. No auxiliary power is applied across the electrodes during operation.

In Rapid start-up, lamp electrodes are heated prior to and during operation. The ballast transformer has two special secondary windings to provide the proper low voltage to the electrodes.

In Instant start-up, lamp electrodes are not heated prior to operation. Ballasts for instant start lamps provide a relatively high starting voltage (compared to preheat and rapid-start lamps) to initiate the discharge across the unheated electrodes.

Rapid-start is the most popular starting method for 4-foot 40-watt lamps and high output 8-foot lamps. The advantages of rapid-start operation include smooth starting, long life, and dimming capabilities. Lamps smaller than 30 watts are generally operated in a preheat circuit, which is more efficient than rapid start as separate power is not required to continuously heat the electrodes. However, lamps flicker during preheat starting and have a shorter lamp life.

Instant start operation is also more efficient than rapid start, but as in preheat operation, lamp life is shorter. Eight-foot “slimline” lamps are operated in instant start mode. The 4-foot 32 watt F32T8 lamp is a rapid-start lamp, commonly operated on an instant start circuit to improve lamp efficacy, but with some penalty in lamp life.

Mode of Operation

In addition, ballasts may be classified according to their mode of operation.

On/Off Ballasts turn either on or off and are the most prevalent type.

Multi-level Ballasts can reduce the lighting and power consumption levels in discrete, pre-established steps. The most typical is a bi-level switching ballast, which can reduce the lighting level by 50 percent with approximately 50 percent power reduction, thus increasing the flexibility of standard electronic ballasts. These ballasts meet the bi-level switching requirements in Title 24. Standard switches, occupant sensors, photocells, or other building energy management control devices may be used to switch the ballast. A two-level ballast is supplied with an additional input lead to allow switching between 50 percent and 100 percent operation.

Dimming Ballasts permit the light output of the lamp to be continuously controlled over a range of approximately 10 percent to 100 percent of full light output. A low-voltage signal (usually between 0 and 10 volts) to the ballast output circuit modifies the current to the lamp. In dimming electronic ballasts, feedback circuits maintain electrode voltage when the lamp current is reduced, allowing the lamp to be dimmed over a wide range without reducing lamp life. Premium electronic dimming ballasts can modulate lamp operation from 1 percent to 100 percent of full light output. With magnetic ballasts, input power to the ballast is modified to alter the lamp current, which also reduces electrode voltage and limits the practical dimming range for magnetic ballasts to about 50 percent of full light output.

Ballast Operating Characteristics

There are a number of different operating characteristics used to evaluate the performance of ballasts. The following terms describe properties of ballasts that are independent of the lamp operated by the ballast.

Power Factor is the ratio of watts to Root Mean Square (RMS) Volt-Amperes of the ballast. High power factor ballasts (power factor above 0.90) draw less current than low power factor ballasts rated for the same wattage lamps.

Frequency refers to the number of cycles per second of the alternating current. Standard magnetic ballasts run on normal building operating frequencies of 60 Hz, while electronic ballasts change the frequency to 20-40 kHz.

Harmonics result from the use of non-sinusoidal waveform devices and are generally measured in terms of Total Harmonic Distortion (THD).

Ballasts are just one of many types of equipment that generate harmonics. The concern for harmonics in the design of building electrical distribution systems is that harmonics add current to the neutral wire, may overload transformers, can cause current/voltage surges and/or spikes, may interfere with electrical equipment or communications on the same circuit, and may cause distortion of the electrical service entrance voltage. As long as the harmonics are limited to less than 33 percent for each phase, the neutral wire will still be sized properly for the load.

PG&E rebates for electronic ballasts require THD values less than 20 percent. To put the issue of harmonics in proper perspective, it is of interest to examine THD values for magnetic ballasts. The harmonics for some magnetic ballasts are well in excess of the 20 percent THD limit and have been measured in excess of 37 percent. Based on this evidence and the fact that these magnetic ballasts have been in use for quite some time with no apparent adverse affect on building performance, it would suggest that the 20 percent THD limit for electronic ballasts is arbitrarily conservative. In any case, electronic ballasts that meet this requirement are readily available at a reasonable cost.

Regulation refers to the ability of the ballast to adjust light output in response to input voltage variations. Recommended values are ± 10 percent light regulation with ± 10 percent input voltage variation.

Lamp Current Crest Factor is the ratio of peak current to the RMS lamp current. High lamp current crest factors reduce lamp life. Ratings for lamp life are based on a lamp current crest factor of 1.7.

Lamp Ballast System Characteristics

The amount of light that any ballasted lamp produces depends on how well the ballast and lamp are matched in operating characteristics. The following terms describe properties of the lamp/ballast combination.

Ballast Factor is the ratio of a lamp's light output using a specific ballast compared to the lamp's rated light output using a reference ballast. The closer the ballast factor to 1.0, the more closely the lamps will generate their rated lumen output. Certain electronic ballasts offer ballast factors slightly higher than 1.0. Although most ballast factors are above 0.90, a designer may choose a ballast with a lower ballast factor in situations where lower lighting levels and lower wattage are desired.

Input Watts is the power required to operate the lamp/ballast combination measured in watts.

Lamp Efficacy is the ratio of the rated light output of a lamp to its rated power consumption in units of lumens/watt. This value does not include ballast losses.

Lamp/Ballast System Efficacy is the ratio of lamp light output to ballast input watts, in units of lumens/watt. This differs from lamp efficacy in that it does account for ballast losses.

Ballast Efficacy Factor (BEF) equals the percent rated light output (ballast factor x 100%) of a particular lamp/ballast combination under ANSI test conditions, divided by the measured input power (%/watts).

$$\text{BEF} = \text{BF} \times 100 / \text{Input Watts}$$

BEF is used in regulations to specify minimum efficiency levels. A comparison of BEF factors is valid only when comparing ballasts operating the same lamp type and quantity. Current federal and state regulations specify BEF limits for ballasts operating standard F40T12 and F96T12 lamps.

Other Considerations

Because ballasts generate noise, they carry sound level ratings A, B, C, or D. An “A” rated ballast will hum softly; a “D” rated ballast will make a loud buzz. Electronic ballasts are almost inaudible, quieter than required for an “A” sound rating.

Starting temperature ratings designate the minimum ambient temperature required to start the lamps. Outdoor use requires a ballast designed for low-temperature operation.

Ambient temperature also affects the life of the ballast. For magnetic ballasts, every 10° F degrees increase above the rating temperature conditions decreases ballast life by one-half. Consequently, ballasts in enclosed fixtures typically have a shorter life than ballasts in open fixtures with better heat dissipation.

For More Information

Contact your PG&E representative or call 1-800-468-4743 for more information about PG&E's energy efficiency programs and other services.

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