NLPIP Lighting Answers
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Adaptable Ballasts

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Abstract

Lighting Answers: Adaptable Ballasts discusses a class of electronic **ballasts** that are compatible with multiple lamp types, different quantities of lamps, and/or different input voltages. The report explains the variety of adaptable ballasts available, examines their strengths and weaknesses, describes how a sample performed in independent tests, and suggests suitable applications for this new technology.

Introduction

In 2001, sales of electronic ballasts for fluorescent lighting systems surpassed magnetic ballast sales for the first time, completing a full market penetration in just over a decade (US Bureau of the Census, 2001). Now, ballast technology is moving into its next evolutionary phase, incorporating advanced electronic circuitry to add functionality and flexibility. Among the new technologies available are ballasts that can dim lamps to 5% of full light output and run on the same dimmers as incandescent lamps, so-called "digital ballasts" that can be connected to networks and controlled individually or in groups using computers, and "adaptable ballasts" that can be used with different quantities or types of lamps, or can be operated on different line voltages. Adaptable ballasts offer the potential for greatly simplified stocking and ordering of replacement ballasts. For example, if a facility has three types of **luminaires**, such as a 120-volt 2-lamp fluorescent system, a 277-volt 2-lamp fluorescent system, and a 277-volt 4-lamp fluorescent system, it may be possible to keep one ballast model on hand that will work for all luminaires in the building.

Lighting Answers: Adaptable Ballasts explains the variety of adaptable ballasts available, examines their strengths and weaknesses, describes how they performed in independent tests, and suggests suitable applications for this new technology.

What is a ballast?

In a fluorescent lighting system, the **ballast** regulates the current to the lamps and provides sufficient voltage to start the lamps. Without a ballast to limit its current, a fluorescent lamp connected directly to a high voltage power source would rapidly and uncontrollably increase its current draw. Within a second the lamp would overheat and burn out. During lamp starting, the ballast must briefly supply high voltage to establish an arc between the two lamp **electrodes**. Once the arc is established, the ballast quickly reduces the voltage and regulates the electric current to produce a steady light output.

Maintaining an optimum electrode temperature is the key to long lamp life. Thus, some ballasts have a separate circuit that provides a low voltage to heat the lamp electrodes during lamp starting and typically during lamp operation (Hammer, 1995).

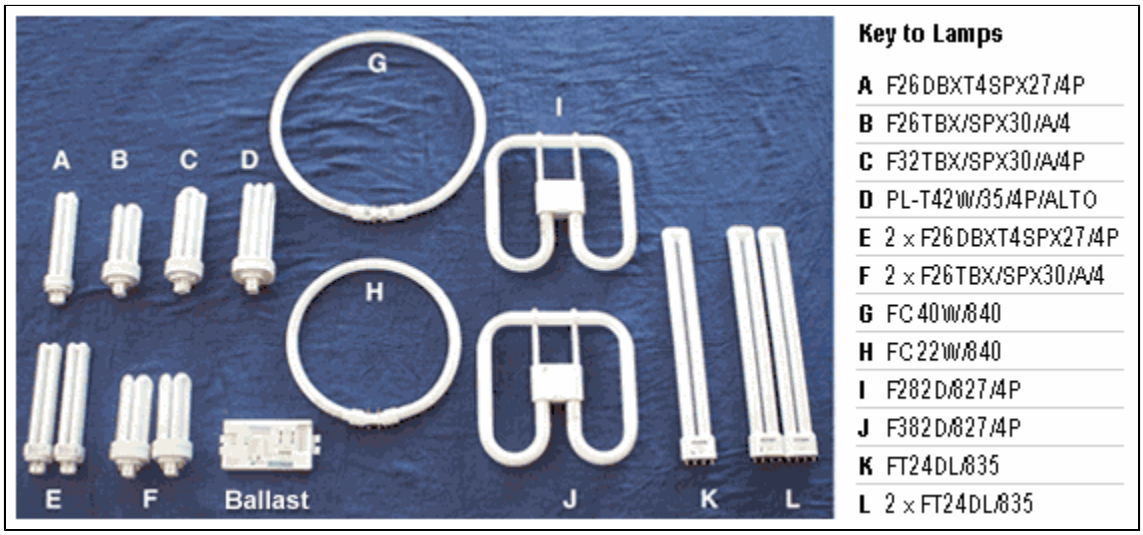
To achieve full **rated light output** and **rated lamp life** from a fluorescent lighting system, a ballast's output characteristics must precisely match the electrical requirements of the lamps it operates. Traditionally, ballasts are designed to operate a specific number (usually one to four) and type of lamp (such as a four-foot T8 lamp) at a specific voltage (in North America either 120, 277, or 347 volts). Thus, to find a ballast compatible with a particular **luminaire** (light fixture), lamp type, lamp quantity, and line voltage must all be known. For more on ballast technology, see NLPIP's Specifier Reports: Electronic Ballasts.

What is an adaptable ballast?

"Adaptable ballast" is a term NLPIP uses to describe an electronic **ballast** with special circuitry that enables it to operate multiple lamp types, operate different quantities of lamps, and/or operate on multiple input voltages. They are sometimes referred to by manufacturers and distributors as *universal ballasts, universal voltage ballasts, generic ballasts, or flexible ballasts*, although none of these terms is an industry standard. Some products are adaptable only in one or two of these options (e.g., they can operate different lamp types at different voltages, but can only operate a single lamp). Products that are adaptable in all three specifications (lamp type, lamp quantity, input voltage) are becoming more common.

Lamp type. Most ballasts for linear fluorescent lamps can now operate different lengths of lamps, provided the total lamp current is fairly constant. An adaptable ballast can accommodate not only different lengths, but different lamp shapes or different lamp wattages. Figure 1 shows an example of the variety of **compact fluorescent lamp (CFL)** combinations that a single adaptable ballast can operate.

Figure 1. An adaptable ballast and the different CFL lamp combinations it can operate



Lamp quantity. **Luminaires** typically contain one to four fluorescent lamps, so most ballasts are designed to operate exactly 1, 2, 3, or 4 lamps. An adaptable ballast may be able to operate either 1, 2, 3, or 4 lamps, although more likely it will operate two lamp quantities (e.g., 1 or 2 lamps, or 3 or 4 lamps).

Input voltage. In the United States, lighting loads are typically within 110- or 277-volt electrical systems. Some Canadian lighting systems use 347 volts (Canadian Standards Assoc., 1999). Most ballasts will operate on only one voltage. Ballasts are now available that can handle any voltage within a wide range (such as 108 volts to 305 volts) and can operate on either 50 hertz or 60 hertz systems for compatibility with both North American and European electrical systems. Regulatory requirements in Europe differ from North America's, so these ballasts may not necessarily meet European requirements for radio interference unless specifically labeled as such. Ballasts operating on 347-volt electrical systems require higher voltage-rated components, and thus are still typically dedicated to that one voltage (Wigglesworth, 2002).

How do adaptable ballasts work?

Adaptable **ballasts** that accommodate multiple lamp type and lamp quantity combinations generally can only do so if the lamp combinations yield roughly the same total lamp current. Thus, it would be unusual to find a ballast that can operate either one 15-watt lamp or two 40-watt lamps, for example. The total lamp current of these two combinations are too different for even an adaptable ballast to handle. Manufacturers could incorporate advanced load sensing circuitry to overcome this limitation, but it would make the ballasts prohibitively expensive.

Instead, manufacturers typically offer a small range of adaptable ballasts to cover most possible lamp combinations. For example, Advance Transformer's SmartMate™ product line includes four models, each of which operates five to ten different lamp combinations, providing coverage for about 25 different combinations between them.

To accommodate different input voltages, some adaptable ballasts have special digital circuitry that detects input voltage and adjusts power characteristics accordingly. These universal input ballasts typically can handle input voltages over a wide continuous range, such as 90V to 308V, and may also work with either 60Hz or 50Hz power systems.

At least one manufacturer (Fulham, Inc.) uses a different approach to achieve flexibility. Rather than having a single circuit that adapts itself to different voltages and loads, and a single set of wires to connect to power and the lamps, the Fulham ballast uses multiple built-in circuits, each with its own set of wires.

What products are available on the market?

Most adaptable **ballasts** that are available now can operate several different lamp types; all but one of the 12 manufacturers whose products NLPIP reviewed offer such a product. The ability to operate different quantities of lamps is less common; less than half of the manufacturers offer these types of products. About two-thirds of the manufacturers offer ballasts with adaptable input voltages. NLPIP found four manufacturers offering products that are adaptable in all three parameters (lamp type, lamp quantity and input voltage). Some companies have also begun offering adaptable ballasts for **high-intensity discharge** (HID) lamps; those ballasts are beyond the scope of this report.

Table 1 shows the availability of adaptable ballasts for fluorescent lamps from several ballast manufacturers. See the Resources section of this report for a list of manufacturer web sites where detailed product specifications are typically available.

Table 1. Adaptable ballast product availability

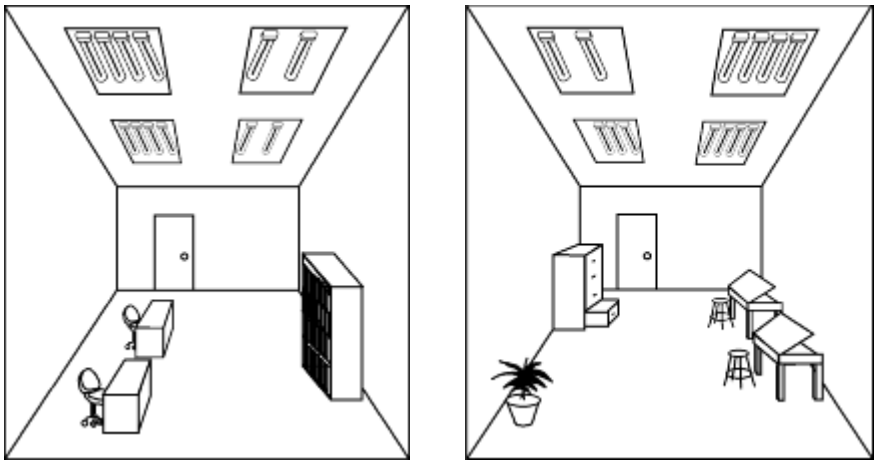
Linear lamps	Manufacturer
Adaptable input voltage	K-Tronic Ballasts
Adaptable lamp quantity	EBW Electronics, Inc.
Adaptable input voltage and lamp type	Advance Transformer Co. GE Lighting
Adaptable lamp type and lamp quantity	Fulham, Inc.
Adaptable input voltage, lamp type and lamp quantity	Ace Compact Electronics Energy Savings, Inc. Future Wave Technologies, Inc. OSRAM Sylvania Pompeian Manufacturing
Compact fluorescent lamps	**Manufacturer**
Adaptable lamp type	EBW Electronics, Inc. Reliable Ballast
Adaptable input voltage and lamp type	Advance Transformer Co. GFL Lighting Co., Ltd.,
Adaptable lamp type and lamp quantity	Fulham, Inc.
Adaptable input voltage, lamp type and lamp quantity	Ace Compact Electronics Energy Savings, Inc. Future Wave Technologies, Inc. K-Tronic Ballasts OSRAM Sylvania

Why should I use adaptable ballasts?

The primary reason to use an adaptable **ballast** is the convenience that its flexibility offers. Users that can benefit from this flexibility include:

Facility managers. Those who are responsible for a large facility with many different types of ballasts can reduce their replacement ballast inventories by stocking adaptable ballasts compatible with their various lighting systems. When servicing **luminaires**, the chance of installing the wrong ballast type is reduced. Also, when a facility manager is called to service a luminaire it won't be necessary to first make a trip to check inside the fixture and get the specs before going to the stockroom to find the right ballast. Also, if the adaptable ballasts support different lamp quantities and the luminaires have the proper sockets and optical design to allow it, light levels (and energy use) can easily be adjusted to suit a space's current use by adding or subtracting lamps from luminaires (see Figure 2). Light levels may also be increased or decreased by using higher or lower wattage lamps. Beyond task tuning, these methods can also be used for **load shedding**.

Figure 2. Flexibility advantage of adaptable ballasts



Office application **Drafting application**

Application flexibility is a primary advantage of adaptable ballasts. In the example above, an office has four 2x2 luminaires that can each accommodate four T5 twin-tube lamps. With adaptable ballasts, if the room is reconfigured from an office space into a drafting area, lamps can be added or removed from the luminaires to achieve the desired light distribution without any need for changing the ballasts. If the drafting tables require higher light levels than the desks in the office application, higher-wattage T5 twin-tube lamps can be used to increase the luminaires' light output.

Electrical contractors and installers. Because they typically work on many diverse projects, contractors spend a great deal of effort matching ballasts with luminaires. If the lighting specifications for a project change partway through a project, contractors may be left with too many of one type of ballast and not enough of another. They may face work delays if their distributor backorders a specific ballast. Adaptable ballasts allow contractors to simplify the ballast selection process. Contractors also may potentially save money via quantity discounts by purchasing adaptable ballasts for several projects at once.

Luminaire manufacturers. Most fluorescent luminaires are sold with ballasts installed. The luminaire manufacturer must carefully manage the ballast inventory to make sure they have sufficient supply to keep their assembly lines productive. Adaptable ballasts allow manufacturers to reduce their total ballast inventory, and reduce the chances that they will run out of a particular ballast or install the wrong ballast. Luminaires equipped with adaptable ballasts can potentially be marketed at a premium, based on multiple voltage capacity and the ability to operate without a full complement of lamps installed. However, due to added circuitry, adaptable ballasts may not be as small as simpler ballasts and may be more difficult to fit into existing luminaires. This is especially true for **compact fluorescent lamp (CFL)** ballasts, which are typically much smaller than those for linear fluorescent lamps.

Lighting specifiers. Architects and lighting designers can also benefit by specifying adaptable ballasts. Then, last minute changes to the client's preferred luminaire type or to the electrical wiring plans won't necessarily mean that the ballast must be re-specified. Implementation and commissioning of the lighting design may also run smoother if the electrical contractors find their jobs simplified by adaptable ballasts.

What are the disadvantages of adaptable ballasts?

Flexibility is the primary advantage of an adaptable **ballast**. However, before specifying, also consider the following disadvantages:

- Increased cost
- Unproven reliability
- Increased ballast case size and weight

- Variations in **ballast factor** for different lamp types
- Lower efficacy

Cost. Initial cost is a concern for any lighting specifier. Adaptable ballasts for linear fluorescent lamps tend to carry a premium for their flexibility. However, adaptable ballasts for **compact fluorescent lamps (CFLs)** tend to have pricing similar to products that are dedicated to a single lamp/voltage combination. In the mature market for linear fluorescent ballasts, initial costs no longer include a premium to earn back the manufacturer's development costs. The new designs for adaptable ballasts for linear fluorescent lamps thus cannot yet compete with commodity ballasts in terms of price. In the emerging CFL ballast market, however, most ballast designs are relatively new, and prices for adaptable ballasts are comparable to those for standard ballasts. According to John Andrews, Director of Operations for K-Tronic, as new CFLs came on the market CFL ballast manufacturers began engineering features such as adaptable voltage compatibility into their products from the start, so there is less of a pricing gap.

Reliability. Product reliability is a greater concern than cost for most users. Most adaptable ballasts are too new to have a proven record of meeting their rated life, and of providing rated life from the lamps they operate. To partially address this concern, most ballast manufacturers offer warranties of at least five years. However, if, in order to accommodate multiple lamp types, the ballasts are starting and operating the lamps at less than optimal conditions, there may be impacts on lamp life (Ji and Davis, 1994). NLPIP tests show that adaptable ballasts may operate lamps below their rated current, potentially reducing lamp life. However, adaptable ballasts typically have a separate circuit to heat lamp **electrodes** during lamp operation, mitigating the negative impact of low lamp current on lamp life.

Size/weight. Although some adaptable ballasts are available with "low profile" cases, the smallest adaptable ballasts are not quite as compact as the smallest non-adaptable ballast due to additional components. This is less of a concern for linear fluorescent lamps because most ballasts are roomy and sturdy enough to accommodate bulky ballasts. With compact fluorescent lamps, however, ballast weight and size are important considerations when designing luminaires.

Ballast factor. The measure of how close actual light output from a fluorescent lamp-ballast combination compared to the lamps' **rated light output** is called the ballast factor (ANSI, 1984). Adaptable ballasts have ballast factors that can vary widely depending on lamp type. For a discussion of variations in ballast factor, see the section How Well Do Adaptable Ballasts Perform?

Efficacy. Adaptable ballasts may be less efficient than non-adaptable ballasts due to the power required for the additional circuitry that makes the ballast adaptable. This additional power requirement of the ballast results in a marginal increase to the combined lamp and ballast power, resulting in lower overall efficacy.

How well do adaptable ballasts perform?

Table 2 shows the results of the NLPIP's independent testing of one manufacturer's adaptable **ballast**, which was capable of operating either one or two of several types of **compact fluorescent lamps**. As expected, the input power and light output vary depending on lamp type. Note that the lamp current remains fairly constant, and that the ballast typically provides less lamp power than the lamp manufacturer recommends.

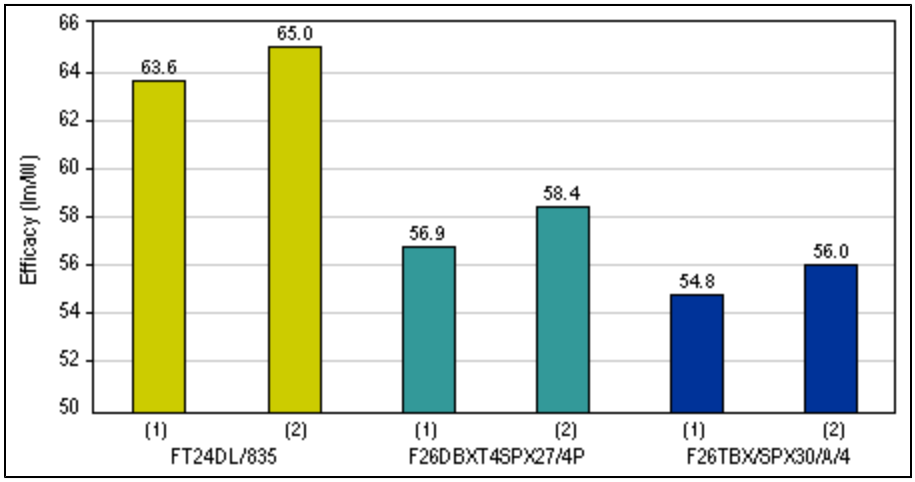
Table 2: NLPIP's test results for a sample adaptable ballast

Lamp	Lamp current (ma)		Lamp input power (W)		Ballast input power (W)*	Light output (lm)	System efficacy (lm/W)
	Mfr. †	NLPIP	Mfr. †	NLPIP	NLPIP	NLPIP	NLPIP
F282D/827/4P	320	277.9	28.0	27.5	31.0	1851	59.7
F382D/827/4P	430	277.4	38.0	27.1	33.6	2162	64.4
FT24DL/835	340	276.3	24.7	21.6	25.4	1619	63.6
FC 22W/840	300	275.4	22.3	21.1	24.2	1630	67.3
FC 40W/840	320	273.6	39.9	33.7	37.3	2573	68.9
F26DBXT4SPX27/4P	325	281.6	26.0	23.8	26.5	1509	56.9
F26TBX/SPX30/A/4	325	282.3	26.0	25.3	29.4	1613	54.8
F32TBX/SPX30A/4P	320	276.7	32.0	28.9	33.5	1902	56.8
PL-T42W/35/4P/ALTO	320	273.8	42.0	39.8	43.8	2817	64.3
2 x FT24DL/835	340	261.8	49.4 ††	41.3	48.7	3165	65.0
2 x F26DBXT4SPX27/4P	325	260.1	52.0 ††	44.3	51.4	3003	58.4
2 x F26TBX/SPX30/A/4	325	259.7	52.0 ††	47.7	55.4	3102	56.0

* Ballast input power includes lamp power.
† For lamp current and lamp input power, both the manufacturer-reported value and NLPIP's test results are shown for comparison.
†† Value reflects the individual lamp power multiplied by the lamp quantity.

Table 2 also indicates that the lamp/ballast system's efficacy is relatively stable over all lamp types, increasing slightly for two-lamp operation compared to one-lamp operation, due to ballast power that is fairly constant regardless of lamp quantity. See Figure 3 for a comparison of system efficacy for one-lamp vs. two-lamp operation.

Figure 3. Comparison of an adaptable ballast's system efficacy for one-lamp vs. two-lamp operation



Lamp-ballast system efficacy is higher when the ballast is operating two lamps than when operating one. The difference is attributable to ballast power that remains fairly constant regardless of lamp quantity.

Although system efficacy remains fairly constant, adaptable ballasts may exhibit different **ballast factors** depending especially on the lamp type operated. For example, the ratio of actual light output to the lamp's **rated light output** varied from 0.75 to 1.0 for Ace Compact Electronics' CSD-UV42PS. Table 3 shows the manufacturer-reported ballast factor for this ballast with several lamp-type/lamp-quantity combinations. Note that for a specific lamp type, the ballast factor remains fairly constant as the voltage or quantity of lamps

changes.

Table 3: Manufacturer's reported ballast factors for an adaptable ballast

Lamp power (W)	Voltage (V)	Lamp quantity	Ballast factor
26	120	2	1.00
	277	2	0.95
32	120	1	1.00
		2	0.95
	277	1	0.95
		2	0.90
36	120	1	0.85
		2	0.85
	277	1	0.85
		2	0.88
38	120	1	0.83
	277	1	0.85
39	120	1	0.85
		2	0.85
	277	1	0.85
		2	0.80
40	120	1	0.90
		2	1.00
	277	1	0.90
		2	1.00
42	120	1	0.95
		2	0.90
	277	1	0.95
		2	0.95
50	120	1	0.75
	277	1	0.75
55	120	1	0.75
	277	1	0.76

Summarized from product literature for Ace Compact Electronics CSD-UV42PS.

Resources

Manufacturer Web Sites

Ballast Manufacturer	Web Site
Ace Compact Electronics	http://www.ace-ballast.com/index.html
Advance Transformer Co.	http://www.advancetransformer.com
EBW Electronics, Inc.	http://www.ebw-electronics.com/
Energy Savings, Inc.	http://www.esavings.com/
Fulham, Inc.	http://www.fulham.com/
Future Wave Technologies, Inc.	http://www.futurewavetechnologies.com/
GE Lighting	http://www.gelighting.com/na/home/
GFL Lighting Co., Ltd.	http://www.gfllighting.com/cgi-bin/gen_home.pl
Hatch Transformers, Inc.	http://www.hatchtransformers.com/
K-Tronic Ballasts	http://www.k-tronik.com/
Pompeian Manufacturing	http://www.pompeianmfg.com/
Reliable Ballast	http://www.reliableballast.com/

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U.S. Bureau of the Census. 1999. *Current Industrial Reports: Fluorescent Lamp Ballasts, MQ36C(98)-5.* Available at www.census.gov/ftp/pub/industry/1/mq36c985.pdf. Accessed March 24, 2003.

Wigglesworth, G. 2002. *Compact Fluorescent Ballasts* – Making the Right Choice! Available at www.universalballast.com/literature/rightchoice.html. Accessed March 24, 2003.

For more information

Many other resources provide information about adaptable ballasts. The following is not intended to be a complete list of additional resources; numerous regional and international organizations disseminate information about this topic.

———. 1985. *American National Standard for Ballasts for Fluorescent Lamps:* Specifications, ANSI C82.1-1985. New York, NY: ANSI.

———. 1993. *High-Frequency Fluorescent Lamp Ballasts*, ANSI C82.11-1993. New York, NY: ANSI.

Electric Power Research Institute, California Energy Commission, and U.S. Department of Energy. 2001. *Advanced Lighting Guidelines: 2001 Edition*. EPRI PB-221-01. Palo Alto, CA: EPRI.

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Glossary

Sources of term definitions: National Lighting Product Information Program (NLPIP), Lighting Research Center's Lighting Education Online, the IEEE Standard Dictionary of Electrical and Electronics Terms (IEEE Std 100-1996).

Ballast	A device required by electric-discharge light sources such as fluorescent or HID lamps to regulate voltage and current supplied to the lamp during start and throughout operation.
Ballast Factor (BF)	The ratio of the light output of a fluorescent lamp or lamps operated on a ballast to the light output of the lamp(s) operated on a standard (reference) ballast. Ballast factor depends on both the ballast and the lamp type; a single ballast can have several ballast factors depending on lamp type.
Compact fluorescent lamp (CFL)	A family of single-ended fluorescent-discharge light sources with small-diameter [16-millimeter (5/8-inch) or less] tubes.
Electrodes	The structure that serves as the electric terminals at each end of electric discharge lamps.
High-intensity discharge (HID)	An electric lamp that produces light directly from an arc discharge under high pressure. Metal halide, high-pressure sodium, and mercury vapor are types of HID lamps.
Load shedding	The practice of turning off electrical devices during peak energy demand hours to reduce building energy use.
Luminaire	A complete lighting unit consisting of a lamp or lamps and the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamp(s) to the power supply. (Also referred

	to as fixture.)
Rated lamp life	See lamp rated life.
Rated lamp life	The number of hours at which half of a group of product samples fail. 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.
Rated light output	The sum of the initial rated lamp lumens of the lamp(s) that were supplied with the luminaire.

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Lighting Answers is a serial publication that complements the National Lighting Product Information Program's (NLPIP's) other serial, *Specifier Reports*. Each issue of *Lighting Answers* presents information in one of three formats: educational information about a specific topic of concern to lighting professionals, a summary of available information about a particular technology in an educational format with no testing, or information about a new or special technology on which NLPIP has performed some limited testing.