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METAL HALIDE LAMP TILT FACTOR

Thomas M. Lemons

TLA-Lighting Consultants, Inc., Salem, MA 01970 USA

Background: It is known that metal halide lamps have reduced light output when operated at angles other than the specified vertical or horizontal operating position[1]. With some lighting installations such as sports lighting the use of a tilt factor is normally an integral part of the lighting calculations when using MH lamps. New data, however, has identified a concern for the correctness of the present data and recent experience has identified that more applications should include the use of a tilt factor when making performance calculations.

Lamp data: There are a variety of metal halide lamp operating restrictions. This includes types designed for vertical operation with either a base up or base down recommendation and others designed for horizontal operation. Some types are known as having a universal operating position of either base up to horizontal operation or base down to horizontal operation. Some lamps have a very limited operating position such as horizontal ± 3°. All of these restrictions come from the fact that the lamps are designed to achieve a stable performance at their specified operating position(s) which can change as the internal thermal conditions change as the operating angle varies. Presently there is little published data for the metal halide lamp lumen output except for published data for the lamps at a horizontal and/or vertical position. It is therefore important to better understand how the operating position of metal halide lamps will modify the lamp lumen output.

Tilt factor: Lamp tilt factor data reported in 1970[12] was obtained in a test laboratory by first stabilizing the operation of a lamp in its nominal position which was vertical. The lamps used therefore were stabilized vertically for 100 hours. The lumen output of the lamp at this stabilized position was then recorded, the lamp was placed at an angle, the lamp was operated at this angle until the light output stabilized and the lumen output was again recorded. The lamp was again returned to the vertical position, stabilized, placed at a new angle, stabilized and the light output recorded. This procedure was repeated over a range of 90° for a number of lamps until an average value for the metal halide lamp was established. The tilt factor was then established for metal halide lamps which identify a variation in light output when the arc tube is at angles from 0° (vertical) to 90° (horizontal).

In actual lighting installations the luminaires are installed, aimed at some angle and operated at that angle without further aiming angle change. The lamps therefore are never stabilized for 100 hours of operation at their designed burning position which might be vertical or horizontal. Many metal halide lamps, however, are operated in their lighting application at some angle where the arc tube is not in the lamp's vertical or horizontal rated position. This raises a question about how applicable the tilt factor is for MH lamps that are operated at an angle for their whole life that is not vertical or horizontal. New tilt

[1] Lemons, T. M., and Levin, R. E.; *High intensity discharge lamps and their environments,* IEEE Conference Record of 1970, Fifth Annual meeting of the Industrial and General Applications of Light Committee, October 8, 1970, Chicago, IL

factor data for all MH lamps must therefore be obtained and the data for the lamps should be the performance at the specific angle over the lamp's life.

Lamp technology: In the first 100 hours of operation of a metal halide lamp, the salts of metal placed in the arc tube find a resting point from which they enter and exit the arc. Each salt of metal produces a separate portion of the spectrum and the color of the light output changes as the lamp starts and slowly reaches its final operating wattage and the resultant internal temperatures. For a vertical operated lamp, the internal temperatures in the arc tube are highest at the top and lowest at the bottom. When the lamp is off, the salt pool is around the bottom of the arc tube. For horizontal operated lamps the arc bows up and the salt pool is at the bottom center of the arc tube. In both cases, some of the salts of metal hide in crevasses at the end of the arc tube and some lamps are coated with a white material at one or both ends to increase the heat at the coated end to limit such salt of metal hiding. Also as lamps age, tungsten from the electrodes cause blackening which reduces the light output and changes the internal temperatures. Lamps operated at an angle other than vertical or horizontal have very different internal temperatures and salt pool locations and therefore their performance varies. As found with the tilt factor established for stabilized lamps, the lowest performance occurs when the arc tube is at an angle from 60° to 75° fro vertical. I can therefore believe that a lamp that is not stabilized at a vertical or horizontal position but is always operated at angles of 10° to 85° will have different lumen output and lamp lumen depreciation than would be expected by using the present tilt factor information.

New tilt factor data: To determine how metal halide lamps perform when operated at a specific angle for the life of the lamp, two types of lamps were tested at angles of 15° and 30° below horizontal. Further data was obtained for these lamps operated horizontally and the results are found in Figure 1. The tilt factor data obtained in 1970 indicated that lamps operated at angles of 60° to 75° had a decrease in the lumen output of about 20%. The performance of the one type metal halide lamp operated at 15° below horizontal had a 100 hour lumen output that was about 55% of the same lamp operated horizontally. The same lamp operated at 30° required 200 hours of operation before it lost about 40% of its performance.

Conclusion: Presently there is no published data from lamp manufacturers that provides metal halide lamp tilt factor data. This paper has been prepared to identify that the present limited data about metal halide lamp tilt factor performance is inaccurate. Recent experience in actual installations was the reason that the material in this paper was obtained. Based on these results, luminaire manufacturers and designers should therefore require the lamp manufacturers to provide specific lamp tilt factor performance data for MH lamps operated for their whole life at an angle other than vertically or horizontally. This information is urgently required to fully understand the performance of MH lamps.