NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

# Specifier Reports

## Screwbase Compact Fluorescent Lamp Products

Energy-efficient alternatives to incandescent lamps

Volume 7 Number 1

New! Supplements begin following page 44.

June 1999

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## 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**

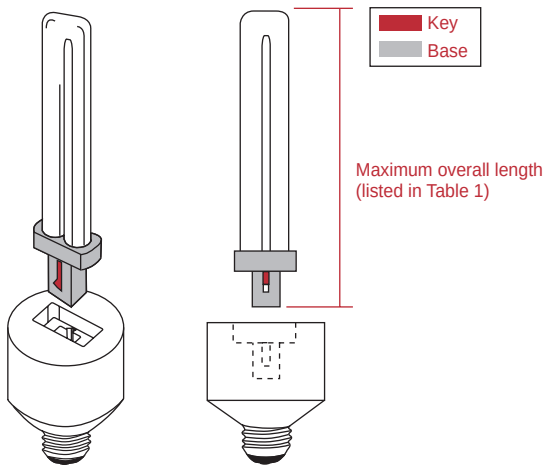



**Figure 4. Modular CFL Products**

**(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 hard-wired 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 elec-

trodeless 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)**

**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.

# 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.

**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.

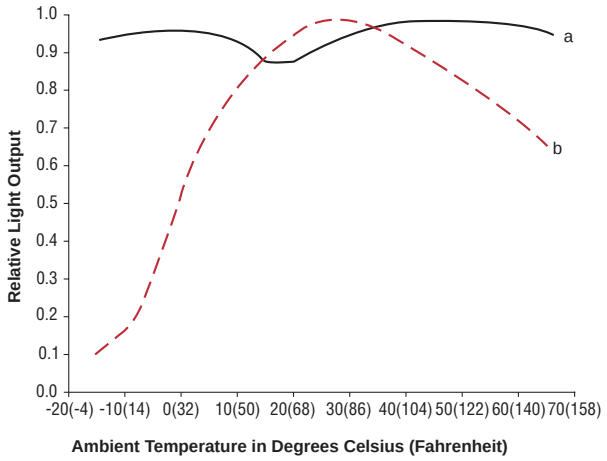
### Thermal Factor

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

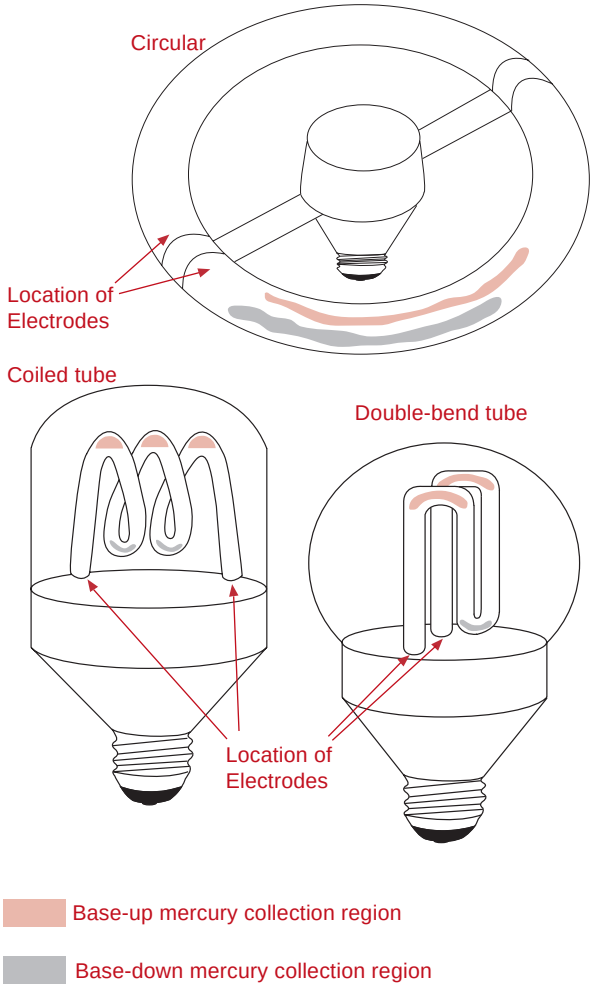
The operating position of a CFL product (such as base up, base down, or horizontal) can affect its light output by varying the mercury vapor pressure inside the CFL. Position factor is defined as the light output produced by the lamp in a certain orientation divided by the light output produced by the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

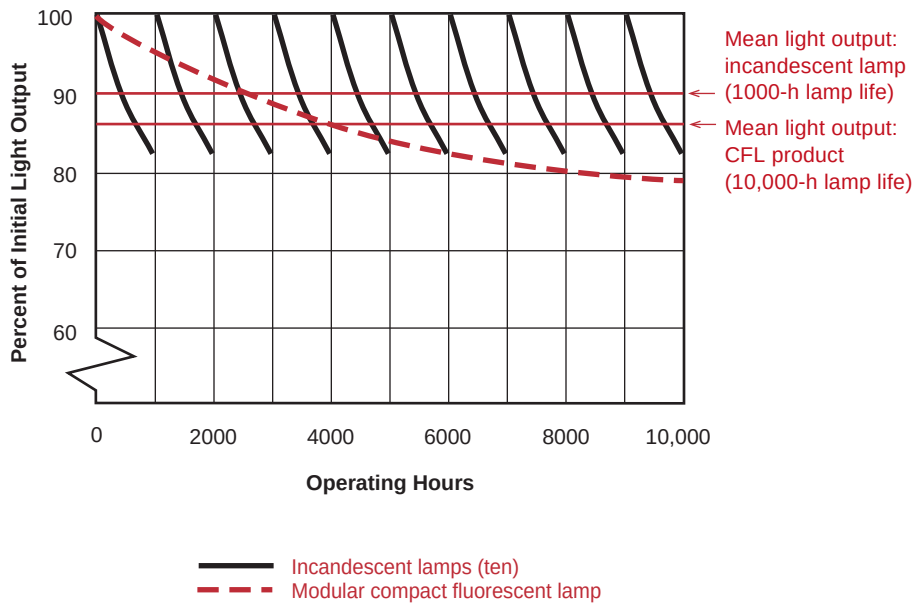



**Table Lamp Application (example)**

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.

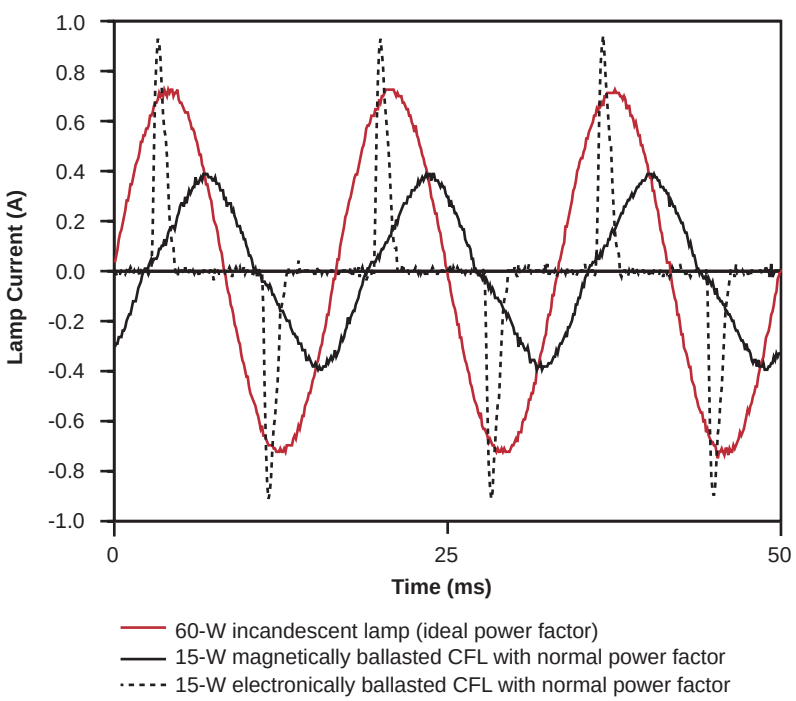
## Power Quality

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

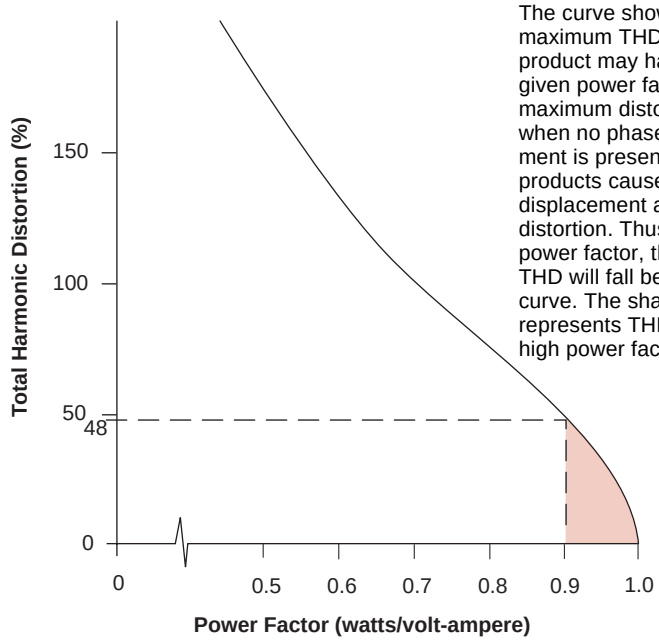
**Root-Mean-Square (rms)**

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.

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.

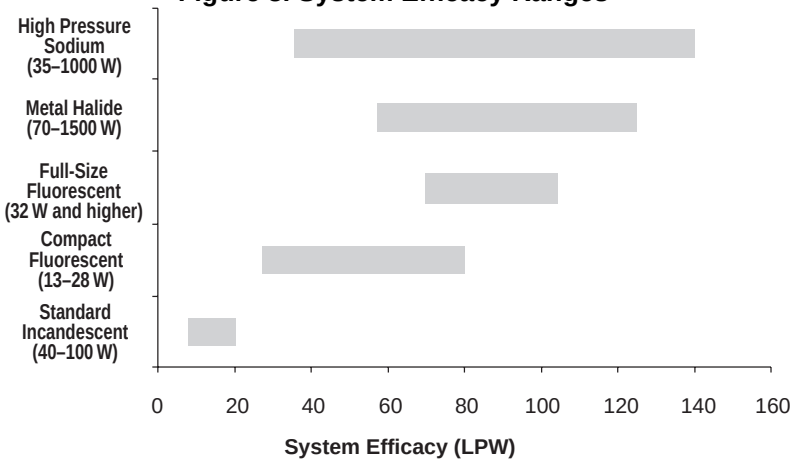
### Light Distribution

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

**Figure 8. System Efficacy Ranges**



(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 lumi-

naires. 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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## 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

| | | | | | 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 | 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

| | | | | | 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) |
| 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 |

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, 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

| | | | | | 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) |
| 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 |

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 | 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

| | | | | | 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) |
| 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-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 | 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) | Electrical Characteristics: 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 |

| Starting Characteristics | | | | Median Lamp Life in Hours — 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**

Volume 7, Number 1
June 1999

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Specifier Reports Supplements

Volume 7 Number 1 Supplement 1 October 1999

# 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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**Principal Investigator:**
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NLPIP
NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports Supplements

Volume 7 Number 1 Supplement 2 June 2000

# Screwbase Compact Fluorescent Lamp Products

## Introduction

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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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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*.

# Screwbase Compact Fluorescent Lamp Products

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*Exit Signs*, 1995, 1998

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NLPIP
NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

Specifier Reports Supplements

Volume 7 Number 1 Supplement 3 May 2001

# 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

Volume 7 Number 1 Supplement 3
May 2001 (revised July 2005)

**Principal Investigator:**
Yutao Zhou

**Program Director:**
Conan O'Rourke

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**Lighting Answers**

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Specifier Reports Supplements

Volume 7 Number 1 Supplement 4 December 2001

# 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

Volume 7 Number 1 Supplement 4
December 2001 (revised July 2005)

**Principal Investigator:**
Yutao Zhou

**Program Director:**
Conan O'Rourke

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NLPIP
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Specifier Reports Supplements

Volume 7 Number 1 Supplement 5 December 2002

# 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 |

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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:**
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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 |

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United States General Services Administration

## 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:**
Yutao Zhou

**Program Director:**
Conan O'Rourke

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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:

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 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.

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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Volume 7 Number 1 Supplement 7 January 2004

# Screwbase Compact Fluorescent Lamp Products

## Introduction

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## Performance Evaluations

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| 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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# Screwbase Compact Fluorescent Lamp Products

Volume 7 Number 1 Supplement 7
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**Principal Investigator:**
Yutao Zhou

**Program Director:**
Conan O'Rourke

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*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

**Specifier Reports Supplements**

*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**

*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

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NLPIP
NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM

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# 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).

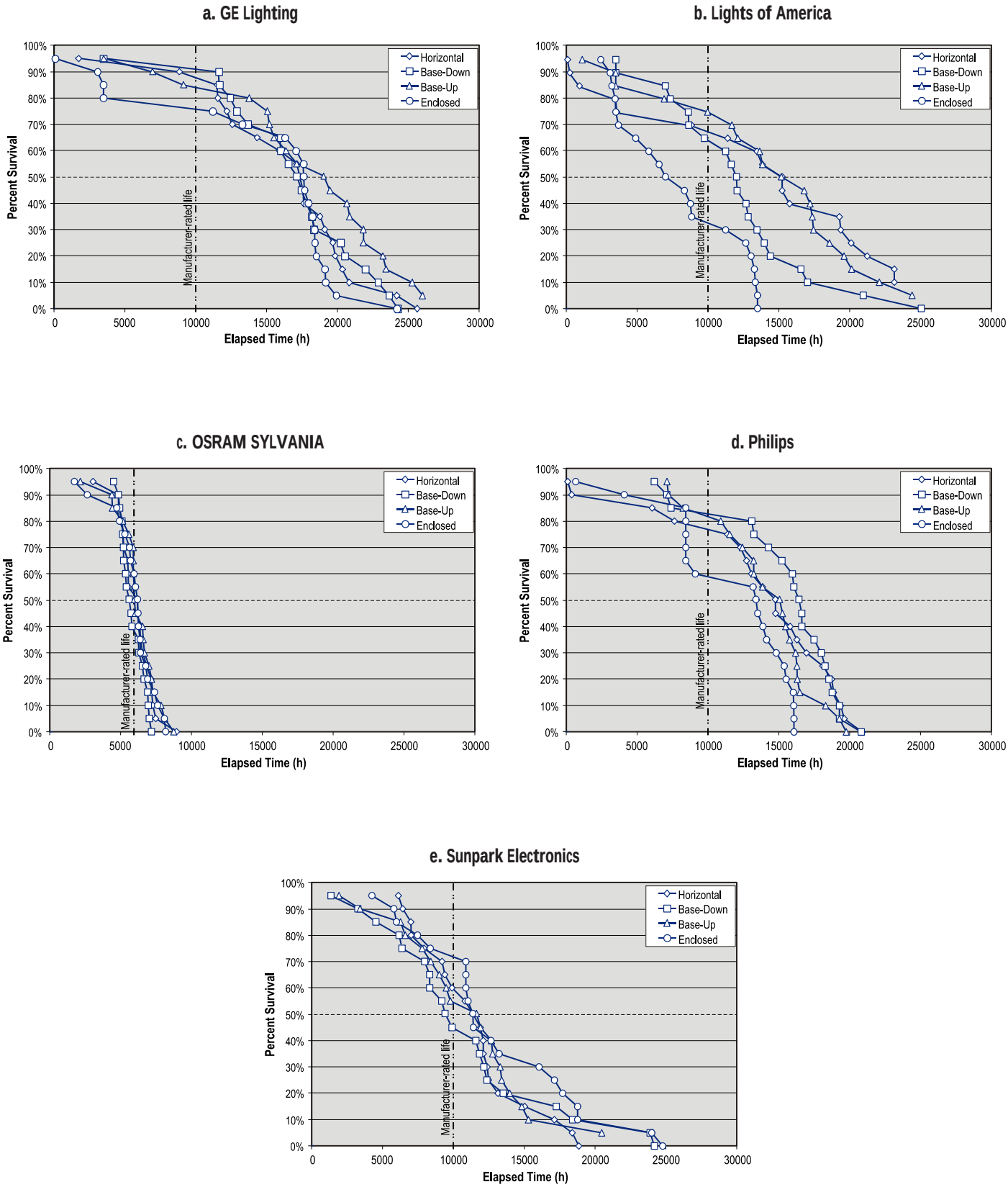
## Results

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**



### *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*

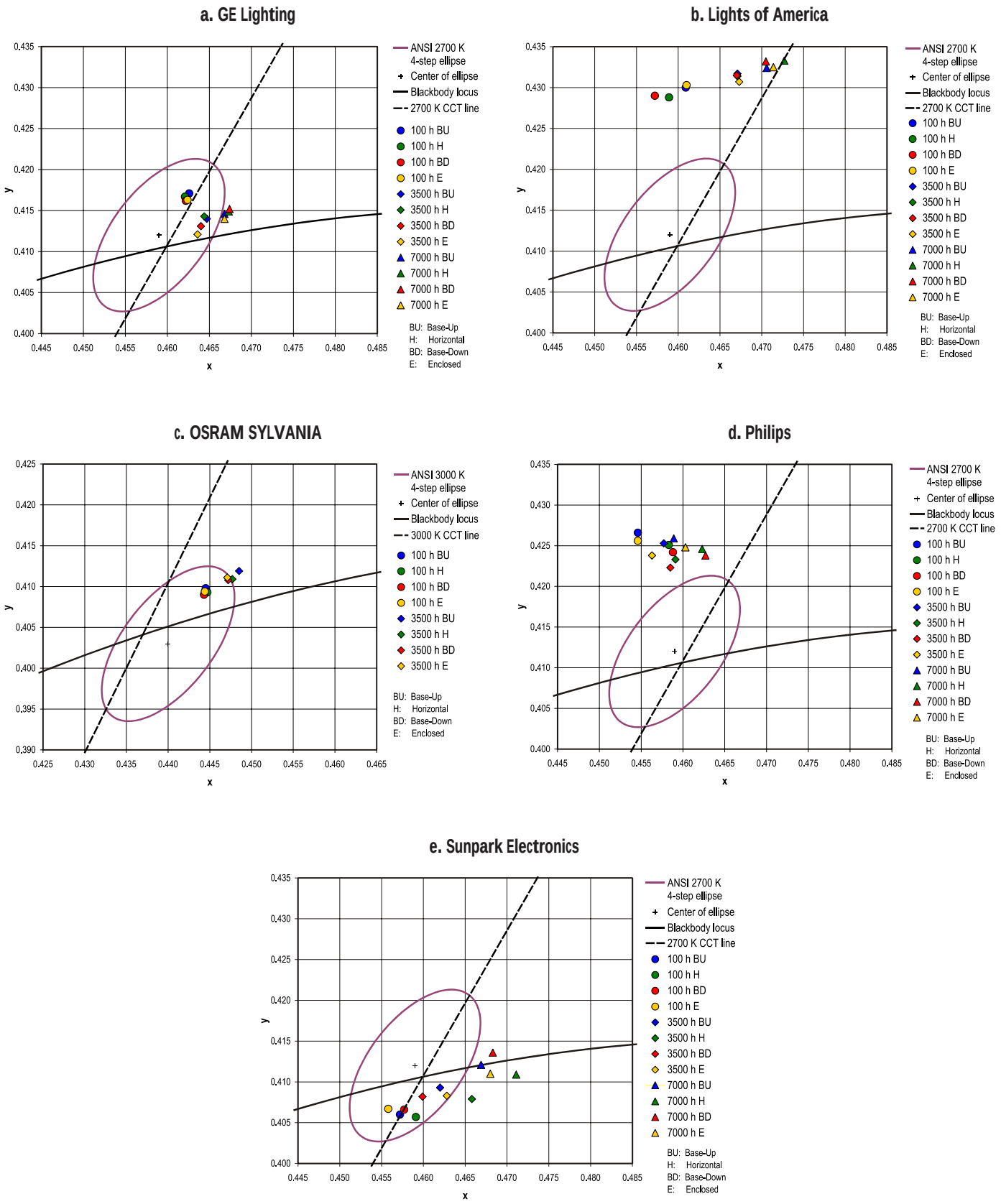
**Power Factor and Total Harmonic Distortion.** As shown in Table 5, NLPIP measured power factor and calculated THD of the input current for each lamp type and in each operating condition. Power factor ranged from about 0.44 to 0.60 for all lamp types and remained stable up to 7000 h. Average THD ranged 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.

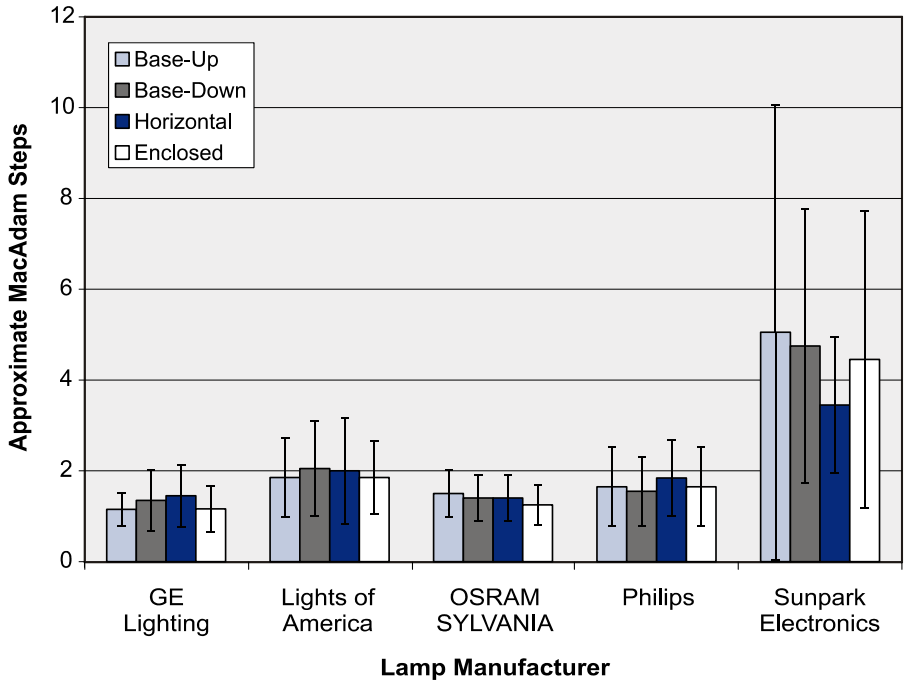
In Figure 3, the dashed line is the CCT line for each rated CCT. The various shapes and their respective colors represent the color variation at 100 h and the color shift from 100 h to 3500 h and then to 7000 h, in each operating condition. The MacAdam ellipse is centered near the intersection of the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

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



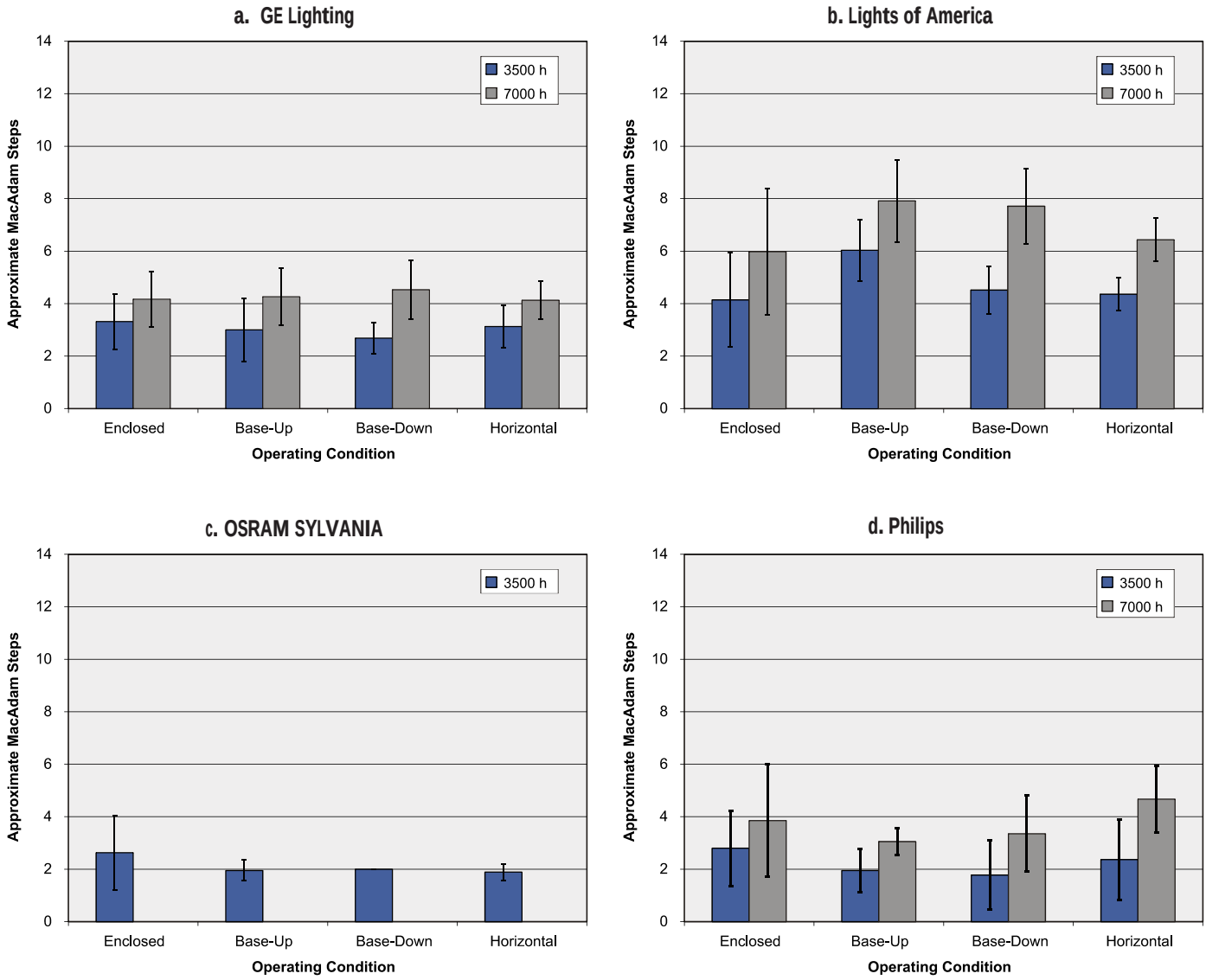
**Color Variation.** The bars in Figure 4 represent the average color variations measured in MacAdam steps for the CFLs from each manufacturer, measured in all four conditions, at 100 h (Rea et al. 2004). Color variation was calculated by determining how many of the individual CFLs were within different 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.**

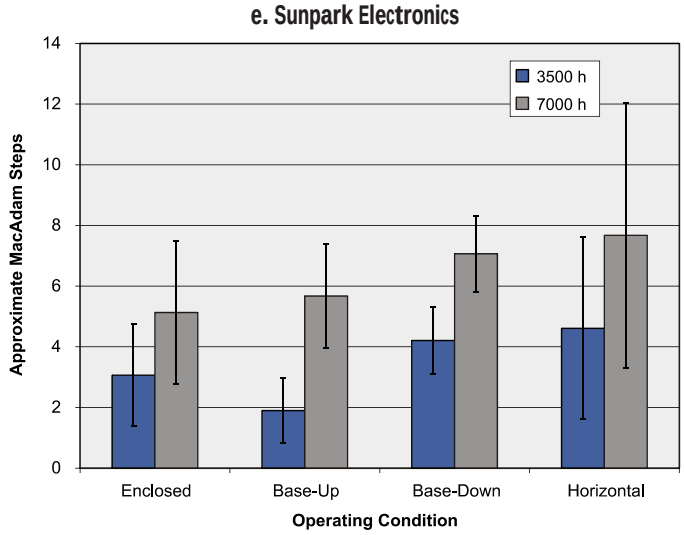



**Color Shift.** A shift in color over time is another potentially important criterion to consider. The color shift for each lamp was determined based on how many MacAdam steps it shifted from the average x and y chromaticity coordinates at 100 h for that specific CFL type. The same technique was used 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.**




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



## 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**

| | | 100 h | | 3500 h | | | 7000 h | | |
|---|---|---|---|---|---|---|---|---|---|
| Manufacturer | Operating Condition | 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] |

(continued on next page)

**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

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