DIMMABLE ELECTRONIC BALLASTS DATA SHEET

DESCRIPTION
Dimmable ballasts for fluorescent lights represent state-of-the-art in lighting controls. With dimming ballasts, light levels can be varied between 15% (typical) and full light output. Dimming ballasts are available as magnetic or electronic ballasts. However, the electronic dimming ballasts have many distinct advantages over the core-coil technology. In particular, electronic dimming ballasts are well-suited to low-voltage control; thus the control wiring can be implemented with less costly Class II wiring. (With dimming core-coil ballasts, the dimming is accomplished using "high-power" switching. This results in greater initial cost to install the controls).

SOURCES
Dimmable electronic ballasts are available from ETTA, Advance, and Lutron. All these vendors also offer dimming for T-8 systems as well.

Dimming magnetic ballasts have been available from major ballast manufacturers for many years (Universal and Advance).

STATUS OF AVAILABILITY
Electronic ballasts are generally in short supply with lead times of several months not uncommon.
There are no known suppliers of dimmable ballast of T-8 lamps that allow individual control.

PROS AND CONS
Dimming ballasts are generally slightly less efficient even at full output than dedicated systems. This is generally because of the extra power required to keep the lamp filaments at the appropriate temperature over all dimming conditions.

ENERGY PERFORMANCE
Most lighting systems suffer some degradation in efficiency when they are dimmed. With fluorescent lighting systems, this is unavoidable especially at heavily dimmed levels because it is necessary to maintain nearly full filament voltage even when the source is dimmed.

IMPACT ON BUILDING DESIGN
The dimming range of the proposed lighting system should be considered in the building design process. Few systems dim to 0% light output although many dim to 20%. It may be desirable to switch off lights that are heavily dimmed for long periods of time since parasitic losses are highest under these conditions.

The choice of control strategy(ies) should be a major determinant for selecting the appropriate lighting hardware and technique. However, this is young field with relatively little written on approaching this problem from a procedural standpoint.

COST, PER UNIT BASIS
A dimmable electronic ballast is currently about $45-55. Most industry experts would agree that in a mature market, the cost could drop to $25 - $30. Dimmable magnetic ballasts are also available (and have been available for many years) at similar prices.

MARKET SHARE, EXPECTED TRENDS
This market will likely expand as end-users start demanding highly efficient lighting control systems. At the present time, Advance is the only large manufacturer of dimming electronic ballasts.

CASE STUDY INSTALLATIONS

A recently-concluded study that was sponsored by PGE R&D at a building in Emeryville demonstrated that an electronically-ballasted lighting control system exploiting all lighting control strategies can save over 50% compared to the usage without the controls.

SCOTOPICALLY RICH LIGHTING DATA SHEET

DESCRIPTION

Recent research suggest that it should be possible to reduce lighting energy requirements for many tasks by the use of light sources whose spectral output is rich in the blue-green wavelengths. Previously, photometric brightness as determined using a photopic response curve (the spectral sensitivity curve of the cones in the human eye responsible for day-time adapted vision) was thought to be the primary determinant of visual performance at interior light levels. Light sources producing whitish light but with different spectra were thought to be visually equal provided they produced equal luminances. Photopic luminance is measured with a common "color-corrected" light meter.

However, research at LBL demonstrated that, when viewing under full field conditions at typical interior light levels, the pupil size is largely determined by the *scotopic* response curve -- the spectral sensitivity curve of the rods in the human eye responsible for night-adapted vision. Previously, the rods were thought to have negligible effect on visual performance at typical interior light levels.

The smaller pupils caused by blue-green rich sources are thought to allow energy efficiency gains in two ways since pupil size affects both depth of field and visual acuity. (Visual acuity is the ability to resolve fine detail. Depth of field is the ability to maintain objects in good focus over a range of object distances.) LBL findings suggest that the energy requirements for lighting a space can be decreased by trading off lumen output (and therefore energy cost) against increased scotopic content of the source. Thus, with a scotopically rich source, the same pupil size could be obtained by using less photopic light (and therefore consuming less power) than a source that is deficient in the blue. This can be done either by using existing lamps that are scotopically rich or designing new lamps that are optimized to provide more scotopic lumens while preserving color rendition and good photopic efficacy.

SOURCES

Lamps developed specifically for scotopic richness have yet to be developed. But some lamps currently available, namely the 5000 °K rare earth, tri-phosphored lamp (Philips Ultralume 5000) are relatively rich scotopically. Other specialty lamp manufacturers also offer the 5000 K lamp. Note that "daylight" fluorescent lamps are also scotopically-rich as well as most sources of higher color temperature (such as natural daylight).

STATUS OF AVAILABILITY

PROS AND CONS

A number of poorly understood past studies on visual performance and brightness perception can be readily explained in terms of scotopic sensitivity (Berman 1991). Effective pupil lumens can be determined for full field of view if the spectrum of light entering the eye is known. For surfaces with broad spectral reflectivity this spectrum is approximately that of the illuminating light source. Brightness perception is also dependent on the scotopic contect of the illumination (Berman et al 1990) but the precise conbination of the relative contributions of photopic and scotopic luminance has yet to be determined. Full field scenes with variable luminances have also not been studied but since pupil size and brightness perception are rather coarse measures of visual response, average luminance is expected to be the primary determinant.

ENERGY PERFORMANCE

Based on Berman's model, effective pupil lumens are equal to P(S/P)EXP.78 where P and S are photopic and scotopic luminances based on the spectral distribution of the light source. Using this model, four fluorescent light sources were evaluated as indicated in Table 1. In

comparison with a cool white lamp, A 5000 K tri-phosphor lamp uses 24% less energy to maintain the same pupil size compared to a cool white lamp. A scotopically-enriched rich lamp would require 31% less energy.

Table I

(40 Watt Fluorescent Lamps)

Lamp	Photopic Lumens	Scotopic Lumens	Effective Pupil Lumens [P(S/P)$^{.78}$]	Relative Power Level for Equal Pupil Sizes	Pupil Lumens Per Watt
Warm White Fluorescent (WW)	3200	3100	3125	136	78
Cool White Fluorescent (CW)	3150	4630	4254	100	106
Narrow Band Phosphor Fluorescent (5000°) [NB(5000)]	3300	6468	5578	76	139
Scotopical Rich Narrow Band (SR-NB)	3000	7500	6130	69	153

Source: Berman, Energy Efficiency Consequences of Scotopic Sensitivity, Proceedings of the 1991 National Illuminating Engineering Society, Montreal.

High color temperature rare-earth phosphor lamps (tri-phosphor lamp) are scotopically rich and energy efficient. It is proposed that an even richer scotopic lamp be developed by adding a phosphor having a sharp emmisive peak at 508 nm (the scotopic response function peak) to a high temperature tri-phosphor lamp. Thus high CRIs should be maintained although cooler temperatures will be standard. This may pose problems for applications where a warm color temperature is desired.

IMPACT ON BUILDING DESIGN

Because scotopically rich lamps can elicit the same pupil size as scotopically-poor lamps with less input power, a 4-lamp fixture with 4 40 watt cool white lamps could be replaced by 3 40 watt scotopically rich lamps (Berman 1991). This would result in a 24% drop in installed lighting load. There will also be a cost reduction associated with using fewer lamps, ballasts, and smaller fixtures.

MARKET SHARE, EXPECTED TRENDS

Accumulating evidence about the eye's scotopical sensitivity under interior light conditions may promote lamp manufacturers to make scotopically rich lamps simply by incremental improvements to existing technologies. But it is difficult to estimate future market directions until the benefits of scotopically rich lighting are more generally recognized.

POLARIZED LIGHTING DATA SHEET

DESCRIPTION
It has long been known that light polarized in the vertical plane is not well reflected from specular horizontal surfaces if the angle between the incident light and the surface normal are close to 57° (Brewster's angle). At this angle, no vertically polarized light from the incident beam will be reflected by a shiny horizontal surface. This means that the veiling reflections caused by overhead light striking a horizontal task surface can be largely eliminated. Since veiling reflection impairs visual performance by reducing contrast, vertically polarized light could be supplied at a lower light level (and therefore use less power) than unpolarized lighting systems while preserving visibility.

SOURCES
1. Polarized International Inc.
2. PCTechnologies

STATUS OF AVAILABILITY
Polarizers for commercial lighting systems typically consist of 2x4 sheets of a special panel that fits above the standard lens in a regular fluorescent fixture. In addition, polarizing panels that replace the standard fluorescent diffuser are available.

PROS AND CONS
Polarized lighting may well allow equal visibility to be achieved for some tasks with lower lighting energy use than a non-polarized lighting system.

However, the benefits of the polarized lighting effect depend strongly on the geometry of the lighting system, the viewing direction and nature and orientation of the task surface. Polarized lighting is most beneficial at an angle (57°) that is considerably higher than the normal viewing angle (20°). At the normal viewing angle, the benefits of vertically polarized light are significantly reduced, though not entirely eliminated. A recent study at LBL (Clear and Berman, "Polarization and Glare on VDUs and Other Tilted Specular Surfaces", Proceedings of the Illuminating Engineering Society, 1991) showed that there were no direct benefits of vertically polarized lighting for reducing glare on computer screens. This study, though, did not examine the effects on horizontal tasks.

The visibility of certain types of industrial tasks (viz. identifying vernier marks on a metallic, horizontally oriented cylindrical device or machine) may be significantly improved with vertically polarized light because of the geometry. But more work is required to identify what tasks and orientations are most benefitted by polarized light and to what degree.

It should be noted that commercial polarizers only partially polarize the light emitted from the fixture. As shown in the attached product sheets, of all the light emitted by the polarized luminaire above 30° (where polarized lighting would be most effective), only 66% of the lumens were vertically polarized; the remaining lumens were horizontally polarized producing no effect.

ENERGY PERFORMANCE
Without further research, it is not possible to state what the energy savings benefits are of vertically polarized lighting.

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