Concerns for Multi-Use Viewing Booths: Impact of Changing Illuminance for Proofing and Monitor Match Applications

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Abstract

One critical variable for proofing workflows is the color viewing technologies. In many virtual proofing instances, color viewing booths are tasked with serving two roles: the traditional "hard proofing mode," in which a hard copy proof is evaluated, and a "monitor match mode," where the viewing booth is dimmed to match the monitor in circumstances when retouching tasks are performed.

In particular, the hard proofing mode is prescribed by ISO3664:2009, which prescribes aiming for a high uniform illuminance of 2,000 lux. This level of illuminance is too high for a monitor match mode when retouching applications require a simultaneous comparison of a hard proof and a monitor display of the same image. The need for a dimmable viewing booth has been addressed by viewing booth manufacturers with three technologies: a user-adjustable dimming control (e.g., potentiometer), an external sensor, and a direct connection to the virtual proofing software.

With the user-adjustable method, the user simply adjusts the booth illumination until a visual match to the monitor display is achieved. This can be thought of as a qualitative method: it is wholly dependent on the visual evaluation of the user.

A more quantitative method involves using an external sensor. With this method, the user places the sensor on an area of the monitor representing substrate-white, and the booth automatically adjusts the booth to achieve an illuminance match.

Another quantitative method involves a direct connection to the virtual proofing software. Here, the booth is connected to the workstation running the software,

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and the user indicates that they wish to move from hard proofing to monitor match mode. The illuminance of the booth is then automatically adjusted.

A review of the academic literature resulted in no found studies that evaluated potential differences between the sensor method and the direct connection method for evaluating viewing booths.

Viewing booth warm-up time is another variable in critical color viewing applications, especially for booths using fluorescent tube luminaires. As the fluorescent tubes warm, variables relevant to color viewing shift until a stable condition is achieved. This is true when working from a cold start, e.g., when the booth is turned on in the morning after being off all night. It is also true when the luminance of the booth is adjusted. In recent years, viewing booths with Light Emitting Diode (LED) luminaires have been introduced. As LEDs do not generate heat at the same level as fluorescent tubes, variation in warm-up time requirements as compared to fluorescent tube technology is expected.

Other relevant variables for standardized viewing include the correlated color temperature (CCT), general color rendering index (Ra), chromaticity error (CE), metamerism index visual (Mivis) and metamerism index UV (Miuv).

Research Questions:

Given the variables, the current study explores the following research questions:

1. What is the quantified stabilization time for fluorescent tube and LED viewing booths from a cold start?
2. What is the quantified stabilization time for fluorescent tube and LED viewing booths when changing from hard proofing mode to monitor match mode?
3. Is there a difference in monitor match illumination between the external sensor viewing booth and a direct connection viewing booth?

Materials:

I. Measurement solution for viewing booths
  - A. GL Optic Spectis 1.0 Spectrometer with GL Optic Spectrosoft software

II. Viewing booths
  - A. GTI 1Xi Fluorescent viewing booth with external sensor for monitor match
  - B. Just Normlicht Color Communicator II LED viewing booth with direct connection for monitor match

III. Soft Proofing System:
  - A. ICS Remote Director software for virtual proofing application, with Eizo monitor and Datacolor Spyder X Pro colorimeter

Methods

To address the first research question addressing the stabilization, each viewing booth was turned off for at least eight hours before testing. The spectrometer was affixed to the back of the first tested booth and set to measure every 20 seconds for at least 40 minutes. Before measuring, the spectrometer was allowed to warm up for at least five minutes, and a dark current calibration of the device was performed per the manufacturer's instructions. The obtained results were recorded in the Spectrosoft software.

It is noted that the fluorescent viewing booth was re-lamped prior to the study and was left on at 100% illuminance for at least 50 hours before data collection, per the manufacturers' recommendations. The LED viewing booth was new, with fewer than 50 hours of use prior to the data collection.

For research questions two and three, each booth was then dimmed to match the monitor using the respective methods: direct connection for the LED booth and using the external sensor for the fluorescent booth; the external sensor was calibrated per the manufacturer's instructions. Stabilization time was recorded, as were differences in each method. In this case, the viewing booths were dimmed from a stable, "warmed-up" condition.

The Eizo monitor was calibrated using ICS Remote Director and the Datacolor Spyder X Pro colorimeter. For the fluorescent booth, the external sensor was used to dim the booth by placing the sensor on the white point of the Eizo display and taking a measurement, per the manufacturer's instructions. In the case of the LED viewing booth, it was dimmed through a USB connection which interfaces with the ICS Remote Director soft proofing application.

The processes were repeated three times, and the average values of the metrics measured were calculated and are reported.

Results

The averaged results from a cold start to hard proofing mode are shown in Table 1.

	Mean	Max	Min	Range	SD
	Illumination Lux				
Fluorescent	1924.67	1963.54	1458.68	504.86	58.22
LED	2397.04	2405.17	2389.83	15.34	3.53
	Correlated Color Temperature (CCT) Kelvin				
Fluorescent	5119.38	5371	5088	283	54.34
LED	5024.50	5047	5012	35	9.12
	Color Rendering Index (CRI) Ra				
Fluorescent	98.51	99.10	98.30	0.80	0.23
LED	97.76	97.80	97.60	0.20	0.05
	Metamerism Index Visual (Mivis)				
Fluorescent	0.29	0.30	0.20	0.10	0.03
LED	0.50	0.50	0.50	0.00	0.00
	Metamerism Index UV (Miuv)				
Fluorescent	0.58	1.10	0.50	0.60	0.13
LED	0.66	0.70	0.60	0.10	0.05

Table 1 *Stabilization time, cold start to hard proofing mode*

Based on the data in Table 1, an examination of the results of illumination and correlated color temperature for the fluorescent booth to stabilize for proofing mode from a cold start is shown in Figures 1 and 2. The other variables (i.e., Color Rendering Index and the metamerism indices) were not further evaluated due to the low variability, as reported in Table 1.

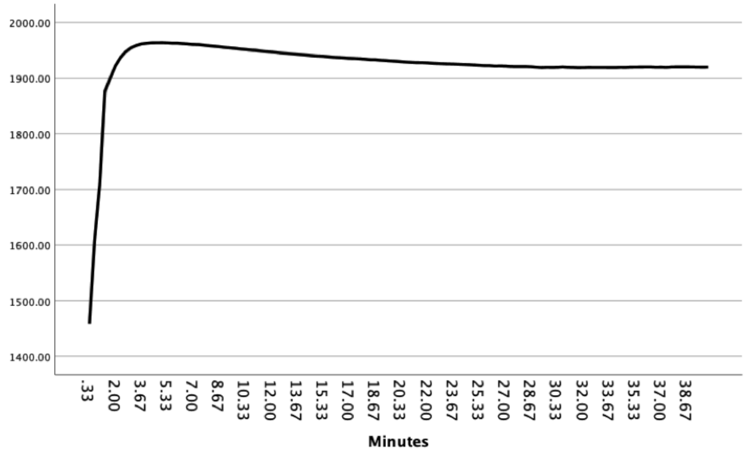

Figure 1 *Fluorescent Viewing Booth, Illuminance (Lux) Cold Start from Proofing Mode in Minutes*

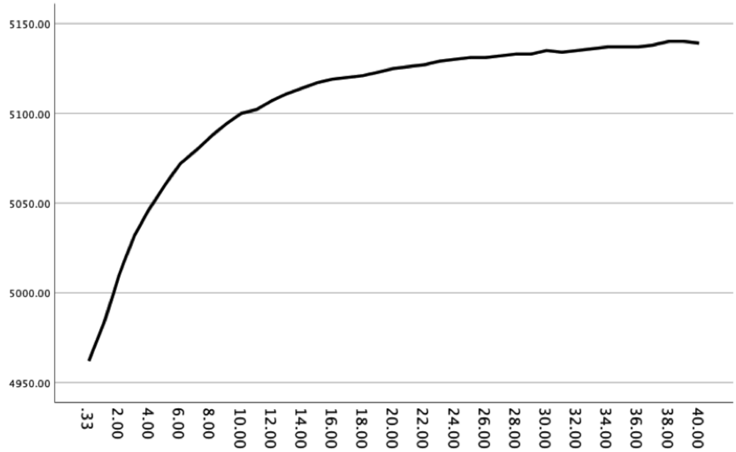

Figure 2 *Fluorescent Viewing Booth, Correlated Color Temperature Cold Start to Proofing Mode in Minutes*

The averaged results from a hard proofing mode to monitor mode are shown in Table 2.

	Mean	Max	Min	Range	SD
			Illumination Lux		
Fluorescent	211.85	212.17	211.32	0.85	0.17
LED	361.45	364.86	359.01	5.85	1.53
			Correlated Color Temperature (CCT) Kelvin		
Fluorescent	5108.63	5140	4962	178	39.53
LED	5016.30	5024	5011	13	3.87
			Color Rendering Index (CRI) Ra		
Fluorescent	97.59	97.50	97.60	0.10	0.23
LED	97.66	97.70	97.60	0.10	0.05
			Metamerism Index Visual (Mivis)		
Fluorescent	0.37	0.40	0.30	0.10	0.44
LED	0.70	0.70	0.70	0.00	0.00
			Metamerism Index UV (Miuv)		
Fluorescent	1.30	1.30	1.30	0.00	0.00
LED	3.01	3.10	3.00	0.10	0.02

Table 2 *Stabilization Time, Monitor Mode from Hard Proofing Mode*

Based on the data in Table 2, an examination of the results of correlated color temperature for the fluorescent booth from proofing mode to monitor match mode is shown in Figure 3.

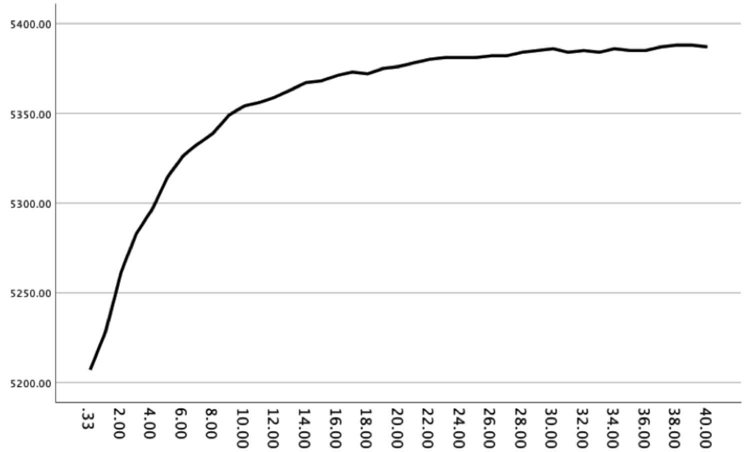

Figure 3 *Fluorescent Viewing Booth, Correlated Color Temperature Proofing Mode to Monitor Match*

Discussion

Unsurprisingly, the fluorescent viewing booth demonstrated more variance than the LED booth due to the warm-up time necessitated for stabilization, as illustrated in Table 1 and Figures 1 and 2. From a cold start to reach proofing mode, the attributes most sensitive to the effects of the warm-up are illuminance as measured in lux and correlated color temperature as measured in kelvins. To reach a point of stabilization, the correlated color temperature required the longest time, as shown in Figures 1 and 2; therefore, subsequent analyses largely focus on that metric. There were also differences in the technologies for dimming to achieve monitor match.

Research question 1: “What is the quantified stabilization time for fluorescent tube and LED viewing booths from a cold start?”

As shown in Table 1, the largest variation is realized with the fluorescent booth with illumination and correlated color temperature. The LED booth did not exhibit meaningful variation attributable to warm-up time, as suggested in Table 1.

Boxplots were constructed to illustrate the variance in the two viewing booth technologies, as presented in Figures 4 and 5.

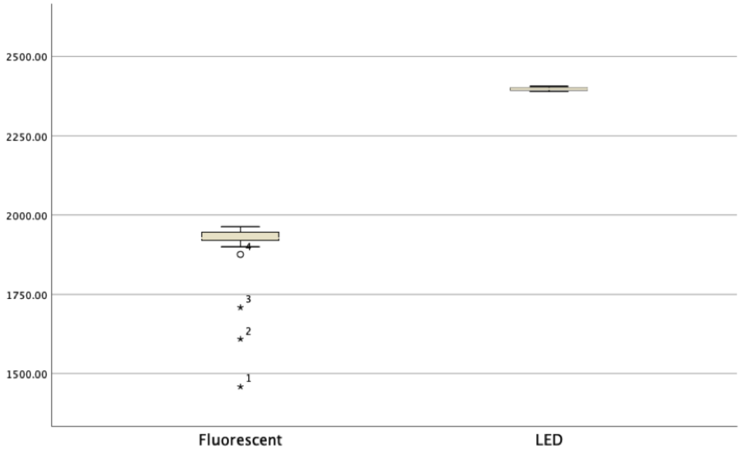

Figure 4 *Boxplots of Illuminance (Lux): Comparison of Fluorescent and LED Viewing Booths, Cold Start to Proofing Mode*

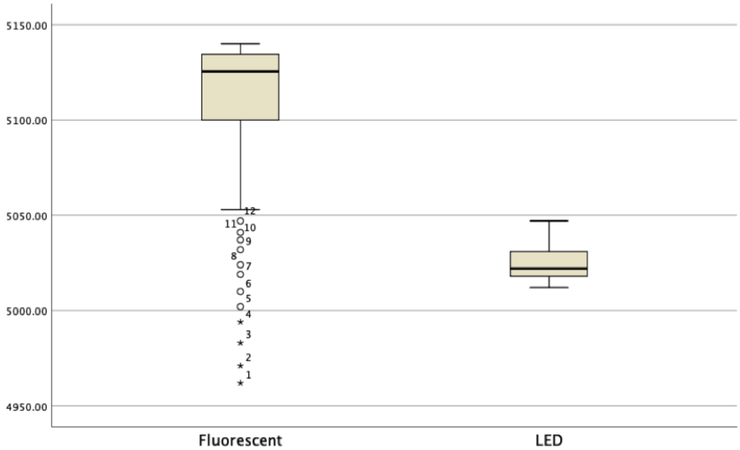

Figure 5 *Boxplots of Correlated Color Temperature: Comparison of Fluorescent and LED Viewing Booths, Cold Start to Proofing Mode*

As shown in Figures 4 and 5, the variation in the fluorescent tube technology exceeds the LED technology, with several outliers and extreme cases shown. The median differences are also illustrated in the boxplots. For illumination, both booths were set to 100%: it is observed that the fluorescent booth is close to 2,000 lux, whereas the LED booth is close to 2,200 lux. It is noted that the LED booth is designed to achieve 2,000 lux at 80% output. In analyzing the correlated color temperature, median differences are observed with the LED closer to the 5,000 kelvins targeted by the ISO3664:2009 standard. The fluorescent booth was within the range specified by the standard.

In plotting these metrics over time for the fluorescent booth, as illustrated in Figures 1 and 2, the data suggest that correlated color temperature requires the longest time to reach a stable state. Consequently, subsequent analyses germane to the research question focus on that metric.

A reasonable suggestion derived from Figure 2 is that a twelve-minute warm-up time is recommended to reach a stable condition in correlated color temperature for the fluorescent booth. Boxplots were generated, omitting the first twelve minutes of readings for the fluorescent viewing booth, as shown in Figure 6.

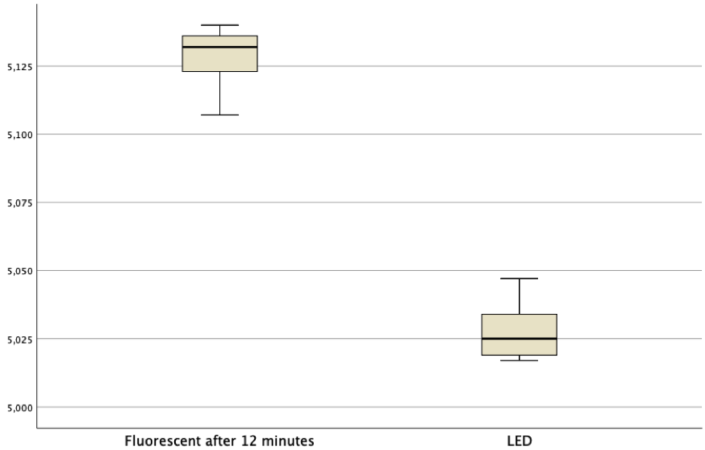

Figure 6 *Boxplots of Correlated: Comparison of Fluorescent and LED Viewing Booths, Cold Start to Proofing Mode, First Twelve Minutes Eliminated from Fluorescent Viewing Booth Data*

With the first twelve minutes of measurement omitted, the variation in the fluorescent tube viewing booth is similar to that of the LED viewing booth, supporting the twelve-minute stabilization time suggestion.

Research question 2: What is the quantified stabilization time for fluorescent tube and LED viewing booths when changing from hard proofing mode to monitor match mode?

In analyzing the obtained data for the second research question, the viewing booths were adjusted to match a monitor for monitor match applications from a stable, proofing mode state. As with the cold-start to proofing mode shown in Figure 3, for critical evaluations, a twelve-minute warm-up time is recommended when dimming the fluorescent tube booth for monitor matching from proofing mode to achieve stability for the correlated color temperature. This is also supported by Figure 7 where the correlated color temperature graphs are compared. Here, it is noted that the shapes of the trajectories appear similar.

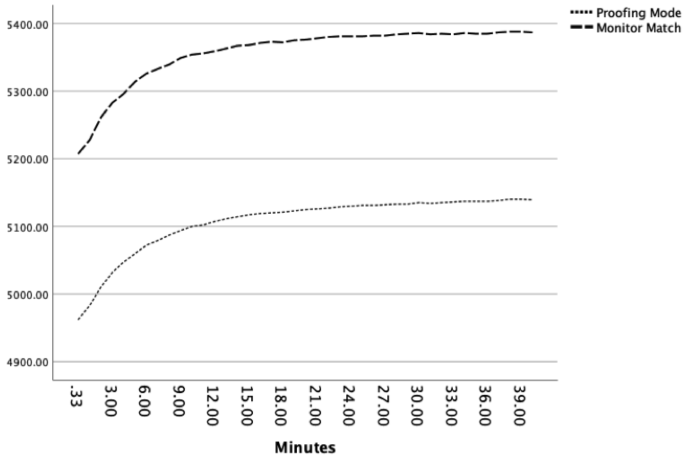

Figure 7 *Correlated Color Temperature: Comparison of Fluorescent Viewing Booth Cold Start to Proofing Mode and Proofing Mode to Monitor Match Mode*

Boxplots were generated, as shown in Figure 8. It is observed that there are several outliers for correlated color temperature with the fluorescent viewing booth. It is also noted that the median correlated color temperature for the fluorescent viewing booth is between 5,300 and 5,400 kelvins in monitor match mode.

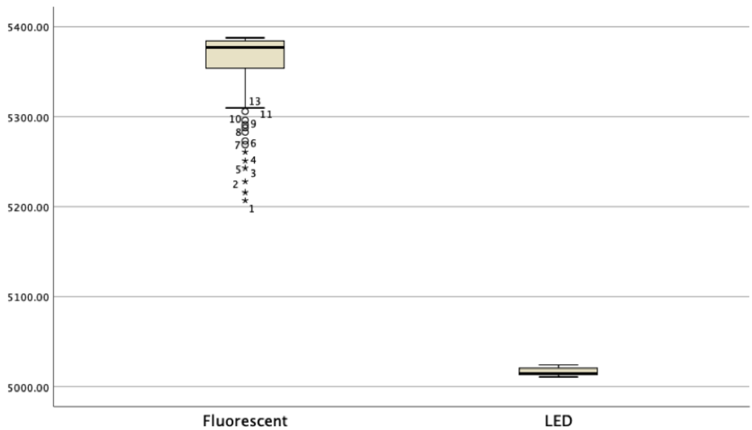

Figure 8 *Boxplots of Correlated Color Temperature: Comparison of Fluorescent and LED Viewing Booths, Proofing Mode to Monitor Match Mode*

As with the analysis of proofing mode, the first twelve minutes of readings were omitted to assess the results of warm-up time, and boxplots were generated, as shown in Figure 9.

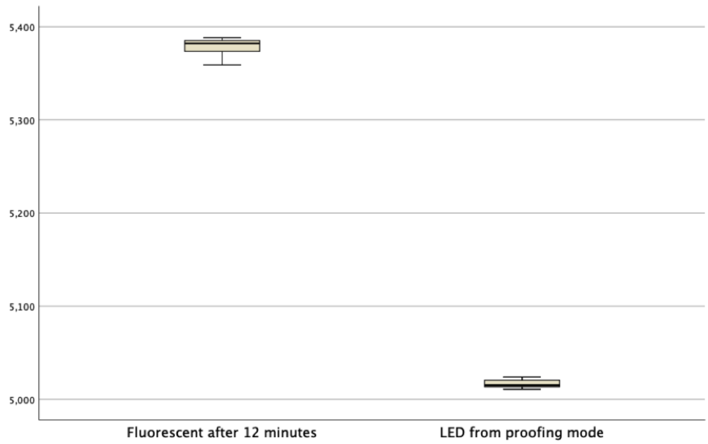

Figure 9 *Boxplots of Correlated Color Temperature: Comparison of Fluorescent and LED Viewing Booths, Proofing Mode to Monitor Match Mode, First Twelve Minutes Eliminated from Fluorescent Viewing Booth Data*

Analysis of the boxplots in Figure 9 suggests that with a twelve-minute warm-up time, the variance in the fluorescent viewing booth is similar to that of the LED viewing booth when dimming from proofing mode to monitor match mode.

Research Question 3: Is there a difference in monitor match illumination between the external sensor viewing booth and a direct connection viewing booth?

The data in Table 2 show a difference in illumination between the two modes of quantitative dimming. The fluorescent viewing booth with the external sensor resulted in a mean of 211.85 lux, whereas the LED viewing booth with the direct connection to the soft proofing system resulted in a mean of 361.45 lux. In discussion with practitioners and the manufacturers of the respective viewing booths, it is noted that in practical utilization the automated dimming is viewed as a starting point. Many professionals adjust the booths from this point to achieve an illuminance match "to their eye." Both viewing booths offer easy-to-use tools to accomplish this task. Although the present research notes that the results of the technologies are different, future studies could explore this area further, as discussed in the following section.

Conclusions and implications

Soft proofing technologies are realizing increased use, and viewing booths are equipped to support both proofing and monitor match modes. Practitioners are advised to allow fluorescent-tube-based viewing booths to warm up for at least twelve minutes before making critical color assessments for both cold starts and when dimming to match monitors. As such, the LED-based booths offer convenience in this role, as the warm-up time is unnecessary to achieve compliance for correlated color temperature and illuminance. It is noted that the variables examined in the present study are not exhaustive for complete compliance, and future researchers may examine metrics unaddressed here.

Further, this study was not longitudinal: over the useful life of the respective luminaires, other differences may be realized.

While the results of the dimming methods for monitor match were different, the recognition that professionals frequently adjust the dimming to achieve a visual match suggests that future researchers could conduct a psychophysical study involving imaging professionals. Such a study could inform the efficacy of the dimming technologies available.

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