NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports

Screwbase Compact Fluorescent Lamp Products

Energy-efficient alternatives to incandescent lamps

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Contents

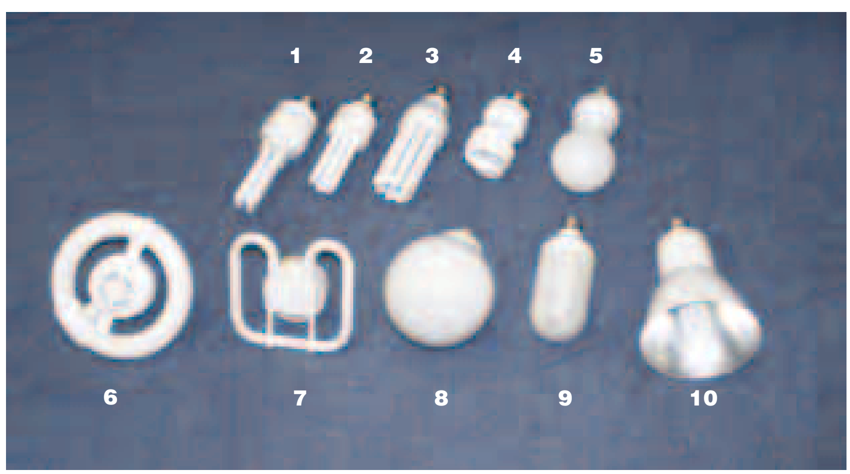
Introduction

Compact fluorescent lamps (CFLs) were introduced in the United States (US) in 1979. By 1994, production of CFLs in the US had increased to approximately 31 million units, but that was less than 4% of the number of standard incandescent lamps produced that year (Conway and Mehra 1998).

Specifiers and end users use CFL products (see the "Nomenclature" sidebar on p. 3) to replace incandescent lamps in luminaires with medium screwbase sockets, such as ceiling- and wall-mounted luminaires, exterior luminaires, recessed downlights, track lighting, and floor and table lamps. CFL products can reduce energy and maintenance costs compared to incandescent lamps. In fact, manufacturers often indicate the "equivalent incandescent wattage" on the packaging of their CFL products. However, CFL products differ from comparable incandescent lamps and from each other in size, shape, light output, power quality, and life. The National Lighting Product Information Program (NLPIP) produced this issue of *Specifier Reports* to promote better understanding of screwbase CFL products and to provide guidance to specifiers on selecting them.

CFLs are fluorescent lamps, that have a tube diameter of 16 millimeters (mm) [⅝ inch (in.)] or less. They are available in various shapes, as shown in Figure 1. Circular lamps have tube diameters equal to or

Figure 1. CFL Envelope Shapes



The terms used in this report to describe envelope shapes are: **1** quad; **2** triple tube; **3** four-tube; **4** coiled tube; **5** A-line; **6** circular; **7** square; **8** globe; **9** capsule; **10** reflector. Other envelope shapes (not shown) are referred to as "decorative." These are NLPIP's descriptions; manufacturers might use other terms.

Figure 2. Self-Ballasted CFLs

(Incandescent A-lamp at front center shown for size comparison)

Figure 3. Modular CFL and Ballast

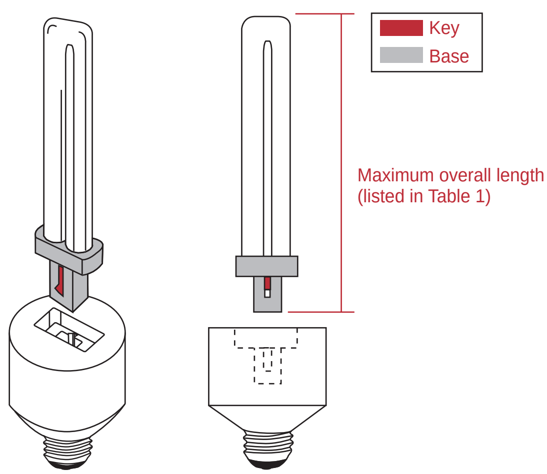


Figure 4. Modular CFL Products

(Incandescent A-lamp at front center shown for size comparison)

larger than 25.4 mm (1 in.). However, this report treats them as CFL products because they are compact in overall size and can be used as alternatives to incandescent lamps.

CFL products are available as either dedicated or screwbase products. Dedicated CFL products, like linear fluorescent lamp systems, use a ballast that is hardwired to lamp holders within a luminaire. Because the lamps fit into specially keyed sockets, only dedicated CFL lamps can be used in the luminaire.

Screwbase CFL products are available in two configurations: self-ballasted and modular. A self-ballasted CFL contains a lamp and ballast as a single unit. Self-ballasted CFLs are rated for 6000 to 15,000 hours (h), and when the lamp fails, the entire unit must be replaced. Figure 2 shows some self-ballasted CFLs with an incandescent A-lamp.

A modular CFL product consists of two components: a screwbase ballast and a replaceable CFL. The ballast and lamp connect together using a socket-and-base design, as shown in Figure 3. Unlike the self-ballasted CFLs, modular CFL products allow the lamp (rated for 7500 to 15,000 h) to be replaced without having to discard the ballast (rated for 20,000 to 150,000 h). Figure 4 shows some modular CFL products with an incandescent A-lamp.

This new *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* replaces previous NLPIP publications on screwbase CFL products and includes performance data for CFL products that were available as of July 1997, designed to fit in a medium screwbase socket, and rated at or above 13 watts (W). This report includes NLPIP test data and manufacturers' data on self-ballasted CFLs and modular CFL products that are sold with ballast and lamp packaged as a single unit.

One manufacturer supplied information on an electrodeless CFL product. This report treats it as a CFL product because it can be used as an alternative to incandescent lamps. However, the technology and operation of the product (current passing through an induction coil generates an electromagnetic field, which excites the mercury vapor) is different from that of the other CFL products in this report. Some sections of the report, such as the discussion of ballasts, do not apply to the electrodeless CFL product. Specifiers considering an electrodeless CFL product should be aware of its possible advantages, such as a longer life and silent operation. They should also consider its possible drawbacks, such as electromagnetic interference. The May/June 1995 issue of *Lighting Futures* (Luo 1995) discusses electrodeless lamps in detail.

Lamps

As with all fluorescent lamps, CFLs emit light when low-pressure mercury vapor is energized inside the lamp, which produces ultraviolet (UV) radiation. The UV radiation is absorbed by a phosphor coating on the inner surface of the lamp, which converts the radiation to light.

Most modular CFL products have bare lamps to make it easier to replace the lamp. Self-ballasted CFLs have either bare or encapsulated lamps. Encapsulated lamps (shown on the right side in Figure 2) have a permanently attached glass or plastic cover, which is available in globe or capsule shape. Figure 1 on p. 1 shows examples of different lamp envelope shapes.

Ballasts

Ballasts provide initial voltage for starting lamps and regulate lamp current during operation. They consume a small amount of energy while performing these functions.

CFL ballasts are either magnetic or electronic. Magnetic ballasts contain a steel core and copper coil, and operate lamps at the power line frequency of 60 Hz. They weigh from 120–453 grams (g) [4–16 ounces (oz)]. Electronic ballasts contain a circuit board and electronic components. They are generally more efficient and quieter than magnetic ballasts but can cause electromagnetic interference. Electronic ballasts operate lamps at frequencies ranging from 20–60 kHz. They usually weigh less than 226 g (8 oz).

Some ballasts can dim CFLs, as discussed in the "Dimming" section on p. 11. Tables 1 and 2 indicate when a ballast is dimmable. The sidebar "Starting Methods" on p. 4 explains the different methods employed by ballasts to start CFL products.

Accessories

Manufacturers provide accessories such as diffusers, lenses, and reflectors that attach to their products to modify the light distribution. Some manufacturers offer other types of accessories such as antitheft locking devices. Some accessories are permanently attached, while others are removable.

Diffusers are useful accessories for bare-lamp CFL systems (both modular and self-ballasted CFLs) where the lamp may be in direct view and cause glare. Focusing reflectors and lenses convert the primarily non-directional light output from a CFL into more directional light output so that it can replace a directional incandescent lamp such as a reflector (R) or a parabolic aluminized reflector (PAR) lamp. Compact fluorescent reflector lamp products often are used in recessed downlight and track lighting luminaires where a directional light source is preferred. However, they don't always perform as well as directional incandescent lamps. See *Specifier Reports: Reflector Lamps* (1994) for a more complete discussion. Figure 5 shows some typical accessories, and Tables 1 and 2 on pp. 18–35 list accessories offered by the manufacturers.

Nomenclature

Throughout this report, NLPIP uses the following nomenclature:

The term *CFL products* includes all self-ballasted and modular CFL products with a medium screwbase.

A *CFL* is the lamp in a CFL product, regardless of whether it is modular or part of a self-ballasted unit.

A *self-ballasted CFL* is an integrated lamp-ballast combination with a medium screwbase; this is also known as an integral CFL or a one-piece CFL.

A *modular CFL product* is the modular CFL and the modular CFL ballast operating together as a unit.

A *modular CFL* is a CFL that fits into a modular CFL ballast.

A *modular CFL ballast* is the medium screwbase ballast with a lamp holder (socket) for a modular CFL.

A *compact fluorescent reflector lamp product* includes a reflector as either a permanent or removable component of the CFL product.

Figure 5. Typical Accessories for CFLs

(Incandescent A-lamp and PAR30 lamp in front center shown for size comparison)

Performance Characteristics

CFL products can replace incandescent lamps in many applications. However, the performance characteristics of CFL products are different from those of the incandescent lamps they replace. This section discusses the performance characteristics (light output, life, power quality, efficacy, light distribution, color characteristics, and dimming) and what specifiers and end users should consider when specifying CFL products.

Light Output

The screwbase CFL products in this report have rated initial light output from 700 to 4800 lumens (lm) under standard test conditions, which are described in the "Standard Testing" sidebar.

The mercury vapor pressure inside the lamp influences light output; if the pressure is either greater than or less than optimal, light output declines. Most older CFLs contain a small amount of excess mercury, which condenses at the coldest point on the wall of the bulb [the location of the minimum bulb wall temperature (MBWT)], thus establishing the vapor pressure. Manufacturers have recently developed amalgam CFLs, which contain a mercury amalgam (two or three metals alloyed with mercury) added to the lamp to control the mercury vapor pressure. Both amalgam and non-amalgam CFL products are still available.

The "wattage equivalence" that CFL manufacturers sometimes include on their packaging refers to the wattage of a standard-life incandescent lamp of comparable initial rated light output. For example, the manufacturer of a 15-W electronic self-ballasted CFL might label it as a 60-W equivalent because its initial rated light output is similar to that of a 60-W incandescent lamp. However, there are no formal standards, and another manufacturer might label a similar CFL product as a 40-W equivalent. Table 3 compares rated light output of some CFL products with measured light output and with the light output of incandescent lamps that match the manufacturer-suggested wattage equivalences. The table also shows how position (base-up or base-down) affects the light output of some of the tested products. This table can be useful when specifiers replace incandescent lamps with CFL products. Tables 4 and 5 contain NLPIP's measured initial light output for some additional CFL products. Generally, a 3:1 ratio between incandescent wattage and CFL wattage provides equivalent in-use light output.

Although the rated initial light output of two lamps might be similar under standard testing conditions, actual light output can differ in common applications. The factors that influence light output are described in the sidebar "Light Loss Factors" on p. 6. A CFL product's expected light output can be estimated by multiplying the initial rated light output by the values of the light loss factors. See the sidebar "Table Lamp Application" on p. 7 for an example.

Installing a diffuser over a bare-lamp CFL product or using a CFL in an enclosed luminaire absorbs some of the light output and can change the lamp's thermal environment, which also affects light output. See "Thermal Factor" in the "Light Loss Factors" sidebar on p. 6.

Standard Testing

The initial rated light output of CFLs is based on standard test conditions approved by the American National Standards Institute (ANSI Standard C78.5-1997) and the Illuminating Engineering Society of North America (IESNA Standards LM-54-1991 and LM-66-1991). Among the conditions listed in the standards are lamp operation on a reference ballast (for modular CFLs) or on the integral ballast (for self-ballasted CFLs) at 25±1° Celsius (C) [77±2° Fahrenheit (F)] in still air; lamp operation in a vertical, base-up position; lamp operation at nominal line voltage; and lamp seasoning for at least 100 h prior to testing. For life testing, the standards also require operating cycles of 3 h on and 20 minutes (min) off.

Starting Methods

Ballasts use one of three methods to start CFLs: preheat, instant start, or rapid start.

Preheat
Preheat (also called switch-start) ballasts preheat the lamp electrodes for several seconds to approximately 800 to 1000°C (1470 to 1830°F). After the electrodes are preheated, the starter switch opens to allow a voltage of 200 to 300 volts (V) to be applied across the lamp to strike the arc. Preheat ballasts stop supplying the electrode heating voltage after starting the lamp. Magnetic preheat ballasts cause the lamp to flash on and off for a few seconds before finally staying lit. Electronic preheat ballasts start lamps without flashing.

Instant Start
Instant-start ballasts were developed to start lamps without delay or flashing. Instead of heating the electrodes prior to starting, instant-start ballasts supply a high initial voltage (over 400 V) to strike the arc. The high voltage is required to initiate the discharge between the unheated electrodes. The electrodes are not heated either before or during operation, so instant-start ballast systems have lower power losses than rapid-start ballasts. It is generally accepted that instant-start ballast systems can reduce lamp life compared to preheat ballasts, especially with frequent switching, because the high initial voltage accelerates the degradation of the emissive coating on the electrodes.

Rapid Start
Rapid-start ballasts provide a low voltage (about 3.5 V) to the electrodes, heating them to approximately 1000°C (1830°F) in 1 to 2 seconds (s). Then a starting voltage of 200 to 300 V is applied to strike the arc. Rapid-start ballasts supply the electrode heating voltage even after the lamp has started, resulting in power losses of 3 to 4 W for each lamp. Rapid-start ballasts start lamps with a brief delay, but without flashing.

Manufacturers are developing new rapid-start technologies that more precisely control the starting process in order to extend lamp life. The new technologies have names such as programmed start, modified rapid-start, and controlled rapid-start.

Life

Rated lamp life is the number of hours at which half the lamps in a large test group have failed under standard testing conditions (see the sidebar "Standard Testing"). A CFL will fail when the emissive coating on its electrodes is all dissipated by evaporation or sputtering (Voorlander and Raddin 1950; Covington 1971). Although the inert fill gas used in CFLs protects the electrodes from bombardment by mercury ions, loss of emissive coating during lamp starting is unavoidable (See the sidebar "Starting Methods"). Therefore, if a CFL is started less frequently than the standard 3-hour-on, 20-minute-off cycle, it will have a life longer than its rated life, but if it is started more frequently than the standard cycle, it will have a life shorter than its rated life. For more details, see the sidebar "Long-Term Performance Testing."

The manufacturer-reported rated life of nearly all modular CFLs included in Table 1 is 10,000 h. However, one product has a 7500-h life and one has a 12,000-h life. For modular CFLs, rated life is based on the assumption that the lamp current crest factor (CCF) is less than 1.7 (see the sidebar "Lamp Current Crest Factor" on p. 8). When a modular lamp fails, it must be replaced by a compatible lamp. If the identical lamp is no longer available, the manufacturer should be able to recommend a replacement. Also, the packaging for replacement lamps usually lists compatible lamps. Replacing a lamp with a compatible lamp from a different manufacturer might affect performance.

Modular ballasts have life ratings of 20,000 to 150,000 h. These ratings are based on a maximum allowable ambient temperature.

The rated life of most self-ballasted CFLs reported in Table 2 is between 6000 and 10,000 h. Only the electrodeless CFL product has a longer rated life (15,000 h) because it has an electrodeless lamp. Like modular CFL ballasts, self-ballasted CFLs have recommended maximum ambient temperatures.

Recommended maximum ambient temperatures are reported in Tables 1 and 2. In enclosed luminaires, the ambient temperature can exceed a manufacturer's recommended maximum temperature.

Long-Term Performance Testing

Long-term performance testing of CFL products was initiated at the LRC in June 1996 and is continuing at the time of this publication. The purpose of the project is to study the effect of different operating cycles used in typical residential applications on the life of CFL products and to document how different characteristics such as ballast technologies, manufacturers, and lamp shapes affect the life of these products. The LRC did not use the number of samples suggested in ANSI Specification C78.5-1997 (ANSI 1997) because the object of the study was not to determine absolute life of the products but to look at factors that might affect life under different operating cycles.

Using industry documentation and company information, NLPIP identified 11 different CFL products to test from six different manufacturers. Six different operating cycles were selected to represent possible applications for CFL products:

Cycle 1: 5 min on and 20 s off
Cycle 2: 5 min on and 5 min off (under cabinet)
Cycle 3: 15 min on and 5 min off (bathrooms)
Cycle 4: 1 h on and 5 min off (dining room)
Cycle 5: 3 h on and 5 min off (kitchen or living room)
Cycle 6: 3 h on and 20 min off (standard cycle)

For cycles 1–4, eight samples of each product were tested; for cycles 5 and 6, four samples of each product were tested. All the lamps were operated base-up because a pilot study (Davis et al. 1996) showed that operating position had no effect on lamp life for CFL products. Four 6- × 5- × 3-foot (ft) lamp racks were built for this study, each with five "shelves" that held 32 lamps. A 45 kVA voltage regulator (120 V±0.5%) regulated the power to the 440 lamps. A computer monitored and controlled testing. Ambient temperature inside the laboratory was 25±10°C (77±20°F).

Long-Term Performance Testing Lab

Lamp starting characteristics (starting time, electrode preheat current, and lamp starting voltage) and lamp electrical characteristics (lamp operating current and CCF) were measured for one sample of each of the 11 different CFL products. The data are presented in Table 6 on p. 42. Samples had to be taken apart to measure these characteristics.

Although the testing is ongoing, the results to date provide insights into the life of CFL products. Some of the products have not failed yet. The following discussion covers only those lamps for which all the samples have failed. Updates will be published through NLPIP Online at www.lrc.rpi.edu. (Table 6 shows the median lamp life in hours and total operating hours as of December 31, 1998.)

The results so far show that shorter operating cycles significantly reduced the median lamp life and that some products did not meet their expected life even with the standard cycle. Lamp lives with 5-min, 15-min, and 1-h on-times were approximately 15, 30, and 80%, respectively, of lamp life under the standard cycle.

Preliminary inferences regarding product design can be drawn when comparing the electrical characteristics of the lamps. For example, ANSI standards currently limit CCF for fluorescent lamps to a maximum of 1.7, because higher CCF ratings are expected to reduce lamp life. However, some OSRAM SYLVANIA products had CCFs greater than 1.7, yet they had relatively long lives. The low operating current of the OSRAM SYLVANIA products (which limits the peak lamp current, even with a higher CCF) might explain their longer lives. This indicates that lamp operating currents might also influence lamp life.

The Lights of America Quad Lite had a high electrode preheat current and a very short starting time compared to the other electronic preheat products; its significantly shorter life may indicate that longer starting time and lower preheat currents are better for the lamp. Similar results for lamp starting parameters for 4-ft linear T8 fluorescent lamps were found by Ji et al. (1997).

Light Loss Factors

In this sidebar, NLPIP discusses factors that influence the light output of a CFL: ballast factor, thermal factor, position factor, and lamp lumen depreciation. In addition, NLPIP explains the effect of amalgam technology on position and thermal factors.

Ballast Factor
The light output of a modular CFL depends on the ballast used with it. Ballast factor is defined as the light output of a lamp operated by that ballast divided by the light output of the same lamp when it is operated by a reference ballast. Because self-ballasted CFLs do not have separable lamps and ballasts, their light output ratings are based on the light output with the integral ballast. Thus, ballast factor does not apply to self-ballasted CFLs.

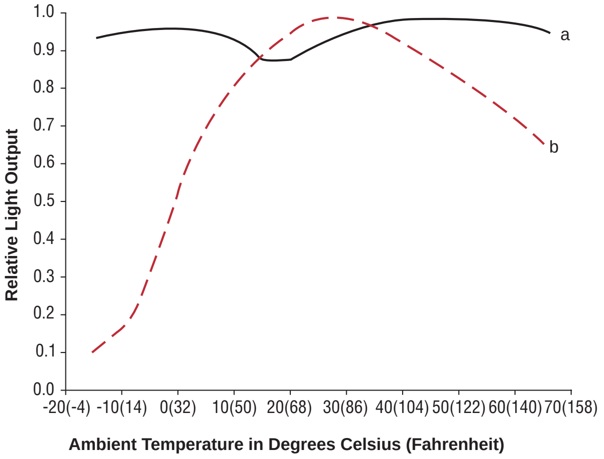
NLPIP's tests of modular CFL products used the ballast provided in the package with the lamps, rather than a reference ballast. NLPIP did not measure the ballast factor for any of the ballasts. Ballast factors are provided by some manufacturers.

Thermal Factor
Thermal factor is defined as the light output of a lamp at a particular ambient temperature divided by the light output of the same lamp when it is operated at 25±1°C (77±2°F) ambient temperature. The thermal environment surrounding a CFL product affects the mercury vapor pressure in the lamp and thus its light output. In non-amalgam CFLs, the mercury vapor pressure is directly related to MBWT, so light output is also a function of MBWT. Every non-amalgam CFL has an optimal MBWT that provides maximum light output. For these CFLs, the optimal MBWT typically occurs at 25±1°C (77±2°F) ambient temperature, which is the temperature used in the standard test conditions.

For amalgam CFLs, the highest light output occurs above 40°C (104°F). Serres and Taelman (1993) showed that the relative light output of some amalgam CFLs peaks at 45°C (113°F). The same study showed that amalgam lamps maintain more than 90% of their light output in the -15 to +65°C (5 to 149°F) range, except for the region between 15 and 20°C (59 and 68°F), where the light output drops to 88% (see Figure A). Specifiers should consider the use of amalgam CFLs when temperatures are likely to be above or below the optimum temperature for non-amalgam CFLs. For example, the temperature within an enclosed luminaire can be much higher than room temperature.

Figure A. Light Output of Amalgam and Non-Amalgam CFLs
[Adapted from the *IESNA Lighting Handbook* (In press)]

Comparison of relative light output vs. ambient temperature for two compact fluorescent lamp designs; one with amalgam (curve a) and non-amalgam (curve b).



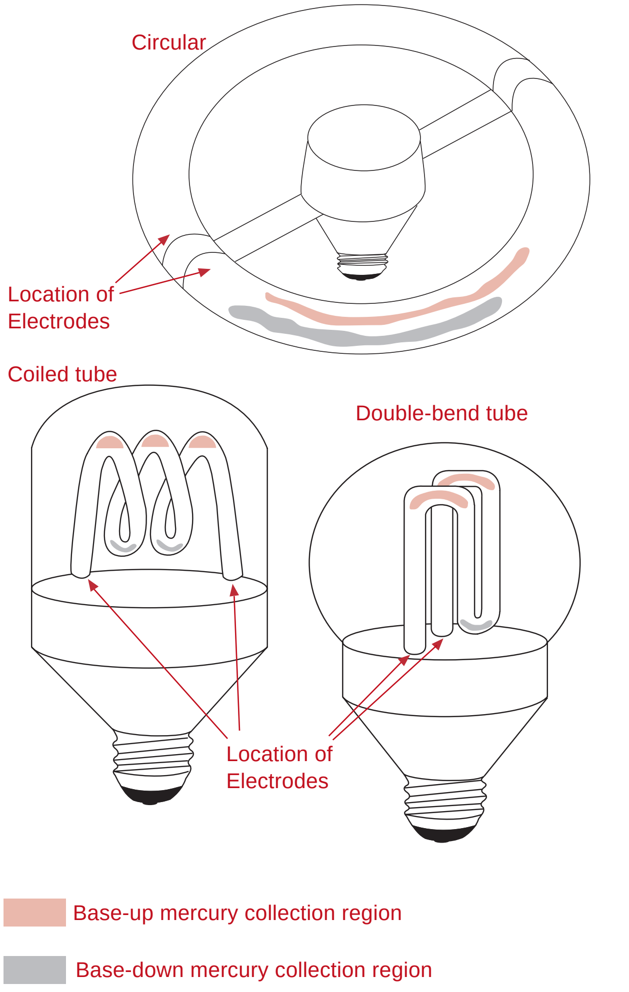
Position Factor
The operating position of a CFL product (such as base up, base down, or horizontal) can affect its light output by varying the mercury vapor pressure inside the CFL. Position factor is defined as the light output produced by the lamp in a certain orientation divided by the light output produced by the lamp in the base-up position.

A study by Serres and Taelman in 1993 showed that when operated at 25±1°C (77±2°F), amalgam CFLs have a position factor very close to 1 (lamps operating in a base-down position produced 1.4% more light output than when operating in a base-up position).

When non-amalgam CFLs are mounted base-up, the excess mercury collects at the end of the lamp opposite the base, and most non-amalgam CFLs are designed so that the optimum vapor pressure occurs in this position. When most non-amalgam CFLs are mounted base-down, the excess mercury collects near the lamp electrodes and ballast. At room temperature, the heat dissipated by the electrodes and ballast causes the mercury to evaporate, which elevates the mercury vapor pressure above the optimum level and thereby reduces light output.

Some non-amalgam CFL products are less sensitive to base-down orientation than others. The less-sensitive CFL products have lamp shapes that allow the excess mercury to collect in a region of the lamp that is away from the lamp electrodes regardless of orientation. See Figure B.

Figure B. Mercury Collection Regions in Some Non-Amalgam CFLs



Lamp Lumen Depreciation

As lamps operate, light output declines. This lamp lumen depreciation (LLD) should be taken into account when comparing incandescent and CFL products. For CFLs, this deterioration is mainly due to phosphor degradation. The mean light output of a lamp is defined as its light output at 40% of rated lamp life. Figure C shows typical light output for ten incandescent lamps and one CFL over the expected life of the CFL. The mean light output of an incandescent lamp is 90% of initial light output. Based on the manufacturer-supplied data in Tables 1 and 2, the mean light output for CFLs ranges from 75 to 93% of initial light output with an average of 86%.

Figure C. Light Loss Factor: Typical Lamp Lumen Depreciation

[Adapted from the *IESNA Lighting Handbook* (In press)]

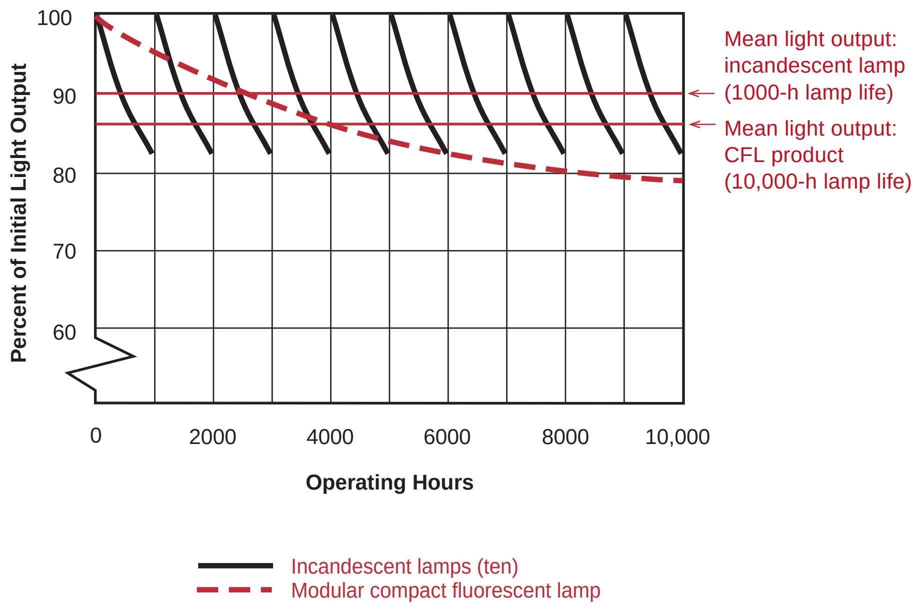


Table Lamp Application (example)

The light loss factors and other performance characteristics described in this report can be used to select an appropriate CFL product to replace an incandescent lamp in a particular application. For example, the table below shows the effect of light loss factors on the light output of an incandescent lamp and two CFL products for a table lamp application.

Design light output is the product of initial rated light output and light loss factors. Design efficacy is the ratio of the design light output to the active power; the table below shows that, even considering the effects of the light loss factors, the CFL products are much higher in efficacy than the incandescent lamp.

This example demonstrates, however, that selecting a CFL product to replace an incandescent lamp based on equivalent initial rated light output results in a design light output that is much lower than the light output of the incandescent lamp. Selecting a CFL product of higher wattage and higher initial rated light output is necessary to overcome the effects of light loss factors.

Light Source	Initial Rated Light Output (lm)	Light Loss Factors				Design Light Output (lm)	Design Efficacy (LPW)
		Ballast Factor[a]	Position Factor	Thermal Factor[b]	LLD		
60-W incandescent lamp	890	NA	NA	NA	0.90	800	13
15-W triple-tube, electronic, self-ballasted CFL[c]	900	NA	0.99	1.00	0.85	757	50
28-W quad, electronic, self-ballasted CFL[d]	1750	NA	0.89	1.00	0.85	1324	47

NA = Not Applicable

[a] Ballast factor does not apply to self-ballasted CFL products. If a modular CFL product is used, the ballast factor should be included in the calculation.

[b] Thermal factor is 1.0 for the compact fluorescent lamp products because the thermal operating conditions in the table lamp are assumed to be similar to the standard test conditions.

[c] A typical 15-W triple-tube lamp was used as an example. Position factor value was measured by NLPIP. Initial rated light output was supplied by the manufacturer. LLD was obtained by dividing the mean light output by the initial light output, both supplied by the manufacturer.

[d] A typical 28-W quad lamp was used as an example. Position factor value was measured by NLPIP. Initial rated light output was supplied by the manufacturer. LLD was obtained by dividing the mean light output by the initial light output, both supplied by the manufacturer.

Lamp Current Crest Factor (CCF)

Lamp current crest factor (CCF) is a measure of the shape of the lamp current and is defined as the peak current divided by the root-mean-square (rms), or "average," current. CCF is determined by the ballast on which a lamp operates, because the ballast controls the operating current of a lamp.

A high CCF indicates that the current wave shape has high peaks; a lower CCF indicates a smoother current wave shape. The CCF of a sine wave is 1.41. ANSI Standard C82.11 (ANSI 1993) recommends a maximum CCF of 1.7. Lamp manufacturers might not warranty their lamps for rated life if the CCF of the ballast exceeds 1.7.

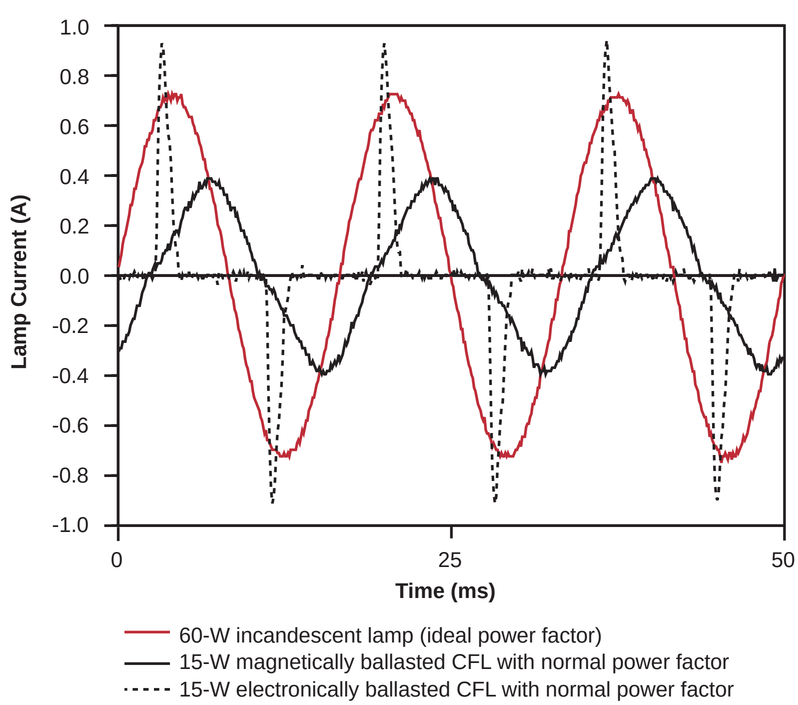
Power Quality

The term "power quality" refers to the level of distortion of the electrical supply voltage or current and to shifts in the phase relationship between the two waveforms. Power quality also includes electromagnetic interference (EMI) caused by devices on an electrical circuit, as discussed on p. 10. CFL products and other devices, such as variable-speed motor drives, can affect power quality. See *Lighting Answers: Power Quality* (1995) for a more complete discussion.

The lighting industry has two metrics for power quality: power factor and total harmonic distortion (THD). THD measures the amount of distortion in the current waveform. Power factor takes into account both THD and phase displacements. The Federal Communications Commission (FCC) regulates the amount of conducted EMI produced by an electronic device. Tables 1 and 2 contain manufacturer-reported power factor and THD values, and Tables 4 and 5 report NLPIP test results for both metrics.

In a single home, replacing incandescent lamps with CFL products does not affect the power quality appreciably. However, complete lamp replacements in large facilities could cause power quality concerns for utility and facility engineers who are responsible for efficient and reliable electrical system operation. For example, replacing all the lamps in a hospital with CFL products that have high THD could affect sensitive equipment unless the utility or facility compensates for the distortion. See the section "Total Harmonic Distortion" on p. 9 for ways to solve this problem.

Figure 6. Lamp Current Comparison of Incandescent Lamps and CFL Products



Power Factor

Power factor is defined as the ratio of active power (W) to apparent power [volt-amperes (VA)], and is a measure of the efficiency with which an electrical device converts input current and voltage into useful electric power. Power factor ranges from 0 to 1, with 1 being the ideal. All incandescent lamps have a power factor of 1. When power factor is less than 1, the device draws non-work-producing current from the electrical system. If two electric loads use identical active power, the one with a lower power factor will require larger electrical supply equipment (circuit conductors, transformers, and switch gear) to carry the additional current. Many utilities penalize customers whose facilities have power factors below 0.8 to 0.9 because utilities must build larger transmission and distribution systems to serve the apparent power demands of their customers instead of just the active power demands.

Devices with power factors greater than or equal to 0.9 are called high power factor devices, and devices with power factors less than 0.9 are called normal power factor devices. Manufacturers' sales literature usually indicates if a CFL product has a high power factor, rather than specifying a numerical value. NLPIP measured power factors from 0.47 to 0.97 in both base-up and base-down orientations.

Two aspects of the current wave shape reduce power factor: phase displacement and THD. Typically, magnetically ballasted CFL products primarily exhibit phase displacement, whereas electronically ballasted CFL products primarily exhibit THD. Figure 6 shows current wave shapes of two normal power factor CFL products and of an incandescent lamp.

Phase Displacement A magnetically ballasted CFL product draws current that lags behind the voltage. Phase displacement is a measure of the degree to which the current and voltage waves of a device are not synchronized with one another. Some manufacturers install a capacitor in their magnetically ballasted CFL products to compensate for the lagging current, which increases the power factor to above 0.9.

When CFL products replace incandescent lamps of comparable light output, the reduced power factor does not cause a current overload in the existing electrical system because the reduced active power more than compensates for the reduced power factor. However, large-scale replacement of incandescent lamps with normal power factor CFL products that have magnetic ballasts could draw enough reactive current to prompt a utility to install additional capacitors on their distribution systems to compensate for the reactive power demand. Capacitors can also be installed in a facility to compensate for reactive power demand and to improve the power factor of the facility's electrical system.

Also, when normal power factor CFL products are installed in new construction, the load must be based on apparent power instead of active power.

Total Harmonic Distortion A harmonic wave has a frequency that is an integer multiple of the fundamental (also called the main wave). The fundamental plus one or more harmonics can describe any distorted waveform. A distorted 60-Hz current wave, for example, might contain harmonics at 120 Hz (second-order harmonic), 180 Hz (third-order harmonic), and other multiples of 60 Hz. Highly distorted current waveforms (such as the electronically ballasted CFL in Figure 6 contain numerous harmonics. The even harmonic components (second-order, fourth-order, and so on) tend to cancel each other's effects, but the odd harmonics tend to add in a way that rapidly increases distortion because the peaks and troughs of their waveforms often coincide.

The lighting industry calls its most common measure of distortion "current total harmonic distortion (THD)." THD indicates the degree to which the current waveform deviates from sinusoidal. The Institute of Electrical and Electronics Engineers (IEEE) defines THD as the ratio of the rms value [See the sidebar "Root-Mean-Square (rms)"] of the harmonic content to the rms value of the fundamental current. The American National Standards Institute (ANSI), the Canadian Standards Association (CSA), and the International Electrotechnical Commission (IEC) define THD as the ratio of the rms value of the harmonic content to the rms value of the total current (*Lighting Answers: Power Quality,* 1995). Manufacturers commonly measure THD as the IEEE defines it; NLPIP uses the ANSI definition to determine THD.

Figure 7 shows the theoretical relationship between THD and power factor. Many devices, such as incandescent lamps, motors, and resistive heaters, draw undistorted, sinusoidal currents. However, nonlinear loads such as electronic devices (including televisions and computers), variable-speed motor drives, and most electronically ballasted CFL products draw highly distorted currents.

Two methods have been developed to reduce THD anywhere within an electrical circuit: passive filtering and active filtering. Passive filters use components like inductors, capacitors, and resistors arranged in a predetermined manner to attenuate the flow of harmonic components through them or to shunt the harmonic component into

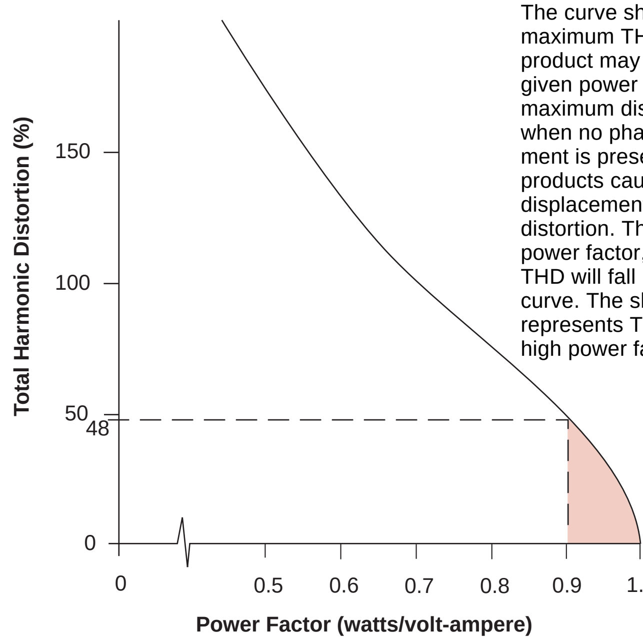
Root-Mean-Square (rms)

Root-mean-square is the effective average value of a periodic quantity such as an alternating current or voltage wave. It is calculated by averaging the squared values of the amplitude over one period and taking the square root of that average.

Components of Apparent Power

Apparent power is the rms voltage multiplied by the rms current, measured in volt-amperes. Apparent power comprises active power, reactive power, and distortion power. Active power is the component that provides useful, work-producing power. Neither reactive power nor distortion power provides work-producing power. Reactive power is produced when the current and voltage waves are out of phase. Distortion power is produced when the current and voltage waves are of different shapes due to harmonics. See the section "Total Harmonic Distortion."

Figure 7. Theoretical Relationship Between Total Harmonic Distortion and Power Factor



The curve shows the maximum THD that a product may have for a given power factor. This maximum distortion occurs when no phase displacement is present. Most CFL products cause both phase displacement and current distortion. Thus, for a given power factor, the actual THD will fall below the curve. The shaded region represents THD values for high power factor products.

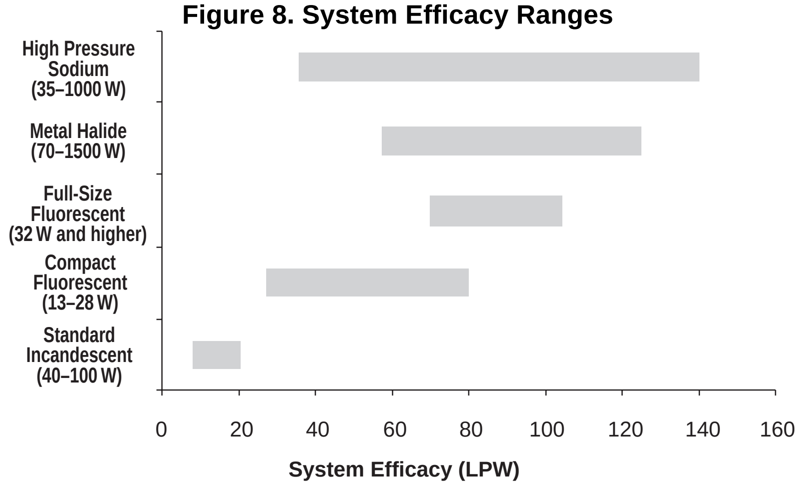
them. Passive filters can reduce THD to as low as 20 to 30%. Active filters introduce a current waveform into the electrical distribution system, which, when combined with the harmonic current, results in an almost perfect sinusoidal waveform. Active filters can reduce THD to under 10% but are more expensive than passive filters.

Distorted currents cause a number of other problems, including neutral conductor current overload in three-phase electric systems, increased heating and aging of transformers and motors, and telephone interference. Specifying high power factor CFL products limits THD values to a maximum of 48%, as shown in Figure 7 on p. 9. Some electric utilities and consumer groups advocate THD values between 20–33% for CFL products. By comparison, other electronic devices, such as television sets and personal computers, have THD values over 100% and require significantly more active power than CFL products.

Electromagnetic Interference (EMI)

Electronic devices employ power supplies that can generate EMI. This interference can be either conducted through the power supply wiring or radiated through the air. Electronically ballasted CFL products must comply with FCC regulations regarding the amount of conducted EMI that they may produce. All but one of the products in this report meet FCC criteria for residential and commercial applications. The electrodeless CFL product presently meets FCC criteria for commercial applications but not for residential applications.

Figure 8. System Efficacy Ranges



Radiated EMI usually occurs in two frequency bands. The first is between 10 kHz and 100 kHz, which is below the amplitude modulation (AM) radio band. The source of this radiation is the lamp circuit, but the small size of the CFL product limits the amount of radio interference, so problems in this frequency band are rare. The second frequency band includes infrared (IR) radiation. EMI in this band is anecdotally reported to interfere with the operation of remote controllers such as those for televisions and videocassette recorders. Many of these controllers use modulated IR radiation for signaling. Specific solutions to specific problems depend on the application, and a more detailed discussion can be found in *Lighting Answers: Electromagnetic Interference Involving Fluorescent Lighting Systems*, 1995.

Efficacy

The efficacy of a lamp or lamp system (lamp plus ballast) is the ratio of light output to active power, measured in lumens per watt (LPW). CFL products are more efficacious than incandescent lamps because CFL products produce approximately the same light output at about one-third the active power. Figure 8 shows the system efficacy ranges of incandescent, compact fluorescent, linear fluorescent, metal halide, and high-pressure sodium lamp systems.

Light Distribution

Every CFL product has a particular light distribution pattern. CFL products without reflectors are primarily non-directional light sources and are best suited for table lamps, floor lamps, and other luminaires designed to provide primarily diffuse light. Compact fluorescent reflector lamp products provide a more directional light. See the section "Application Guides" on p. 12 for more information about using CFL products in different luminaires.

Color Characteristics

Two measures commonly describe the color characteristics of a light source, correlated color temperature (CCT) and color rendering index (CRI). CCT indicates whether a light source appears warm (yellow-white) or cool (blue-white). CCT is measured in Kelvin (K), with higher CCT ratings meaning cooler color appearances. Incandescent lamps appear warm and typically have CCT ratings between 2700 and 3000 K. CFL products are available with CCT ratings ranging from 2700 to 6500 K, but most of them simulate the color of incandescent light with CCT ratings of 2700, 2800, or 3000 K. The availability of several CCT options allows specifiers to select a CFL product with a color appearance that matches the dominant colors and other light sources within a space.

A lamp's CCT is a result of two lamp components: the phosphor coating and the mercury arc discharge. Both components react differently to temperature changes. Color differences become apparent when side-by-side luminaires have greatly different internal temperatures.

Light sources having the same CCT can have different chromaticity coordinates (Wyszecki and Stiles 1982), so two CFLs with the same CCT may not appear identical when viewed side by side. Therefore, using products from a single manufacturer in a multiple-lamp installation helps to ensure that all CFLs have the same color appearance.

The second color metric, CRI, is a measure of the similarity with which a light source with a particular CCT renders certain reference colors in comparison to a reference light source with the same CCT. The highest CRI attainable is 100. Incandescent lamps have CRIs above 95. All but two of the CFLs with manufacturer-reported CRIs (see Tables 1 and 2) contain rare-earth phosphor (triphosphor) coatings, which result in CRIs that range from 82 to 88.

Dimming

A dimmable light source allows a single lighting system to vary its light output. Manufacturers have recently introduced dimmable CFL products that can be used with the same variable resistance dimmers that are used with incandescent lamps. Modular and self-ballasted CFLs with dimming electronic ballasts allow users to control light levels from full light output down to 5% of maximum output. The "Ballast Type" column in Table 2 indicates the products (all are self-ballasted) that are dimmable.

"Step-dimming" products that are similar to three-way incandescent systems are also available. Table 1 lists these products (all are modular) with all three wattage settings.

A CFL product not designed for dimming should never be operated with a dimmer.

Human Response

Starting

Incandescent lamps provide full light output nearly instantaneously. Instant-start CFL products start almost as quickly as incandescent lamps, whereas rapid- and preheat-start CFL products may take up to a few seconds to start. See the sidebar "Starting Methods" on p. 4 for a summary of the three starting methods. CFL products with magnetic preheat ballasts flash on and off when starting. CFL products with electronic preheat ballasts, however, do not flash.

Most CFL products provide between 50 and 80% of maximum light output immediately after starting and may require several minutes to achieve full light output, particularly at low ambient temperatures. Warm-up time for amalgam CFLs is longer than for CFLs without amalgam additives. In some amalgam CFLs, an auxiliary amalgam accelerates the rise in light output when the lamp is started.

These starting characteristics might not be acceptable to people for some application. Manufacturer-supplied information on starting method and minimum starting temperature is reported in Tables 1 and 2. Table 6 reports NLPIP-measured starting times for some products.

Flicker

In North America, electrical systems operate at 60 Hz. Under these conditions, magnetically ballasted CFL products flicker at a frequency of 120 Hz, which very few people can consciously perceive. CFLs with electronic ballasts operating at high frequencies (20 to 60 kHz) do not have any perceptible flicker. However, some electronic ballasts flicker at 120 Hz, depending on the ballast design. A British study (Wilkins et al. 1989) suggests that flicker can adversely affect a greater portion of the population than those who can perceive it. The study found that workers' complaints of eye soreness and headaches decreased when the British fluorescent lighting system, which flickers at a frequency of 100 Hz (the electrical supply system operates at 50 Hz), was operated at 32 kHz. This effect may be less pronounced or nonexistent in North America, where the electrical supply system operates at a higher frequency.

Glare

When a lamp is in direct view, such as in an open luminaire, diffusers can reduce objectionable lamp brightness (glare). In some downlights, a CFL product might be too long for the luminaire and extend below the ceiling plane, causing glare. Lengths of CFL products are provided in Tables 1 and 2. In addition, CFL products have different light distributions than incandescent lamps. In recessed downlights, CFL products generally provide higher illuminances on the wall at vertical angles above 50 degrees, which is likely to reduce visual comfort due to glare in large, open interior spaces (Ji and Davis 1993).

Sound

Magnetic ballasts often produce a faint hum with a frequency of 120 Hz, which might annoy some people. Because sound drops off rapidly with distance, most objections will occur when people are close to luminaires that contain operating magnetic ballasts. Electronic ballasts have significantly reduced ballast noise, which is normally imperceptible. Both types of ballasts are sound rated from "A" to "F." "A"-rated ballasts are for indoor applications, and noisier "B"-rated ballasts are intended for outdoor applications or indoor spaces such as warehouses where quietness is not important. However, in any given system (such as inside a particular luminaire), an electronic ballast could produce an audible noise.

Application Guides

These guides are intended to point out some of the most common CFL product applications and give some tips on how to better use these products.

Indoor Versus Outdoor

All CFL products are rated for a minimum starting temperature, which means that below that temperature they cannot be expected to start reliably. In addition, operating non-amalgam CFL products at temperatures above or below the optimal MBWT can affect light output. For outdoor applications in cool weather, encapsulated lamps or enclosed luminaires retain some of the heat produced by the lamp, so the light output of the lamp is higher.

Indoor enclosed luminaires, particularly airtight recessed downlights surrounded with thermal insulation, reduce the light output of a non-amalgam CFL product because the heat accumulated inside the luminaire affects the mercury vapor pressure inside the lamp (See "Thermal Factor" in the "Light Loss Factors" sidebar on p. 6). Tables 1 and 2 list the manufacturer-supplied recommended maximum temperatures. CFLs with amalgam additives are an alternative for luminaires that are not properly ventilated, such as lensed recessed downlights. Most new CFL products use amalgam technology, but specifiers should contact the manufacturer to verify whether a particular product contains an amalgam.

Frequent Starting Versus Long-Term Operation

If a CFL product is started less frequently than the standard 3-hour on, 20-minute off cycle, it will have a life longer than its rated life, but if it is started more frequently than the standard cycle, it will have a shorter operating life. With frequent switching, instant-start ballasts are generally assumed to reduce lamp life more than other ballast types. CFL products are not recommended in spaces where lights are switched on and off frequently, such as bathrooms and closets. CFL products are recommended in spaces such as living rooms, dining rooms, bedrooms, hotel rooms, and outdoors, where they are likely to be started less frequently than the standard cycle. See the sidebar "Long-Term Performance Testing" on p. 5.

Installation in Luminaires

One of the greatest barriers preventing the widespread use of CFL products is the difficulty of fitting them into some luminaires. In comparison to incandescent lamps, CFL products can be bulky, awkwardly shaped, and heavy. Some CFL products are almost as small as an incandescent A-lamp (see Figures 1, 2, and 4), but all are heavier. Even the A-line CFL does not quite match the shape or light distribution of an incandescent A-lamp because the ballast is wider than the narrow neck of the A-lamp's glass bulb.

Table or floor lamp shades that clip onto incandescent A-lamps generally are incompatible with CFL products. Harps that support the lamp shade may interfere with installation. Inexpensive harp extenders are available to widen the harp near the lamp base, and longer replacement harps are available to accommodate the taller CFL products.

Screwbase circular and square CFL products are available with initial light output ratings that are comparable to incandescent lamps of up to 150 W. These products, although they may interfere with a small lamp shade, usually are more compatible with lamp shade harps than other CFL products with comparable light output ratings. The "bat-wing arm" available with some circular products, which allows the lamp to fit below the level of the screwbase adapter, makes the products more compatible with some shades.

The added weight of a magnetically ballasted CFL product in a tall, narrow-based table, floor, or task lamp might make the luminaire unstable. The sockets in some luminaires, such as vanity lights, may not be able to support the added weight of magnetically ballasted CFL products. The use of lighter electronically ballasted CFL products can overcome these problems.

Using an encapsulated or bare-lamp CFL product in a recessed downlight designed for an incandescent reflector lamp is a common misapplication. Much of the diffuse light emitted by the CFL is absorbed within the luminaire, reducing illuminance compared to that of the original incandescent lamp. In these situations, a compact fluorescent reflector lamp product might provide a suitable replacement for the directional incandescent lamp. However, compact fluorescent reflector lamp products do not always perform as well as directional incandescent lamps. See *Specifier Reports: Reflector Lamps* (1994) for details.

In recessed downlights for incandescent lamps, if a compact fluorescent reflector lamp product is too short to reach the trim ring, too much light will be absorbed within the luminaire. Screwbase lamp socket extenders are available that may solve this problem.

Application Testing

Ji and Davis (1993) reported results from application tests designed to compare the performance of CFL products with their manufacturer-suggested equivalent incandescent lamps. In the experiment, which used CFL products in a table lamp application, tabletop illuminances more closely approximated the tabletop illuminances of incandescent lamps of the next-lower available wattage than their manufacturer-suggested wattage equivalences. For example, a CFL product claimed to be equivalent in light output to a 60-W incandescent lamp produced tabletop illuminance closer to that of a 40-W incandescent lamp. The same results were obtained in the recessed downlight application testing.

Alternative Technologies

Dedicated CFL Luminaires

Luminaires dedicated to CFLs, which contain hardwired ballasts, are an alternative when screwbase CFL products cannot be used to replace incandescent lamps or when a more energy-efficient product is desired. ("Installation in Luminaires" on p. 12 discusses some barriers to replacing incandescent lamps with CFLs.) Recessed downlights, torchieres, and surface-mounted and suspended luminaires that are dedicated to CFLs are widely available in the market. Table lamps dedicated to CFLs are available as well, though not as widely as the products listed above. Although luminaire replacement is more expensive and more difficult than simple lamp replacement, the improvements in energy efficiency and optical performance from a dedicated luminaire might justify the added expense. Dedicated CFL luminaires also guarantee continued CFL use. If a luminaire is not dedicated to CFLs, the user can replace a CFL product with an incandescent lamp instead. Retrofit kits are available that convert a recessed downlight designed for an incandescent lamp to a luminaire dedicated to CFLs.

Incandescent Lamps

Incandescent lamps are available in a wide variety of types but their life and efficacy usually are inferior to those of other light sources. Because of their low purchase price, incandescent lamps can be economical for applications where light is needed infrequently, including utility rooms in commercial buildings. Incandescent sources also are preferable where specific color properties, optical control, or frequent switching (such as with an occupancy sensor) are necessary. Such applications include retail spot lighting, museum art displays, certain medical tasks, and theatrical lighting. Additionally, incandescent lamps can be used in extremely cold starting conditions.

The energy used by incandescent lamps can be reduced significantly by the use of appropriate lighting controls, such as dimmers, timers, and occupancy sensors.

Tungsten-Halogen Incandescent Lamps

Tungsten-halogen lamps are a special type of incandescent lamp that can provide modest improvements in lamp life and efficacy compared to other incandescent lamps. Lamp lumen depreciation is also reduced in comparison to incandescent lamps. Hazardous operating characteristics, such as a lamp temperature high enough to ignite nearby flammable materials and the possibility of non-passive failure, should be considered when choosing some types of tungsten-halogen lamps.

Low-Wattage HID Lighting

High-intensity discharge (HID) lamps include low-wattage (150 W or less) metal halide (MH) and color-improved high-pressure sodium (HPS) lamps. They have several advantages over CFL products in some commercial and residential applications. HID lamps provide a concentrated light source that allows good optical control. They are available with higher initial light output than CFL products. HID lamps are less sensitive to starting and operating temperatures than CFL products. For example, HID lamps are a good choice for exterior lighting applications because they start reliably in low temperatures.

However, HID lamps have several disadvantages. HID lamps provide only a fraction of their rated light output for several minutes after starting. Also, if the power to an HID lamp is interrupted, the lamp arc will be extinguished and several minutes must elapse before it can restrike. HPS lamps generally have fewer color temperature choices and poorer color rendering than CFL products. Color-improved HPS lamps are available but only with CCTs below 3000 K. Metal halide lamps are available with various CCT ratings and with CRI ratings up to 93. However, shifts in color temperature take place over the life of a metal halide lamp. New metal halide technologies with reduced warm-up and restrike time and better color consistency are becoming available. Replacing incandescent lighting with an HID lighting system requires new luminaires. Finally, HID lamps, particularly HPS lamps, flicker at a frequency of 120 Hz during operation and can produce a stroboscopic effect on moving parts.

Performance Evaluations

Manufacturer-Supplied Data

Manufacturers of CFL products provided the data in Tables 1 and 2 to NLPIP. In August and September 1998, NLPIP used industry documentation and company information to identify 18 manufacturers of screwbase CFL products. NLPIP asked them to send sales literature and photometric and electrical data. Data sheets for two types of products were included: modular CFL products (lamp and screwbase adapter sold as a whole package, not sold as individual lamps or adapters) and self-ballasted CFLs.

One company that received the request had discontinued all their CFL products, eight manufacturers sent the information requested, and nine did not reply. For six of these nine, NLPIP gathered the information from the manufacturers' most recent available catalogs. NLPIP had no access to sales literature for three of the manufacturers, so no data were gathered for them. In January 1999, the 14 manufacturers for which NLPIP had data were given the opportunity to review the data submittals and the data NLPIP gathered from their catalogs and to provide corrections. At the same time, a final request for data was sent to the three manufacturers for whom NLPIP did not have catalogs. The same three manufacturers did not send any reply, so they were removed from the manufacturer-supplied data tables. Only those products that were commercially available in August 1998 were included in the data tables.

NLPIP collected manufacturers' contact information (see Table 7) from their sales literature and Web sites.

Independent Product Testing

Prior to compiling the manufacturers' data, NLPIP surveyed retailers in the Albany, New York, area in June and July 1997 and identified 28 CFL products for testing. The testing was intended to spot-check the accuracy of the manufacturers' photometric and electrical performance ratings and to indicate the likely range of performance that could be expected from the CFL products.

Under NLPIP's direction, Independent Testing Laboratories (ITL) of Boulder, Colorado, conducted photometric and electrical tests during the months of September and October 1997. It is important to note that since the testing was performed, the design of some products may have changed, even though catalog numbers may still be the same. Some products have been discontinued but might still be in stores or in use. NLPIP will periodically test new products and report results through NLPIP Online at www.lrc.rpi.edu.

All modular and self-ballasted CFLs were seasoned for 100 h and operated at least 15 h continuously in the base-up position prior to testing. The lamp-ballast combination was operated on a voltage conditioner and regulator. The light output was monitored until stabilization occurred with the lamp in a base-up position; data were then recorded. The lamp was seasoned again for at least 15 h in the base-down position and the above procedure was repeated. Unless indicated, all tests were conducted under IESNA (LM 66-1991, LM-9-1988, LM-54-1991) and ANSI (C82.11-1993) standard conditions (see the sidebar "Standard Testing" on p. 4). Unless stated otherwise, only one sample of each product was tested.

Two magnetic, modular circular CFL products and seven electronic, modular circular CFL products were tested in both base-up and base-down positions. One of the products had the option to be used at three different power levels. This product was tested at the three available power levels (low, medium, and high). Each modular CFL product was tested with its original ballast. The results are shown in Table 4.

One magnetic, self-ballasted CFL and 18 electronic, self-ballasted CFLs were tested in both base-up and base-down positions. Results for self-ballasted CFLs appear in Table 5.

Further Information

American National Standards Institute. 1993. *High-frequency fluorescent lamp ballast*, ANSI C82.11-1993. New York, NY: ANSI.

American National Standards Institute. 1997. *Specification for performance of self-ballasted compact fluorescent lamp*, ANSI C78.5-1997. New York, NY: ANSI.

Conway, K. and M. Mehra. 1998. Lighting market opportunities: Reconciling consumers' purchasing behaviors with environmental values. *Journal of the Illuminating Engineering Society* 27(2): 67–76.

Covington, E.J. 1971. Life prediction of fluorescent lamps. *Illuminating Engineering* 66(4): 159–164.

Davis, R., Y. Ji, and W. Chen. 1996. Rapid-cycle testing for fluorescent lamps: What do the results mean? *Illuminating Engineering Society of North America annual conference*: *Technical papers*. New York, NY: IESNA. pp. 460–481.

Davis, R., Y. Ji, and W. Chen. 1998. An investigation of the effect of operating cycles on the life of compact fluorescent lamps. *Illuminating Engineering Society of North America annual conference: Technical papers*. New York, NY:IESNA. pp. 381–392.

Illuminating Engineering Society of North America. 1988. *IES Approved method for the electrical and photometric measurements of fluorescent lamps*, LM-9-1988. New York, NY:IESNA.

Illuminating Engineering Society of North America. 1991. *IES guide to lamp seasoning*, LM-54-1991. New York, NY:IESNA.

Illuminating Engineering Society of North America. 1991. *IES Approved method for the electrical and photometric measurements for single-ended compact fluorescent lamps*, LM-66-1991. New York, NY:IESNA.

Illuminating Engineering Society of North America (In press). *IESNA lighting handbook*, 9th ed. Edited by M.S. Rea. New York, NY:IESNA.

Ji, Y., and Davis, R. 1993. Application testing of compact fluorescent lamps: Table lamps and recessed downlights. *Illuminating Engineering Society of North America annual conference: Technical papers*. New York, NY: IESNA. pp. 22–42.

Ji, Y., R. Davis, C. O'Rourke, and E. Chui. 1997. Compatibility testing of fluorescent lamp and ballast systems. *Conference record of the 1997 IEEE industry applications conference thirty-second IAS annual meeting*. Piscataway, NJ: Institute of Electrical and Electronics Engineers. pp. 2340–2345.

Lindsey, J.L. 1991. *Applied illuminating engineering*. Lilburn, GA: Fairmont Press Inc.

Lowry, E.F., W.S. Frohock, and G.A. Meyers. 1946. Some fluorescent lamp parameters and their effect on lamp performance. *Journal of the Illuminating Engineering Society* 46(12): 859–872.

Luo, C., ed. 1995. Electrodeless lamps: The next generation. *Lighting Futures* 1(1):1, 4–6.

Serres, A.W. and W. Taelman. 1993. A method to improve the performance of compact fluorescent lamps. *Journal of the Illuminating Engineering Society* 22(2): 40–48.

Vorlander, F.J., and E.H. Raddin. 1950. The effect of operating cycles on fluorescent lamp performance. *Illuminating Engineering* 40(1): 21–27.

Wilkins, A.J., I. Nimmo-Smith, A.I. Slater, and L. Bedocs. 1989. Fluorescent lighting, headaches and eyestrain. *Lighting Research and Technology* 21(1): 11–18.

Wolf, S., and R.F.M. Smith. 1990. *Student reference manual for electronic instrumentation laboratories.* Englewood Cliffs, NJ: Prentice Hall.

Wyszecki, G., and W.S. Stiles. 1982. *Color science; concepts and methods, quantitative data and formulae*, 2nd ed. New York, NY: John Wiley.

Data Table Terms and Definitions

The following data tables present product information supplied by manufacturers to NLPIP (Tables 1 and 2) and data collected by NLPIP researchers in the tests described in the "Performance Evaluations" section (Tables 3, 4, 5, and 7). Data discussed in the sidebar "Long-term Performance" on p. 5 appear in Table 6. Although most of the performance characteristics listed in these tables are discussed in this report or are self-explanatory, some items bear further explanation and are listed below in alphabetical order:

Accessories available. A brief list of the accessories available for a CFL product. Some accessories are permanently attached, while others are removable.

Active power. For both modular and self-ballasted CFLs, the total rated or tested wattage of a lamp-ballast combination.

Ballast rated life. The number of hours at which half of a group of ballasts have failed under standard test conditions. The rated life is a median value of life expectancy; any ballast, or group of ballasts, might vary from the published rated life.

CCF. Current crest factor. Peak lamp current divided by rms lamp current.

CCT. Correlated color temperature. Relates the color appearance of a lamp to that of a reference light source.

CRI. Color rendering index. A measure of the similarity with which a light source with a particular CCT renders certain reference colors in comparison to a reference light source of equal CCT. Maximum CRI is 100.

Electrode preheat current. The current flowing through the electrodes to heat them during starting.

Initial light output. Light output measured under standard testing conditions.

Lamp base position. The location of the lamp socket, either in the center of the top of the ballast or on the side of the ballast. Modular ballasts for circular CFLs have a lamp socket located at the end of a wiring harness.

Lamp envelope. The shape of either the bare lamp or the capsule surrounding the lamp. NLPIP grouped the lamps according to the following shapes: quad, triple tube, four-tube, coiled tube, A-line, circular, square, globe, capsule (bullet), reflector, and decorative. See Figure 1 on p. 1 for examples of these shapes.

Lamp operating current. Current flowing through the lamp during normal operation.

Lamp rated life. The number of hours at which half of a group of product samples have failed. The rated life is a median value of life expectancy; any lamp, or group of lamps, may vary from the published rated life. Rated life is based on standard test conditions. See the sidebar "Standard Testing" on p. 4.

Maximum ambient temperature. The maximum ambient temperature for which the CFL product is warranted to achieve rated life.

Maximum overall length. For self-ballasted CFLs, the length from the top of the lamp to the bottom of the screwbase. For modular CFL products, the length from the top of the lamp to the bottom of the lamp base; this length must be added to the height of the modular CFL ballast to determine the total length of a modular product. See Figure 3 on p. 2. For compact fluorescent reflector lamp products, maximum overall length includes the length of the reflector.

Mean light output. For CFL products without reflector accessories, light output at 40% of rated lamp life. In combination with initial light output, mean light output may be used to estimate lamp lumen depreciation.

Minimum ambient temperature. The lowest temperature at which the CFL product is warranted to start.

Operating cycle. The frequency with which the lamps were cycled on and off.

Position factor. The light output of the lamp in a certain position divided by the light output of the lamp in the base-up positions. The position factors reported in Tables 4 and 5 are base-down light output divided by base-up light output.

Power factor. The ratio of active power (watts) to apparent power (rms volt-amperes). Power factor ranges from 0 to 1. See p. 8 for more information.

Starting method. Ballasts use one of three methods to start CFLs: instant, preheat, or rapid. See the sidebar "Starting Methods" on p. 4.

Starting time. The time it takes the lamp to start from the point at which voltage is applied to the lamp until stable operation.

Starting voltage. The voltage applied across the lamp during starting.

Suggested retail price. Manufacturer's suggested retail price based on the purchase of a single unit from a retailer. Final prices usually are set at the discretion of the retailer, so actual costs may vary widely.

THD. A measure of the degree to which the current waveform deviates from sinusoidal. THD is expressed as a percentage and ranges from zero to infinity. See p. 8 for more information.

Weight. For modular CFL ballasts, the weight of the ballast without a lamp. For self-ballasted CFLs, this indicates the total product weight.

Table 1. Manufacturer-Supplied Data: Modular Compact Fluorescent Lamp Products

					Electrical Characteristics				Photometric Characteristics	
Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Initial Light Output (lm)	Mean Light Output (lm)
ABCO	CFL w/adapter	07373	quad	magnetic	16	NS	NS	NS	900	NS
	CFL w/adapter	07377	quad	magnetic	16	NS	NS	NS	860	NS
	ER-30 CFL System	07410	quad	magnetic	16	0.53	<15	NS	695	NS
	PAR-38 Electric Saver	07411	quad	magnetic	16	0.53	<15	NS	695	NS
	R-40 CFL System	07412	quad	magnetic	16	NS	NS	NS	695	NS
Enertron	Downlight	2000-L	quad	magnetic	13	NS	<20	NS	900	NS
	NS	3700HPF-L	quad	magnetic	13	>0.90	<20	NS	900	NS
	NS	3700-L	quad	magnetic	13	NS	<20	NS	900	NS
	NS	3800HPF-L	quad	magnetic	13	>0.90	<20	NS	900	NS
	NS	3800-L	quad	magnetic	13	NS	<20	NS	900	NS
	NS	3900HPF-L	quad	magnetic	22	NS	<20	NS	1300	NS
	NS	3900-L	quad	magnetic	22	NS	<20	NS	1300	NS
	NS	4700HPF-L	quad	magnetic	13	>0.90	<20	NS	900	NS
	NS	4700-L	quad	magnetic	13	NS	<20	NS	900	NS
	NS	4800HPF-L	quad	magnetic	13	>0.90	<20	NS	900	NS
	NS	4800-L	quad	magnetic	13	NS	<20	NS	900	NS
Feit Electric	ECO Bulb	BPMLPL13	quad	magnetic	16	0.55	10	NS	900	NS
	ECO Bulb	BPMLPLD13	quad	magnetic	16	0.53	11	NS	870	NS
	ECO Bulb	ML801	circular	magnetic	22	0.54	14	NS	1100	NS
	ECO Bulb	MLPL13	quad	magnetic	16	0.55	10	NS	900	NS
	ECO Bulb	MLPL13R	quad	magnetic	16	0.55	10	NS	920	NS
	ECO Bulb	MLPLD13	quad	magnetic	16	0.53	10	NS	870	NS
	ECO Bulb	MLPLD13R	quad	magnetic	16	0.53	10	NS	920	NS
	ECO Bulb	PLD13ER30	reflector	magnetic	16	0.53	11	NS	750	NS
	ECO Bulb	PLD13G30	globe	magnetic	16	0.53	11	NS	700	NS
	ECO Bulb	PLD13G40	globe	magnetic	16	0.53	11	NS	700	NS
	ECO Bulb	PLD13PAR	reflector	magnetic	16	0.53	11	NS	750	NS
GE Lighting	2D Lamp	FEA212D/827/B	square	electronic	22	0.50	<170	NS	1300	1105
	2D Lamp	FEA212D/835/B	square	electronic	22	0.50	<170	NS	1300	1105
	2D Lamp	FEA382D/3W/827/B	square	electronic	15-25-39	0.50	<170	NS	750-1570-2780	640-1335-2365
	2D Lamp	FEA382D/3W/835/B	square	electronic	15-25-39	0.50	<170	NS	750-1570-2780	640-1335-2365
	2D Lamp	FEA382D/827/B	square	electronic	39	0.50	<170	NS	2780	2365

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2700	82	10,000	40,000	NS	0 (32)	none	23.9 (9.4)	NS	center	NS
2700	82	10,000	40,000	NS	0 (32)	none	18.0 (7.1)	NS	center	NS
2700	82	10,000	50,000	NS	0 (32)	diffuser, reflector	19.1 (7.5)	NS	center	NS
2700	82	10,000	50,000	NS	0 (32)	diffuser, reflector	20.3 (8.0)	NS	center	NS
2700	82	10,000	50,000	NS	0 (32)	diffuser, reflector	20.3 (8.0)	NS	center	NS
NS	NS	10,000	45,000	NS	-18 (0)	reflector	16.5 (6.5)	NS	center	NS
NS	NS	10,000	45,000	NS	-18 (0)	none	22.4 (8.8)	NS	side	NS
NS	NS	10,000	45,000	NS	-18 (0)	none	21.6 (8.5)	NS	side	NS
NS	NS	10,000	45,000	NS	-18 (0)	none	16.0 (6.3)	NS	side	NS
NS	NS	10,000	45,000	NS	-18 (0)	none	15.0 (5.9)	NS	side	NS
NS	NS	10,000	45,000	NS	-32 (-26)	none	20.1 (7.9)	NS	side	NS
NS	NS	10,000	45,000	NS	-32 (-26)	none	19.1 (7.5)	NS	side	NS
NS	NS	10,000	45,000	NS	0 (32)	none	25.1 (9.9)	NS	center	NS
NS	NS	10,000	45,000	NS	0 (32)	none	25.1 (9.9)	NS	center	NS
NS	NS	10,000	45,000	NS	0 (32)	none	18.8 (7.4)	NS	center	NS
NS	NS	10,000	45,000	NS	0 (32)	none	18.8 (7.4)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	none	21.1 (8.3)	NS	side	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	none	14.0 (5.5)	NS	side	NS
4100	82	12,000	50,000	38 (100)	-18 (0)	none	20.3 (8.0)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	none	21.1 (8.3)	NS	side	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	none	25.4 (10.0)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	none	14.0 (5.5)	NS	side	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	none	20.3 (8.0)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	diffuser, reflector	20.3 (8.0)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	diffuser	20.3 (8.0)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	diffuser	22.9 (9.0)	NS	center	NS
2700	82	10,000	50,000	38 (100)	-18 (0)	diffuser, reflector	20.3 (8.0)	NS	center	NS
2700	82	10,000	40,000	NS	0 (32)	locking device	10.2 (4.0)	NS	center	NS
3500	82	10,000	40,000	NS	0 (32)	locking device	10.2 (4.0)	NS	center	NS
2700	82	10,000	40,000	NS	0 (32)	locking device	10.9 (4.3)	NS	center	NS
3500	82	10,000	40,000	NS	0 (32)	locking device	10.9 (4.3)	NS	center	NS
2700	82	10,000	40,000	NS	0 (32)	locking device	10.9 (4.3)	NS	center	NS

Table 1 (continued). Manufacturer-Supplied Data: Modular Compact Fluorescent Lamp Products

					Electrical Characteristics				Photometric Characteristics	
Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Initial Light Output (lm)	Mean Light Output (lm)
GE Lighting	2D Lamp	FEA382D/835/B	square	electronic	39	0.50	<170	NS	2780	2365
	Biax Lamps	FEA13TBX/I/827	triple tube	electronic	15	0.50	170	NS	775	660
	Biax Lamps	FEA13TBX/I/830	triple tube	electronic	15	0.50	170	NS	775	660
	Biax Lamps	FEA13TBX/I/835	triple tube	electronic	15	0.50	170	NS	775	660
	Biax Lamps	FEA18TBX/I/827	triple tube	electronic	20	0.50	170	NS	1100	935
	Biax Lamps	FEA18TBX/I/830	triple tube	electronic	20	0.50	170	NS	1100	935
	Biax Lamps	FEA18TBX/I/835	triple tube	electronic	20	0.50	170	NS	1100	935
Lights of America	Circle Lite	2602	circular	magnetic	22	NS	NS	NS	1100[b]	NS
	Circle Lite	2620	circular	electronic	20	NS	NS	instant	1150[b]	NS
	Circle Lite	2622	circular	electronic	22	NS	NS	instant	1550[b]	NS
	Circle Lite	2630	circular	electronic	30	NS	NS	instant	2100[b]	NS
	Circle Lite	2730 (3-way)	circular	electronic	13-23-34	NS	NS	instant	800-1600-2100[b]	NS
	Double-U-Lite	2614	quad	magnetic	15	NS	NS	NS	775[b]	NS
	Mighty Lite	2992	circular	electronic	30	NS	NS	instant	2000[b]	NS
	Multi Lite	2633 (3-way)	circular	electronic	13-23-34	NS	NS	instant	800-1600-2100[b]	NS
	Ready Lite	2990	circular	electronic	20	NS	NS	instant	1100[b]	NS
	Reflectors	2931	quad	electronic	13	NS	NS	preheat	880[b]	NS
	Reflectors	2941	quad	electronic	13	NS	NS	preheat	880[b]	NS
	Twin Lite	2213LPF	quad	electronic	13	NS	NS	preheat	775[b]	NS
Lumatech	Microlamp	21320	quad	magnetic	14	NS	<25	preheat	NS	NS
	Microlamp	22220	quad	magnetic	22	NS	NS	preheat	NS	NS
	Microlamp	22820	quad	magnetic	28	NS	NS	preheat	NS	NS
	Reflect-A-Star	11835	triple tube	electronic	19	>0.95	<30	instant	NS	NS
	Reflect-A-Star	11836	triple tube	electronic	19	>0.95	<30	instant	NS	NS
	Reflect-A-Star	11323	quad	magnetic	15	NS	<25	preheat	NS	NS
	Reflect-A-Star	11324	quad	magnetic	15	NS	<25	preheat	NS	NS
	Reflect-A-Star	11325	quad	magnetic	15	NS	<25	preheat	NS	NS
	Reflect-A-Star	11326	quad	magnetic	15	NS	<25	preheat	NS	NS
MaxLite	Downlights	SK320EBR	coiled tube	electronic	20	0.60	>100	instant	1200	960
	Electronic Circline	SK120ER	circular	electronic	20	0.60	>100	instant	1300	1040
	Electronic Circline	SK120ERH	circular	electronic	20	0.97	<15	instant	1300	1040
	Electronic Circline	SK122ER	circular	electronic	22	0.60	>100	instant	1600	1350
	Electronic Circline	SK122ERH	circular	electronic	22	0.97	<15	instant	1600	1350
	Electronic Circline	SK130ER	circular	electronic	30	0.60	>100	instant	2000	1760

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.

1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
3500	82	10,000	40,000	NS	0 (32)	locking device	10.9 (4.3)	NS	center	NS
2700	82	10,000	40,000	NS	0 (32)	none	15.0 (5.9)	NS	center	NS
3000	82	10,000	40,000	NS	0 (32)	none	15.0 (5.9)	NS	center	NS
3500	82	10,000	40,000	NS	0 (32)	none	15.0 (5.9)	NS	center	NS
2700	82	10,000	40,000	NS	0 (32)	none	16.5 (6.5)	NS	center	NS
3000	82	10,000	40,000	NS	0 (32)	none	16.5 (6.5)	NS	center	NS
3500	82	10,000	40,000	NS	0 (32)	none	16.5 (6.5)	NS	center	NS
3000	53	10,000	45,000	NS	0 (32)	none	8.9 (3.5)	NS	center	7.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	15.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	15.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	15.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	17.99
3000	84	10,000	45,000	NS	0 (32)	none	17.3 (6.8)	NS	center	7.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	24.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	17.99
2700	84	10,000	65,000	NS	-23 (-9)	none	8.9 (3.5)	NS	center	24.99
2700	84	10,000	65,000	NS	-23 (-9)	none	15.5 (6.1)	NS	center	19.99
2700	84	10,000	65,000	NS	-23 (-9)	none	17.3 (6.8)	NS	center	19.99
2700	84	10,000	65,000	NS	-23 (-9)	none	16.3 (6.4)	NS	center	12.99
NS	NS	15,000	NS	NS	-7 (+9)	globe, bullet	16.5 (6.5)	NS	center	NS
NS	NS	NS	NS	NS	NS	none	NS	NS	NS	NS
NS	NS	NS	NS	NS	NS	none	NS	NS	NS	NS
NS	NS	NS	NS	NS	-18 (0)	reflector, lens	17.3 (6.8)	NS	center	NS
NS	NS	NS	NS	NS	-18 (0)	reflector, lens	17.3 (6.8)	NS	center	NS
NS	NS	NS	NS	NS	-7 (+9)	reflector, lens	17.3 (6.8)	NS	center	NS
NS	NS	NS	NS	NS	-7 (+9)	reflector, lens	17.3 (6.8)	NS	center	NS
NS	NS	NS	NS	NS	-7 (+9)	reflector, lens	17.3 (6.8)	NS	center	NS
NS	NS	NS	NS	NS	-7 (+9)	reflector, lens	17.8 (7.0)	NS	center	NS
2800	84	10,000	20,000	71 (160)	-18 (0)	reflector, frosted capsule cover, lenses	17.5 (6.9)	251.4 (8.8)	center	NS
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	16.5 (6.5)	228.6 (8.0)	center	NS
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	16.5 (6.5)	228.6 (8.0)	center	NS
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	21.1 (8.3)	228.6 (8.0)	center	NS
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	21.1 (8.3)	228.6 (8.0)	center	NS
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	22.6 (8.9)	274.3 (9.6)	center	NS

Table 1 (continued). Manufacturer-Supplied Data: Modular Compact Fluorescent Lamp Products

					Electrical Characteristics				Photometric Characteristics	
Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Initial Light Output (lm)	Mean Light Output (lm)
MaxLite	Electronic Circline	SK130ERH	circular	electronic	30	0.97	<15	instant	2000	1760
	Electronic Circline	SK320EAR	coiled tube	electronic	20	0.60	>100	instant	1200	960
	Magnetic Circline	SK122MR	circular	magnetic	22	0.60	<15	rapid	1300	1040
Mitor	Compact	2D	square	electronic	16–21	NS	NS	NS	NS	NS
	Compact	2D	square	electronic	28	NS	NS	NS	NS	NS
	Compact	2D	square	electronic	38	NS	NS	NS	NS	NS
	Compact	NS	triple tube	electronic	13	NS	NS	NS	NS	NS
	Compact	NS	triple tube	electronic	18	NS	NS	NS	NS	NS
	EH	CEH13	triple tube	electronic	14	>0.90	<25	rapid	600	528
	EH	CEH18	triple tube	electronic	19	>0.90	<25	rapid	900	792
	EL	CEL13	triple tube	electronic	14	0.55	>110	rapid	600	528
	EL	CEL18	triple tube	electronic	19	0.55	>110	rapid	900	792
	Flood	AL-30	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Flood	AL-40	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Flood	BR-40	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Flood	ER-30	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Flood	PAR-38	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Flood	PLT-30	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Flood	PLT-40	triple tube	electronic	NS	NS	NS	NS	NS	NS
	Power Compact	PCEN26	triple tube	electronic	28	0.55	>110	rapid	1800	1584
	Power Compact	PCEN32	triple tube	electronic	34	0.55	>110	rapid	2400	2112
	Power Compact	PCEN42	triple tube	electronic	45	0.55	>110	rapid	3200	2816
	Vapor Proof	VPSEH26	triple tube	electronic	28	>0.90	<25	rapid	1800	1584
	Vapor Proof	VPSEH32	triple tube	electronic	34	>0.90	<25	rapid	2400	2112
OSRAM SYLVANIA	DULUX EL	CF30EL/C/830/ MED	circular	electronic	30	>0.93	<25	instant	1850	1670

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	22.6 (8.9)	274.3 (9.6)	center	NS
2800	84	10,000	40,000	71 (160)	-18 (0)	locking device, batwing arm	17.3 (6.8)	251.4 (8.8)	center	NS
2800, 6000	63	7500	40,000	40 (104)	0 (32)	locking device, batwing arm	22.4 (8.8)	457.1 (16.0)	center	NS
NS	NS	NS	NS	NS	-40 (-40)	none	10.2 (4.0)	171.4 (6.0)	center	NS
NS	NS	NS	NS	NS	-40 (-40)	none	12.2 (4.8)	257.1 (9.0)	center	NS
NS	NS	NS	NS	NS	-40 (-40)	none	12.2 (4.8)	257.1 (9.0)	center	NS
NS	NS	NS	NS	NS	-40 (-40)	none	15.7 (6.2)	171.4 (6.0)	center	NS
NS	NS	NS	NS	NS	-40 (-40)	none	17.3 (6.8)	171.4 (6.0)	center	NS
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	18.0 (7.1)	85.7 (3.0)	center	34.20
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	21.1 (8.3)	85.7 (3.0)	center	34.20
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	18.0 (7.1)	85.7 (3.0)	center	31.20
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	21.1 (8.3)	85.7 (3.0)	center	31.20
NS	NS	NS	NS	NS	-40 (-40)	none	17.3 (6.8)	228.6 (8.0)	center	16.95
NS	NS	NS	NS	NS	-40 (-40)	none	17.3 (6.8)	228.6 (8.0)	center	16.95
NS	NS	NS	NS	NS	-40 (-40)	none	18.5 (7.3)	257.1 (9.0)	center	9.95
NS	NS	NS	NS	NS	-40 (-40)	none	17.5 (6.9)	257.1 (9.0)	center	9.95
NS	NS	NS	NS	NS	-40 (-40)	none	17.5 (6.9)	257.1 (9.0)	center	9.95
NS	NS	NS	NS	NS	-40 (-40)	frosted lens	17.3 (6.8)	257.1 (9.0)	center	9.95
NS	NS	NS	NS	NS	-40 (-40)	frosted lens	17.3 (6.8)	257.1 (9.0)	center	9.95
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	19.6 (7.7)	171.4 (6.0)	center	53.84
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	21.3 (8.4)	171.4 (6.0)	center	53.84
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	none	22.6 (8.9)	171.4 (6.0)	center	57.52
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	15.2 (6.0)	314.3 (11.0)	center	66.95
2700, 3000, 3500, 4100	82	10,000	50,000	60 (140)	-40 (-40)	reflector	17.3 (6.8)	314.3 (11.0)	center	66.95
3000	82	10,000	50,000	50 (122)	-18 (0)	none	10.2 (4.0)	NS	center	14.99

Table 1 (continued). Manufacturer-Supplied Data: Modular Compact Fluorescent Lamp Products

					Electrical Characteristics				Photometric Characteristics	
Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Initial Light Output (lm)	Mean Light Output (lm)
ProLight	Circle	CL22H/D827	circular	magnetic	24	>0.90	<33	NS	1300	NS
	Circle	CL22M/D827	circular	magnetic	22	>0.90	<33	NS	1200	NS
	Circle	CL30/D827	circular	electronic	30	>0.90	<33	NS	1800	NS
	Circle	CL30H/D827	circular	electronic	30	>0.90	<33	NS	1800	NS
	Circle	CL30H/D827/L9	circular	electronic	30	>0.90	<33	NS	2100	NS
	Floodlamp	ER30-453WQ	quad	magnetic	15	0.53	<15	NS	NS	NS
	Floodlamp	ER30-613WQ	quad	magnetic	15	0.47	<15	NS	NS	NS
	Floodlamp	ER30-713WQ	quad	magnetic	15	0.53	<15	NS	NS	NS
	Floodlamp	P38-453WQ	quad	magnetic	15	0.53	<15	NS	NS	NS
	Floodlamp	P38-613WQ	quad	magnetic	15	0.47	<15	NS	NS	NS
	Floodlamp	P38-713WQ	quad	magnetic	15	0.53	<15	NS	NS	NS
	Floodlamp	R40-453WQ	quad	magnetic	15	0.53	<15	NS	NS	NS
	Floodlamp	R40-613WQ	quad	magnetic	15	0.47	<15	NS	NS	NS
	Floodlamp	R40-713WQ	quad	magnetic	15	0.53	<15	NS	NS	NS
	Horizontal	EH18W	quad	electronic	19	>0.90	<33	NS	NS	NS
	Horizontal	EH27W	quad	electronic	24	>0.90	<33	NS	NS	NS
	Horizontal	EH27W/HO	quad	electronic	29	>0.90	<33	NS	NS	NS
	Horizontal	EH32W/HO	quad	electronic	31	>0.90	<33	NS	NS	NS
	OMNI Flood	QCR38BFO	quad	magnetic	14	NS	10	NS	860	NS
	OMNI Flood	QCR38BSO	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR30B	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR30BF	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR30BP	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR30BS	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR38B	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR38BF	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR38BP	quad	magnetic	14	NS	10	NS	860	NS
	OMNI II	QR38BS	quad	magnetic	14	NS	10	NS	860	NS

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2700	84	10,000	70,000	NS	-18 (0)	none	10.4 (4.1)	NS	center	NS
2700	84	10,000	70,000	NS	-18 (0)	none	8.9 (3.5)	NS	center	NS
2700	84	10,000	70,000	NS	-18 (0)	none	10.4 (4.1)	NS	center	NS
2700	84	10,000	70,000	NS	-18 (0)	none	8.9 (3.5)	NS	center	NS
2700	84	10,000	70,000	NS	-18 (0)	none	8.9 (3.5)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	19.1 (7.5)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	16.8 (6.6)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	20.3 (8.0)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	19.1 (7.5)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	16.8 (6.6)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	20.3 (8.0)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	20.3 (8.0)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	18.0 (7.1)	NS	center	NS
2700	84	10,000	70,000	NS	-37 (-34)	none	21.6 (8.5)	NS	center	NS
2800	84	10,000	70,000	NS	-18 (0)	none	11.2 (4.4)	NS	side	NS
2800	84	10,000	70,000	NS	-18 (0)	none	11.2 (4.4)	NS	side	NS
2800	84	10,000	70,000	NS	-18 (0)	none	11.2 (4.4)	NS	side	NS
2700	84	10,000	70,000	NS	-18 (0)	none	11.2 (4.4)	NS	side	NS
2700	82	10,000	150,000	NS	-18 (0)	flood lens	16.3 (6.4)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	spot lens	16.3 (6.4)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	open reflector	15.5 (6.1)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	flood lens	16.5 (6.5)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	none	16.8 (6.6)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	spot lens	16.5 (6.5)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	open reflector	15.2 (6.0)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	flood lens	16.3 (6.4)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	none	16.3 (6.4)	NS	center	NS
2700	82	10,000	150,000	NS	-18 (0)	spot lens	16.3 (6.4)	NS	center	NS

Table 2. Manufacturer-Supplied Data: Self-Ballasted Compact Fluorescent Lamp Products

Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Electrical Characteristics: Active Power (W)	Electrical Characteristics: Power Factor	Electrical Characteristics: THD (%)	Electrical Characteristics: Starting Method[a]	Photometric Characteristics: Initial Light Output (lm)	Photometric Characteristics: Mean Light Output (lm)
ABCO	Integrated Electronic CFL	07364	quad	electronic	23	0.50	NS	instant	600	NS
	Integrated Electronic CFL	07365	quad	electronic	15	0.50	NS	instant	900	NS
	Integrated Electronic CFL	07366	quad	electronic	20	0.50	NS	instant	1200	NS
	Integrated Electronic CFL	07367	triple	electronic	23	0.50	NS	instant	1500	NS
	Light Capsule	07390	globe	electronic	15	0.58	NS	instant	850	NS
	Light Capsule	07395	capsule	electronic	15	0.58	NS	instant	850	NS
	Light Capsule	07396	capsule	electronic	20	0.58	NS	instant	1200	NS
	Light Capsule	07397	capsule	electronic	28	0.58	NS	instant	1750	NS
	Light Capsule	07398	globe	electronic	25	0.58	NS	instant	1370	NS
Feit Electric	ECO Bulb	BPESL13A	A-line	electronic	13	NS	NS	instant	780	NS
	ECO Bulb	BPESL13C	decorative	electronic	13	NS[b]	NS[c]	instant	580	NS
	ECO Bulb	BPESL15	coiled tube	electronic	15	NS	NS	instant	900	NS
	ECO Bulb	BPESL15	coiled tube	electronic	15	NS[b]	NS[c]	instant	807	NS
	ECO Bulb	BPESL15PAR30	reflector	electronic	15	NS	NS	instant	900	NS
	ECO Bulb	BPESL15R30	reflector	electronic	15	NS	NS	instant	900	NS
	ECO Bulb	BPESL15T	coiled tube	electronic	15	NS	NS	instant	1000	NS
	ECO Bulb	BPESL20T	coiled tube	electronic	20	NS	NS	instant	1200	NS
	ECO Bulb	BPESL23T	coiled tube	electronic	23	NS	NS	instant	1400	NS
	ECO Bulb	BPESL315	coiled tube	electronic	15	NS[b]	NS[c]	instant	807	NS
	ECO Bulb	BPESL316	triple tube	electronic	16	NS	NS	instant	1050	NS
	ECO Bulb	BPESL316D	triple tube	dimmable electronic	16	NS	NS	instant	1050	NS
	ECO Bulb	BPESL316SN	triple tube	electronic	16	NS	NS	instant	1050	NS
	ECO Bulb	BPESL320	coiled tube	electronic	20	NS[b]	NS[c]	instant	1094	NS
	ECO Bulb	BPESL322	triple tube	electronic	22	NS	NS	instant	1250	NS
	ECO Bulb	BPESL322D	triple tube	dimmable electronic	22	NS	NS	instant	1250	NS

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Available in medium and high power factor.
[c] Dependent on medium or high power factor specifications.
[d] The electrodeless CFL product uses a different starting technology than other CFL products. However, the manufacturer treats it as a CFL product.
[e] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2700	82	10,000	NA	NS	-23 (-9)	none	14.7 (5.8)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	none	17.5 (6.9)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	none	18.3 (7.2)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	none	21.3 (8.4)	NS	center	NS
2800	84	10,000	NA	NS	-30 (-22)	none	13.0 (5.1)	NS	center	NS
2800	84	10,000	NA	NS	-30 (-22)	none	13.5 (5.3)	NS	center	NS
2800	84	10,000	NA	NS	-30 (-22)	none	16.5 (6.5)	NS	center	NS
2800	84	10,000	NA	NS	-30 (-22)	none	16.8 (6.6)	NS	center	NS
2800	84	10,000	NA	NS	-30 (-22)	none	13.5 (5.3)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
NS	NS	8000	NA	NS	NS	none	17.0 (6.7)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	17.5 (6.9)	NS	center	NS
2700	NS	8000	NA	NS	NS	none	14.7 (5.8)	NS	center	NS
2700	NS	8000	NA	NS	NS	none	14.7 (5.8)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	10.9 (4.3)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	15.0 (5.9)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	sensor	14.0 (5.5)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	16.3 (6.4)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	15.0 (5.9)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	15.0 (5.9)	NS	center	NS

Table 2 (continued). Manufacturer-Supplied Data: Self-Ballasted Compact Fluorescent Lamp Products

Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Electrical Characteristics: Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Photometric Characteristics: Initial Light Output (lm)	Mean Light Output (lm)
Feit Electric	ECO Bulb	BPESL322SN	triple tube	electronic	22	NS	NS	instant	1250	NS
	ECO Bulb	BPESL324	triple tube	electronic	24	NS	NS	instant	1375	NS
	ECO Bulb	BPESL325	coiled tube	electronic	25	NS[b]	NS[c]	instant	1367	NS
	ECO Bulb	BPESL326	triple tube	electronic	26	NS	NS	instant	1500	NS
	ECO Bulb	ESL13C	decorative	electronic	13	NS[b]	NS[c]	instant	580	NS
	ECO Bulb	ESL15	coiled tube	electronic	15	NS[b]	NS[c]	instant	807	NS
	ECO Bulb	ESL15C	capsule	electronic	15	NS[b]	NS[c]	instant	807	NS
	ECO Bulb	ESL15G	globe	electronic	15	NS[b]	NS[c]	instant	807	NS
	ECO Bulb	ESL16	circular	electronic	16	NS[b]	NS[c]	instant	950	NS
	ECO Bulb	ESL20C	capsule	electronic	20	NS	NS	instant	1200	NS
	ECO Bulb	ESL20G	globe	electronic	20	NS	NS	instant	1200	NS
	ECO Bulb	ESL25PAR38	reflector	electronic	25	NS	NS	instant	1500	NS
	ECO Bulb	ESL315	coiled tube	electronic	15	NS[b]	NS[c]	instant	807	NS
	ECO Bulb	ESL320	coiled tube	electronic	20	NS[b]	NS[c]	instant	1094	NS
	ECO Bulb	ESL325	coiled tube	electronic	25	NS[b]	NS[c]	instant	1387	NS
GE Lighting	Biax Lamps	FLE15TBX/HPF/SPX27/SW	triple tube	electronic	15	0.95	<32	NS	825	700
	Biax Lamps	FLE15TBX/SPX27	triple tube	electronic	15	<0.60	170	NS	900	765
	Biax Lamps	FLE20TBX/HPF/SPX27/SW	triple tube	electronic	20	0.95	<32	NS	1200	1020
	Biax Lamps	FLE20TBX/SPX27	triple tube	electronic	20	<0.60	170	NS	1200	1020
	Biax Lamps	FLE24TBX/SPX27	triple tube	electronic	24	<0.60	170	NS	1520	1290
	Biax Lamps	FLE25TBX/HPF/SPX27/SW	triple tube	electronic	25	0.95	<32	NS	1520	1290
	Biax Lamps	FLE28QBX/SPX27	four-tube	electronic	28	<0.60	170	NS	1750	1485
	Biax Reflectors	FLE15TBX/L/R30	triple tube	electronic	15	<0.60	170	NS	515	440
	Biax Reflectors	FLE20TBX/HPF/RFL/SW	triple tube	electronic	20	0.90	<32	NS	800	680
	Biax Reflectors	FLE20TBX/L/R40	triple tube	electronic	20	<0.60	170	NS	885	750
	Bullet	FLB17	capsule	magnetic	17	<0.50	<32	NS	700	595
	Bullet	FLE15TBX/S/T19	capsule	electronic	15	<0.60	170	NS	775	720
	Genura[d]	EL23/R25/27	reflector	electronic	23	0.55	130	NS	1100	880
	Genura[d]	EL23/R25/30	reflector	electronic	23	0.55	130	NS	1100	880
	Globe	FLE15TBX/L/G29	globe	electronic	15	<0.60	170	NS	650	550
	Globe	FLG15E	globe	electronic	15	0.50	<150	NS	850	720
	Globe	FLG17	globe	magnetic	17	0.50	<32	NS	700	650

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1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Available in medium and high power factor.
[c] Dependent on medium or high power factor specifications.
[d] The electrodeless CFL product uses a different starting technology than other CFL products. However, the manufacturer treats it as a CFL product.
[e] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2700, 4100	NS	8000	NA	NS	NS	sensor	15.0 (5.9)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	15.2 (6.0)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	17.8 (7.0)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	16.0 (6.3)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	17.5 (6.9)	NS	center	NS
NS	NS	8000	NA	NS	NS	none	16.0 (6.3)	NS	center	NS
NS	NS	8000	NA	NS	NS	none	17.5 (6.9)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	11.4 (4.5)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	16.0 (6.3)	NS	center	NS
2700, 4100	NS	8000	NA	NS	NS	none	16.0 (6.3)	NS	center	NS
2700	NS	8000	NA	NS	NS	none	16.5 (6.5)	NS	center	NS
2700, 4100	NS	10,000	NA	NS	NS	none	14.0 (5.5)	NS	center	NS
2700, 4100	NS	10,000	NA	NS	NS	none	16.3 (6.4)	NS	center	NS
NS	NS	10,000	NA	NS	NS	none	17.8 (7.0)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	15.2 (6.0)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	13.2 (5.2)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	16.8 (6.6)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	14.7 (5.8)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	17.0 (6.7)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	17.5 (6.9)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	locking device	16.0 (6.3)	142.9 (5.0)	center	NS
2700	82	10,000	NA	NS	-23 (-9)	color lens	14.2 (5.6)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	reflector	15.7 (6.2)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	color lens	16.0 (6.3)	NS	center	NS
2800	82	9000	NA	NS	0 (32)	none	17.0 (6.7)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	none	18.3 (7.2)	NS	center	NS
2700	82	15,000	NA	NS	0 (32)	none	12.4 (4.9)	NS	center	NS
3000	82	15,000	NA	NS	0 (32)	none	12.4 (4.9)	NS	center	NS
2700	82	10,000	NA	NS	-23 (-9)	none	14.7 (5.8)	NS	center	NS
2700	82	10,000	NA	NS	-18 (0)	none	13.0 (5.1)	NS	center	NS
2800	82	9000	NA	NS	0 (32)	none	18.8 (7.4)	NS	center	NS

Table 2 (continued). Manufacturer-Supplied Data: Self-Ballasted Compact Fluorescent Lamp Products

Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Electrical Characteristics: Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Photometric Characteristics: Initial Light Output (lm)	Mean Light Output (lm)
Lights of America	Deco Bulb	2001	decorative	electronic	13	NS	NS	preheat	720[e]	NS
	Mega Lite	2332	triple tube	electronic	34	NS	NS	preheat	2050[e]	NS
	Mega Lite	2342	triple tube	electronic	45	NS	NS	preheat	3000[e]	NS
	The Bulb	2000	A-line	electronic	13	NS	NS	preheat	720[e]	NS
	Tri-Lite	2315	triple tube	electronic	15	NS	NS	preheat	840[e]	NS
	Tri-Lite	2320	triple tube	electronic	20	NS	NS	preheat	1150[e]	NS
	Tri-Lite	2325	triple tube	electronic	25	NS	NS	preheat	1380[e]	NS
	Twister Bulb	2415	coiled tube	electronic	15	NS	NS	preheat	860[e]	NS
	Twister Bulb	2420	coiled tube	electronic	20	NS	NS	preheat	1200[e]	NS
	Twister Bulb	2425	coiled tube	electronic	25	NS	NS	preheat	1500[e]	NS
Link USA	Link USA	SLKG100	coiled tube	electronic	23	0.65	30	instant	1380	NS
Litetronics	Spiral-Lite	F15 SPL (L-315)	coiled tube	electronic	15	NS	NS	NS	900	NS
	Spiral-Lite	F20 SPL (L-320)	coiled tube	electronic	20	NS	NS	NS	1200	NS
	Spiral-Lite	F23 SPL (L-323)	coiled tube	electronic	23	NS	NS	NS	1440	NS
MaxLite	Downlights	SK320EBH	coiled tube	electronic	20	0.97	<15	instant	1200	NS
	Downlights	SK320EBHLN	coiled tube	electronic	20	0.97	<15	instant	1200	NS
	Downlights	SK323EBH	coiled tube	electronic	23	0.97	<15	instant	1500	NS
	Downlights	SKM315EB	coiled tube	electronic	15	0.60	>100	instant	900	NS
	Magnetic Capsule	SK217MC	coiled tube	magnetic	17	0.60	<15	rapid	700	NS
	Magnetic CFL	SK217MA	coiled tube	magnetic	17	0.60	<15	rapid	780	NS
	Mini-Max	SKM315EA	coiled tube	electronic	15	0.60	>100	instant	900	720
	Mini-Max	SKM315EAH	coiled tube	electronic	15	0.97	<15	instant	900	720
	SpiraMax	SKS20EA	coiled tube	electronic	20	0.60	>100	instant	1250	NS
	Tri-Max	SKT320EAH	triple tube	electronic	20	0.97	<15	instant	1200	NS
	Tri-Max	SKT323EAH	triple tube	electronic	23	0.97	<15	instant	1500	NS
Mitor	Powerlum	MTH15	triple tube	electronic	15	>0.90	<25	instant	900	792
	Powerlum	MTH20	triple tube	electronic	20	>0.90	<25	instant	1200	1056
	Powerlum	MTH23	triple tube	electronic	23	>0.90	<25	instant	1500	1230
	Powerlum	MTL15	triple tube	dimmable electronic	15	0.55	>110	instant	900	792
	Powerlum	MTL20	triple tube	dimmable electronic	20	0.55	>110	instant	1200	1056
	Powerlum	MTL23	triple tube	dimmable electronic	23	0.55	>110	instant	1500	1230

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1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Available in medium and high power factor.
[c] Dependent on medium or high power factor specifications.
[d] The electrodeless CFL product uses a different starting technology than other CFL products. However, the manufacturer treats it as a CFL product.
[e] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2700	84	10,000	NA	NS	-23 (-9)	NS	16.0 (6.3)	NS	center	9.99
2700	84	10,000	NA	NS	-23 (-9)	NS	17.0 (6.7)	NS	center	17.99
2700	84	10,000	NA	NS	-23 (-9)	NS	17.5 (6.9)	NS	center	17.99
2700	84	10,000	NA	NS	-23 (-9)	NS	14.7 (5.8)	NS	center	9.99
2700	84	10,000	NA	NS	-23 (-9)	NS	12.7 (5.0)	NS	center	9.99
2700	84	10,000	NA	NS	-23 (-9)	NS	14.0 (5.5)	NS	center	9.99
2700	84	10,000	NA	NS	-23 (-9)	NS	16.3 (6.4)	NS	center	9.99
2700	84	10,000	NA	NS	-23 (-9)	NS	11.9 (4.7)	NS	center	12.99
2700	84	10,000	NA	NS	-23 (-9)	NS	13.2 (5.2)	NS	center	12.99
2700	84	10,000	NA	NS	-23 (-9)	NS	15.0 (5.9)	NS	center	12.99
NS	82	10,000	NA	NS	NS	none	14.0 (5.5)	185.7 (6.5)	NS	18.00
2700	85	10,000	NA	NS	NS	none	13.0 (5.1)	NS	center	NS
2700	85	10,000	NA	NS	NS	none	14.5 (5.7)	NS	center	NS
2700	85	10,000	NA	NS	NS	none	14.5 (5.7)	NS	center	NS
2800, 6000	84	10,000	NA	71 (160)	-18 (0)	reflector, lenses	17.5 (6.9)	251.4 (8.8)	center	NS
2800	84	10,000	NA	71 (160)	-18 (0)	long neck, reflector	18.5 (7.3)	251.4 (8.8)	center	NS
2800	84	10,000	NA	71 (160)	-18 (0)	reflector, lenses	18.5 (7.3)	251.4 (8.8)	center	NS
2800, 6000	84	10,000	NA	71 (160)	-18 (0)	reflector, lenses	15.2 (6.0)	182.9 (6.4)	center	NS
2800, 6000	84	7500	NA	40 (104)	0 (32)	frosted capsule cover	19.6 (7.7)	471.4 (16.5)	center	NS
2800, 6000	84	7500	NA	40 (104)	0 (32)	clear lamp cover	15.7 (6.2)	434.3 (15.2)	center	NS
2800, 6000	84	10,000	NA	71 (160)	-18 (0)	none	14.7 (5.8)	137.1 (4.8)	center	NS
2800	84	10,000	NA	71 (160)	-18 (0)	none	14.7 (5.8)	137.1 (4.8)	center	NS
2800, 6000	84	10,000	NA	71 (160)	-18 (0)	none	13.0 (5.1)	120.0 (4.2)	center	NS
2800, 6000	84	10,000	NA	71 (160)	-18 (0)	none	16.3 (6.4)	145.7 (5.1)	center	NS
2800	84	10,000	NA	71 (160)	-18 (0)	none	19.6 (7.7)	137.1 (4.8)	center	NS
2700, 3500, 4100, 6500	82	10,000	NA	60 (140)	-40 (-40)	none	14.5 (5.7)	114.3 (4.0)	center	17.95
2700, 3500, 4100, 6500	82	10,000	NA	60 (140)	-40 (-40)	none	15.2 (6.0)	114.3 (4.0)	center	18.95
2700, 3500, 4100, 6500	82	10,000	NA	60 (140)	-40 (-40)	none	17.3 (6.8)	114.3 (4.0)	center	19.95
2700, 3500, 4100, 6500	82	10,000	NA	60 (140)	-40 (-40)	photocell	14.5 (5.7)	114.3 (4.0)	center	15.95
2700, 3500, 4100, 6500	82	10,000	NA	60 (140)	-40 (-40)	none	15.2 (6.0)	114.3 (4.0)	center	15.95
2700, 3500, 4100, 6500	82	10,000	NA	60 (140)	-40 (-40)	none	17.3 (6.8)	114.3 (4.0)	center	17.95

Table 2 (continued). Manufacturer-Supplied Data: Self-Ballasted Compact Fluorescent Lamp Products

					Electrical Characteristics				Photometric Characteristics	
Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Initial Light Output (lm)	Mean Light Output (lm)
OSRAM SYLVANIA	DULUX EL	CF13EL/830/MED	quad	electronic	13	0.60	160	instant	550	500
	DULUX EL	CF15EL/830/MED	triple tube	electronic	15	0.60	160	instant	925	830
	DULUX EL	CF15EL/G30/830/MED	globe	electronic	15	0.60	160	instant	725	650
	DULUX EL	CF15EL/R30/830/MED	reflector	electronic	15	0.60	160	instant	600	540
	DULUX EL	CF20EL/830/MED	triple tube	electronic	20	0.60	160	instant	1280	1150
	DULUX EL	CF20EL/G40/830/MED	globe	electronic	20	0.60	160	instant	1000	900
	DULUX EL	CF20EL/R40/830/MED	reflector	electronic	20	0.60	160	instant	875	790
	DULUX EL	CF23EL/830/MED	triple tube	electronic	23	0.60	160	instant	1580	1420
	DULUX EL	CFL17EL/830/MED	quad	electronic	17	0.60	160	instant	950	860
Panasonic	Light Capsule	EFG15E28	capsule	electronic	15	NS	NS	instant	850	NS
	Light Capsule	EFG15E50	capsule	electronic	15	NS	NS	instant	810	NS
	Light Capsule	EFG25E28	capsule	electronic	25	NS	NS	instant	1370	NS
	Light Capsule	EFG25E50	capsule	electronic	25	NS	NS	instant	1320	NS
	Light Capsule	EFT15E28	capsule	electronic	15	NS	NS	instant	850	NS
	Light Capsule	EFT15E28.UHD	capsule	electronic	15	<0.90	<25	instant	810	NS
	Light Capsule	EFT15E50	capsule	electronic	15	NS	NS	instant	810	NS
	Light Capsule	EFT20E28	capsule	electronic	20	NS	NS	instant	1200	NS
	Light Capsule	EFT20E28.UHD	capsule	electronic	20	<0.90	<25	instant	1100	NS
	Light Capsule	EFT20E50	capsule	electronic	20	NS	NS	instant	1150	NS
	Light Capsule	EFT28E28	capsule	electronic	28	NS	NS	instant	1750	NS
	Light Capsule	EFT28E50	capsule	electronic	28	NS	NS	instant	1680	NS
	Performance Collection	EFS15E27	quad	electronic	15	NS	NS	instant	900	NS
	Performance Collection	EFS20E27	quad	electronic	20	NS	NS	instant	1200	NS
	Reflector Light Capsule	EFG15E28R	capsule	electronic	15	NS	NS	instant	550	NS
Philips	Earth Light Bug-A-Way EL/O 15 BAW	28778-9	capsule	electronic	15	0.55–0.62	NS	NS	750	635
	Earth Light Decor Globe SLS/G30 15	26166-9	globe	electronic	15	0.55–0.62	NS	NS	750	635
	Earth Light Decor Globe SLS/G40 15	26164-4	globe	electronic	15	0.55–0.62	NS	NS	750	635
	Earth Light Dimmable SLS/D 23	27115-5	triple tube	dimmable electronic	23	0.50–0.70	NS	NS	1500	1275
	Earth Light Flood SLS/R30 15	22035-0	triple tube	electronic	15	0.55–0.62	NS	NS	500	425
	Earth Light Flood SLS/R30 20	22038-4	triple tube	electronic	20	0.55–0.62	NS	NS	575	485
	Earth Light Flood SLS/R40 15	22037-6	triple tube	electronic	15	0.55–0.62	NS	NS	625	530

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Available in medium and high power factor.
[c] Dependent on medium or high power factor specifications.
[d] The electrodeless CFL product uses a different starting technology than other CFL products. However, the manufacturer treats it as a CFL product.
[e] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics					
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
3000	82	6000	NA	50 (122)	-30 (-22)	none	14.2 (5.6)	97.1 (3.4)	center	10.50
3000	82	10,000	NA	38 (100)	-30 (-22)	none	14.2 (5.6)	42.9 (1.5)	center	12.99
3000	82	10,000	NA	38 (100)	-30 (-22)	none	16.5 (6.5)	NS	center	19.95
3000	82	10,000	NA	38 (100)	-30 (-22)	none	14.7 (5.8)	NS	center	19.95
3000	82	10,000	NA	38 (100)	-30 (-22)	none	16.0 (6.3)	42.9 (1.5)	center	12.99
3000	82	10,000	NA	38 (100)	-30 (-22)	none	18.5 (7.3)	NS	center	19.95
3000	82	10,000	NA	38 (100)	-30 (-22)	none	16.0 (6.3)	NS	center	19.99
3000	82	10,000	NA	38 (100)	-30 (-22)	none	17.3 (6.8)	42.9 (1.5)	center	12.99
3000	82	6000	NA	50 (122)	-30 (-22)	none	18.5 (7.3)	117.1 (4.1)	center	10.50
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.0 (5.1)	160.0 (5.6)	center	NS
5000	88	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.0 (5.1)	160.0 (5.6)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.5 (5.3)	182.9 (6.4)	center	NS
5000	88	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.5 (5.3)	182.9 (6.4)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.5 (5.3)	128.6 (4.5)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.5 (5.3)	131.4 (4.6	center	NS
5000	88	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	13.5 (5.3)	128.6 (4.5)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	15.7 (6.2)	151.4 (5.3)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	15.7 (6.2)	151.4 (5.3)	center	NS
5000	88	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	15.7 (6.2)	151.4 (5.3)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	17.0 (6.7)	191.4 (6.7)	center	NS
5000	88	10,000	NA	50 (122)	-30 (-22)	reflector, locking device	17.0 (6.7)	191.4 (6.7)	center	NS
2700	84	10,000	NA	50 (122)	-30 (-22)	reflector	15.2 (6.0)	82.9 (2.9)	center	NS
2700	84	10,000	NA	50 (122)	-30 (-22)	none	17.3 (6.8)	100.0 (3.5)	center	NS
2800	84	10,000	NA	50 (122)	-30 (-22)	locking device	13.7 (5.4)	131.4 (4.6)	center	NS
NA	NA	10,000	NA	60 (140)	-23 (-9)	none	13.7 (5.4)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	14.5 (5.7)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	17.0 (6.7)	NS	center	NS
2700	82	10,000	NA	60 (140)	0 (32)	none	16.8 (6.6)	NS	center	NS
2700	82	8000	NA	60 (140)	-23 (-9)	reflector	15.2 (6.0)	NS	center	NS
2700	82	8000	NA	60 (140)	-23 (-9)	reflector	15.2 (6.0)	NS	center	NS
2700	82	8000	NA	60 (140)	-23 (-9)	reflector	16.8 (6.6)	NS	center	NS

Table 2 (continued). Manufacturer-Supplied Data: Self-Ballasted Compact Fluorescent Lamp Products

Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Electrical Characteristics: Active Power (W)	Power Factor	THD (%)	Starting Method[a]	Photometric Characteristics: Initial Light Output (lm)	Mean Light Output (lm)
Philips	Earth Light Flood SLS/R40 20	22039-2	triple tube	electronic	20	0.55-0.62	NS	NS	825	700
	Earth Light Outdoor EL/O 15	28774-8	capsule	electronic	15	0.55-0.62	NS	NS	800	680
	Earth Light Outdoor EL/O 18	28775-5	capsule	electronic	18	0.55-0.62	NS	NS	1100	935
	Earth Light Table Lamp EL/T 15	28772-2	triple tube	electronic	15	0.55-0.62	NS	NS	900	765
	Earth Light Table Lamp EL/T 18	28773-0	triple tube	electronic	18	0.55-0.62	NS	NS	1150	975
	Earth Light Universal SLS 15	22003-8	triple tube	electronic	15	0.55-0.62	NS	NS	900	765
	Earth Light Universal SLS 20	22008-7	triple tube	electronic	20	0.55-0.62	NS	NS	1200	1020
	Earth Light Universal SLS 23	22558-1	triple tube	electronic	23	0.55-0.62	NS	NS	1500	1275
	Earth Light Universal SLS 25	22009-5	triple tube	electronic	25	0.55-0.62	NS	NS	1750	1490
	Earth Light Universal/RH SLS/RH 16	22324-8	triple tube	electronic	16	>0.90	≤32	NS	900	765
	Earth Light Universal/RH SLS/RH 20	22012-9	triple tube	electronic	20	>0.90	≤32	NS	1200	1020
	Earth Light Universal/RH SLS/RH 23	22013-7	triple tube	electronic	23	>0.90	≤32	NS	1500	1275
ProLight	Twister	ET15	coiled tube	electronic	15	NS	NS	NS	800	NS
	Twister	ET18	coiled tube	electronic	18	NS	NS	NS	1100	NS
	Twister	ET23	coiled tube	electronic	23	NS	NS	NS	1350	NS
	Twister	R32/ET15	coiled tube	electronic	15	NS	NS	NS	580	NS
	Twister	R32/ET18	coiled tube	electronic	18	NS	NS	NS	800	NS
	Twister	R32/ET23	coiled tube	electronic	23	NS	NS	NS	1350	NS
	Twister	R40/ET18	coiled tube	electronic	18	NS	NS	NS	1100	NS
	Twister	R40/ET23	coiled tube	electronic	23	NS	NS	NS	1350	NS

NA = Not Applicable
NS = Not Supplied
°F = (9/5)°C+32
1 cm = 0.394 in.
1 g = 0.035 oz
[a] Rapid-start includes programmed and modified rapid-start.
[b] Available in medium and high power factor.
[c] Dependent on medium or high power factor specifications.
[d] The electrodeless CFL product uses a different starting technology than other CFL products. However, the manufacturer treats it as a CFL product.
[e] Supplied for the base-down position.

Photometric Characteristics		Life		Temperature Requirements		Physical Characteristics				
CCT (K)	CRI	Lamp Rated Life (h)	Ballast Rated Life (h)	Maximum Ambient Temperature [°C (°F)]	Minimum Ambient Temperature [°C (°F)]	Accessories Available	Maximum Overall Length [cm (in.)]	Weight [g (oz)]	Lamp Base Position	Suggested Retail Price ($US)
2700	82	8000	NA	60 (140)	-23 (-9)	reflector	16.8 (6.6)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	13.7 (5.4)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	15.5 (6.1)	NS	center	NS
2700	82	7000	NA	38 (100)	0 (32)	none	14.2 (5.6)	NS	center	NS
2700	82	7000	NA	38 (100)	0 (32)	none	16.0 (6.3)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	12.2 (4.8)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	14.0 (5.5)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	15.7 (6.2)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	15.7 (6.2)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	13.5 (5.3)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	15.2 (6.0)	NS	center	NS
2700	82	10,000	NA	60 (140)	-23 (-9)	none	16.8 (6.6)	NS	center	NS
2700	85	10,000	NA	NS	NS	none	12.7 (5.0)	NS	center	NS
2700	85	10,000	NA	NS	NS	none	13.5 (5.3)	NS	center	NS
2700	85	10,000	NA	NS	NS	none	15.2 (6.0)	NS	center	NS
2700	85	10,000	NA	NS	NS	reflector	14.0 (5.5)	NS	center	NS
2700	85	10,000	NA	NS	NS	reflector	14.0 (5.5)	NS	center	NS
2700	85	10,000	NA	NS	NS	reflector	14.7 (5.8)	NS	center	NS
2700	85	10,000	NA	NS	NS	reflector	15.2 (6.0)	NS	center	NS
2700	85	10,000	NA	NS	NS	reflector	15.2 (6.0)	NS	center	NS

Table 3. NLPIP Evaluations: Comparison of CFL and Equivalent Incandescent Light Output

			Incandescent	
Manufacturer	Catalog Number	Lamp Envelope	Claimed Equivalent (W)	Initial Light Output[a] (lm)
Lights of America	2633 (low)	circular	50	800
GE Lighting	FLE15TBX/SPX27	triple tube	60	750
	FLE15TBX/HPF/SPX27	triple tube		
OSRAM SYLVANIA	CF15EL/830/MED	triple tube		
Panasonic	EFT15E28	capsule		
Philips	SL/T 16[c]	triple tube		
	SL/O 17[c]	triple tube		
Litetronics	L-315	coiled tube	75	1310
Philips	SL/O 18[c]	triple tube		
OSRAM SYLVANIA	CF20EL/830/MED	triple tube		
Panasonic	EFT20E28	capsule		
Philips	SL/T 20[c]	triple tube		
GE Lighting	FEA222D/HPF/SW[c]	square		
Lights of America	2620	circular	90	1320
GE Lighting	FLE23TBX/SPX27[c]	triple tube		
Panasonic	EFG25E28	globe		
Litetronics	L-320	coiled tube	100	1505
Lights of America	2633 (medium)	circular		
GE Lighting	FLE28QBX/SPX27	four-tube		
Panasonic	EFT28E28	capsule		
Lights of America	2630	circular	150	2615
	2633 (high)	circular		
GE Lighting	FEA392D/HPF/SW[c]	square		

[a] Initial light output averaged from incandescent lamp information in GE Lighting, Philips, and OSRAM SYLVANIA catalogs.
[b] Supplied for the base-down position.
[c] Manufacturer-supplied data does not include these products because they were discontinued; information obtained from lamp packaging.

CFL Products					
Manufacturer-Supplied		Base-Up Position		Base-Down Position	
Active Power (W)	Initial Light Output (lm)	Initial Measured Light Output (lm)	Ratio of Initial Measured Light Output to Initial Light Output	Initial Measured Light Output (lm)	Ratio of Initial Measured Light Output to Initial Light Output
13	800[b]	844	1.06	861	1.08
15	900	839	0.93	829	0.92
15	825	802	0.97	777	0.94
15	925	922	1.00	932	1.01
15	850	782	0.92	758	0.89
16	900	936	1.04	947	1.05
17	870	868	1.00	892	1.03
15	900	864	0.96	649	0.72
18	1100	1102	1.00	1071	0.97
20	1280	1060	0.83	1013	0.79
20	1200	1063	0.89	1039	0.87
20	1200	1257	1.05	1271	1.06
22	1300	1108	0.85	1115	0.86
20	1150[b]	1228	1.07	1231	1.07
24	1520	1434	0.94	1106	0.73
25	1370	1073	0.78	1087	0.79
20	1200	1283	1.07	1028	0.86
23	1600[b]	1500	0.94	1520	0.95
28	1750	1676	0.96	1486	0.85
28	1750	1451	0.83	1303	0.74
30	2100[b]	1892	0.90	1874	0.89
34	2100[b]	2232	1.06	2245	1.07
39	2780	2316	0.83	2323	0.84

Table 4. NLPIP Evaluations of Modular Compact Fluorescent Lamp Products

Manufacturer	Trade Name	Catalog Number	Ballast Type	Manufacturer-Supplied Performance Data, Base-Up Position: Active Power (W)	Power Factor	THD (%)	Initial Light Output (lm)
GE Lighting	2D Lamp	FEA222D/HPF/SW[a]	electronic	22	NS	NS	1300
	2D Lamp	FEA392D/HPF/SW[a]	electronic	39	NS	NS	2780
	Circlite	FCA21/CD[a]	magnetic	21	NS	NS	1200
	Circlite	FCA24/WW/CD[a]	magnetic	24	NS	NS	1100
Lights of America	Circle Lite	2620	electronic	20	NS	NS	1150[b]
	Circle Lite	2630	electronic	30	NS	NS	2100[b]
	Multi Lite	2633 (low)	electronic	13	NS	NS	800[b]
	Multi Lite	2633 (medium)	electronic	23	NS	NS	1600[b]
	Multi Lite	2633 (high)	electronic	34	NS	NS	2100[b]
MaxLite	Electronic Circline	SK122ER	electronic	22	0.60	>100	1600
	Electronic Circline	SK130ER	electronic	30	0.60	>100	2000

NS = Not Supplied
[a] Manufacturer-supplied data does not include these products because they were discontinued; information obtained from lamp packaging.
[b] Supplied for the base-down position.

NLPIP Test Results								
Base-Up Position				Base-Down Position				
Active Power (W)	Power Factor	THD (%)	Initial Light Output (lm)	Active Power (W)	Power Factor	THD (%)	Initial Light Output (lm)	Position Factor
19.6	0.97	16	1108	19.8	0.97	18	1115	1.01
30.9	0.97	19	2316	31.1	0.97	19	2323	1.00
19.7	0.50	15	1106	19.7	0.51	15	1114	1.01
20.9	0.54	13	1142	20.8	0.55	12	1146	1.00
18.9	0.49	169	1228	19.1	0.49	169	1231	1.00
27.5	0.53	150	1892	27.6	0.53	150	1874	0.99
11.6	0.49	168	844	11.7	0.49	167	861	1.02
21.0	0.50	164	1500	21.2	0.50	164	1520	1.01
33.0	0.54	141	2232	32.8	0.54	141	2245	1.01
21.8	0.97	20	1546	21.3	0.97	20	1523	0.99
28.5	0.92	35	1613	28.8	0.92	36	1613	1.00

Table 5. NLPIP Evaluations of Self-Ballasted Compact Fluorescent Lamp Products

				Manufacturer-Supplied Performance Data			
				Base-Up Position			
Manufacturer	Trade Name	Catalog Number	Ballast Type	Active Power (W)	Power Factor	THD (%)	Initial Light Output (lm)
GE Lighting	Biax Lamps	FLE15TBX/HPF/SPX27/SW	electronic	15	0.95	<32	825
	Biax Lamps	FLE15TBX/SPX27	electronic	15	<0.60	170	900
	Biax Lamps	FLE23TBX/SPX27[a]	electronic	23	NS	NS	1520
	Biax Lamps	FLE28QBX/SPX27	electronic	28	<0.60	170	1750
Link USA	Link USA	SLKG100	electronic	23	0.65	30	1380
Litetronics	Spiral-Lite	F15 SPL (L-315)	electronic	15	NS	NS	900
	Spiral-Lite	F20 SPL (L-320)	electronic	20	NS	NS	1200
MaxLite	Mini-Max	SKM315EAH	electronic	15	0.97	<15	900
OSRAM SYLVANIA	DULUX EL	CF15EL/830/MED	electronic	15	0.60	160	925
	DULUX EL	CF20EL/830/MED	electronic	20	0.60	160	1280
Panasonic	Light Capsule	EFG25E28	electronic	25	NS	NS	1370
	Light Capsule	EFT15E28	electronic	15	NS	NS	850
	Light Capsule	EFT20E28	electronic	20	NS	NS	1200
	Light Capsule	EFT28E28	electronic	28	NS	NS	1750
Philips	Earth Light	SL/G 17[a]	magnetic	17	NS	NS	600
	Earth Light	SL/O 17[a]	electronic	17	NS	NS	870
	Earth Light	SL/O 18[a]	electronic	18	NS	NS	1100
	Earth Light	SL/T 16[a]	electronic	16	NS	NS	900
	Earth Light	SL/T 20[a]	electronic	20	NS	NS	1200

NS = Not Supplied
[a] Manufacturer-supplied data does not include these products because they were discontinued; information obtained from lamp packaging.

NLPIP Test Results								
Base-Up Position				Base-Down Position				
Active Power (W)	Power Factor	THD (%)	Initial Light Output (lm)	Active Power (W)	Power Factor	THD (%)	Initial Light Output (lm)	Position Factor
15.1	0.97	24	802	15.2	0.97	23	777	0.97
14.3	0.47	180	839	14.5	0.47	179	829	0.99
22.7	0.57	122	1434	18.7	0.55	132	1106	0.77
25.9	0.52	153	1676	23.0	0.51	159	1486	0.89
19.5	0.57	129	987	18.6	0.56	132	897	0.91
16.9	0.58	129	864	15.7	0.57	132	649	0.75
20.9	0.60	114	1283	19.6	0.60	116	1028	0.80
13.9	0.53	150	750	13.7	0.53	151	733	0.98
15.3	0.51	161	922	15.2	0.51	161	932	1.01
19.6	0.53	149	1060	18.8	0.53	151	1013	0.96
25.1	0.56	140	1073	24.5	0.56	141	1087	1.01
15.0	0.57	133	782	15.2	0.57	132	758	0.97
19.7	0.60	121	1063	19.7	0.60	120	1039	0.98
28.8	0.56	142	1451	27.9	0.56	144	1303	0.90
16.9	0.57	14	564	17.1	0.57	13	583	1.03
17.7	0.58	131	868	17.7	0.58	131	892	1.03
18.8	0.59	117	1102	18.7	0.59	116	1071	0.97
17.3	0.58	128	936	17.6	0.58	127	947	1.01
21.4	0.60	118	1257	21.4	0.60	118	1271	1.01

Table 6. Long-Term Performance Testing

Manufacturer	Trade Name	Catalog Number	Lamp Envelope	Ballast Type	Electrical Characteristics: Active Power[a] (W)	Electrical Characteristics: Lamp Operating Current (mA)	CCF
GE Lighting	Biax Lamps[d]	FLE15TBX/HPF/SPX27/SW	triple tube	electronic	15	160	1.51
	Biax Lamps	FLE20TBX/HPF/SPX27/SW	triple tube	electronic	20	171	1.46
Lights of America	Circle Lite[d]	2620	circular	electronic	20	553	1.58
	Quad Lite	2118	quad	electronic	18	275	1.66
MaxLite	Mini-Max	SK217MA	coiled tube	magnetic	17	284	1.59
	Mini-Max[d]	SKM315EAH	coiled tube	electronic	15	160	1.54
OSRAM SYLVANIA	DULUX EL	CF15EL/827/MED/HPF	triple tube	electronic	15	193	2.14
	DULUX EL	CF23EL/827/MED/HPF	triple tube	electronic	23	177	1.92
Panasonic	Light Capsule	EFT16LE	capsule	electronic	16	363	1.52
Philips	Earth Light	SLS15/RH	triple tube	electronic	15	168	1.60
	Earth Light[d]	SL/O17	capsule	electronic	17	223	1.62

NA = Not Applicable
NM = Not Measured
[a] Information obtained from lamp packaging.
[b] Total number of operating (on) hours for this cycle between 6/11/96 and 12/31/98.
[c] Rated life is based on an operating cycle of 3 h on, 20 min off.
[d] These products were also tested by NLPIP and are reported in Tables 4 and 5.
[e] Median lamp life cannot be determined until half the samples have failed. These products, therefore, have a median lamp life exceeding the total operating hours for this cycle. Number in parentheses indicates the number of lamps that have failed as of December 31, 1998.

Table 7. Manufacturer Contact Information

Company	Customer Service #	Web Site
Angelo Brothers Company (ABCO)	800-999-ABCO	www.angelobrothers.com
Enertron Technologies, Inc.	800-537-7649	www.enertron.com
Feit Electric	800-543-3348	www.feit.com
GE Lighting	800-626-2000	www.ge.com/lighting
Lights of America, Inc.	800-321-8100	www.lightsofamerica.com
Link USA International, Inc.	212-719-1930	www.linkusa.bola.net
Litetronics International, Inc.	708-389-8000	www.litetronics.com
Lumatech Corporation	800-932-0637	www.lumatech.com
MaxLite, a Division of SK America, Inc.	800-555-5MAX	www.light-link.com/maxlite
Mitor Lighting	800-743-9148	www.mitor.com
OSRAM SYLVANIA	800-544-4828	www.sylvania.com
Panasonic Lighting	201-348-5381	www.panasonic.com/lighting
Philips Electronics N.V.	800-555-0500	www.lighting.philips.com
ProLight, Inc.	800-968-2556	www.prolight.com

				Median Lamp Life in Hours						
Starting Characteristics				Operating Cycles						
Starting Method	Starting Time (s)	Electrode Preheat Current (mA)	Starting Voltage (V)	5 min on 20 s off (20,598)[b]	5 min on 5 min off (10,998)[b]	15 min on 5 min off (16,481)[b]	1 h on 5 min off (70,291)[b]	3 h on 5 min off (21,414)[b]	3 h on 20 min off (19,821)[b]	Rated Life[c] (h)
preheat	1.06	232	212	7278	(0)[e]	(0)[e]	(0)[e]	(1)[e]	(0)[e]	10,000
preheat	1.08	217	235	751	6668	3253	13,559	17,799	(0)[e]	10,000
instant	0.08	NA	230	1632	1158	1401	3181	4025	3965	12,000
preheat	0.50	725	165	1914	859	1797	4269	5073	5397	12,000
preheat	1.70	NM	106	1817	1236	2557	5628	7364	6341	7500
preheat	0.98	323	173	667	1950	5390	12,217	12,134	(0)[e]	10,000
preheat	1.10	229	178	582	(1)[e]	(0)[e]	(1)[e]	(2)[e]	(2)[e]	10,000
preheat	0.90	265	198	12,054	(3)[e]	14,950	19,887	10,356	17,723	10,000
instant	0.08	NA	113	1258	533	2753	6704	9618	10,212	10,000
preheat	1.00	266	162	286	10,157	12,577	12,962	11,103	11,966	10,000
preheat	0.88	372	115	8893	4265	12,868	13,436	19,005	16,350	10,000

NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports

Screwbase Compact Fluorescent Lamp Products

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The National Lighting Product Information Program

The National Lighting Product Information Program (NLPIP) was established in 1990 and is administered by the Lighting Research Center at Rensselaer Polytechnic Institute. The Lighting Research Center is a nonprofit educational and research organization dedicated to the advancement of lighting knowledge.

NLPIP's mission is to rapidly provide the best information available on energy efficient lighting products. NLPIP strives to provide complete, current, and valuable manufacturer-specific performance data in useful formats to guide lighting decisions. Priority is given to information not available now or not easily accessible from other sources.

The National Lighting Product Information Program tests lighting products according to accepted industry procedures. If procedures are not available or applicable, NLPIP develops interim tests, focusing on those performance issues that are important to the lighting specifier and end user. The program does not accept funding from manufacturers.

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Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about nine modular and self-ballasted screwbase compact fluorescent lamp (CFL) products from six manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

http://www.lrc.rpi.edu/programs/nlpip/screwbase.asp.

Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database on October 20, 1999.

Manufacturer	Model Name	Model Number
FEIT	ECO Bulb	MLPL13
GE Lighting	Circlite	FCA21/CD
Lights of America	Twister Bulb	2420
Maxlite	Mini-Max	SKM315EA (CCT 2800)
OSRAM SYLVANIA	DULUX EL	CF17EL/830/MED
OSRAM SYLVANIA	DULUX EL	CF23EL/830/MED
Philips	Earth Light Universal	SLS 20
Philips	Earth Light Universal	SLS 23
Philips	Earth Light Universal	SLS 25

Evaluation Methods

The testing procedure in this supplement differs slightly from the testing method in the original report. Three samples of each CFL product were tested here: in the initial study, one sample of each CFL was tested. The products were purchased at retail stores in eastern New York State. The stores, which were scattered over a wide geographic area, had the products readily available. NLPIP purchased two samples of each CFL from one retailer and the third sample of each CFL from a different store in a different geographic area.

NLPIP directed the product testing from September to October 1997. Intertek Testing Services (ITS) in Cortland, New York, an independent testing organization dedicated to commodity products, performed the tests. ITS followed all testing procedures and conducted all the tests described in *Specifier Reports: Screwbase Compact Fluorescent Lamp Products*.

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Screwbase Compact Fluorescent Lamp Products

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Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 22 modular and self-ballasted screwbase compact fluorescent lamp (CFL) products from 6 manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:
http://www.lrc.rpi.edu/programs/nlpip/screwbase.asp.

Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database in June 2000.

Manufacturer	Model Name	Model Number	
Energy Efficient Technologies	Mini Lite	ETU15	
Harmony Lighting International	LightWiz	1100.842	
Harmony Lighting International	LightWiz	1100.843	
JKRL USA	ECO-GLO	YER(SB)15P	
JKRL USA	ECO-GLO	YER(SB)20P	
JKRL USA	ECO-GLO	YER(SB)23P	
Shunde Corso Electronics Co., Ltd.		“A” Lamp	CPOB
Sunpark Electronics Corp.	Spiral	SP 15S	
Sunpark Electronics Corp.	Spiral	SP 15SL	
Sunpark Electronics Corp.	Spiral	SP 20S	
Sunpark Electronics Corp.	Spiral	SP 23S	
Sunpark Electronics Corp.	Spiral	SP 23SL	
Technical Consumer Products, Inc.		SpringLamp	10111
Technical Consumer Products, Inc.		SpringLamp	10115
Technical Consumer Products, Inc.		SpringLamp	10118
Technical Consumer Products, Inc.		SpringLamp	10123
Technical Consumer Products, Inc.		SpringLamp	18009
Technical Consumer Products, Inc.		SpringLamp	18011
Technical Consumer Products, Inc.		SpringLamp	18015
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Technical Consumer Products, Inc.		SpringLamp	18023
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Evaluation Methods

The testing procedure in this supplement differs slightly from the testing method in the original report. Three samples of each CFL product were tested here: in the initial study, one sample of each CFL was tested. The products were purchased from online retail sources and, where necessary, directly from manufacturers.

NLPIP directed the product testing during April 2000. Intertek Testing Services (ITS) in Cortland, New York, an independent testing organization dedicated to commodity products, performed the tests. ITS followed all procedures and conducted all the tests described in *Specifier Reports: Screwbase Compact Fluorescent Lamp Products*.

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The products described herein have not been tested for safety. The Lighting Research Center and Rensselaer Polytechnic Institute make no representations whatsoever with regard to safety of products, in whatever form or combination used, and the results of testing set forth for your information cannot be regarded as a representation that the products are or are not safe to use in any specific situation, or that the particular product you purchase will conform to the results found in this report.

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NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

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Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 11 self-ballasted screwbase compact fluorescent lamp (CFL) products from six manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

http://www.lrc.rpi.edu/programs/nlpip/screwbase.asp.

Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database on May 1, 2001.

Manufacturer	Model Name	Model Number
FEIT	ECOBULB	BPESL15G
FEIT	ECOBULB	BPESL15T
GE Lighting	NS	FEA382D/3WAY
GE Lighting	Spiral	FLE21HLX/8/SW
Lights of America	The Bulb	2000
Lights of America	The Twister Reflector	2935
Maxlite	SpiraMax	SKS23EA
OSRAM SYLVANIA	DULUX EL	CF15EL/ G30/ 830/MED
Philips	EARTH LIGHT Household	EL/A 16W
Philips	MARATHON	EL/O 18W
Philips	EARTH LIGHT Dimmable	SLS/D 23W

NS = not supplied

Evaluation Methods

The testing procedure in this supplement differs from the testing method in the original report. The product samples tested were procured from retail locations throughout the U.S. in December 2000. Three samples of the CFL products were purchased and tested. In the initial study, one sample of each CFL was tested.

Testing occurred from January to February 2001 in the NLPIP fluorescent lamp testing laboratory in Troy, N.Y., which is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

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Screwbase Compact Fluorescent Lamp Products

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Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 18 self-ballasted screwbase compact fluorescent lamp (CFL) products from 12 manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

http://www.lrc.rpi.edu/programs/nlpip/screwbase.asp.

Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database on December 1, 2001.

Manufacturer	Model Name	Model Number
Angelo Bros-Westinghouse	TWIST	37353
Commercial Electric	NS	738-703
Commercial Electric	NS	846-038
FEIT	ECO Bulb	BPESL13T
FEIT	ECO Bulb	BPESL25T
GE Lighting	ULTRA	FLE15TBX/L/LLCD
GE Lighting	NS	FLE20/6/T19/827
GE Lighting	NS	FLE20TBX/L/R40
GE Lighting	ULTRA	FLG15/E
Harmony Lighting International	Lightwiz	H20027
Harmony Lighting International	Lightwiz	H23327
JKRL USA	ECO-GLO	YER(SB)26P
MaxLite	SpiraMax	SKS15EA
OSRAM SYLVANIA	DULUX EL	CF20EL/Twist
Panasonic	GenIV	EFA14E28
Philips	MARATHON	SLS 15
Sunpark Electronics Corp.	NS	SP 20SL
Surya/PMI	NS	ET15

NS = not supplied

Evaluation Methods

The testing procedure in this supplement differs from the method in the original report. The product samples tested were procured from retail locations throught the U.S. from August to September 2001. Three samples of the CFL products were purchased and tested.

Testing occurred from August to November 2001 in the NLPIP fluorescent lamp testing laboratory in Troy, NY, which is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

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Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 20 self-ballasted screwbase compact fluorescent lamp (CFL) products from 12 manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

http://www.lrc.rpi.edu/programs/nlpip/screwbase.asp.

Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database on December 1, 2002.

Manufacturer	Model Name	Model Number
Commercial Electric	NS	738-702
FEIT	ECOBULB	BPESL11G
FEIT	ECOBULB	BPESL15R30
FEIT	ECOBULB	BPESL16A
FEIT	ECOBULB	BPESL30-100T
GE Lighting	NS	FLE27HLX/8/CD
GE Lighting	NS	FLE29QBX/DV/CD
GREENLITE	NS	ELR30
GREENLITE	NS	ELS-M 15W
Harmony Lighting	Lightwiz	H20027
Lights of America	the Twister	2415
Lights of America	the Twister	2425
MaxLite	EconoMax	SKE215EA
Philips	MARATHON	SLS/R30 15W
Philips	MARATHON	SLS/TW34W
Sunrise Lighting	NS	SSE15M
Surya/PMI	NS	ET15
Verilux	Sunshine in a Box	CFS 15VLX
Westinghouse	TWIST	37351
Westinghouse	NS	37488

NS = not supplied

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Evaluation Methods

The testing procedure in this supplement differs from the test method in the original report. The product samples were procured from retail locations throughout the U.S. during July and August 2002. Five samples of the CFL products were purchased and tested.

Testing occurred from August to November 2002 in the NLPIP fluorescent lamp testing laboratory in Troy, NY, which is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

Screwbase Compact Fluorescent Lamp Products

Volume 7 Number 1 Supplement 5
December 2002 (revised July 2005)

Principal Investigator:
Yutao Zhou

Program Director:
Conan O'Rourke

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Guide to Fluorescent Lamp-Ballast Compatibility, 1996
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NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports Supplements

Volume 7 Number 1 Supplement 6 June 2003

Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 21 self-ballasted screwbase compact fluorescent lamp (CFL) products from 11 manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

http://www.lrc.rpi.edu/programs/nlpip/screwbase.asp.

Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database on June 1, 2003.

Manufacturer	Model Name	Model Number
COSTCO	Technabright	EDA-14
COSTCO	Technabright	EDXR-38-19
COSTCO	Technabright	EDXR-40-16
FEIT	Ecobulb	BPESL15R30
FEIT	Conserv-Energy	BPCE15R30
GE Lighting	NS	FLE11/2/R30/SW/CD
GE Lighting	NS	FLE15HLX/8/SW/CD
GE Lighting	NS	FLE9/2/G25/SW/CD
Harmony Lighting	Lightwiz	H23027
Home Depot	Commercial Electric	368-875
Home Depot	Commercial Electric	772-720
Home Depot	Commercial Electric	772-739
Lights of America	the Mini Twister	2414
Lights of America	NS	2920
MaxLite	SpiraMax	MLS25EA3
MaxLite	SpiraMax	MLS26EA
OSRAM SYLVANIA	Sylvania	CF13EL/MINITWIST
Sunpark Electronics Corp.	Sunpark	SP 30SL
Sunrise Lighting	NS	SSE-24
Westinghouse	NS	07201
Westinghouse	NS	37354

NS = not supplied

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Evaluation Methods

The testing procedure in this supplement differs from the test method in the original report. The product samples were procured from retail locations throughout the U.S. from January to March 2003. Five samples of the CFL products were purchased and tested.

Testing occurred from March to June 2003 in the NLPIP fluorescent lamp testing laboratory in Troy, NY, which is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

Screwbase Compact Fluorescent Lamp Products

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Principal Investigator:
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Specifier Reports Supplements

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Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 18 self-ballasted screwbase compact fluorescent lamp (CFL) products from 10 manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

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Performance Evaluations

NLPIP is reporting test data for the CFLs listed below. Manufacturer-supplied data for these products, and NLPIP-measured data appear in the NLPIP searchable database. All the CFL products tested here were added to the online database on December 30, 2003.

Manufacturer	Model Name	Model Number
American Top Lighting	Toplite	TL3U25L
Feit Electric	Conserv-Energy	BPCE13T/8
Feit Electric	EcoBulb	BPESL18PAR38
GE Lighting	GE Lighting	FLE26HT3/2/SW
Greenlite Lighting	Greenlite	15W/ELX
Greenlite Lighting	Greenlite	20W/ELS-M
Greenlite Lighting	Greenlite	23W/ELS/DIM
Harmony Lighting	Lightwiz	H15OG25
Harmony Lighting	Lightwiz	H15OR30
Harmony Lighting	Lightwiz	H23327
Home Depot	Commercial Electric	772-747
Home Depot	Commercial Electric	774-265
Lights of America	Lights of America	2509
Lights of America	Lights of America	2920
Nedco International	Save A Watt	DEC3-U-25W
Osram Sylvania	Sylvania DULUX EL	CF15/EL/BR30/1/BL
Osram Sylvania	Sylvania DULUX EL	CF27EL/TWIST/1/BL
Sunpark Electronics	Sunpark	SP-11SL

NS = not supplied

Evaluation Methods

The testing procedure in this supplement differs from the test method in the original report. The product samples were procured from retail locations throughout the U.S. from August to October 2003. Five samples of the CFL products were purchased and tested.

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Specifier Reports Supplements

Volume 7 Number 1 Supplement 7 January 2004

Screwbase Compact Fluorescent Lamp Products

Introduction

This supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* contains information about 18 self-ballasted screwbase compact fluorescent lamp (CFL) products from 10 manufacturers that were tested subsequent to the group of CFLs reported in the original study. This supplement was created to provide additional information of new products on the NLPIP searchable online database, located at:

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GE Lighting	GE Lighting	FLE26HT3/2/SW
Greenlite Lighting	Greenlite	15W/ELX
Greenlite Lighting	Greenlite	20W/ELS-M
Greenlite Lighting	Greenlite	23W/ELS/DIM
Harmony Lighting	Lightwiz	H15OG25
Harmony Lighting	Lightwiz	H15OR30
Harmony Lighting	Lightwiz	H23327
Home Depot	Commercial Electric	772-747
Home Depot	Commercial Electric	774-265
Lights of America	Lights of America	2509
Lights of America	Lights of America	2920
Nedco International	Save A Watt	DEC3-U-25W
Osram Sylvania	Sylvania DULUX EL	CF15/EL/BR30/1/BL
Osram Sylvania	Sylvania DULUX EL	CF27EL/TWIST/1/BL
Sunpark Electronics	Sunpark	SP-11SL

NS = not supplied

Evaluation Methods

The testing procedure in this supplement differs from the test method in the original report. The product samples were procured from retail locations throughout the U.S. from August to October 2003. Five samples of the CFL products were purchased and tested.

Testing occurred from November to December 2003 in the NLPIP fluorescent lamp testing laboratory in Troy, NY, which is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

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Screwbase Compact Fluorescent Lamp Products

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Exit Signs, 1995, 1998; *Energy-Efficient Ceiling-Mounted Residential Luminaires,* 2000; *HID Accent Lighting Systems*, 2000; *Screwbase Compact Fluorescent Lamp Products*, 1999, 2000, 2001, 2002, 2003

Lighting Answers

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Specifier Reports Supplements

Volume 7 Number 1 Supplement 8 July 2005

Screwbase Compact Fluorescent Lamp Products

Results of Long-Term Performance Testing

Introduction

This publication is the eighth supplement to *Specifier Reports: Screwbase Compact Fluorescent Lamp Products*, 1999. This supplement differs from the previous supplements in that it describes the results of both a long-term performance test and a life test of screwbase compact fluorescent lamp (CFL) products. This study was conducted to better understand how long-term CFL performance is affected by operating at different positions and by operating within a luminaire. The tables presented here contain information gathered from manufacturers and the results of testing conducted by NLPIP.

Performance Evaluations

Manufacturer-Supplied Data: CFL Products Tested

Table 1 lists the five CFL products evaluated and their manufacturer-supplied performance data and contact information. That information was obtained from the packaging, from manufacturer-supplied data published previously in Table 2 of *Specifier Reports: Screwbase Compact Fluorescent Lamp Products,* and from the manufacturers' web sites and catalogs.

When products were selected, they all had manufacturer-rated lives of 10,000 hours (h), so testing at 100, 3500 and 7000 h corresponded to equivalent points in the rated lives of each product. However, between the testing at 3500 h and 7000 h, NLPIP discovered that the OSRAM SYLVANIA product (CFL20EL/830/MED/6) had been re-rated by the manufacturer to a life of 6000 h. While the testing at 3500 h and 7000 h corresponds to 35 and 70% of rated life for the other products, these intervals correspond to 58 and 116% of rated life for the re-rated OSRAM SYLVANIA product. Coupled with the fact that a maximum of six CFLs remained at 7000 h in any operating condition, NLPIP is not reporting the 7000 h performance data for this product.

Evaluation Methods

NLPIP purchased 400 CFLs (80 of each product type) via the Internet and throughout the U.S., from electrical distributors, big-box retail and do-it-yourself stores. These CFLs were selected because of their equally rated wattages and similarly rated performance characteristics. NLPIP conducted life testing under different operating conditions from August 2000 through July 2004. During this period, NLPIP also tested long-term performance in terms of light output and electrical and color characteristics at these three intervals:

- 100 h, from August to October 2000
- 3500 h, from March to May 2001
- 7000 h, from October to December 2001

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Previous long-term performance testing used different operating cycles. (Refer to the sidebar on p. 5 and to Table 6 in *Specifier Reports: Screwbase Compact Fluorescent Lamp Products*.) In the study reported here, NLPIP used the 3-hours-on, 20-minutes-off cycle specified by the Illuminating Engineering Society of North America (IESNA) in the *IESNA Guide to Lamp Seasoning* (1999). NLPIP monitored performance in these operating conditions:

- base-up (standard testing position)
- base-down
- horizontal
- enclosed (CFLs were operated base-up, in a luminaire)

Testing occurred in the NLPIP fluorescent lamp testing laboratory in Troy, N.Y., which is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP). The CFLs in each product type were divided randomly into four groups of 20, corresponding to the four operating conditions. As shown in Figure 1, the CFL products were mounted on four racks with 20 CFLs from each manufacturer, for a total of 100 on each rack. The CFLs without luminaires were mounted in their respective operating positions on three racks; the fourth rack contained 100 CFLs mounted base-up in enclosed globe luminaires (Lightcraft Ceiling Light, model # 7827 WH). The luminaire had a white base with a translucent white glass ball-shaped diffuser, eight inches (in.) in diameter and approximately 1/32 in. thick.

Electrical power to each rack was provided by an alternating current (ac) power supply set to provide a constant root-mean-square voltage of 120 volts ± 1%. The order of the CFL mounting heights on the racks was constant for all operating conditions, as follows:

- Row 1 (Top): GE Lighting
- Row 2: Lights of America
- Row 3: OSRAM SYLVANIA
- Row 4: Philips
- Row 5 (Bottom): Sunpark Electronics

Figure 1. Lamp testing racks for horizontal, base-up and base-down conditions (left), and for enclosed conditions (right).

The CFLs in the base-up, horizontal, and base-down operating conditions were spaced approximately 9 in. apart horizontally and approximately 11 in. apart vertically. The enclosed CFLs were spaced approximately 19 in. apart.

The ambient laboratory temperature during life testing was maintained at 25°C ±10°C (77°F ±18°F). The average ambient temperature measured at the center of each row of CFLs was between 24.5°C (76.1°F) and 25.2°C (77.4°F).

The CFLs were seasoned on a 3-hours-on, 20-minutes-off cycle for their first 100 h (IESNA 1999), in the same conditions they were maintained during the long-term testing. After seasoning, NLPIP used an integrating sphere and testing apparatus to measure four aspects of each CFL:

- light output
- input power
- power factor
- spectral power distribution (SPD)

From these measurements, several calculations were made:

- efficacy
- color characteristics—chromaticity, correlated color temperature (CCT), and color rendering index (CRI)
- lumen maintenance (for 3500 h and 7000 h)
- total harmonic distortion (THD) of input current

The testing temperature inside the sphere was 25°C ±1°C (77°F ±2°F). Each CFL was measured in the base-up position, following the procedures specified by the IESNA in LM-66-00 (2000). While CFLs were operated in life testing in three different orientations, all CFLs were temporarily placed base-up to take measurements, and then returned to their respective orientations for additional life testing.

The CFL products were tested at 100, 3500, and 7000 h. All CFLs reached the 7000 h mark in December 2001. Power to all surviving CFLs was switched off in July 2004, after more than 25,000 h, exceeding the manufacturer-rated life of any product tested. At the end of the test, 5 of the 400 CFLs were still operating (see Figure 2: a, b and e).

Results

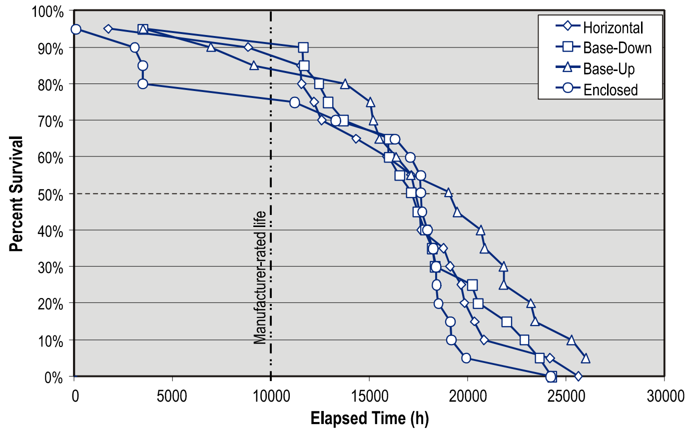
NLPIP-measured data of the CFLs tested are summarized in Tables 2 through 5. The elements in each of the tables are defined and discussed below, in the order they are reported in the tables.

Operating Life

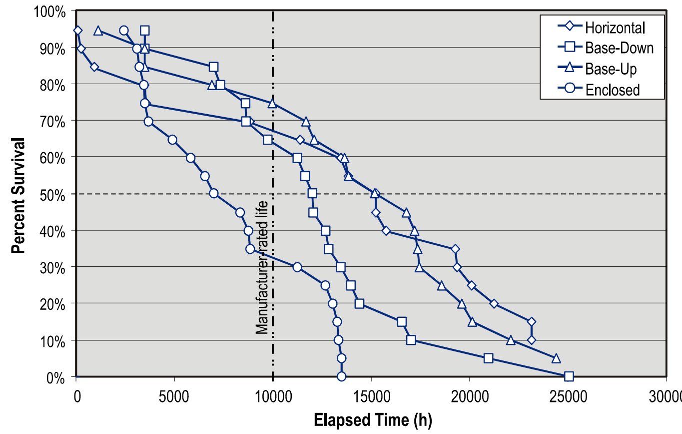
Table 2 lists the median operating life of each lamp type, in both hours of operation and as a percentage of its rated life, under each of the four operating conditions. All of the CFL products met or exceeded their rated lives when operated in the base-up position. With some exceptions, life was longest for the base-up condition. Figure 2 shows the number of elapsed hours and the percent survival under each of the four operating conditions, for each CFL type. Manufacturer's rated life is usually determined by the median operating life or when 50% of the CFLs have failed (indicated by the dashed line in each figure). The initial sample size for each operating condition was 20 CFLs.

Figure 2. CFL survival vs. elapsed time

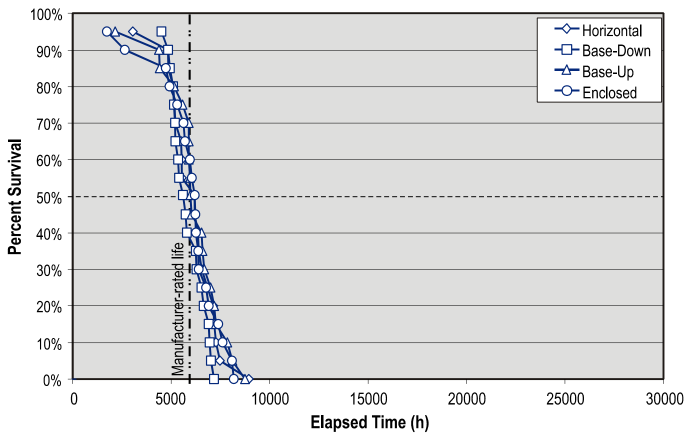
a. GE Lighting



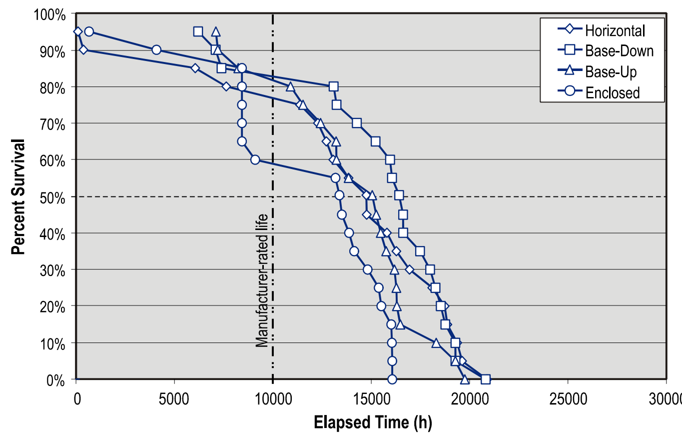
b. Lights of America



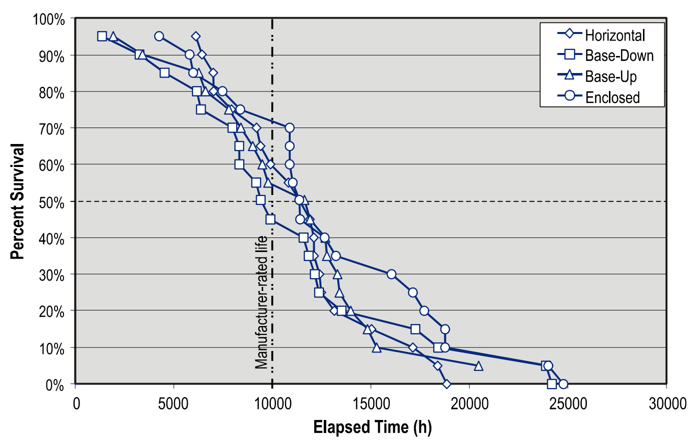
c. OSRAM SYLVANIA



d. Philips



e. Sunpark Electronics



Lamp Power and Efficacy

Table 3 shows the average power drawn by each group of surviving CFLs at each testing interval. Lamp power either remained relatively constant or increased slightly while light output reduced with time. The average lamp efficacy reduced over time from over 50 lumens per watt (lm/W) at 100 h for all CFLs to as low as approximately 35 lm/W at 7000 h, in some cases. The GE Lighting product showed 11 to 16% increases in lamp power over time while maintaining the highest light output, presumably because the potential reduction in light output was offset by the increase in lamp power. This CFL used between 17.5 and 17.7 W at 100 h and between 19.6 and 20.2 W at 7000 h.

Light Output and Lumen Maintenance

Table 4 lists the average light output at each testing interval of all surviving CFLs in each group. In all cases, the average light output was lower than the rated light output. There were reductions in light output at 3500 h and 7000 h relative to 100 h. Lumen maintenance ranged from 70.1 to 100.8% at 3500 h, and from 60.8 to 94.7% at 7000 h.

Electrical Characteristics

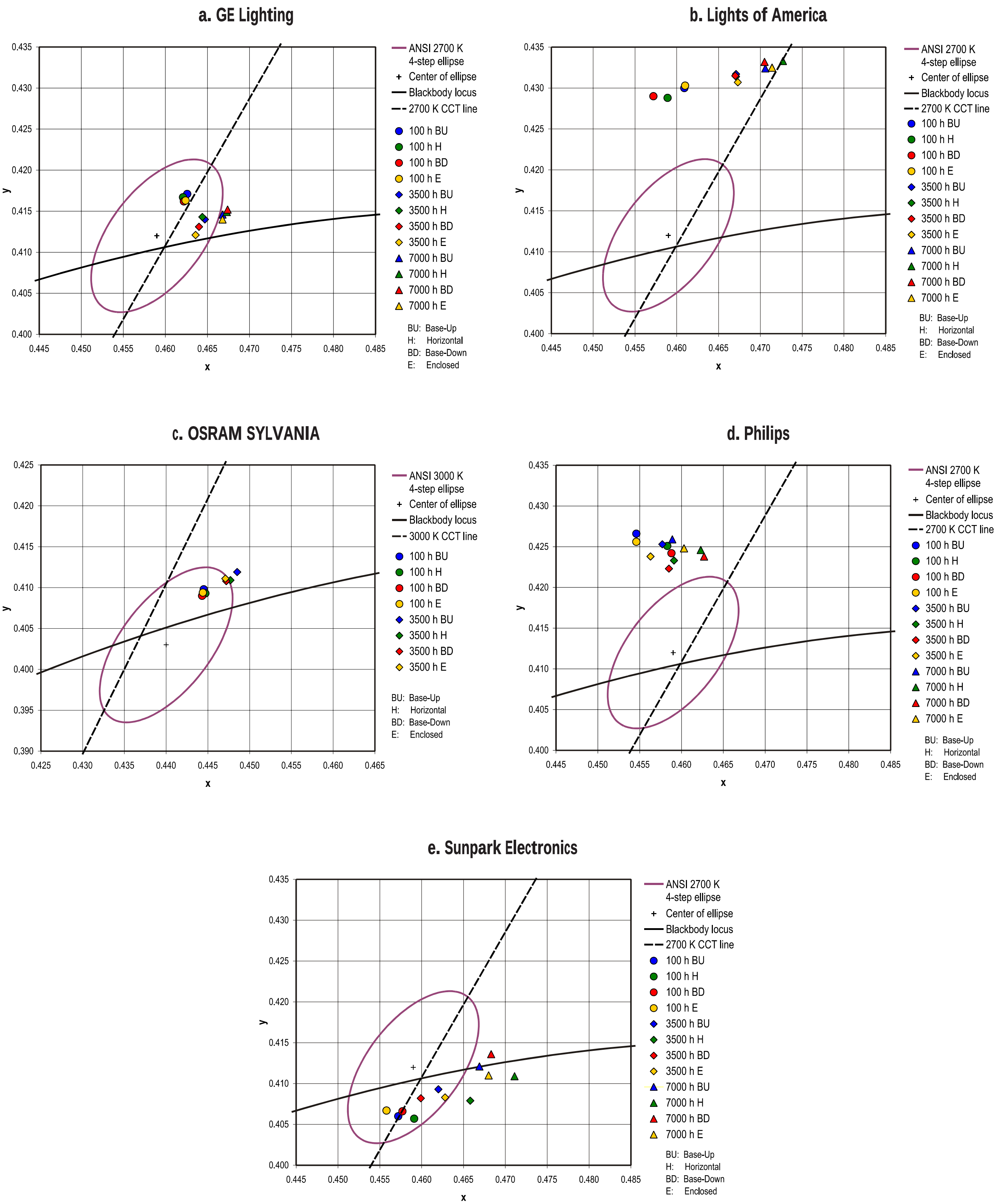
Power Factor and Total Harmonic Distortion. As shown in Table 5, NLPIP measured power factor and calculated THD of the input current for each lamp type and in each operating condition. Power factor ranged from about 0.44 to 0.60 for all lamp types and remained stable up to 7000 h. Average THD ranged from 117 to 212%. Average THD decreased for each lamp type as a function of operating time, but to different degrees.

Color Characteristics

Table 5 shows the average values of CCT, CRI, and chromaticity coordinates for all surviving CFLs, which were calculated based on the SPD measured for each CFL type. As stated, each CFL was measured in the base-up position. CFL types were rated at 2700 kelvins (K) except the OSRAM SYLVANIA CFL, which was rated at 3000 K. Average CRI ranged from 79 to 83 and did not change with operating life. Table 5 and Figure 3 show the average measured chromaticity coordinates for each CFL type in each operating condition. Figure 3 also shows a four-step MacAdam ellipse, as specified by the American National Standards Institute (ANSI) for linear and some compact fluorescent lamps in ANSI C78.376-2001 (2001). Ellipses of this type indicate acceptable manufacturing tolerances for the color of light emitted by fluorescent lamps with the same designated CCT. Ideally, the chromaticities of fluorescent lamps should lie within a particular four-step MacAdam ellipse.

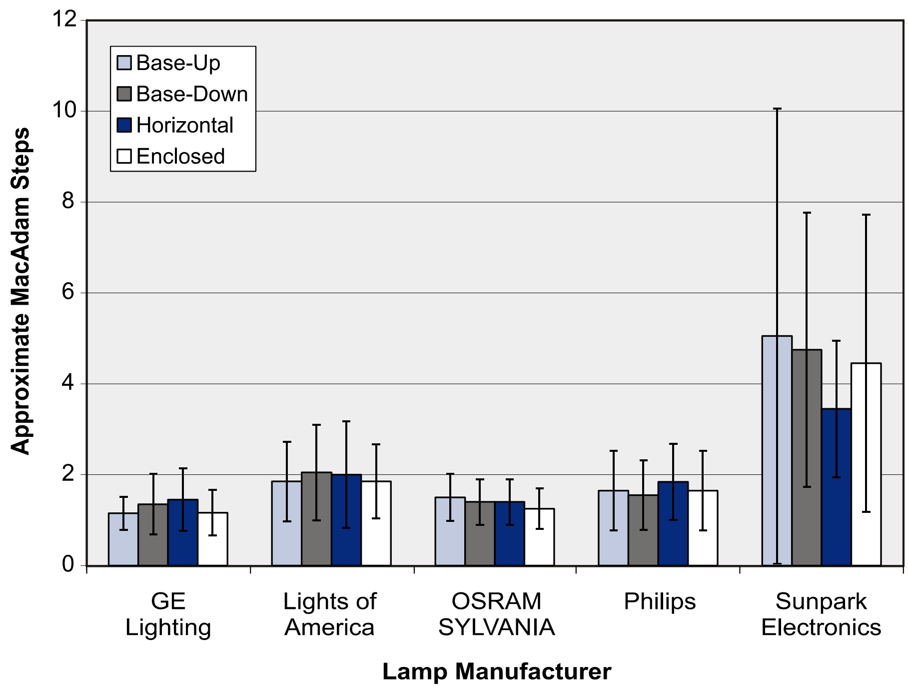
In Figure 3, the dashed line is the CCT line for each rated CCT. The various shapes and their respective colors represent the color variation at 100 h and the color shift from 100 h to 3500 h and then to 7000 h, in each operating condition. The MacAdam ellipse is centered near the intersection of the CCT line and the blackbody locus.

Figure 3. Average chromaticity coordinates for each operating interval and condition.



Color Variation. The bars in Figure 4 represent the average color variations measured in MacAdam steps for the CFLs from each manufacturer, measured in all four conditions, at 100 h (Rea et al. 2004). Color variation was calculated by determining how many of the individual CFLs were within different sized MacAdam ellipses, centered at the average x and y chromaticity coordinates for that group of CFLs. For example, one group of CFLs had eleven lamps within a one-step MacAdam ellipse, six lamps within a two-step MacAdam ellipse, two lamps within a three-step MacAdam ellipse and one lamp within a four-step MacAdam ellipse. The number of MacAdam steps was then averaged, yielding 1.65 MacAdam steps, with a standard deviation of 0.88. Assuming that a four-step MacAdam ellipse represents a useful tolerance criterion for lamp color (ANSI 2001), all but the Sunpark Electronics CFL would have "acceptable" (by this criterion) color variation at 100 h of operation. The error bars are standard deviations.

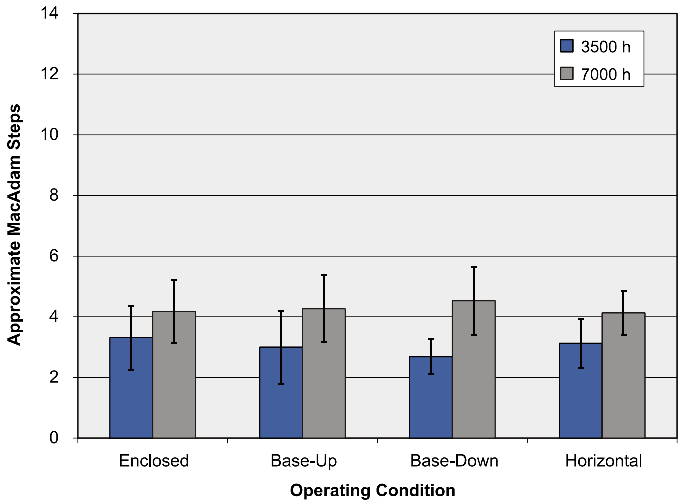
Figure 4. Average color variations (and standard deviations) at 100 h of operation for the CFLs in each operating condition.



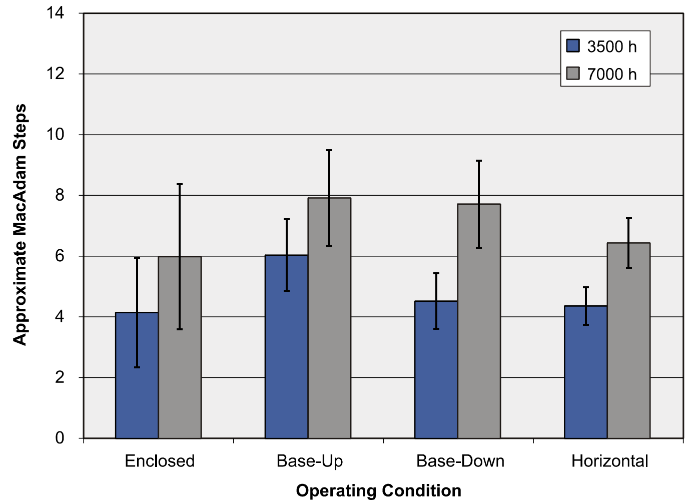
Color Shift. A shift in color over time is another potentially important criterion to consider. The color shift for each lamp was determined based on how many MacAdam steps it shifted from the average x and y chromaticity coordinates at 100 h for that specific CFL type. The same technique was used for determining the approximate MacAdam steps as described in *Color Variation* (above). Figure 5 shows the color shift from 100 to 3500 h for each lamp type operated in the four operating conditions, and from 100 to 7000 h for the CFLs with lives rated longer than 7000 h. The height of each bar in Figure 5 represents the distance in color space the average chromaticities changed from 100 to 3500 h and from 100 to 7000 h for each manufacturer. The error bars are standard deviations.

Figure 5. Average color shifts (and standard deviations) from 100 to 3500 h and from 100 to 7000 h of operation for the CFLs in each operating condition.

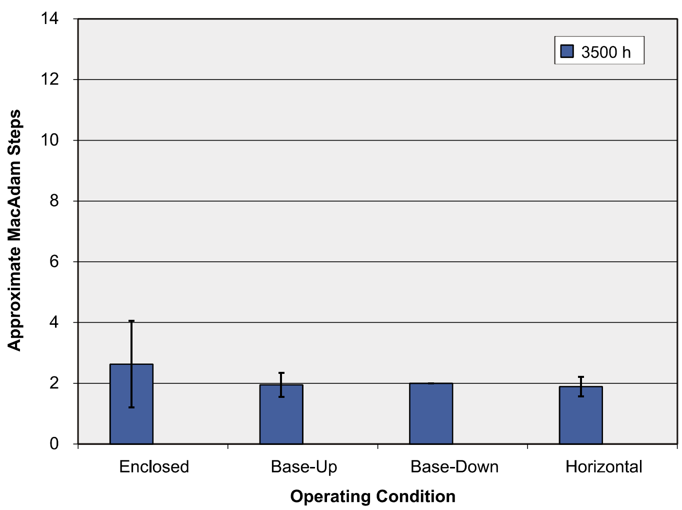
a. GE Lighting



b. Lights of America

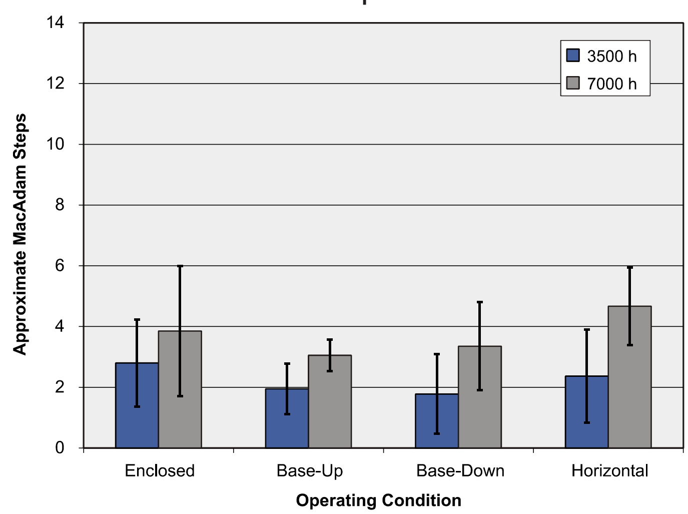


c. OSRAM SYLVANIA

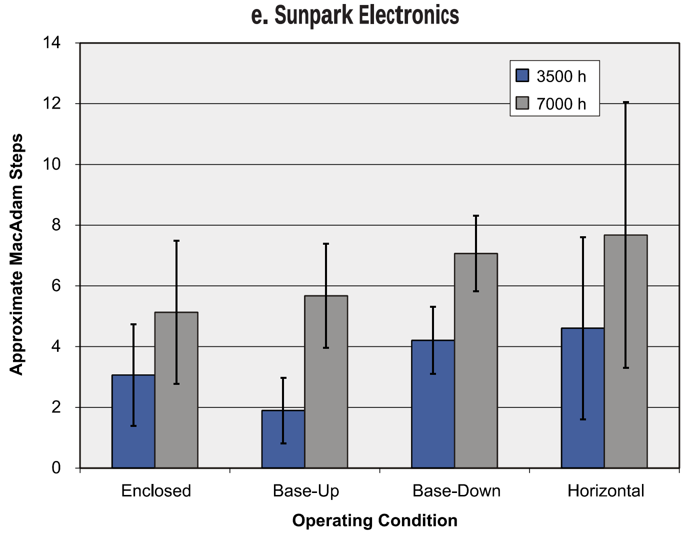


During testing, OSRAM SYLVANIA re-rated the life of its product from 10,000 h to 6000 h.

d. Philips



e. Sunpark Electronics



Data Table Terms and Definitions

Table 1 presents manufacturer product and contact information gathered by NLPIP. Tables 2 through 5, described in the *Performance Evaluations* section, contain data measured and calculated by NLPIP. Table 2 shows median operating life, Table 3 shows lamp power and efficacy, Table 4 shows light output and lumen maintenance, and Table 5 shows electrical and color characteristics. Although most of the performance characteristics listed in these tables are either discussed in the report or are self-explanatory, some items bear further explanation. Please refer to this section in *Specifier Reports: Screwbase Compact Fluorescent Lamp Products* for definitions of other terms that are used in this document but not explained here.

Chromaticity coordinates. The chromaticity coordinates of a light source give the relative proportions of three special color stimuli (*primaries*) that will match the color appearance of the light source. In the Commission Internationale de l´Eclairage (CIE) 1931 chromaticity system, the coordinates are named x, y, and z (representing the relative proportions of the three primaries named X, Y, and Z). The sum of the three coordinate values always equals 1, so knowing x and y predetermines the value of z (1 – x – y). The coordinates can be conveniently plotted on a two-dimensional diagram along the x and y axes. Generally, chromaticity coordinates that plot near the center of the CIE 1931 chromaticity diagram match colors that are unsaturated in appearance, while those that plot near the edges match saturated colors.

Efficacy. The ratio of the light output (lumens) of a lamp to its active power (watts), expressed as lm/W.

Lamps surviving. The number of CFLs still functioning at each testing interval.

Lumen maintenance. The light output produced by a light source at any given time during its operating life as a percentage of its light output at the beginning of life (measured at 100 h).

Median life. Median number of hours each CFL type operated.

Operating condition. CFLs were tested in the base-up, base-down, horizontal, or enclosed (in a base-up manner) operating conditions.

Percent of rated life. The ratio of median life (found in this test) to the manufacturer's rated life, expressed as a percentage.

Table 1. Manufacturer-Supplied Data: CFL Products Tested

Manufacturer	Catalog Number	Active Power (W)	Initial Light Output (lm)	CCT (K)	CRI	Rated Life (h)	Customer Service	Web Site
GE Lighting	FLE20TBX/L/SPX27	20	1200	2700	82	10,000	(800) 435-4448	www.gelighting.com
Lights of America	Model 2420	20	1200	2700	84	10,000	(800) 321-8100	www.lightsofamerica.com
OSRAM SYLVANIA [a]	CFL20EL/830/MED/6	20	1280	3000	82	6000	(800) 544-4828	www.sylvania.com
Philips	SLS 20 LLG	20	1200	2700	82	10,000	(800) 555-0050	www.lighting.philips.com
Sunpark Electronics	SP-20 SL MPF	20	1200	2700	NS	10,000	(310) 320-7880	www.sunpkco.com

NS = not supplied

[a] During testing, OSRAM SYLVANIA re-rated the life of its product from 10,000 h to 6000 h.

Table 2. NLPIP-Measured Data: Median Operating Life

	Operating Condition	Median Operating Life (h)	Percent of Rated Life (%)
GE Lighting	Base-up	19,251	193
	Horizontal	17,434	174
	Base-down	16,522	165
	Enclosed	17,637	176
Lights of America	Base-up	15,990	160
	Horizontal	15,375	154
	Base-down	12,037	120
	Enclosed	7677	77
OSRAM SYLVANIA [a]	Base-up	6007	100
	Horizontal	6195	103
	Base-down	5671	95
	Enclosed	6217	104
Philips	Base-up	15,153	152
	Horizontal	14,760	148
	Base-down	16,519	165
	Enclosed	13,447	134
Sunpark Electronics	Base-up	11,775	118
	Horizontal	11,640	116
	Base-down	9660	97
	Enclosed	11,392	114

[a] During testing, OSRAM SYLVANIA re-rated the life of its product from 10,000 h to 6000 h.

Table 3. NLPIP-Measured Data: Lamp Power and Efficacy

Manufacturer	Elapsed Time (h)	Operating Condition	Lamps Surviving	Light Output (lm)	Active Power (W)	Efficacy (lm/W)
GE Lighting	100	Base-up	20	1079 [39]	17.6 [0.60]	61.4 [0.08]
		Horizontal	20	1115 [45]	17.5 [0.71]	63.6 [0.10]
		Base-down	20	1117 [50]	17.7 [0.79]	63.3 [0.13]
		Enclosed	19	1063 [26]	17.5 [0.47]	60.7 [0.04]
	3500	Base-up	19	1075 [20]	19.6 [0.25]	55.0 [0.01]
		Horizontal	19	1049 [54]	19.0 [0.93]	55.3 [0.14]
		Base-down	19	1083 [25]	19.3 [0.23]	56.0 [0.01]
		Enclosed	16	1071 [13]	19.7 [0.20]	54.4 [0.01]
	7000	Base-up	18	1021 [30]	19.9 [0.28]	51.3 [0.02]
		Horizontal	19	1019 [33]	19.9 [0.48]	51.3 [0.04]
		Base-down	19	992 [37]	19.6 [0.58]	50.6 [0.06]
		Enclosed	16	1002 [10]	20.2 [0.21]	49.5 [0.01]

NLPIP measurements are reported as an average [standard deviation].

(continued on next page)

Table 3. NLPIP-Measured Data: Lamp Power and Efficacy (continued)

Manufacturer	Elapsed Time (h)	Operating Condition	Lamps Surviving	Light Output (lm)	Active Power (W)	Efficacy (lm/W)
Lights of America	100	Base-up	20	1056 [83]	19.4 [0.50]	54.3 [0.11]
		Horizontal	20	982 [113]	19.0 [1.30]	51.6 [0.40]
		Base-down	20	1079 [79]	19.1 [0.47]	56.4 [0.10]
		Enclosed	20	1081 [62]	19.8 [0.41]	54.7 [0.07]
	3500	Base-up	19	851 [71]	19.4 [0.53]	43.9 [0.10]
		Horizontal	16	822 [73]	19.2 [1.53]	42.7 [0.30]
		Base-down	19	846 [61]	19.9 [0.48]	42.6 [0.07]
		Enclosed	16	784 [72]	19.8 [0.54]	39.6 [0.10]
	7000	Base-up	15	709 [79]	19.2 [0.57]	36.9 [0.12]
		Horizontal	15	724 [73]	19.4 [1.59]	37.4 [0.31]
		Base-down	16	713 [67]	19.8 [0.56]	36.1 [0.10]
		Enclosed	11	657 [86]	19.7 [0.42]	33.3 [0.09]
OSRAM SYLVANIA [a]	100	Base-up	20	1235 [28]	20.0 [0.27]	61.6 [0.02]
		Horizontal	20	1219 [28]	20.0 [0.25]	61.0 [0.02]
		Base-down	20	1271 [31]	19.9 [0.27]	63.9 [0.02]
		Enclosed	20	1219 [37]	20.1 [0.25]	60.6 [0.02]
	3500	Base-up	19	1034 [68]	20.4 [0.31]	50.8 [0.05]
		Horizontal	19	1044 [65]	20.5 [0.36]	51.0 [0.06]
		Base-down	20	1027 [80]	20.6 [0.26]	49.8 [0.05]
		Enclosed	18	1014 [95]	20.3 [0.28]	49.9 [0.06]
Philips	100	Base-up	20	995 [104]	17.0 [1.34]	58.7 [0.49]
		Horizontal	19	1111 [65]	19.1 [0.96]	58.1 [0.17]
		Base-down	20	1205 [30]	19.3 [0.16]	62.5 [0.01]
		Enclosed	20	973 [102]	16.8 [1.22]	57.9 [0.44]
	3500	Base-up	20	943 [106]	17.3 [1.21]	54.4 [0.43]
		Horizontal	18	1087 [46]	19.5 [0.21]	55.6 [0.02]
		Base-down	20	1027 [81]	19.3 [0.82]	53.1 [0.18]
		Enclosed	19	909 [116]	18.0 [1.25]	50.4 [0.44]
	7000	Base-up	20	866 [105]	17.8 [1.28]	48.7 [0.43]
		Horizontal	17	978 [51]	19.7 [0.19]	49.7 [0.03]
		Base-down	19	910 [51]	19.7 [0.23]	46.1 [0.03]
		Enclosed	18	805 [94]	18.4 [1.16]	43.7 [0.32]
Sunpark Electronics	100	Base-up	20	932 [145]	17.3 [0.95]	53.7 [0.46]
		Horizontal	20	1009 [148]	17.4 [1.05]	58.1 [0.52]
		Base-down	20	975 [149]	17.4 [0.91]	55.9 [0.44]
		Enclosed	20	933 [89]	17.2 [1.22]	54.2 [0.40]
	3500	Base-up	18	729 [103]	17.3 [0.83]	42.1 [0.28]
		Horizontal	20	780 [88]	17.8 [0.72]	43.9 [0.20]
		Base-down	18	709 [75]	16.9 [0.81]	41.9 [0.21]
		Enclosed	20	654 [131]	17.3 [1.31]	37.7 [0.57]
	7000	Base-up	16	626 [105]	17.1 [0.77]	36.6 [0.28]
		Horizontal	17	645 [85]	17.7 [0.78]	36.3 [0.21]
		Base-down	15	654 [66]	17.5 [0.71]	37.3 [0.15]
		Enclosed	12	571 [95]	17.3 [0.87]	33.1 [0.28]

NLPIP measurements are reported as an average [standard deviation].

[a] During testing, OSRAM SYLVANIA re-rated the life of its product from 10,000 h to 6000 h.

Table 4. NLPIP-Measured Data: Light Output and Lumen Maintenance

Manufacturer	Operating Condition	100 h		3500 h			7000 h		
		Lamps Surviving	Light Output (lm)	Lamps Surviving	Light Output (lm)	Lumen Maint. (%)	Lamps Surviving	Light Output (lm)	Lumen Maint. (%)
GE Lighting	Base-up	20	1079 [39]	19	1075 [20]	100	18	1021 [30]	95
	Horizontal	20	1115 [45]	19	1049 [54]	94	19	1019 [33]	91
	Base-down	20	1117 [50]	19	1083 [25]	97	19	992 [37]	89
	Enclosed	19	1063 [26]	16	1071 [13]	101	16	1002 [10]	94
Lights of America	Base-up	20	1056 [83]	19	851 [71]	81	15	709 [79]	67
	Horizontal	20	982 [113]	16	822 [73]	84	15	724 [73]	74
	Base-down	20	1079 [79]	19	846 [61]	79	16	713 [67]	66
	Enclosed	20	1081 [62]	16	784 [72]	73	11	657 [86]	61
OSRAM SYLVANIA [a]	Base-up	20	1235 [28]	19	1034 [68]	84	NA	NA	NA
	Horizontal	20	1219 [28]	19	1044 [65]	86	NA	NA	NA
	Base-down	20	1271 [31]	20	1027 [80]	81	NA	NA	NA
	Enclosed	20	1219 [37]	18	1014 [95]	83	NA	NA	NA
Philips	Base-up	20	995 [104]	20	943 [106]	95	20	866 [105]	87
	Horizontal	19	1111 [65]	18	1087 [46]	98	17	978 [51]	88
	Base-down	20	1205 [30]	20	1027 [81]	85	19	910 [51]	76
	Enclosed	20	973 [102]	19	909 [116]	93	18	805 [94]	83
Sunpark Electronics	Base-up	20	932 [145]	18	729 [103]	78	16	626 [105]	67
	Horizontal	20	1009 [148]	20	780 [88]	77	17	645 [85]	64
	Base-down	20	975 [149]	18	709 [75]	73	15	654 [66]	67
	Enclosed	20	933 [98]	20	654 [131]	70	12	571 [95]	61

NLPIP measurements are reported as an average [standard deviation].

[a] During testing, OSRAM SYLVANIA re-rated the life of its product from 10,000 h to 6000 h.

NA = not applicable

Table 5. NLPIP-Measured Data: Electrical and Color Characteristics

Manufacturer	Elapsed Time (h)	Operating Condition	Lamps Surviving	Power Factor	THD (%)	CCT (K)	CRI	x Chromaticity Coordinate	y Chromaticity Coordinate
GE Lighting	100	Base-up	20	0.48 [0.01]	198 [2.4]	2719 [14]	82 [0.27]	0.4626 [0.0008]	0.4171 [0.0011]
		Horizontal	20	0.48 [<0.01]	173 [2.1]	2723 [20]	82 [0.34]	0.4621 [0.0009]	0.4167 [0.0014]
		Base-down	20	0.48 [<0.01]	173 [1.5]	2719 [19]	82 [0.33]	0.4622 [0.0009]	0.4162 [0.0011]
		Enclosed	19	0.48 [<0.01]	198 [1.7]	2717 [14]	82 [0.22]	0.4624 [0.0008]	0.4163 [0.0010]
	3500	Base-up	19	0.49 [0.01]	166 [2.5]	2659 [16]	82 [0.11]	0.4647 [0.0010]	0.4140 [0.0007]
		Horizontal	19	0.49 [<0.01]	168 [3.5]	2666 [26]	82 [0.38]	0.4644 [0.0012]	0.4143 [0.0015]
		Base-down	19	0.49 [<0.01]	167 [2.3]	2662 [13]	83 [0.10]	0.4640 [0.0006]	0.4131 [0.0011]
		Enclosed	16	0.49 [<0.01]	165 [1.3]	2660 [15]	83 [0.14]	0.4636 [0.0011]	0.4121 [0.0008]
	7000	Base-up	18	0.49 [<0.01]	164 [2.3]	2637 [16]	82 [0.13]	0.4668 [0.0010]	0.4146 [0.0008]
		Horizontal	19	0.49 [<0.01]	165 [2.4]	2633 [19]	82 [0.18]	0.4673 [0.0012]	0.4149 [0.0010]
		Base-down	19	0.49 [<0.01]	166 [2.6]	2633 [13]	82 [0.17]	0.4674 [0.0006]	0.4152 [0.0011]
		Enclosed	16	0.50 [<0.01]	163 [1.2]	2633 [13]	82 [0.10]	0.4668 [0.0010]	0.4140 [0.0006]

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Table 5. NLPIP-Measured Data: Electrical and Color Characteristics (continued)

Manufacturer	Elapsed Time (h)	Operating Condition	Lamps Surviving	Power Factor	THD (%)	CCT (K)	CRI	x Chromaticity Coordinate	y Chromaticity Coordinate
Lights of America	100	Base-up	20	0.55 [<0.01]	171 [1.3]	2835 [30]	81 [0.59]	0.4609 [0.0032]	0.4300 [0.0027]
		Horizontal	20	0.55 [0.01]	172 [3.4]	2853 [36]	80 [0.73]	0.4589 [0.0034]	0.4288 [0.0022]
		Base-down	20	0.55 [<0.01]	139 [1.5]	2876 [37]	80 [0.74]	0.4572 [0.0035]	0.4290 [0.0022]
		Enclosed	20	0.56 [<0.01]	170 [0.9]	2835 [27]	81 [0.55]	0.4610 [0.0030]	0.4303 [0.0024]
	3500	Base-up	19	0.56 [0.01]	137 [2.7]	2760 [27]	81 [0.66]	0.4671 [0.0026]	0.4317 [0.0024]
		Horizontal	16	0.56 [0.01]	138 [4.8]	2757 [28]	81 [0.61]	0.4671 [0.0028]	0.4314 [0.0022]
		Base-down	19	0.56 [<0.01]	136 [1.6]	2759 [27]	81 [0.55]	0.4670 [0.0027]	0.4315 [0.0024]
		Enclosed	16	0.56 [<0.01]	136 [1.3]	2751 [32]	81 [0.73]	0.4673 [0.0035]	0.4307 [0.0023]
	7000	Base-up	15	0.56 [<0.01]	137 [2.0]	2719 [34]	81 [0.86]	0.4706 [0.0032]	0.4324 [0.0023]
		Horizontal	15	0.56 [0.01]	137 [5.1]	2697 [30]	81 [0.64]	0.4727 [0.0029]	0.4333 [0.0019]
		Base-down	16	0.56 [0.01]	135 [1.9]	2726 [31]	81 [0.65]	0.4705 [0.0028]	0.4332 [0.0021]
		Enclosed	11	0.56 [<0.01]	135 [1.0]	2709 [31]	81 [0.80]	0.4714 [0.0034]	0.4325 [0.0022]
OSRAM SYLVANIA [a]	100	Base-up	20	0.52 [<0.01]	181 [1.2]	2916 [19]	81 [0.30]	0.4445 [0.0020]	0.4098 [0.0014]
		Horizontal	20	0.52 [<0.01]	182 [1.2]	2910 [18]	82 [0.27]	0.4447 [0.0019]	0.4093 [0.0015]
		Base-down	20	0.52 [<0.01]	152 [1.7]	2913 [19]	82 [0.30]	0.4443 [0.0021]	0.4090 [0.0018]
		Enclosed	20	0.52 [<0.01]	181 [1.4]	2916 [16]	81 [0.37]	0.4444 [0.0017]	0.4094 [0.0014]
	3500	Base-up	19	0.52 [<0.01]	150 [1.7]	2876 [24]	81 [0.21]	0.4485 [0.0021]	0.4119 [0.0014]
		Horizontal	19	0.52 [<0.01]	150 [1.6]	2882 [23]	82 [0.26]	0.4477 [0.0020]	0.4109 [0.0013]
		Base-down	20	0.52 [<0.01]	149 [1.7]	2888 [23]	81 [0.28]	0.4472 [0.0020]	0.4108 [0.0014]
		Enclosed	18	0.52 [<0.01]	149 [1.3]	2892 [16]	81 [0.36]	0.4471 [0.0014]	0.4111 [0.0010]
Philips	100	Base-up	20	0.57 [0.01]	163 [3.1]	2894 [32]	79 [0.76]	0.4546 [0.0020]	0.4266 [0.0012]
		Horizontal	19	0.58 [0.01]	158 [1.8]	2834 [31]	81 [0.55]	0.4583 [0.0019]	0.4251 [0.0011]
		Base-down	20	0.58 [<0.01]	122 [1.8]	2822 [24]	81 [0.19]	0.4588 [0.0014]	0.4242 [0.0014]
		Enclosed	20	0.57 [0.01]	164 [3.1]	2887 [27]	79 [0.71]	0.4546 [0.0009]	0.4256 [0.0008]
	3500	Base-up	20	0.58 [0.01]	126 [3.4]	2871 [29]	80 [0.66]	0.4577 [0.0016]	0.4253 [0.0013]
		Horizontal	18	0.59 [<0.01]	119 [1.0]	2808 [25]	81 [0.18]	0.4591 [0.0013]	0.4233 [0.0013]
		Base-down	20	0.58 [0.01]	120 [3.0]	2809 [36]	81 [0.56]	0.4585 [0.0019]	0.4223 [0.0016]
		Enclosed	19	0.58 [0.01]	122 [3.8]	2853 [35]	80 [0.74]	0.4563 [0.0021]	0.4238 [0.0012]
	7000	Base-up	20	0.58 [0.01]	123 [3.7]	2830 [36]	80 [0.71]	0.4589 [0.0020]	0.4259 [0.0016]
		Horizontal	17	0.59 [<0.01]	119 [1.1]	2773 [25]	81 [0.16]	0.4623 [0.0012]	0.4246 [0.0014]
		Base-down	19	0.59 [<0.01]	119 [1.9]	2761 [17]	81 [0.15]	0.4627 [0.0008]	0.4238 [0.0013]
		Enclosed	18	0.60 [0.02]	117 [7.1]	2802 [32]	81 [0.65]	0.4603 [0.0019]	0.4248 [0.0010]
Sunpark Electronics	100	Base-up	20	0.44 [0.01]	212 [5.2]	2710 [143]	82 [1.84]	0.4572 [0.0008]	0.4060 [0.0053]
		Horizontal	20	0.45 [0.01]	187 [4.7]	2680 [73]	83 [0.85]	0.4591 [0.0045]	0.4057 [0.0029]
		Base-down	20	0.45 [0.01]	187 [4.7]	2705 [93]	82 [1.13]	0.4577 [0.0043]	0.4066 [0.0080]
		Enclosed	20	0.45 [0.01]	187 [5.7]	2735 [109]	82 [1.64]	0.4558 [0.0079]	0.4067 [0.0044]
	3500	Base-up	18	0.45 [0.01]	186 [5.0]	2663 [135]	81 [1.73]	0.4620 [0.0073]	0.4093 [0.0051]
		Horizontal	20	0.46 [0.01]	183 [3.4]	2599 [67]	83 [0.76]	0.4658 [0.0041]	0.4079 [0.0024]
		Base-down	18	0.45 [0.01]	187 [4.5]	2687 [117]	81 [1.55]	0.4599 [0.0050]	0.4082 [0.0076]
		Enclosed	20	0.46 [0.01]	184 [5.7]	2644 [106]	82 [1.70]	0.4628 [0.0080]	0.4083 [0.0051]
	7000	Base-up	16	0.46 [0.01]	185 [6.9]	2618 [134]	81 [1.81]	0.4669 [0.0077]	0.4121 [0.0049]
		Horizontal	17	0.46 [0.01]	183 [3.4]	2554 [69]	82 [0.81]	0.4711 [0.0043]	0.4109 [0.0024]
		Base-down	15	0.46 [0.01]	184 [3.8]	2612 [138]	82 [1.84]	0.4683 [0.0064]	0.4136 [0.0078]
		Enclosed	12	0.46 [0.01]	184 [5.1]	2596 [132]	81 [1.92]	0.4680 [0.0082]	0.4110 [0.0042]

NLPIP measurements are reported as an average [standard deviation].

[a] During testing, OSRAM SYLVANIA re-rated the life of its product from 10,000 h to 6000 h.

Further Information

American National Standards Institute. 2001. *American National Standards for Electric Lamps– Specifications for the Chromaticity of Fluorescent Lamps,* ANSI C78.376-2001. Rosslyn, VA: ANSI.

Illuminating Engineering Society of North America. 1991. *Life Testing Methods of Single-Ended Compact Fluorescent Lamps*, LM-65-91. New York, NY: IESNA.

———. 1991. *Electrical and Photometric Measurements of Compact Fluorescent Lamps*, LM-66-91. New York, NY: IESNA.

———. 1999. *IESNA Guide to Lamp Seasoning*, LM-54-99. New York, NY: IESNA.

———. 2000. *Testing Methods for Electrical and Photometric Characteristics of Compact Fluorescent Lamps*, LM-66-00. New York, NY: IESNA.

———. 2001. *Testing Methods for Life Testing of Compact Fluorescent Lamps*, LM-65-01. New York, NY: IESNA.

Rea M., L. Deng and R. Wolsey. 2004. *Lighting Answers: Light Sources and Color*. Troy, NY: Rensselaer Polytechnic Institute.

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Specifier Reports *Supplements*

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National Lighting Product Information Program Publications

Guides

Guide to Fluorescent Lamp-Ballast Compatibility, 1996
Guide to Specifying High-Frequency Electronic Ballasts, 1996
Guide to Selecting Frequently Switched T8 Fluorescent Lamp-Ballast Systems, 1998

Specifier Reports

Power Reducers, 1992; *Specular Reflectors*, 1992; *Cathode-Disconnect Ballasts*, 1993; *Exit Signs*, 1994; *Reflector Lamps*, 1994; *CFL Downlights*, 1995; *HID Accent Lighting Systems*, 1996; *Occupancy Sensors*, 1998; *Photosensors*, 1998; *Lighting Circuit Power Reducers*, 1998; *Screwbase Compact Fluorescent Lamp Products*, 1999; *Energy-Efficient Ceiling-Mounted Residential Luminaires*, 1999; *Dimming Electronic Ballasts*, 1999; *Electronic Ballasts*, 2000; *Parking Lot and Area Luminaires*, 2004

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Exit Signs, 1995, 1998; *Energy-Efficient Ceiling-Mounted Residential Luminaires,* 2000*; HID Accent Lighting Systems*, 2000; *Screwbase Compact Fluorescent Lamp Products*, 1999, 2000

Lighting Answers

T8 Fluorescent Lamps, 1993; *Multilayer Polarizer Panels*, 1993; *Task Lighting for Offices*, 1994; *Dimming Systems for High-Intensity Discharge Lamps*, 1994; *Electromagnetic Interference Involving Fluorescent Lighting Systems*, 1995; *Power Quality*, 1995; *Thermal Effects in 2' x 4' Fluorescent Lighting Systems*, 1995; *T10 and T9 Fluorescent Lamps*, 1995; *T5FT Lamps and Ballasts*, 1996; *Controlling Lighting with Building Automation Systems*, 1997; *Alternatives to Halogen Torchieres*, 2000; *T5 Fluorescent Systems*, 2002; *MR16 Lamps*, 2002; *Light Pollution*, 2003; *LED Lighting Systems*, 2003; *Adaptable Ballasts*, 2003; *Light Sources and Color*, 2004; *Full-Spectrum Light Sources*, 2005; *Mid-wattage Metal Halide Lamps*, 2005

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