RECENT ADVANCES IN LIGHTING QUALITY AND ENERGY EFFICIENCY WITH TRADITIONAL LIGHT SOURCE TECHNOLOGY

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While there has been much activity in the development of solid state lighting devices in the past five years, progress in improving the performance of lighting systems based on traditional light sources has continued almost unnoticed by those not directly involved. Not only have there been significant advances in the well established product lines such as linear fluorescent, compact fluorescent and metal halide discharge lamps but also newer technologies such as electrodeless light sources, especially those based on low-pressure inductively coupled discharges and microwave-powered high-pressure discharges, have begun to make impacts on the market. It is vital for lighting designers, specifiers and building services engineers to keep abreast of this progress so that the most appropriate technology can be selected for each lighting application.

A review of the development of metal halide discharge lamps from their first introduction to the market to the present day helps to illustrate the technical advances made and some of the challenges that are still to be overcome. Although the first generation of metal halide discharge lamps offered a considerable performance improvement compared to high-pressure mercury lamps, some of their limitations were soon recognised. Despite the lamps having better efficacies and colour rendering properties than the high-pressure mercury lamps, the colour variations and lumen maintenance factors presented opportunities for further performance enhancements.

The advent of metal halide discharge lamps with ceramic arctubes (ceramic metal halide lamps) in the mid- to late-1990's led to major changes in the customers' expectations for the performance of metal halide lamps. Many of the limitations of the early generations of metal halide discharge lamps with fused silica arctubes were overcome. At first the range of ceramic metal halide lamps was restricted to 70 & 150 W but this has now been extended to a vast array of products from 20 to 400 W. The past 10 years has also seen major improvements in electronic ballasts for high intensity discharge lamps with many offering dimming. It has to be noted that not all of the benefits shown by ceramic metal halide lamps in the 20 to 150 W range have been translated into the higher power range, 250 to 400 W.

Despite the principles of electrodeless discharge light sources having been known for more than a century, the first patent being granted in 1891 [1], it took many years for the first commercially viable product to be introduced. Electrodeless discharge lamps have several advantages over conventional light sources: the deposition of electrode material onto the arctube walls which reduces lumen maintenance is eliminated; chemical systems which are known to have high efficacies but are not compatible with electrode materials can be employed; lamp design and production are not restricted by the need to provide a conductive path into the arctube. Advances in the conversion efficiency of mains power to microwave radiation together with inventions to improve the transfer of energy into the discharge chamber have recently given rise to a growing number of highly efficient lighting systems becoming available.

Although increases in the efficacies of light sources and efficiencies of ballasts are well documented and widely publicised by manufacturers, it is rather more difficult to quantify the potential opportunities for improvements in lighting quality. Conventional quantitative measures for lighting quality concentrate on colour rendering and colour chromaticities. The difficulties in defining new models to describe the colour rendering properties of light sources are reflected in the large amount of activity in the CIE, especially in the work of TC 1-69. An alternative quantitative measure of lighting quality is that of colour control which may be regarded as a combination of colour spread and colour shift. The former can be taken to be represented by the range of colour appearances in a group of light sources after a specified burning time. The latter can be quantified by the difference in mean colour appearances for a group of light sources between 100 h and a specified burning time.

In this paper, colour spread is defined as the size of the Standard Deviation of Colour Matching (SDCM) ellipse that will contain 90 per cent of the light sources of a particular group. Similarly, colour shifts will be quantified both by the change in colour point, again by reference to the size of the SDCM ellipse that contains 90 per cent of the light sources of a particular group, and by the change in Correlated Colour Temperature (CCT) with respect to the corresponding values at 100 h.

The table below describes the colour control of a set of 150 W ceramic metal halide lamps operated horizontally at 100 and 9000 h [2]. This illustrates that metal halide discharge lamps can now match the colour control demonstrated for many years by fluorescent lamps.

Burning time	CCT	Chromaticity		Colour spread	Colour shift	
hours	K	x	y	SDCM	CCT/K	SDCM
100	3849	0.382	0.363	3	-	-
9000	3897	0.381	0.367	3	+48	2

It should be remembered that the colour control as described above relates to the characteristics of the light sources, the actual appearance in an installation will depend upon the skill of the lighting designer and the nature of the immediate surroundings.

References

[1] N Tesla, Improved methods of and apparatus for generating and utilizing electric energy for lighting purposes, British Letters Patent No. 8575 (1891).

[2] E C Guest, M H Girach, S A Mucklejohn & U Rast, *Lighting Res. Tech.*, 40, p.333-346 (2008).