UNCERTAINTY OF CORRELATED COLOR TEMPERATURE DUE TO VARIATION IN ELECTRICAL OPERATING CURRENT FOR NIS-TOTAL LUMINOUS FLUX WORKING STANDARD LAMPS

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Abstract

In this research, correlated color temperature of nine NIS-working standard OSRAM lamps at different electrical current values has been measured at different electrical current variation. The lamps have been seasoned and calibrated since 1969. A set up based on NIS Spectroradiometer Ocean optics HR 2000 with uncertainty 4.7% and photometric bench have been used to measure the correlated color temperature for the lamps. The correlated color temperature equations are very useful to determine the uncertainty due to changing in electrical operating current for each lamp.

Keywords: *Correlated color temperatures, Total Luminous Flux Working Standard Lamps, Electrical Current, Uncertainty.*

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1. INTRODUCTION

Before the widespread use of fluorescent and other discharge lamps, most light sources were incandescent and therefore had a color similar to a blackbody radiator. Because of this, it became common to describe the color of a light source by its "correlated color temperature" [1]. This is the temperature of the blackbody radiator whose color is closest to that of the light considered.

As the temperature of a blackbody radiator is increased, its chromaticity co-ordinates move along a curved line in the chromaticity diagram as shown in Figure 1. This line is known as the blackbody locus or Planckian locus. Obviously, if the color of a light source is very far from this line, correlated color temperature is not a very good description of its color, as it describes only the yellow-blue variation of blackbody radiation and does not describe variation in other directions such as green-purple. The recommended method of calculating the correlated color temperature of a stimulus is to determine, on a chromaticity diagram, the temperature corresponding to the point on the blackbody locus that is intersected by an iso-temperature line which contains the point representing the stimulus. The iso-temperature lines currently recommended by the CIE [2] are those normal to the blackbody locus in a chromaticity diagram.

The correlated color temperature and distribution temperature of a source are normally determined either by a direct experimental method, such as red/blue ratio method, or graphically from the chromaticity coordinates. With the ever-increasing use of digital computers, methods for evaluation of these temperatures from the spectral power distribution are very useful [1].

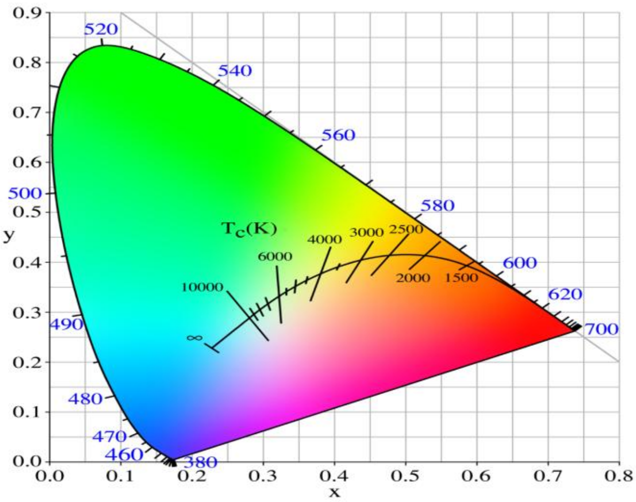

Figure 1. CIE 1931 Chromaticity Diagram Showing the Spectrum Locus.

The integrating sphere as shown in Figure 2 is a device for measuring total luminous flux for any light source and its function is to spatially integrate radiant flux. Light incident on a diffuse surface creates a virtual light source by reflection [3].

Items located inside the sphere, including baffles, lamps, and lamp sockets as shown in Figure 3 absorb some of the energy of the radiant source and decrease the throughput of the sphere. This decrease in throughput is best avoided by coating all possible surfaces with a highly reflective.

As any part of the sphere surface sees all other parts of the sphere surface equally; the detector at any point on the surface can measure the total power in the entire sphere [4].

In addition, the reflections from the coating added to the power of the lamp, lead to the fact that there is always more power inside a sphere than the lamp generates [5].

Figure 2. The NIS Integrating Sphere Photometer system(2.5meter diameter).

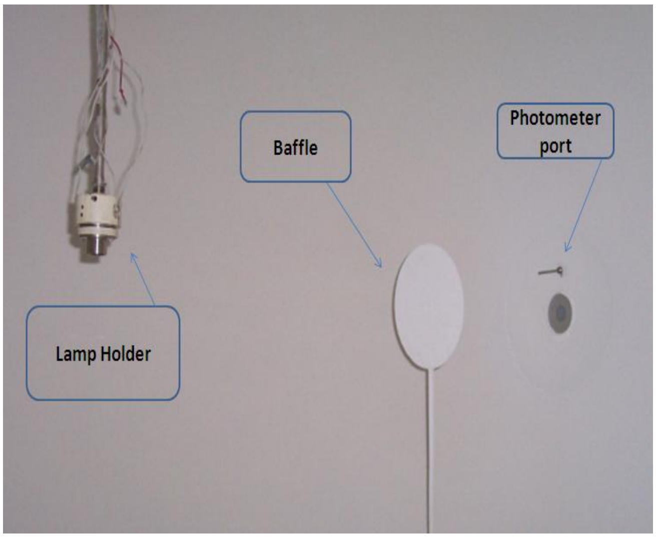

Figure 3. The Lamp baffle, the photometer port, and the lamp holder of the 2.5 integrating sphere system.

Since irradiance is the amount of light falling on a surface [6], we need to set up the diffusing surface at the point at which we wish to know the irradiance, and measure the light reflected off the diffuser as shown in Figure 4.

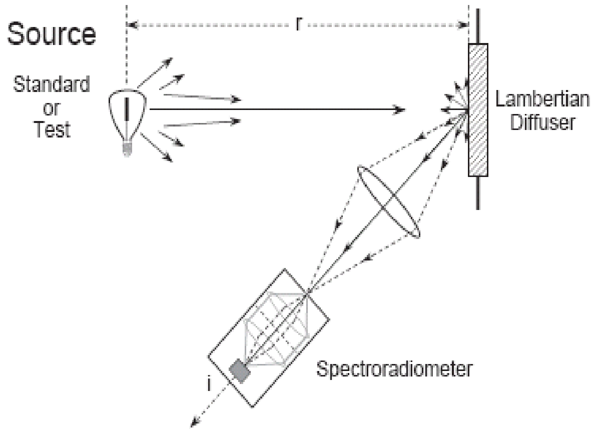

Figure 4. Set up for measuring correlated color temperature of lamps [6].

The more Lambertian the diffuser, the better the light reflected off the diffuser. A sample of the light from the diffuser is focused by the lens onto the input slit of the monochromator. Since the radiance of the diffuser is uniform, any slight motion of the lenses or the monochromator is not serious. Also, the radiance at any one point is due to incident light from all parts of the source. The flat diffuser, like the integrating sphere, is very sensitive to stray light since any light incident upon it will be reflected (diffused) into all directions, some of which are into the input to the monochromator.

2. METHODS

2.1 Measurements Set-up of Correlated Color Temperature (CCT)

A set of twenty one NIS working standard OSRAM lamps were aged seasoned and calibrated since 1969 [7]. Table (1) is representing the electrical control results of NIS total luminous flux standard lamps calibrated at NPL in England with uncertainty 0.8%. Tables (2) to (4) are representing the electrical control results of nine NIS working standard OSRAM lamps [8].

Table 1. The Electrical Control Results of NI total luminous flux standard Lamps

NIS Standard Lamps	***SET Current***	***Voltage***	***Color temperature***	***Total luminous flux***
	(amperes)	***(Volts)***	***(Kelvin)***	***(lumen)***
NIS-E21	1.7869	102.1	2750	2587
NIS-E22	1.7991	101.6	2750	2597
NIS-E31	0.20482	91.9	2400	131.5
NIS-E32	0.20315	92.0	2400	130.8
NIS-E33	0.20382	92.4	2400	132.4

Table 2. The Electrical Control Results of 40 Watt NIS total luminous flux working standard lamps.

NIS Working Standard Lamps	*SET Current (amperes)*	*Voltage (Volts)*	*Power (Watts)*	*Color temperature (Kelvin)*	*Total luminous flux (lumen)*
NIS-F7	0.37883	108.7	40	2693	423.1±0.3%
NIS-F9	0.38033	109.5	40	2693	428.8±0.3%

Table3. The Electrical Control Results of 60 Watt NIS total luminous flux working standard lamps.

NIS Working Standard Lamps	*SET Current (amperes)*	*Voltage (Volts)*	*Power (Watts)*	*Color temperature (Kelvin)*	*Total luminous flux (lumen)*
NIS-F11	0.57724	108.5	60	2761	782.7±0.4%
NIS-F13	0.57850	108.2	60	2761	781.8±0.4%
NIS-F14	0.58203	109.4	60	2761	803.5±0.4%

Table 4. The Electrical Control Results of 75 Watt NIS total luminous flux working standard lamps.

NIS Working Standard Lamps	*SET Current (amperes)*	*Voltage (Volts)*	*Power (Watts)*	*Color temperature (Kelvin)*	*Total luminous flux (lumen)*
NIS-F16	0.70383	109.2	75	2737	960.2±0.4%
NIS-F17	0.70389	106.9	75	2737	924.4±0.4%
NIS-F18	0.71908	109.0	75	2737	973.7±0.4%
NIS-F20	0.71005	109.0	75	2737	969.4±0.4%

All the total luminous flux lamps are clear round bulb. The lamps were aged [7] at correlated color temperature (CCT) as show in tables (2) to (4). Spectroradiometer was used to measure the relative spectral output of the lamps, from which the CCT was determined. The Set up of measuring the spectral power distribution lamps [9] is in Figure.

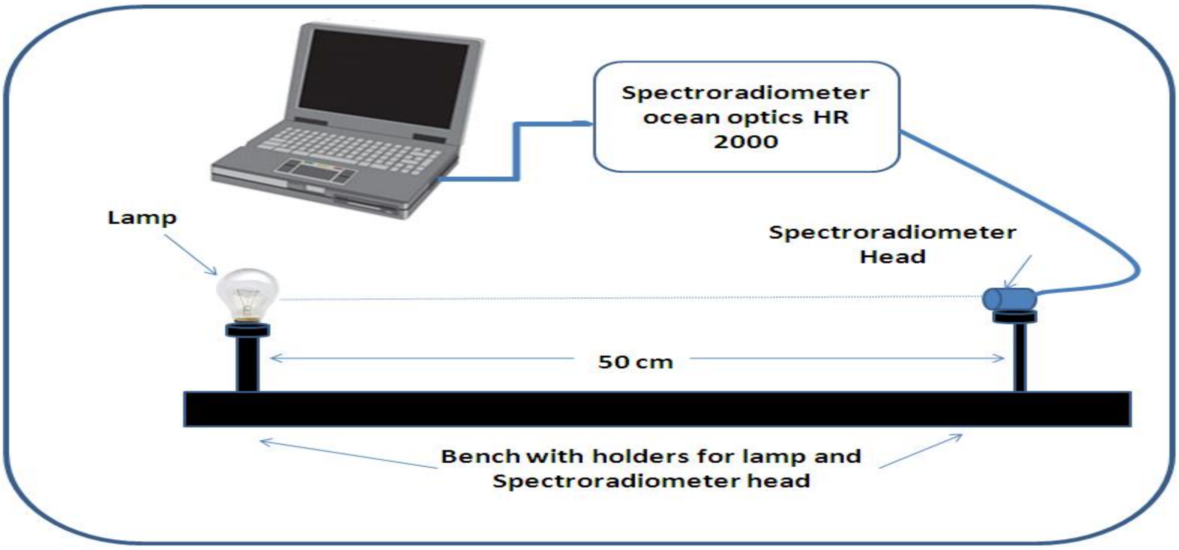

Figure 5. Set up of measuring the spectral power distribution of NIS total luminous flux lamps.

It measured directly using the photometric bench and the Spectroradiometer ocean optics HR 2000 at NIS with uncertainty 4.7% [10 - 12].

3. RESULTS AND ANALYSIS

It has been measured the correlated color temperatures (CCT) at several electrical operating conditions for each lamp to enable us to operate the lamps at the required CCT and to determine the behavior of the lamps at different operating conditions. The results of these measurements are presented in Figures (6) to (14). These Figures present the correlated color temperature at different current values [13,14]. The equations of the fitted lines can help us to determine the correlated color temperature (CCT) for each lamp at different current.

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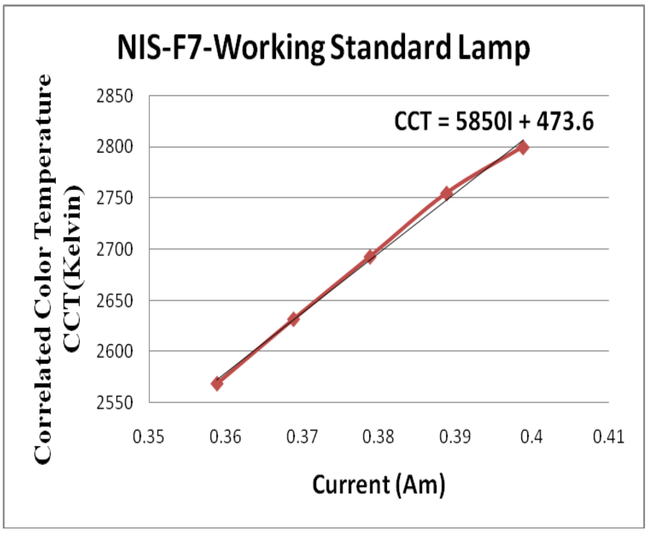

Figure 6. Correlated Color Temperature (CCT) (Kelvin) of 40 W NIS-F7- Working Standard Lamp at different electrical current.

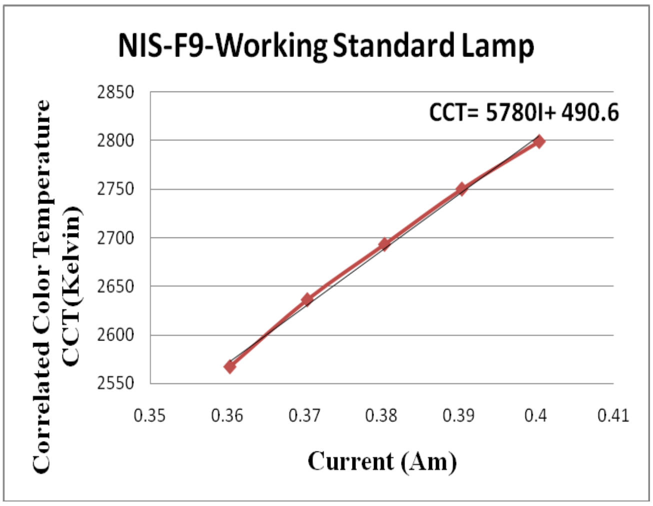

Figure 7. Correlated Color Temperature (CCT) (Kelvin) of 40 W NIS- F9-Working Standard Lamp at different electrical current.

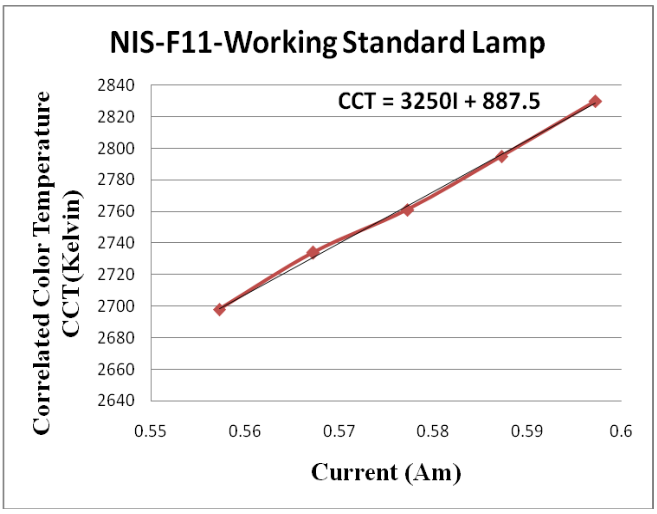

Figure 8. Correlated Color Temperature (CCT) (Kelvin) of 60 W NIS-F11- Working Standard Lamp at different electrical current.

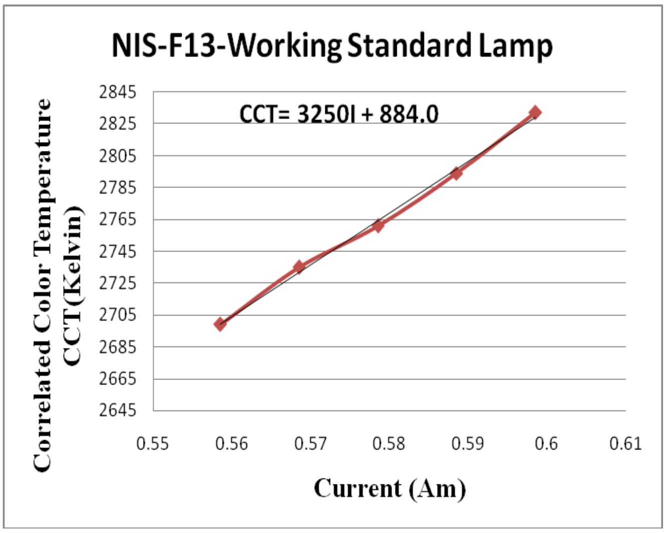

Figure 9. Correlated Color Temperature (CCT) (Kelvin) of 60 W NIS-F13- Working Standard Lamp at different electrical current.

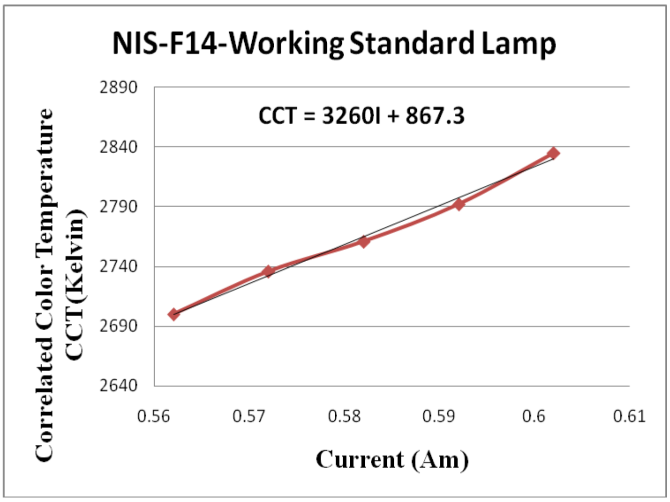

Figure 10. Correlated Color Temperature (CCT) (Kelvin) of 60 W NIS-F14- Working Standard Lamp at different electrical current.

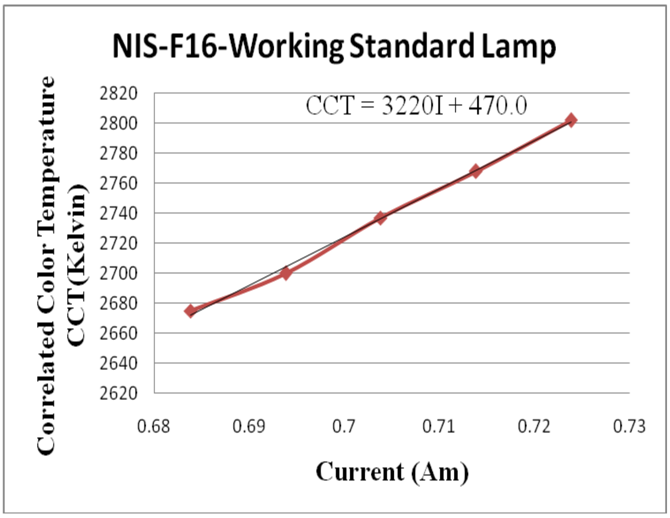

Figure 11. Correlated Color Temperature (CCT) (Kelvin) of 75 W NIS-F16- Working Standard Lamp at different electrical current.

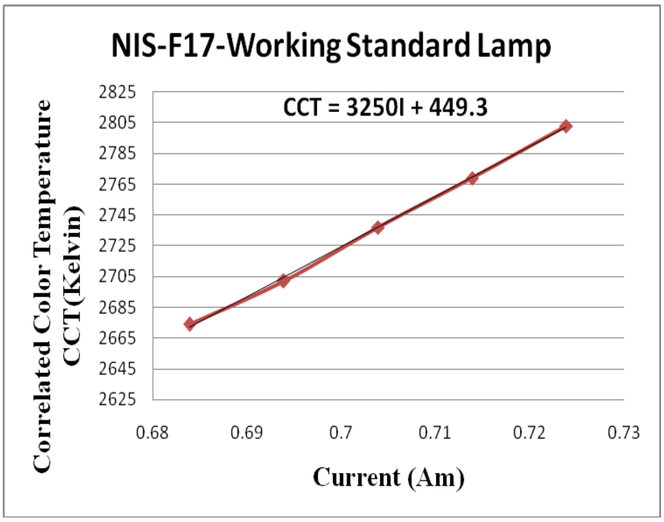

Figure 12. Correlated Color Temperature (CCT) (Kelvin) of 75 W NIS-F17- Working Standard Lamp at different electrical current.

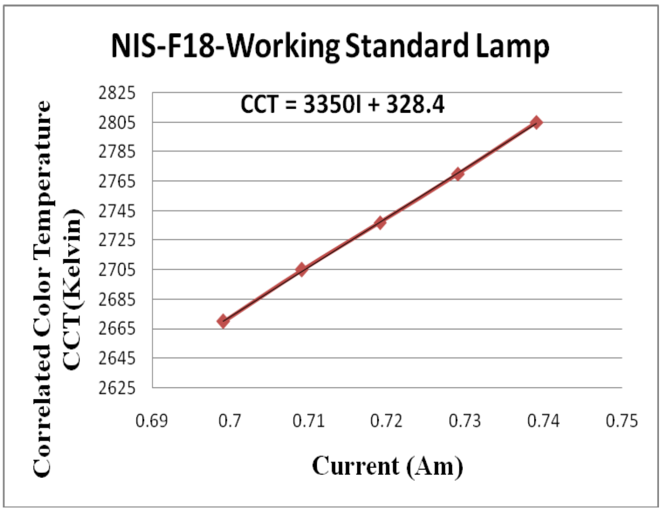

Figure 13. Correlated Color Temperature (CCT) (Kelvin) of 75 W NIS-F18- Working Standard Lamp at different electrical current.

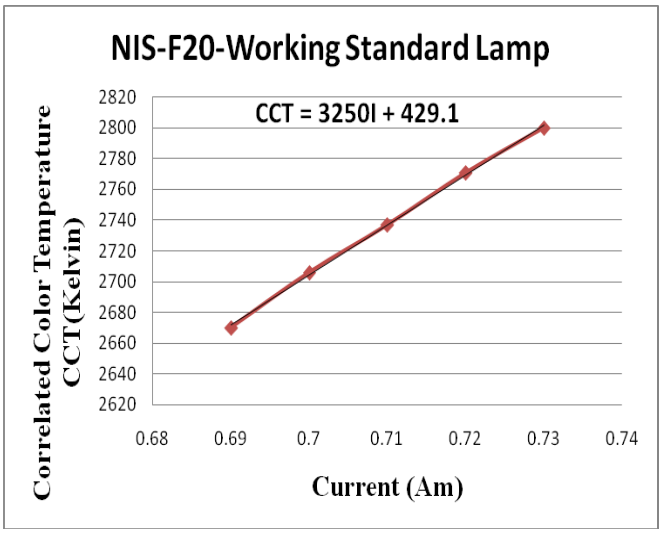

Figure 14. Correlated Color Temperature (CCT) (Kelvin) of 75 W NIS-F20- Working Standard Lamp at different electrical current.

4. CONCLUSIONS

This research demonstrates the correlated color temperature (CCT) as a function of the electrical current applied to the lamp. This enables to determine the uncertainty in the correlated color temperature of each lamp due to the changing in the electrical operating current of the lamp by using the curves and equations presented in Figures 6 to 14. The equations of the fitted lines can help us to determine the correlated color temperature (CCT) and total luminous flux for each lamp at different current.

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