Making the Switch to White Light

Through the 70's and 80's, the preferred lamp technology for industrial facilities was high pressure sodium (HPS). This light source is most readily identified by the orange-yellow cast of its light. Its popularity in industrial applications was due to a number of factors, but relatively long life and high luminous efficacy were chief among them. HPS lamps lasted longer and produced more light per input watt than any other light source on the market. They were available in high output configurations (400W, 1000W) which allowed a single luminaire to service a relatively large area, thus reducing installation and maintenance costs. HPS was also thermally insensitive, and the arc tube was sufficiently compact to permit an ample degree of optical control.

However, the HPS lamp did have one significant drawback related to color. The light that it produced was distinctly "off white" in appearance and objects placed in its path did not exhibit the degree of color contrast we normally associate with so-called "white" light. Blues and greens were dull and difficult to distinguish due to the relative absence of energy in that portion of the HPS spectrum. While the luminous efficacy of HPS was "best in class", the quality of the visual environment that it created was decidedly lacking.

In order for light to be perceived as white, it must be comprised of a sufficiently diverse blend of wavelengths, or colors. As a point of reference, it may be helpful to recall the behavior of white light as it passes through a prism. The special optical properties of the prism act to separate the incident white light into its various color components.

This blend of colors is also what allows white light to provide superior color rendering. Color rendering is a technical term that refers to the capacity of a given light source to reveal a broad range of colors throughout the visible spectrum. Objects considered to exhibit color do so by preferentially reflecting specific wavelengths of light. In other words, an object that is perceived to be red in color achieves its appearance by preferentially reflecting wavelengths in the red portion of the visible spectrum. Those wavelengths must, of course be present in order for the object to reflect them. Thus, only light sources having a red spectral component are capable of rendering such an object in a natural way. Daylight is commonly used as a reference condition in color science due to its special blend. All colors are present and this allows daylight to provide a rich and complete color experience.

The lighting industry utilizes a metric known as CRI (color rendering index) to gauge the overall color rendering ability of a light source. CRI ranges from 0 to 100 (100 being the best). The following is a list of common white light sources and their associated CRI values in comparison to HPS:

Light Source	CRI
Incandescent	95
T8 Linear Fluorescent	75-85
Compact Fluorescent	82
Standard Metal Halide	65
Cool White Linear Fluorescent	62
Standard HPS	**22**

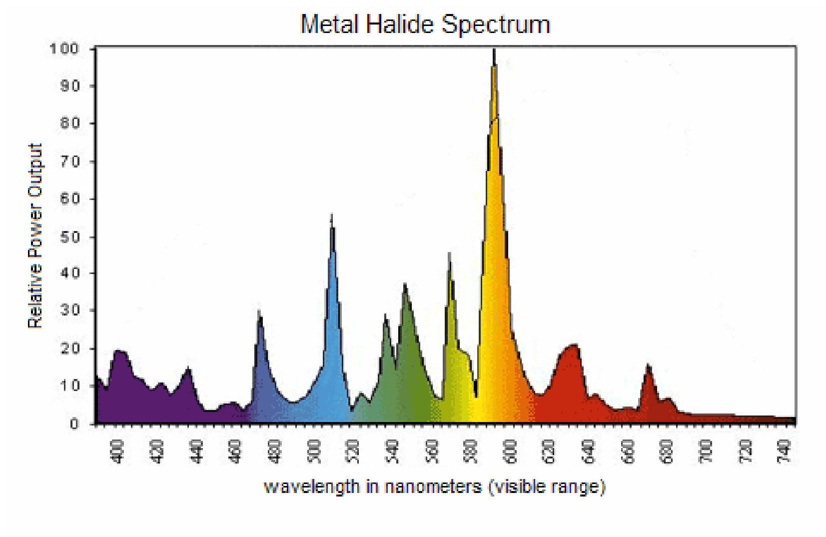
The human eye uses contrast to distinguish objects from their surroundings and there are only two types of contrast, luminance and color. Luminance contrast exists whenever an object's brightness is different than its surround - for example, black text on white paper. As the name implies, color contrast occurs whenever the color of an object is different than its surround. White light improves color contrast due to its increased color rendering ability, and therefore improves overall visibility under most circumstances.

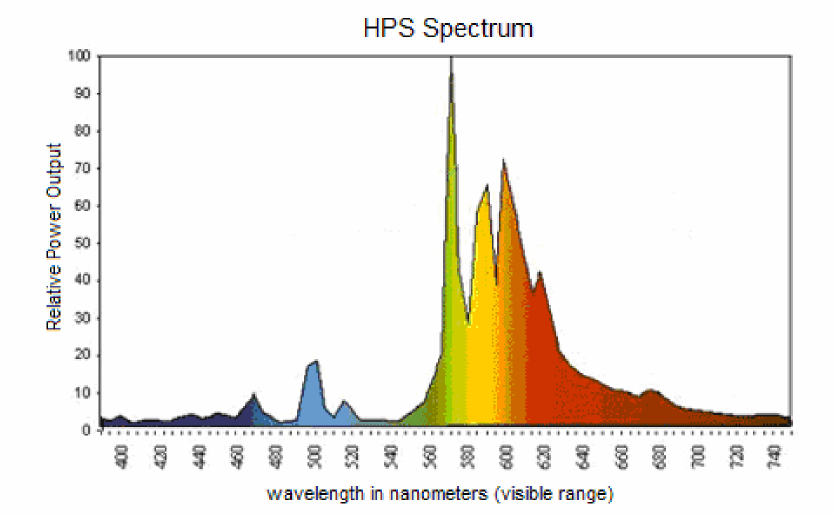
Additionally, it should come as no surprise that people tend to prefer "white light" or sources that are perceived as providing a "natural color of light", particularly in the work environment. Beyond merely having a preference, occupants and professional lighting practitioners have long observed that spaces lit with white light sources appear brighter than those lit with HPS even when the light meter would suggest otherwise. The orange-yellow hue of HPS light is often associated with a perception of dinginess, even at relatively high light levels. Conversely, white light is typically perceived as clean, crisp and vibrant even at lower measured light levels. These perceptions have been shown to impact everything from worker satisfaction and corporate image to customer perceptions of cleanliness and efficiency[2].

In the late 80's, these observations led to a trend toward the use of more truly white light sources for the illumination of industrial environments. Metal halide lamp technology provided a viable alternative. While it lacked the luminous efficacy and life of HPS, the respective value of the white light that it provided began to overshadow the virtues of HPS. The image below helps to convey this distinction.

In the last decade, this trend has been accelerated by the advent of pulse start metal halide lamps. This generation of technology significantly improved both the efficacy and useful life of metal halide lamps. From 1990 to the year 2000, metal halide lamp shipments grew at twice the rate of HPS, and a 2002 survey estimated that the installed base of metal halide lamps had grown to outnumber HPS by 4 to 1 in the industrial sector[1]. White light systems are now specified for the vast majority all new facilities.

Ongoing research that emerged in the 90's has begun to establish a possible scientific basis for the observations described herein[3]. This research shows that both brightness perception and visual acuity (the ability to distinguish fine detail) are more strongly affected by wavelengths in the blue-green portion of the visible spectrum. Various light sources produce a unique proportion of wavelengths based on their construction and operating conditions. This color signature is known as the Spectral Power Distribution (SPD) of the light source and is shown graphically below for metal halide and HPS light sources.





As can be seen, HPS produces relatively little energy in the blue-green portion of the spectrum and these are the wavelengths that the research suggests are most critical to visual acuity and the perception of environmental brightness. The research quantifies these findings through a metric known as the S/P ratio - where the S stands for scotopic and the P for photopic. Scotopic and photopic refer to two different characterizations of the eye's relative sensitivity to different wavelengths of light. The photopic system is the basis for defining the lumen output of lamps and the calibration of light meters used to measure illuminance (footcandles). The research proposes adjusting traditional photopic light measurements by S/P ratio factors to better align with the perceptions and measured responses of research participants. This method implies that a factor of up to 1.5 to 2.0 (depending on the lighting application) should be applied to metal halide in comparison to HPS when evaluating traditional lighting metrics such as lamp lumens and illuminance.

Though this research is still controversial, and has not yet been officially adopted by the Illumination Engineering Society of North America (IESNA), many lighting practitioners have already begun implementing its recommendations. These individuals feel that it more accurately represents their own professional observations as well as those of their clients and end users. It has certainly been the experience of many, including Stingray Energy Systems and its customers, that somewhat reduced levels of metal halide lighting (relative to HPS) appear at least equivalent in terms of brightness and visibility.

Making the switch from HPS to white light represents a dramatic change to the visual environment. Without fail, those who make the transition are delighted with the results. The environment becomes brighter, more vivid and natural. Worker morale often improves and very tangible benefits such as enhanced productivity, lower reject rates and reduced absenteeism are not uncommon.

References:

[1] U.S. Department of Energy. Draft Report: High-Intensity Discharge Lamps Analysis of Potential Energy Savings. December 2004.

[2] Fetter, J. New Lighting Technologies Make Old Manufacturing Facilities Seem New. Energy & Power Management. October 2001.

[3] Berman, S. The Coming Revolution in Lighting Practice. Energy User News. 25(10), 2000.