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May 13, 2025

Rebuttal to the Testimony of Megan Russo
In Opposition to LD1934

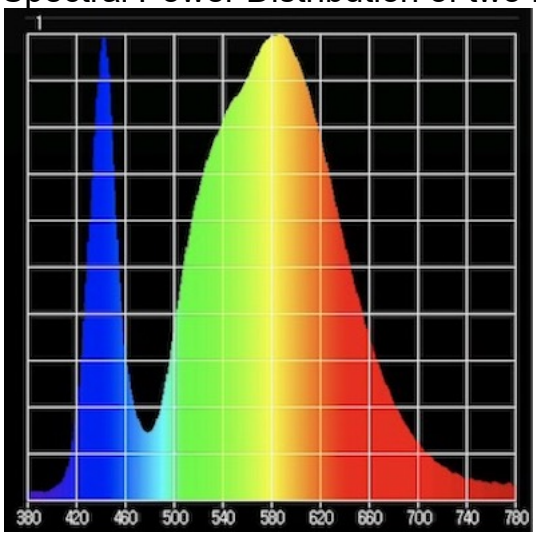
My objection is to the statement in paragraph four which says:

"MaineDOT moved to 4000 Kelvin Lighting fixtures many years ago to provide better light levels for vehicular and pedestrian safety. Kelvin is the unit used to describe color temperature of a light source. The lower the color temperature, the more subtle the light is."

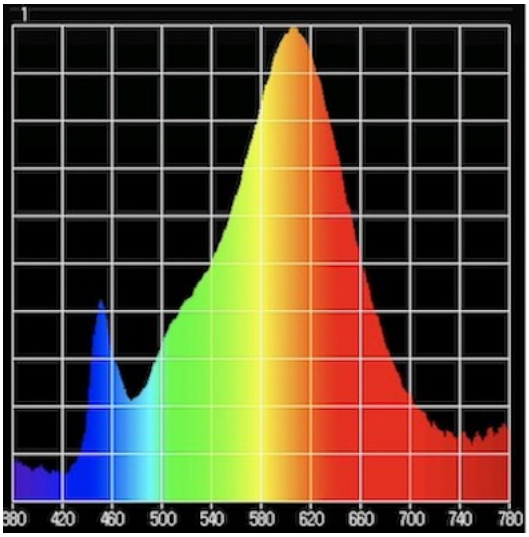
Kelvin has no relationship to light levels. As stated Kelvin is the [Correlated] Color Temperature of a light source. Lux or footcandles refer to the illumination levels. It's possible to have either too high or too low levels of lighting regardless of the Kelvin Correlated Color Temperature. Subtle is an undefined and meaningless term in roadway lighting. It may be related to indirect lighting fixtures, glare, or distribution but it has nothing to do with Correlated Color Temperature. A low color temperature does not make light more subtle. On the shelves of lighting supply houses "Light bulbs" are not marked with the color "subtle." However, low CCT bulbs are often marked "warm white" and high CCT "cool white".

"For safety reasons, MaineDOT looks for contrast on our Maine roadways and lighting with higher Kelvin help us achieve optimal contrast." This statement is incorrect.
Higher Kelvin light sources have high levels of blue light; but this comes at the expense of red light[1] See the graphs below for color balance. If your goal is to more intensely light that ultra-violet blue car, maybe use 4000 K. But, you'll be reducing the visibility of the pedestrian wearing a dark red coat. And those objects that are Indigo blue (480 nanometers) are less illuminated, too.

Spectral Power Distribution of two LED sources with different Kelvin CCT's



4063 Kelvin LED Light Source



2865 Kelvin LED Light Source

Another point is that the higher the correlated color temperature of LED sources, the lower the color rendering index. CRI is the ability to match the color rendering under sunlight. These numbers can be read off the manufacturer's literature. Attached (see Appendix A) are field measurements I took of the Color Rendering Index versus Correlated Color Temperature for typical LED street lighting. These numbers can also be confirmed from manufacturer's catalog literature. It would seem a reasonable assumption that accuracy of colors might be loosely associated with contrast. Muted, less saturated, colors would necessarily be lower contrast.

Further problems come for emergency services. The weakness in the reds reduce the ability of EMT's to correctly assess skin pallor of victims of accidents. And what color are older fire trucks? There is a reason that they have been changing their paint color to Lime Green.

> "For reference, international research has proven the traditional red fire apparatus have 3 times the accident rate compared to the safety yellows. Yes, the research did included using the latest developments in sirens, horns and flashing lights." -Quora.

The weakness of the red spectrum in LED streetlights are making that even more critical.

Blue light cannot be focused as easily by older drivers. Any level of cataracts in the eyes causes Rayleigh scattering because of the higher frequency of the LED blue light. All of us have experienced the blinding glare of HID and now LED headlights. Car manufacturers use high kelvin CCT sources because of the increase in efficiency needed in mobile lighting systems.

In the photographic examples of I-295 in Portland, the original 2100K high-pressure sodium lighting is compared with 4000 Kelvin LED lighting. This is a strawman argument. High-pressure sodium is an older light source that is lower efficiency, poorer color rendering and higher maintenance cost than LED's. High-pressure sodium lamps are rarely used for new construction because of these deficiencies.

LED street lighting luminaires are commonly available in nominal 2,700K, 3,000K, 4,000K and 5000K versions. The new lighting Act is not advocating the use of high-pressure sodium lighting, rather that new lighting should be 3000K or lower. The argument was made that "Guidance from the Federal Highway Administration (FHWA) has also confirmed there is evidence that light with high blue content can increase alertness and enhance cognitive performance of motorists." This is being challenged by Dark Sky International. What is known is that Blue Rich LED Sources can reset human circadian rhythms resulting in a number of medical issues for those with increased susceptibility. The American Medical Association links blue rich LED sources as a source of medical concerns:
https://www.ama-assn.org/press-center/press-releases/ama-adopts-guidance-reduce-harm-high-intensity-street-lights.
Blue Rich LED Sources have also been shown to have negative affects wildlife, insects and fish.

Just because MaineDOT moved to 4000 Kelvin LED lighting many years ago, doesn't mean that it's the right choice. Major cities all across America have banned 4000 Kelvin LED lighting in favor of <3000K sources. I found this in an email I wrote in 2017:

> "So far: Tucson, Phoenix, NYC, Chicago, Montreal, LA, Honolulu, Monterrey, all changed from demanding 4000K to now changing to 3000K, and now the state of Georgia."

In 2013, Davis California spent $350,000 to replace new 4000 Kelvin LED street lights with 2700 Kelvin units.
Just because it's the way that we've done it in the past, I don't believe we need to continue the mistake.

Sincerely,

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design & consulting engineers

Illumination Engineering Society, Member Emeritus
Institute of Electrical & Electronic Engineers, Life Member
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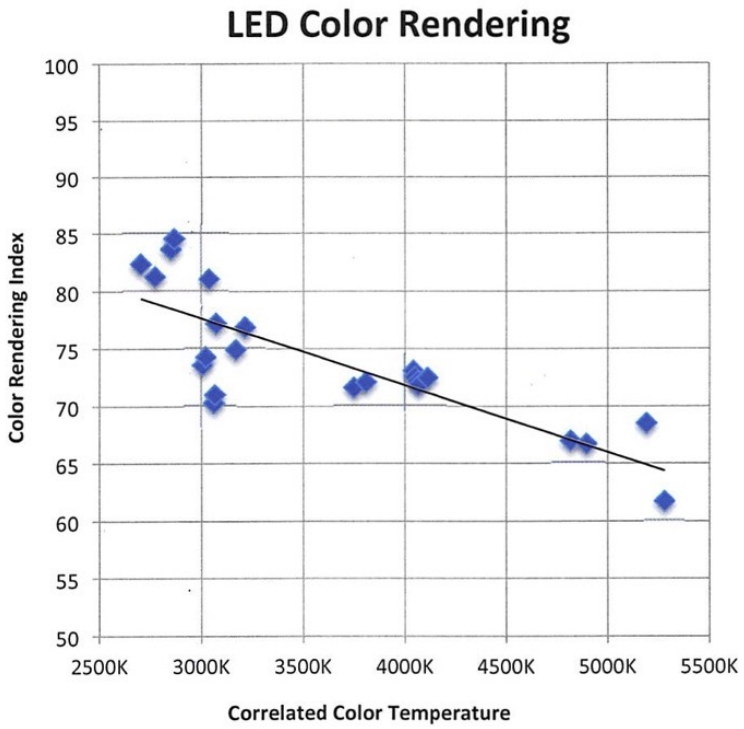
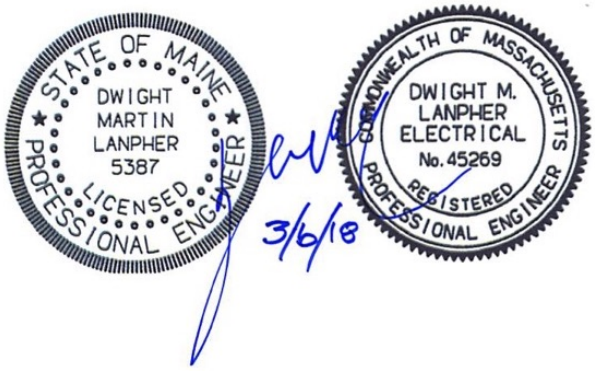
Maine P.E. No. 5387
Massachusetts P.E. No. 45629 (retired)
Vermont P.E. 7783 (retired)

[1] White LED's have a high efficiency gallium nitride blue semiconductor light source. This semiconductor junction is coated with phosphors which are energized to reradiate light in other parts the visible spectrum. Integrating more phosphor reduces the blue, and increases the red portions of the visible spectrum.

Appendix A


LED Color Rendering
Color Rendering Index
100
95
90
85
80
75
70
65
60
55
50
2500K
3000K
3500K
4000K
4500K
5000K
5500K
Correlated Color Temperature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LANPHER
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PROFESSIONAL ENGINEER
COMMONWEALTH OF MASSACHUSETTS
DWIGHT M.
LANPHER
ELECTRICAL
No. 45269
REGISTERED
PROFESSIONAL ENGINEER
3/6/18

Nancy Hathaway
Surry
LD 1934

This is from Dark Sky Maine, president Nancy Hathaway
Lighting Engineer, Dwight Lanpher