Abstracts

The Blue-Light Hazard: A Review

John D. Bullough, M.S., MIES

A primary purpose of electric lighting is to aid vision in conditions when natural light (daylight, sunlight) is unavailable. Such conditions occur at night and indoors. Lighting recommendations of organizations such as the IESNA are almost entirely based on requirements for visibility.[1]

An increasing body of evidence exists to support the effects of light and lighting in psychological and physiological areas of life. Light affects moods, metabolism and even communicates meaning. Light is used therapeutically to combat depression, to rid the body of toxins, and to reset the body's internal circadian clock.[2] With such capacity to impact human life, it is reasonable to suppose the use of light might also carry certain risks. This brief review discusses one specific type of potential risk associated with light — namely, the ability of short-wavelength ("blue") light of sufficient intensity and duration to cause photochemical damage to the visual system.

Roadway Lighting Design for Optimization of UPFD, STV and Uplight

David M. Keith

In accordance with the new ANSI/IESNA RP-8-00, roadway lighting calculations were made to investigate relationships between Unit Power Density (UPD), Small Target Visibility (STV), and Unit Uplight Density (UUD).

Calculations were made for specific luminaires, roadway configurations and lighting system geometry, for a range of mounting heights. At each mounting height, the luminaire spacing was increased until any one of the illuminance or luminance criteria was not met. The last spacing which meets all the criteria (for both the illuminance and luminance methods) is the maximum for that run. As the mounting height increased over successive runs, maximum spacing initially increased before usually decreasing. Optimum spacing typically occurred when the mounting height was increased until, at the greatest maximum spacing, uniformity and average criteria both reached their limit.

For the same wattage luminaire, as spacing increases, UPD decreases proportionally. Decreases in UPD correspond to decreases in UUD values. The STV value at the optimum spacing is typically a local maximum for that range of luminaire spacing or UPD values.

Typically, luminaires with semi-cutoff distributions produce the lowest UPD, along with low UUD and relatively high STV values. Distributions with greater cutoff have greater UPD and UUD values, with full cutoff distributions having even higher values.

When mounting height and luminaire spacing are optimized to meet just the luminance criteria, UPD and UUD values decrease, typically 10-20 percent. When designing to the STV criteria alone, further reductions occur, between 5-12 percent less than for the luminance criteria. This is proportionally true for every category of cutoff.

High Efficiency Quad Luminaire Prism Light Guide

Peter Kan, Lorne A. Whitehead and Andrzej Kotlicki, Stephen J. Harrison and Craig S. McIntyre

Prism light guides are usually used in remote-source lighting applications, where the lamp is generally an intense point source with a high luminous efficacy, and it is desirable to produce a uniform illumination. Typically, a transparent protective housing is used to support a cylindrical prism light guide, made of flexible prismatic optical lighting film.[1] The prisms in the film confine the light by means of total internal reflection[2-5] and scattering structures within the guide cause uniform light emission along its length.

The advantages of using a prism light guide include lower maintenance costs because there are fewer light sources and lower glare as a result of a more uniform light distribution. However, there is some energy loss associated with guiding light, which results in a lower net system efficacy than that of some conventional fixtures. Although the light guidance loss can be small, it is a common preconception that light guides are not efficient enough for conventional illumination. One of the motivations for the research described here was to demonstrate high efficiency is indeed possible with a prism light guide luminaire system.

In this paper, we describe such a system, based on four-fold symmetrical illumination of prism light guides having rectangular cross-section. We achieve a net system luminous efficacy of 71 lumens per Watt, which is a 25 percent improvement over the best previous system.

The net system efficacy was determined independently by two groups. The first group at the University of British Columbia (UBC) measured the surface exitance as a function of position and spatially integrated it to obtain total output flux. The second group at Queens University (QU) confirmed the net system efficacy using the same method and as a further verification, measured the luminous intensity as a function of direction and integrated over solid angle to obtain the flux. These tests agreed substantially and showed 76 percent of the lamp lumens are emitted from the output surface of the light guide.

The Effect of Overhead Glare on Visual Discomfort

P. Ngai and P. Boyce

This paper describes a series of four experiments designed to study the phenomenon of overhead glare. In

each experiment, sixteen subjects, experienced in lighting, provided an assessment of the degree of discomfort caused by a luminaire positioned at five different positions, corresponding to 55, 65, 75, 85 and 95 degrees above a horizontal line of sight. The luminance of the luminaire was set at one of three different values, approximately 17,000 or 8,000 or 5,000 cd/m2, at each angle. The ambient lighting in the room was provided by a direct/indirect lighting system. This lighting was set to provide an average illuminance on the working plane of 280 lx (26 fc) or 506 lx (47 fc). The results obtained demonstrate a significant number of people do experience discomfort from a luminaire overhead, provided the luminaire luminance is high enough. This finding has important implications for the design of luminaires, specifically those using highly specular reflectors and high luminance lamps.

Comparison of Control Options in Private Offices in an Advanced Lighting Controls Testbed
Judith D. Jennings, Francis M. Rubinstein, Dennis DiBartolomeo, and Steven L. Blanc

In a major test of different lighting control technologies in a typical office building, we present analyses of seven months' results from five control scenarios in private offices. We compare the energy savings and effectiveness of various combinations of occupant detection, daylight dimming, and switching techniques. Comparing measured energy use with occupant sensors against baseline energy use calculated using wall switch operation only, we found occupant sensors saved 20-26 percent lighting energy compared to manual switching alone. In offices where light sensor controls were installed and properly commissioned, additional savings up to 27 percent for a total of 46 percent were obtained over a seven-month period, even in an area with unusually high minimum lighting requirements. Dimming the lighting system to desired task levels (task tuning) also resulted in significant (23 percent additional, 43 percent total) energy savings in over lighted areas. On the base case floor, where only bi-level switches were installed, we found significant usage of only one switch resulting in an additional 23 percent savings over single-level switches, an unexpected result with implications for building code requirements.

We found the energy savings due to occupant sensing vs. dimming depended on the behavior of occupants. In offices whose occupants tended to stay at their desks all day, dimming controls saved more energy, and vice versa. The lighting requirements of occupants appear to depend on their type of work.

Modulation and Flicker Frequency Effects on Data Entry Personnel
Marie E. Fleming, S. Ganesh, C.J. Studman, and R.A. Phipps

Recent research has suggested fluorescent light flicker may be a culpable factor in the frequency and severity of health symptoms in the work place. Furthermore, these effects may result in reduced productivity of personnel.

An interventional study was conducted in three data entry offices to assess the effects of fluorescent light flicker on the health and productivity of office personnel. The study compared flicker frequency and modulation depth utilizing low frequency halophosphate, low frequency triphosphor and high frequency triphosphor lamps and control gear. Office personnel completed a questionnaire on a daily basis, which included their health symptoms, satisfaction and perceived productivity. The number of units of data entry work completed per day by each participant was also recorded for the duration of the study.

This paper presents the preliminary results of a key objective of this study: determining if modulation and flicker frequency affects the health symptoms and perception of flicker by office personnel. The results to date suggest the flicker frequency and modulation depth of the fluorescent tubes did not significantly affect the severity of eye strain, lethargy and headache symptoms experienced by the office personnel. The pattern of responses indicates the color rendition of the fluorescent tubes may have been a significant factor.

Just-Perceivable Color Difference Between Similar Light Sources in display Lighting Applications
Nadarajah Narendran, Sandra Vasconez, Peter Boyce and Neil Eklund

Some light source technologies are notorious for being inconsistent in color between lamps of the same nominal type. Producing the same type of lamp with no apparent color differences depends on the manufacturing process and its tolerances. These requirements directly impact the cost of the final product. Therefore, the manufacturers want to know how much color variation can there be between lamps of the same nominal type. An experimental study was conducted to investigate at what point observers perceive a color difference between similar lamps when used in display lighting applications. A mock-up refrigerator display case with two side-by-side cabinets was used as the experimental setup. A novel fiberoptic lighting system with color tuning capabilities was developed and used as the light source in the display cabinets. Human subjects made comparative judgements between the reference cabinet and the test cabinet when the color in the test cabinet was changed in a systematic manner. Several types of colored displays were used in this study. The results indicate a color tolerance criterion

such as the four-step MacAdam ellipse, recommended by ANSI, for a given lamp type is too generous for display lighting applications where the scene has white objects and little visual noise. On the other hand for lighting multicolored displays with a lot of visual noise, the four-step MacAdam ellipse criterion seems adequate. The conclusion that can be drawn is a single criterion for a lamp type will not satisfy all applications. Therefore, it might be better to set different ranges to cover the various application categories.

Structure for Efficiently Coupling Large Light Sources into Prism Light Guides

Peter Kan and L. Whitehead, S.J. Pojar, and K.G. Kneipp

Most prism light guide luminaires receive light through an end window and distribute it uniformly along their length. They work best when the input light is collimated within a half-angle of about 30 degrees. This requirement limits the range of suitable light sources because input efficiency drops rapidly as lamp size increases.

One of the most practical light sources for prism light guides is the metal halide lamp, due to its high efficiency, compact size, and reasonably long lamp life. The most practical designs employ a narrow envelope lamp, mounted axially within a cylindrically symmetrical reflector.

Typically, the maximum coupling efficiency depends on the ratio of prism light guide diameter, D, to lamp arc length, L. For a typical D:L ratio of about 5:1, reflector efficiencies have been around 70 percent. Lower D:L ratios are highly desirable, as this would enable the use of larger, higher output, more efficient metal halide lamps. Unfortunately, however, even modest reductions in the D:L ratio substantially reduces coupling efficiency. For example a ratio of about 3.5:1 typically yields an input coupling efficiency of only about 50 percent.

In this paper, we describe a prism light guide system design, which overcomes the coupling efficiency problems often associated with conventional prism light guide systems. Using this design, it is now possible to efficiently couple light from a 1,000 W metal halide lamp with a 12,000 hour rated life into a 25 cm diameter prism light guide. Such a system will be advantageous in general lighting situations where high efficiency linear lighting is required and where maintenance of multiple point source or fluorescent fixtures is difficult.

4000K Low Wattage Metal Halide Lamps with Ceramic Envelopes: A Breakthrough in Color Quality

F.H. van Lierop and C.A. Rojas, G.J. Nelson, H. Dielis and J.L.G. Suijker

New ceramic envelope technology is now also applied in 4000K lamps. Instead of quartz (straight or formed body) the ceramic material gives opportunities to better meet customer requirements. Elimination or reduction of interaction between lamp filling and envelope material results in remarkable color control and maintenance. Design features of ceramic material will be discussed, and compared to features of fused quartz.

Color rendering and control will be compared, and luminous efficacy and maintenance will be discussed. A comparison with ceramic 3000K lamps will be made.

A discussion of the advantages of ceramic manufacturing processes will be presented, and the influence on lamp properties.

Ballasting Electrodeless Fluorescent Lamps

James N. Lester, and Benjamin M. Alexandrovich

One of the newest high output fluorescent lamps to be used in general lighting contains no electrodes and operates at high frequencies. These lamps present new problems to the ballast designer with regards to starting, operation, end-of-life, radio interference and power measurement. The lamp as a load, appears differently to the ballast compared to traditional electroded fluorescents. This paper examines the unique load properties and provides ballast design information for the new inductively coupled electrodeless fluorescent lamps.

Development and Analysis of a Pedestrian Crossing Warning System

Ian Lewin and John O'Farrell

Research has been conducted in the development of a system of in-pavement warning lights for use at pedestrian crosswalks for increased safety. The system consists of ground embedded units which contain Light Emitting Diodes (LEDs). The units are aligned along each side of the crosswalk. Optics have been designed to provide concentrated beams aimed towards approaching drivers. Several means of system activation have been investigated, both manual and automatic, allowing the system to power up whenever a pedestrian is in the crosswalk.

Investigations have centered upon: Beam spread, ver tical and horizontal; light source color; aiming and lane coverage; and system optics. These factors are discussed in the paper.

Pulsing of the LEDs is used to increase visibility of the lights. Various pulsing schemes have been analyzed to maximize the conspicuity of the system.

Investigations have been conducted to test drivers' reaction time to determine system effectiveness. Results will be provided which report the increases in reaction distances achieved.

Comparison of Operating Characteristics of Ceramic Metal Halide Lamps on Electronic, Magnetic and Reference Ballasts

Mark W. Fellows

This paper reviews variations in electrical and photometric characteristics of aged ceramic metal halide lamps operating on commercially available low frequency electronic, high reactance magnetic, and ANSI standard reference ballasts. Lamp and ballast performance comparisons of wattage, voltage, current, luminous flux, CCT, CRI, and chromaticity values (x-y coordinates) were made at nominal and at 90 percent of rated ballast input voltage and at constant lamp wattage. The most notable performance characteristics were the lower lamp voltage and current on electronic ballasts, variation in luminous flux at different input voltages on magnetic ballasts, and the remarkable consistency of color of the lamps operating at varying power levels on magnetic ballasts. There were no appreciable differences found in the quality of light from operation of ceramic metal halide lamps on either electronic or magnetic ballasts.

Composite CRI

Kevin W. Houser and Ronald B. Gibbons

The Color Rendering Index (CRI) is the most common tool for quantifying a light source's ability to render objects in a way both familiar and natural. One limitation of CRI is it is generally reported for only one type of light ofamiy is it is generally rtiorted for only one type of lightofamiy is it is generally rtiorted for only one type of lightofamiy is it is g