Appendix

Ballasts

The ballast for any fluorescent lamp has two main functions: it provides the high voltage required to start the lamp, and it controls the current provided to the lamp during operation. Magnetic ballasts have a transformer that consists of a magnetic core with copper or aluminum wire wound around it. Electronic ballasts transform voltage by using solid-state circuitry rather than magnetic components. Electronic ballasts operate lamps at high frequency (20,000 hertz (Hz) or higher compared to 60 Hz for magnetic ballasts), resulting in a 10 to 12 percent increase in lamp efficacy over magnetic ballasts.

Ballasts start fluorescent lamps in one of three ways: preheat start, rapid start, or instant start. For preheat starting, the starter is a component separate from the ballast. Preheat starting is characterized by the lamp flashing on and off a few times before it starts. For screwbase compact fluorescent lamps, the starter is actually built into the base of the lamp, whereas for other fluorescent lamp systems, the starter is a separate component.

A rapid-start mode usually is used to operate 4-foot linear fluorescent lamps. In rapid-start systems, the starter is an integral part of the ballast. A 1- to 2-second delay occurs before the lamps start, but the lamps do not flash on and off. Rapid-start ballasts are presently not available for screwbase compact fluorescent lamps.

For the instant-start method, a very high voltage is applied to the lamps while they are cold. No preheating is required, and the lamps start instantly. Most electronic ballasts are instant start. In some cases, instant start operation reduces the life of the lamp.

For remodeling projects, contractors and residents should note that ballasts that were manufactured prior to 1978 may contain polychlorinated biphenyls (PCBs), which are toxic and must be disposed of with caution. The label “No PCBs” should appear on all ballasts manufactured after 1978; assume that all others contain PCBs. Consult your state’s department of environmental conservation for more information.

Power Quality

In a residential electrical system, the current and voltage supplied to electrical equipment should be sinusoidal in wave shape and should be in phase with one another. Any technology that causes variations in the shape of the current and voltage waves or in the phase relationship between current and voltage raises power quality concerns. Many electrical devices used in residences, including some efficient lighting technologies, affect power quality. Poor power quality can cause inefficient operation or failure of other electrical equipment on the same supply line, and it can result in excessive current in electrical distribution systems. The total impact of poor power quality from lighting products on other residential appliances and on the utility distribution grid is not yet fully understood.

One measure used to evaluate the power quality of electrical devices is power factor. Power factor is defined as a ratio: power (watts) divided by root-mean-square (rms) volt-amps (the product of the rms voltage and rms current). The rms of any wave shape expresses the effective average value of the wave shape. The power factor indicates the amount of current and voltage that a utility must supply with respect to the power that produces useful work. Power factor is a measure of the efficiency with which an electrical device converts input current and voltage into useful electric power. Power factor may range from zero to one, with one being the ideal. Power factor is lowered by devices that shift the phase of the voltage and current and by devices that distort the sinusoidal wave shapes of the input voltage and current. The figure illustrates possible relationships between voltage and current and their impact on power factor.

In fluorescent lighting systems, magnetic ballasts usually cause the current to be out of phase with the voltage. Reductions in power factor that are caused by a phase shift may be corrected by including a capacitor in the ballast design. This correction is commonly included in ballasts for 4-foot linear fluorescent lamps, resulting in a high power factor (0.95 and higher). However, many compact fluorescent magnetic ballasts do not use a capacitor to correct the phase shifts, and thus they have...
low power factors (some as low as 0.50). Newer magnetic ballasts for compact fluorescent lamps are available that include power factor correction.

Electronic ballasts for fluorescent lighting systems seldom affect the voltage-current phase relationship, but they often distort the voltage and current wave shapes. Distorted wave shapes contain components with frequencies that are multiples of the fundamental frequency, which usually is 60 Hz. As in music, these higher-frequency components are known as harmonics. Total harmonic distortion (THD) is a measure of the degree by which a sinusoidal wave shape is distorted by harmonics. THD expresses the harmonic components as a percentage of the fundamental component.

Electronic ballasts for 4-foot linear fluorescent lamps often are designed to minimize THD; some ballasts are available with THD less than 10 percent. Many utilities have established a limit of 20 percent maximum THD for ballasts that are approved for incentive programs. However, compact fluorescent devices for residential use may have THD greater than 100 percent.

Techniques for minimizing THD and improving power factor are available but increase the cost of manufacturing ballasts.