NIGHT VISION AND NIGHTTIME LIGHTING FOR MARINERS

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ABSTRACT

Night vision has not received the same attention in maritime operations as it has in aviation operations. Our objective is to discuss night vision concepts and compare them to low level white light. The paper concludes that commercial maritime operators and dredgers should consider the advantages of low-level white light over the use of red light.

Keywords: Night vision, night time safety, red light, low level white light

INTRODUCTION

A dredge worker drowned in the Houston Ship Channel when the tugboat on which he was riding collided with an inbound barge. The captain of the tug maintained he saw nothing until just before impact. We now suspect when the captain looked out in the darkness of Galveston Bay before pulling away, after having been docked under the brightly illuminated dredge, that loss of night vision may have greatly reduced his ability to detect the inbound towboat and barges. As a result of this incident, the Galveston District has devoted considerable effort in addressing ways to minimize the loss of night vision.

Preserving night vision has long been of concern in the aviation industry, but has not received the same emphasis in maritime operations. We know that bright lighting in cabins and cockpits greatly reduces our night vision sensitivity. The traditional lore has been to use dim red lighting to allow sufficient light to read charts and equipment, yet maintain good night vision. However, in this day of computerized navigation equipment, red light is not the best choice. This article will discuss our night vision and recommend low-level *white* light as a better choice for bridge lighting.

RODS AND CONES: THE TWO VISUAL SYSTEMS

How do we see at night, anyway? And how is it different from our daytime vision? The answer is that the human eye contains receptors for two essentially independent visual systems. The receptors are light-sensitive cells in the back of the eye (the retina) called “rods” and “cones” (due to their shapes when viewed under a microscope).

When the sun is out, or when we are under normal indoor lighting, we are using our daytime, (or “photopic”) vision provided by our cones. There are three types of cones – red, green, and blue – that allow us to see the world in color. The cones are also very densely packed together, especially in the very center of the retina (called the “fovea”), which allows us to have very acute spatial vision (i.e., we can read very small print and see fine details).

At night, with little or no light, we see using our rod vision, or night (“scotopic”) vision. The rods are about ten thousand times more sensitive to light than are the cones. Thus, in dark environments, the rods can “see” things that the cones cannot. Unlike the color vision we have in daytime, rod vision is black and white (shades of gray). Rods are also more sparsely distributed in the retina than are cones, which means rod vision is not nearly as acute as is cone vision. A person having normal, 20/20 daytime vision will generally see over ten times worse (i.e., less than 20/200) in the dark or in very dim illumination. Thus, you can’t read the small print on nautical charts or computer displays with only your rods.

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THE NIGHTTIME NAVIGATION PARADOX

That leads us to the crux of the problem for nighttime navigation. In order to see a ship in the distance on a cloudy night, we need our rod vision. But in order to read charts and computer displays, we need our cone vision. And we can't have both at the same time. We need higher light levels for the cones to be active and to read fine print. But at that level of illumination, the rods are not nearly as sensitive as they are in total darkness. And just turning off the lights is not sufficient: it takes time for the rods to readjust to the dark—in fact, if you started out under very bright lights, and then turned off all lights, it would take about 30 minutes before the rods would regain their peak sensitivity. What to do? This has led scientists to consider whether there might be certain wavelengths ("colors") of light that will allow the cones to "see" without disturbing the sensitivity of the rods.

RIG FOR RED: A SCIENTIFIC "OOPS!"

Vision scientists have known for a long time that the rods and cones are sensitive to different wavelengths of light (called "spectral sensitivity"). The visible spectrum – that is, the wavelengths of light that the eye can see – goes from about 400 nm (nanometers, or billionths of a meter) to about 700 nm. The short wavelengths (at the 400-450 nm end of the spectrum) appear violet or blue using daytime vision, and the longer wavelengths (at the 650-700 nm end of the spectrum) appear red. It has been found that under normal daytime light levels (cone vision), we are most sensitive to light around 555 nm (appears yellowish-green), whereas our nighttime vision (rod vision) is most sensitive to light around 505 nm (light at this wavelength would appear blue-green to the cones, but of course it, and all wavelengths, appear gray to the rods). These relative spectral sensitivities were confused in the early days with absolute sensitivity of the rods and cones, and as a result, a scientific blunder was committed.

Around World War II scientists were trying to figure out how to light Navy ships and submarines so that mariners could see well at night. Someone noticed that the relative spectral sensitivity curve appeared to show thlenivity s displays, avoids eye fatigue, and is psychologically more agreeable. And when kept at low illuminance levels, there is very little additional dark adaptation time needed when turning off the lights to see in the dark. The last point is very important, since it was the reason people went to red lighting in the first place. The Navy recommends a very dimly lit bridge at night: 0.5-2.0 foot-candles (fc) is the range of light intensity recommended. (For comparison, normal office lighting is about 40 – 60 fc, the light from a street lamp is around 1 fc, and the light from a full moon on a clear night is roughly 0.03 fc.) When a ship's bridge is illuminated at 1.0 fc with red lighting, and the lights are turned off, it will take approximately three to four minutes for the rods to reach their peak sensitivity. Using white light instead of red light increases the adaptation time by only about a minute and a half. Therefore, at low levels of illumination, the practical difference between the effects of red vs. white light on dark adaptation time is almost insignificant. This is not true, however, at higher light levels.

One additional point to consider: the two eyes adapt independently of each other. To maintain the greatest degree of dark adaptation, one can place a black patch over one eye before turning on lights to read charts and displays. The patched eye will retain its level of dark adaptation (if little or no light leaks under the patch), while the unpatched eye can read the charts. When the lights are turned off again, take the eye patch off. The eye that was exposed to the light will need time to readjust to the dark, but the eye that was covered will still be at or near its peak sensitivity. (A word of warning: some people find a patch over one eye to be disorienting, especially if worn in higher light levels, since it prevents normal binocular depth perception. Take special care in moving around while wearing an eye patch.)

In summary, recreational and commercial mariners should consider the advantages of using low-level white light and make a concerted effort to use less light. As with red lighting, the lights will need to be turned off for about five minutes before maximum rod sensitivity is obtained for detecting ships and potential hazards in the water. Low-level white lighting greatly surpasses red lighting in supporting good color discrimination and, therefore, accurate reading of charts and displays.

The views expressed in this article are those of the authors and do not reflect an opinion, standard, or recommendation by the U.S. Coast Guard or U.S. Army Corps of Engineers.