LBL-25043

To be presented at the Renewable Energy Technology Symposium
and International Exposition, Santa Clara, CA, July 7–10, 1988,
and to be published in the Proceedings

Status and Applications of New Lighting Technologies

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June 1988

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

Presentated at the Renewable Energy Technologies Symposium and International Exposition - The International Power Exhibition and Energy Conference, Santa Clara, CA, July 7-10, 1988

LBL-25043
L-134

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This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Buildings and Community Systems, Building Equipment Division of the U.S. Department of Energy under Contract No. DE-ACO3-76SFOOO98.

STATUS AND APPLICATIONS OF NEW LIGHTING TECHNOLOGIES

by

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Abstract

This paper discusses fluorescent lamps, ballasts, compact fluorescent lamps and lighting controls. The introduction of these new energy efficient products has provided new choices to obtain optimum results in meeting the illumination requirements of spaces. However, the lack of understanding their fundamental characteristics and mutual interactions have led to serious design errors. We provide some of the essential information one must know about these new lighting systems, in order to evaluate proposed lighting designs and equipment selection.

Introduction

For the past ten years there have been many new lighting products introduced that provide lighting designers with many options to attain their goals. It is important for the architect, or building operator, who is not involved with the design details to understand some features of these products for them to provide sound judgements when their approval of the lighting designs are required. Lighting has emerged as an important element of buildings, not only for its aesthetics and a means to improve productivity, but as a key component to optimize its energy performance.

This report will describe the recent advances and status of three lighting components (ballasts, lamps, and lighting controls) that can affect the performance of buildings. I will attempt to highlight some of their features that may not be clearly understood, and could lead to misapplications of good products.

Fluorescent Ballasts

The electrical performance of standard core-coil ballasts have been improved by reducing the electrical and magnetic losses. The ballast losses have been reduced by about eight watts resulting in an eight to ten percent increase in the system efficiency. In several states the use of the standard core-coil ballast is no longer permitted. There is also a current effort to enact a similar efficiency standard by the United States Congress. More recently, these energy efficient ballasts have been designed to remove filament power after the fluorescent lamp is ignited. This reduces the power by about four to five watts for a system improvement of five percent. However, this is obtained at some loss to lamp life of about twenty-five percent which could be a cost-effective trade-off.

Electronic ballasts which operate fluorescent lamps at high frequency are more efficient than core-coil ballasts, and also improve the lamp efficacy. In general the total increase in efficacy is 20 to 25 percent above a standard core-coil ballast system. The electronic ballast was developed in earnest in 1976 and was on the market in 1981. There were ballast failures by some of the manufacturers that increased the resistance to their widespread use. The Department of Energy had established that there were no technical problems with the electronic ballast concept; however, the initial problems were due to poor quality control of the product. Since that time, the electronic ballast product has improved, and several manufacturers have been producing product for over four years. In fact, today all of the major core-coil ballast manufacturers offer electronic ballasts, which indicates that they are considered a reliable product by the traditional lighting community. There are probably over 2 million electronic ballasts in place, and the industry expects to sell over 1.5 million this year. Next year the electronic ballast industry projects that sales will double. For the first time, the demand for electronic ballasts exceeds the supply.

In the course of their development and manufacture, various aspects of their performance have been assessed: lamp life, ballast life, electromagnetic interference, surge protection and open circuit protection. Ballast designers have evolved that addressed these issues that have resulted in improved reliability. In addition to the improved efficacy, electronic ballasts reduce or eliminate lamp flicker, have systems that operate three and four fluorescent lamps (further improving efficacy and reducing initial cost), and can dim fluorescent lamps over a large range of light levels.

There are recent ballast designs (both electronic and core-coil) that remove filament power after the lamps are ignited. This further improves system efficacy, but at the expense of lamp life. Conservative estimates derate the life of lamps operated in this manner by 25 percent. It is essential that the designer or engineer question the ballast manufacturers, and properly specify the ballast product they require to assure satisfaction.

Fluorescent Lamps

There are two basic types of fluorescent lamps that are available: the standard argon filled 40 watt F40, and the krypton filled 34 watt F40 lamps. Table 1 lists the input-output data for these lamps, operated with a standard core-coil ballast and an electronic ballast.

TABLE 1: Performance of 40 and 34 Watt F40 Lamps

	Core-Coil		Electronic	
TWO LAMPS	40W	34W	40W	34W
Rated Light Output (lm)	6300	5850	6300	5850
Rated Power (W)	80	68	72	61
Rated Efficacy (lm/W)	79	86	79	86
TWO LAMP SYSTEM				
Measured Light output (lm)	6100	5060	5940	5270
Measured Power (W)	96	79	75	66
Measured Efficacy (lm/W)	63.5	64.1	79.2	79.8
Ballast Factor	0.968	0.865	0.943	0.901

Notice that the rated efficacy of the 34 watt lamp with the lite white phosphor is 7.5 percent greater than the 40 watt lamp with the cool white phosphor, but the system efficacy is less than 1 percent greater. Although the two lamp types have been operated with the same ballasts, the ballast factor is less for the ballast operating the 34 watt lamps. Thus, the expected change in light output of 7 percent is actually 17 percent for the core-coil ballast.

Thus, because of the above changes in ballast factor for ballast lamp systems, the designer must exercise caution in their lamp selection. In many cases, too low of a light output obtained for a lighting design. In new construction the 40 watt system, with its equal efficacy and higher light output, is the preferred choice since less fixtures, lamps, and ballasts will be required. The 34 watt lamp is an effective option for retrofitting over illuminated spaces.

Compact Fluorescent Lamps

In the last couple of years an efficient replacement for the incandescent lamp has been introduced. The lamps is the compact fluorescent lamp. The lamp industry has developed new phosphors (narrow band) that make this possible. These phosphors can be mixed to attain a color temperature and color rendering almost equivalent to the popular incandescent light source. In addition this rare earth phosphor has a lumen depreciation superior to the halophosphates, allowing the compact lamps to be made of small diameter tubing that increases its intensity. This permits these lamps to be sufficiently compact, and obtain light outputs equivalent to a 75 watt incandescent lamp. Table 2 compares the performance of the compact fluorescent lamps with incandescent lamps. The important aspects of this table is the light output of the various compact fluorescent lamps. The input power to these lamps include an estimate of the ballast losses. Their light output is taken from the manufacturers catalog. One must be aware that if one uses a ballast with a ballast factor less than one, which is generally the case, the light output and the input power will be less by this factor. Most vendors do not provide the systems performance, and generally state their equivalence to a particular incandescent lamp. Usually such comparisons are not valid.

TABLE 2: Light Output, Life, and Efficacy of Incandescent and Compact Fluorescent Lamps

Incandescents				Compact Fluorescents***			
Power (W)	Light (lm)	Life (h)	Efficacy (lm/W)	Power (W)	Light (lm)	Life (h)	Efficacy (lm/W)
150	2780	750	18.5	22*	870	9000	39.5
100	1750	750	17.5	44*	1750	9000	39.8
75	1210	750	16.1	7	250	10000	35.6
60	890	1000	148	10	400	10000	40.0
40	1500	12.0	13	13	600	10000	46.2
25	238	2500	9.5	19	900	10000	47.4
--	--	--	--	18**	1100	7500	61.0

* Circline (Adaptive)
** Electronic Ballast
*** Including Ballast

Thus, if the lighting system's light level is an important feature of the design, it is essential the the light output of the system (lamp and ballast) be specified. These compact lamps are <u>not</u> a point source and the light distribution cannot be controlled as well as an incandescent lamp. They can be used most effectively as a diffuse source of illumination.

Lighting Controls

It is common to think of lighting control systems only in conjunction with daylighting techniques. In reality, daylighting is only one of several cost effective control strategies which include scheduling, tuning, lumen depreciation, and load shedding. Techniques that can be executed over large areas (scheduling, lumen depreciation, and load shedding) require the least expensive equipment, and generally have the fastest return on an investment. These strategies can be accomplished very simply with on-off controls (relays). Strategies such as tuning and daylighting generally require the lamps to be dimmed over a continuous range, in which relatively small areas (100 to 200 square feet) are independently controlled.

Lighting control systems are available the can switch and dim fluorescent lamps operated with standard core-coil ballasts. These systems are based upon switch input power to the lamp systems, and are most cost effective when used to switch or dim large groups of lamps. Thus, tuning and daylighting are not generally effective strategies with these systems. The most effective equipment to accomplish daylighting and tuning are with electronic ballasted fluorescent lamps. The electronic dimming ballasts are not based on switching input power, but respond to a low voltage command signal to switch one or more fluorescent lamps. Thus, these systems dim a few lamps as easily as a large bank of lamps. These systems are available today, and in the future will permit independent control of the light output from each luminaire. The future systems will combine these electronic ballasts with power line carrier techniques to communicate inputs from sensors (light, occupancy, clocks, and occupants) to commands to the lighting system. The emergence of lighting controls has been one of reducing operating costs. However, the activities in the current "electronic" office spaces dictate a wide range of illumination levels, e.g., writing and reading hard copy tasks as well as viewing video terminals, and multi-purpose spaces having different visual tasks and the need to create a variety of moods.

Acknowledgement

This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Buildings and Community Systems, Building Equipment Division of the US. Department of Energy under Contract Number DE-AC03-76SF00098.