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Author(s): Robin Siegel
Topics in Photographic Preservation, Volume 2.
Pages: 62-68
Compiler: Maria S. Holden

Topics in Photographic Preservation is published biannually by the Photographic Materials Group (PMG) of the American Institute for Conservation of Historic & Artistic Works (AIC). A membership benefit of the Photographic Materials Group, *Topics in Photographic Preservation* is primarily comprised of papers presented at PMG meetings and is intended to inform and educate conservation-related disciplines.

LIGHT-FADING OF COLOR TRANSPARENCIES ON DESK-TOPS

Robin Siegel

Conservator, National Geographic Society

Presented to the American Institute for Conservation
Photographic Materials Group
February 7, 1987

In 1984, the Illustrations Library of the National Geographic Society moved into a newly constructed building. Designed by a parliament of outside consultants, the new facility combined state-of-the-art office equipment with expert direction in effective work-place design.

An inherent problem was discovered with the Lightolier lighting system, designed to combine high illumination with cost effective climate control. The light fixtures recessed into the ceilings feature a ventillated, stainless-steel, parabolic reflector which maximizes the beneficial rays of the two flourescent bulbs by focussing the light directly down while simultaneously reflecting it to the sides.

The lighting consultants had recommended equipping the fixtures in the Illustrations Library with the Norelco Color 84 series tube, a low ultraviolet tube rated at a color temperature of 4100 K, with an ultraviolet emission level of 47 microwatts per lumen, which is considered extremely low and should require no

filtration. (Incandescents emit less than 75 microwatts per lumen, whereas sunlight is composed of about 400 microwatts per lumen.) They were also recommended because of their high color rendering index and good color temperature, and of course, high lumen output per watt. In spite of the fact that these bulbs were used, it quickly became apparent that an unacceptable amount of light-fading was taking place at a much faster rate than had been experienced in the old building.

Almost as soon as we had moved, employees began to notice that their personal prints and wall decorations were fading rapidly, and original transparencies began appearing in the re-filing boxes with unusual discolorations. Some slides, for example, were clearly faded by light falling on them while they were bound to others with a rubber band.

To get an idea of where the fading might be occurring, I surveyed storage and handling procedures throughout the Society, and then set up a series of fading tests. The first step was to establish that the ceiling illumination alone was capable of effecting the amount of fade we had been seeing.

Fresh rolls of Ektachrome 64, Fujichrome 50, and Kodachrome 64 were exposed with grey scales and color patches. Kodachrome was processed at Kodak. Fujichrome and Ektachrome were processed in the National Geographic Photo Lab.

Samples were enclosed in polypropylene pages, placed on white paper, and laid on a counter in the cubicle area of the

Illustrations Library, where they were exposed to approximately 100 footcandles of illumination, 18-24 hours a day for ten weeks. Temperature remained between 72-75 degrees, relative humidity between 45-55%.

Simultaneous tests were conducted in several areas in the older building.

Readings of color density were made before the test and again at two-week intervals, on three samples of each film type, at ten points on each sample. As was expected, the Kodachrome showed a far greater rate of fade than either Ektachrome or Fujichrome, especially in the magenta dye.

The lack of a white diffusion filter combined with the parabolic design of the reflector result in a focussing of the light and an increase in the fading properties. In the Illustrations Library, under the new Lightolier fixtures, the Kodachrome lost as much as 50% of the magenta by the end of eight weeks.

The results of these early tests convinced me that, in fact, the unexpected fading could be attributed to exposure to nothing but ceiling light falling onto the desks and countertops. These results appeared consistent with findings published in Kodak's two leaflets titled "Evaluating Dye Stability of Kodak Products," (January 1982, CIS-50, and June 1982, CIS-50-41), so I contacted Stan Anderson at Kodak to try to discover the conditions under which their tests had been conducted.

Stan informed me that their samples had been exposed to regular cool white and deluxe cool white tubes at an illumination of 500 footcandles.

We agreed that although my tests were conducted at a lower rate and illumination level, they could be considered comparable to the Kodak results. Due to the variations in consumer conditions, Kodak has set no guidelines for the predicted rate of fade under normal conditions.

Satisfied with the initial results, I set out to discover a means of improving our own lighting system. As the Illustrations Library is an editorial office and not a fine arts exhibit area, we have to provide the recommended level of illumination for proofreading, or around 100 to 135 footcandles of light at the desk level. The fact that the offices in the old building had been adequately lit, while not causing any fading problems, was a mystery, and I could get very little information from the various lighting experts and manufacturers. The physics involved in the production of flourescent light is highly complex, and there is a great deal of variation in products on the market, so I decided to compare a few of the bulbs and see if any were better than the rest.

I obtained a Lightolier ceiling fixture in June, and situated it in an area of the Lab that wouldn't receive other extraneous light.

I tested four types of flourescent bulbs:

The Sylvania Cool White Deluxe, rated at a color temperature of 4100K, an overall lumen output of 2150, and a UV output of 123 microwatts per lumen.

The Philips Ultra Lume equivalent to the Norelco Color 84, rated at 4100K, 2900 lumen output, and 47 microwatts of UV per lumen.

The Duro Test Color Gard 50, rated at 5000K, 2200 lumen, and a UV level of under 1 microwatt per lumen

The Verilux VLX/M Full Spectrum, rated at 6200K, 1984 lumen, and 47 microwatts of UV per lumen.

I also conducted a test using the Sylvania bulbs sleeved in Rohm and Haas ultraviolet shields.

Fresh Kodachrome 64 slide film was exposed to a sensitometry step tablet. Film was processed normally by Kodak.

Samples were exposed vertically in the same manner as in the first test, but at a distance of 24 inches from the front bulb. This produced 130 to 260 footcandles of illumination, varying with the intensity of the bulb. This distance allowed me to accelerate the test without significantly raising the temperature or affecting the humidity. In fact, measurements taken in front of the fixture at that distance were the same as those taken off to the side.

Tests ran continuously. The light fixture was disconnected only to change bulbs between tests. Temperature and humidity was monitored throughout. Where variations in either occurred, tests were repeated for verification.

Densitometric readings were taken at beginning of test, at ten days, 21 days, and 28 days. Tests were ended on 28th day. Readings were made at five points on a twenty point step tablet, and at five points on a color chart.

Results, interestingly, appeared roughly proportional to the total lumen output of the bulbs, and not the UV output, except in the case of the Sylvania in the sleeves. I don't have a lumen rating for this arrangement, but I suspect it is more than a ten percent loss, putting it below the Verilux.

In general, the quantitative results broke down as follows:

In front of the Philips bulbs, the green density decreased between 9% and 50%, averaging 36%

In front of the Sylvania bulbs the green density decreased between 8% and 50%, averaging 35%.

The Verilux caused a decrease of from 6% to 48%, averaging 32%.

The Duro Test caused a decrease of from 5% to 46%, averaging 31%

Considering there exists such a difference in their ultraviolet output, the closeness of these results is somewhat surprising.

With ultraviolet shields, the Sylvania magenta fade rate was between 5 and 44%, averaging 27%. This appears to be a vast improvement when compared to the 35% fade without the shields, but is not that much better than the Duro Test.

I would like to continue testing lighting conditions, but I have tentatively recommended the following to our engineers:

Where possible, fixtures should have only one bulb. Eventually we should install some sort of diffusion filter over the Lightolier fixtures.

Bulbs that illuminate areas in which slides are viewed and stored should be Duro Test Color Gard bulbs, or a comparable bulb if I can find one (at $11.25 a piece, they are about ten times the price of the Sylvanias) or be sleeved in UV shields. I hesitate to recommend these sleeves for all applications, because:

I have found the sleeves to be extremely awkward to install in our fixtures.

The sleeves increase the heat in the bulb and reduce lamp life.

Sleeves, although relatively inexpensive, are brittle and likely to break every so often when bulbs are changed.

Here again, a flat filter would be effective but is not available for the Lightolier.

I am not recommending the Verilux for the editing of photographs, because with its low lumen output and high color temperature, I found it to have an objectionably blue cast, and at only 1984 lumen, they are a bit too dim for this purpose.