Demonstration and Assessment of a Sulfur Lamp Retrofit Lighting System at Hill Air Force Base, Utah

Summary

In late 1997 and early 1998, a partnership between government and industry combined efforts to replace the lighting in a hangar at Hill Air Force Base (HAFB) in Utah with new sulfur lamp (S-lamp) systems as part of a project to test and evaluate the technology. S-lamps use microwave energy to produce a plasma that emits a high level of visible light across a broad color spectrum, and they promise efficiency savings compared to conventional high intensity discharge lamps in comparable applications. Fusion Lighting, Inc., which developed the technology with assistance from the US Department of Energy (DOE), initially introduced the product as the Solar 1000™ lamp in 1994 and replaced this version in the fall of 1997 with an improved model, the Light Drive™ 1000.

The test space is located in a 284,000 square foot area in a building that houses maintenance and rebuilding activity for F-16 and C-130 aircraft at the base. Part of the area has a low ceiling, requiring hollow light guides, developed by 3M Corporation, to distribute the high intensity light with adequate uniformity. The remainder of the area has a high enough ceiling to permit the use of more traditional high-bay luminaires adapted for S-lamps by Cooper Lighting. In all, 288 Light Drive™ 1000 lamps have been installed, 50 in each of four high-bay areas, and 88 in the low-bay area at the ends of 44 tubular light guides, each 104 feet long.

With DOE program direction and financial support, Pacific Northwest National Laboratory (PNNL)[1] undertook to assess the efficiency and performance of the system. Both before and after installation, PNNL collected data characterizing lighting level and color, as well as electric energy consumption and power quality characteristics, for a section of the low-bay area and a section of one of the four high-bay areas. Because the lighting that was replaced by the S-lamps was antiquated, PNNL also developed a conceptual scheme for lighting the areas with conventional modern metal halide low-bay and high-bay downlight luminaires for purposes of comparison. Finally, the lab administered pre- and post-installation surveys of building occupant responses to gain insights into worker satisfaction and possible impacts on productivity.

The following findings resulted from the assessment:

- S-lamps produced lighting levels that were approximately 39 percent to 47 percent higher in the low-bay area, and 130 percent to 160 percent higher in the high-bay area, compared to the conventional high-intensity discharge systems they replaced.

- The S-lamp high-bay luminaires generally exceeded the 75 foot-candle lighting level target by 25 percent, while the light guides in the low-bay area fell short of the same target by approximately 19 percent.

- Characterized in terms of the CIE Uniform Chromaticity Scale, the new and old systems produced similar coloring on surfaces. S-lamps appear to provide greater uniformity in the high-bay area.

- Energy consumption increased by 63 percent in the high-bay area with the installation of the S-lamps. This was due to the inadequate lighting in place beforehand, the requirement to use preëxisting fixture locations that were closer than optimally-spaced, and the addition of 16 more S-lamps to illuminate side and storage areas not previously lighted. Had all of the pre-retrofit lamps been working and the 16 additional side lights not been installed, the high-bay energy consumption would have increased by

[1] Pacific Northwest National Laboratory (PNNL) is operated for the U.S. Department of Energy by Battelle Memorial Institute

only 26 percent and still provided at least twice the light level. In the low-bay area, energy consumption decreased by 42 percent, where the light guides replaced inefficient fixtures.

- Compared to an appropriately designed lighting system to achieve comparable lighting levels with metal halide lamps, the S-lamps in the low-bay area would consume 17 percent less energy, and the ones in the high-bay would consume 37 percent less. The difference in savings is due primarily to losses in the light guide arrangement needed to compensate for the lower ceiling in the low-bay area.

- As measured at individual lighting circuits, the S-lamps' power factor, total harmonic distortion (THD) and crest factor were approximately 99 percent, 2.7 percent and 1.4 respectively. These figures are similar to pre-installation values, except for THD, which was between 7 percent and 16 percent beforehand. Metal halide lamps typically have THD values around 19 percent.

- Workers in the building reported being able to read samples of small type on the occupant survey more easily after the S-lamp installation than before. Compared to pre-installation conditions, fewer workers perceived flicker from overhead lights as a problem, while more were bothered somewhat by reflections on computer screens, possibly due to the increased light levels from the S-lamps. Because defective fixtures were replaced in the low-bay area after the the post-installation survey was administered, the responses do not fully reflect the performance of the lighting now in place. The later replacements probably enhanced the ability of workers to read small type and increased the reflections on computer screens compared to what was reported.