Introduction to the Technical Notes on General Service Lamps and Outdoor Lighting

FORTALECIMIENTO DE ESTÁNDARES DE EFICIENCIA ENERGÉTICA EN ILUMINACIÓN
Primera Reunión y Taller Presencial del Grupo Técnico de Eficiencia Energética (GTEE)

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Technical Note Objectives

- Policy measures can shift markets toward better quality, energy-efficiency lighting
- In the context of LED lighting expanding into the market, policies are urgently needed
- Two technical notes – one on general lighting and one on street lighting
- Identify key metrics and test methods that are used for setting requirements on efficacy, color, power quality, lifetime, health and more
- Discuss regional harmonization, market surveillance and MEPS

Establish Cost-Effective Lighting Policies

- Governments can establish cost-effective policy measures that will remove the least efficient products from the market, and accelerate the adoption of the most efficient models

- Energy-efficient LED lighting advantages:
  - lower energy bills
  - reduction in peak electricity demand
  - longer service life (i.e., less material going to landfill)
  - eliminates the use of mercury

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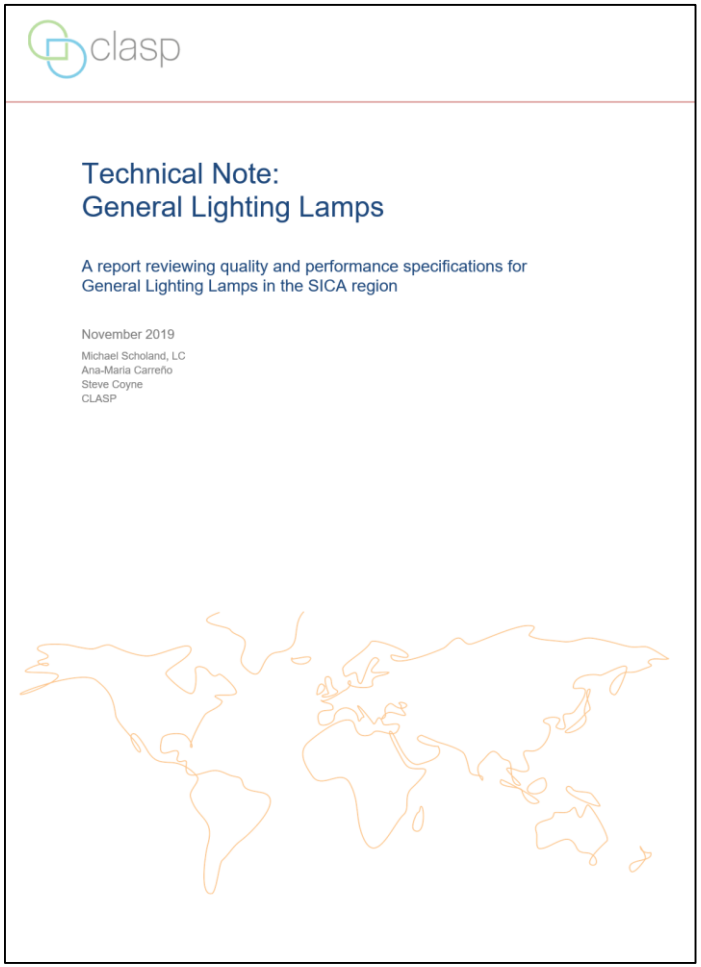
Establish Cost-Effective Lighting Policies

- Scope of coverage
- Key metrics
  - Energy performance
  - Color quality metrics
  - Electrical performance
  - Lifetime and operation
  - Health and safety
  - Other factors
- Information for consumers
- Market surveillance
- Test laboratory requirements
- Regional harmonization
- MEPS process



Scope of Coverage – General Lighting Service

- Technology-neutral definition, all general lighting service lamps
  - Incandescent / halogen lamps
  - Compact fluorescent lamps
  - Light Emitting Diode (LED) lamps

- Brief technology overviews
- Advantages / Disadvantages
- Typical performance specification

- Highlights the benefit of Technology Neutral scope
  - (*note: presentation on that later*)

Scope of Coverage – General Lighting Service

- Compares the technologies, indicative values

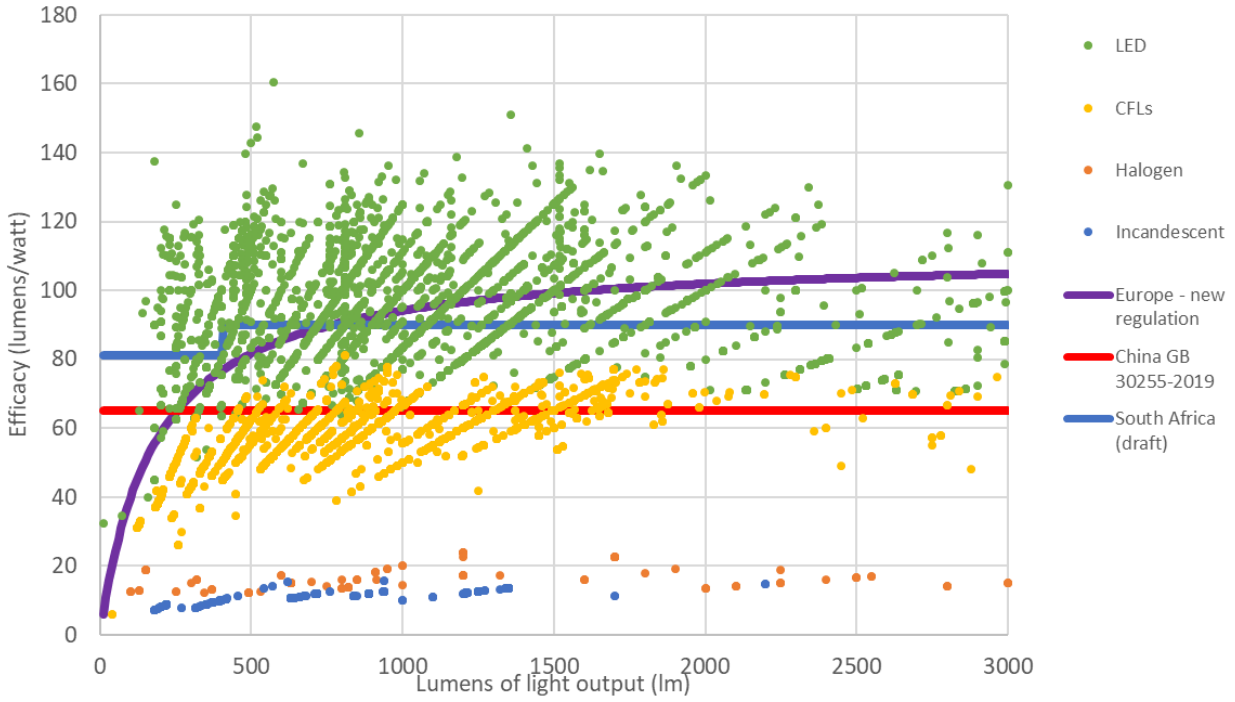
Table 4. Examples of Non-Directional Household Lamps, Screw-Base, Mains-Voltage

Characteristic	Incandescent	Halogen	Compact Fluorescent Lamp	Light Emitting Diode Lamp
				
Efficacy	8-15 lm/W	11-18 lm/W	55-65 lm/W	60-160 lm/W
Lifetime	1000-1500 hrs	2000-3000 hrs	6000-12,000 hrs	15-30,000 hrs
Color rendering index	100	100	70-90	70-95
Cost to buy*	$	$$	$$	$$
Cost to run*	$$$$$	$$$$	$$	$

* For both of these characteristics, of the four technologies shown, only LED is changing significantly. As LED technology continues to evolve and improve, the cost to purchase will decrease and the cost to run will decrease even more. This technology, therefore, is expected to dominate all end-use lighting applications in the future.

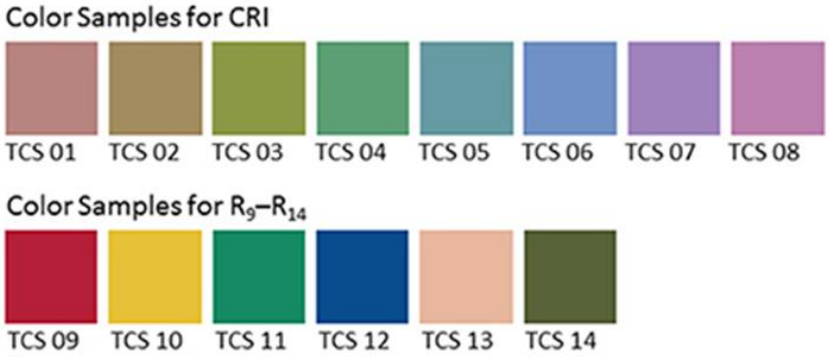
Metric: Energy Performance - Efficacy

- The principle metric for regulating lighting products is luminous efficacy – lumens of light / watt of power
- Technology-neutral metric
- Higher values equate to better performance

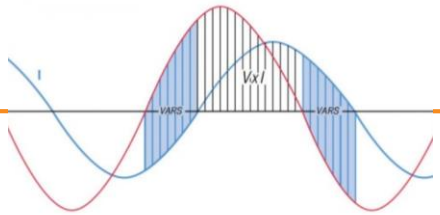


Metrics for Color Quality

- Color rendering index – accurate color
- Correlated color temperature - type of white (cool vs. warm)
- Color consistency / chromaticity tolerance – similar appearance
- Color maintenance – stable color throughout the useful life



Metrics on Electrical Performance



- Power factor – active power following the load divided by apparent power of the circuit; low PF's can adversely affect electricity distributors by as low PF's result in higher real power.

- Fundamental power factor – (also: displacement factor or displacement power factor) - quantifies the displacement (phase-shift) between the fundamental current and voltage waveforms

- Total harmonic distortion (THD) – the RMS-sum of all the harmonic currents divided by the current at the fundamental frequency; it is important for quality and safety of the grid

Metrics for Lifetime and Operation

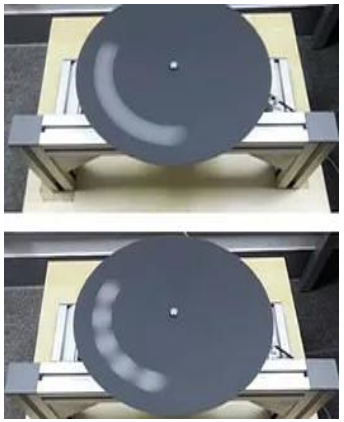
- Lifetime test designed to be lower cost
- Combines switching cycles (endurance) with lumen maintenance
- Long duration (2.5 hr on / 0.5 hr off) switching cycles, thermal expansion and contraction of circuit board
  - More representative of real life use
- 1200 cycles – for 3600 hour total test
- Lamps must survive (still be operational) and have an average lumen maintenance of at least:

$$X_{LMF,MIN}\% = 100 \times e^{\frac{(3000 \times \ln(0.7))}{L_{70}}}$$

Metrics for Health and Safety

- Photobiological safety – important for consumer safety as UV and blue light can cause irreparable damage to eyesight. IEC 62471 sets risk group classes and specifies the limits of optical radiation in the 100-400nm (UV) and 400-500nm (blue) spectrums

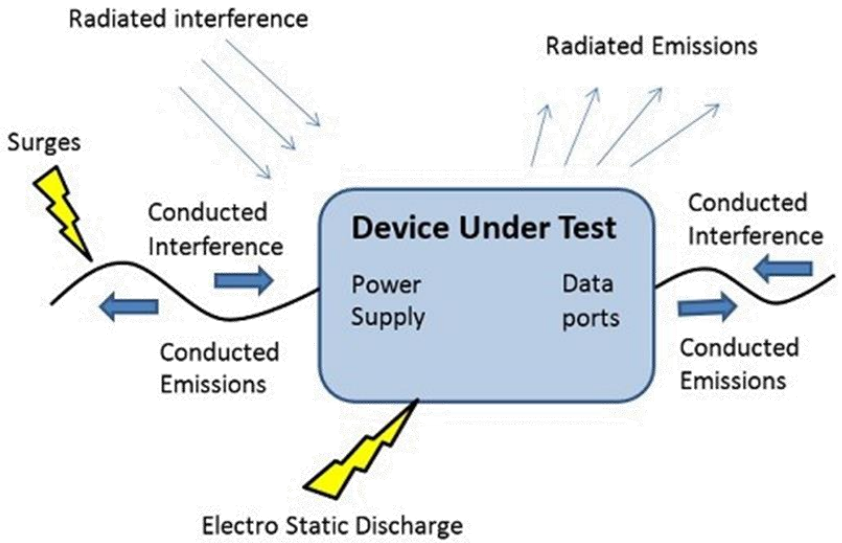
- Flicker and stroboscopic effect – concern about health impacts including eye strain, migraine, seizures, anxiety and fatigue. LED lighting is highly responsive to the driver, thus flicker (PstLM[1]) and stroboscopic effect (SVM[2]) are both regulated



1. Short term flicker indicator (PstLM) ≤ 1.0 at full load and a sinusoidal input voltage using Test method: IEC TR 61547-1:2017 Equipment for general lighting purposes - EMC immunity requirements - Part 1: An objective light flicker meter and voltage fluctuation immunity test method
2. Stroboscopic effect visibility measure (SVM) ≤ 1.6 at full load and a sinusoidal input voltage using Test method: IEC TR 63158:2018 Equipment for general lighting purposes - Objective test method for stroboscopic effects of lighting equipment

Other Factors for Consideration

- Dimmer compatibility – difficult to ensure 100% compatibility, thus information for consumers
- Electromagnetic Compatibility (EMC)
  - EMC emissions – makes sure the LED lamp or luminaire doesn't interfere with other products using the electromagnetic spectrum (e.g., TV, radio)
  - EMC immunity – makes sure the LED lamp or luminaire continues to function when exposed to other electromagnetic emitters



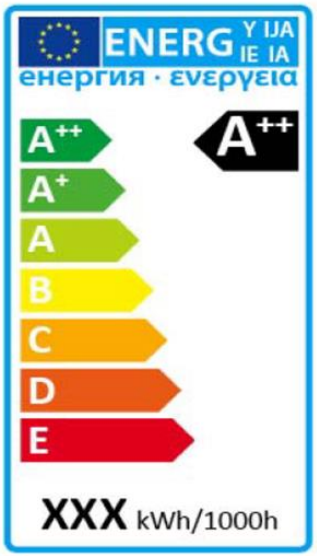
Consumer Information Requirements

- Lamp information – information printed on the lamp, for example: rated power, rated voltage, brand, flux
- Packaging information – information included on the packaging (the box): watts, voltage, flux, efficacy, lifetime, CCT, base type and more.
- Energy and product labelling – consider an energy label

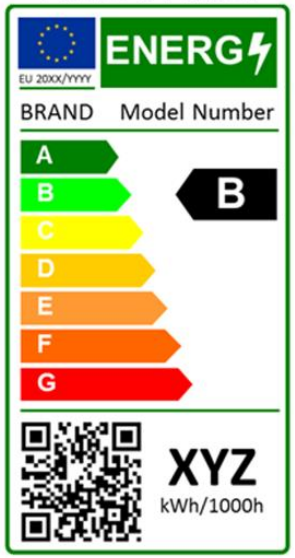
Table 1

Energy efficiency class	Total mains efficacy η_{TM} (*lm /W*)
A	$210 \leq \eta_{TM}$
B	$185 \leq \eta_{TM} < 210$
C	$160 \leq \eta_{TM} < 185$
D	$135 \leq \eta_{TM} < 160$
E	$110 \leq \eta_{TM} < 135$
F	$85 \leq \eta_{TM} < 110$
G	$85 \leq \eta_{TM}$

2013 – 2021
Current Label



2021 – c. 2030
Future Label



Regional Harmonization

- Need a willingness to cooperate between countries

- Harmonization on testing standards
- Harmonization on MEPS

- Some of the benefits:
  - Removes a barrier to trade
  - Avoids cost of duplicating tests for countries – one test for all
  - Ensures better prices and wider choice for consumers
  - Improves compliance rates – larger market through harmonization

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  - Lifetime and operation
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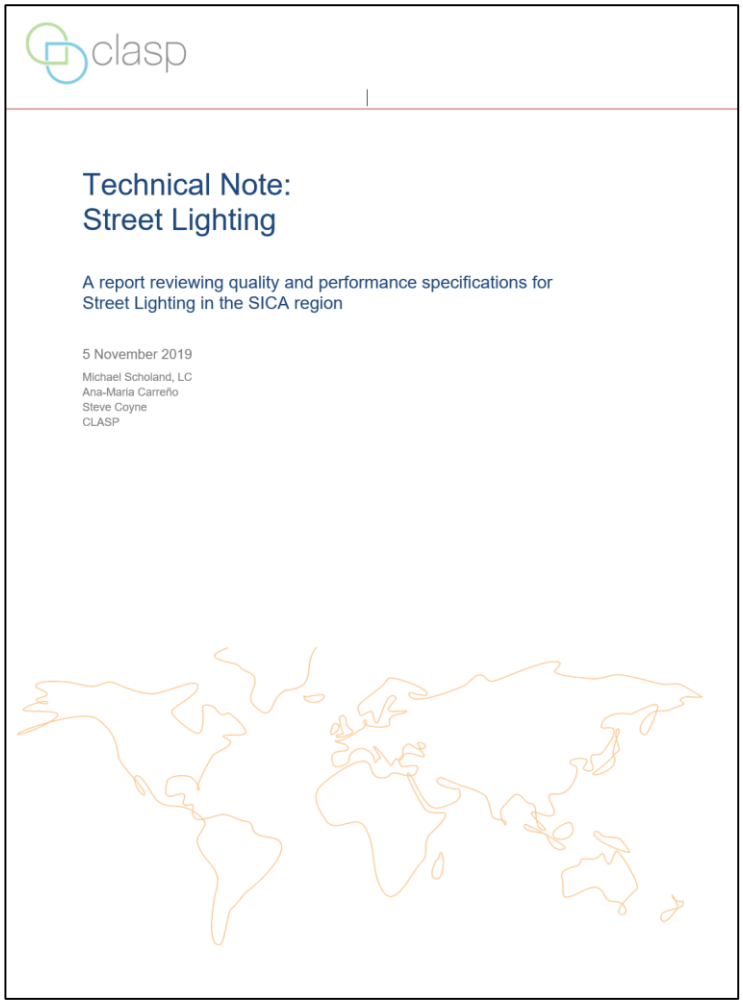
  - Other factors
- Information requirements
- Test laboratory requirements
- Regional harmonization
- Procurement specifications



Scope of Coverage – Street Lighting

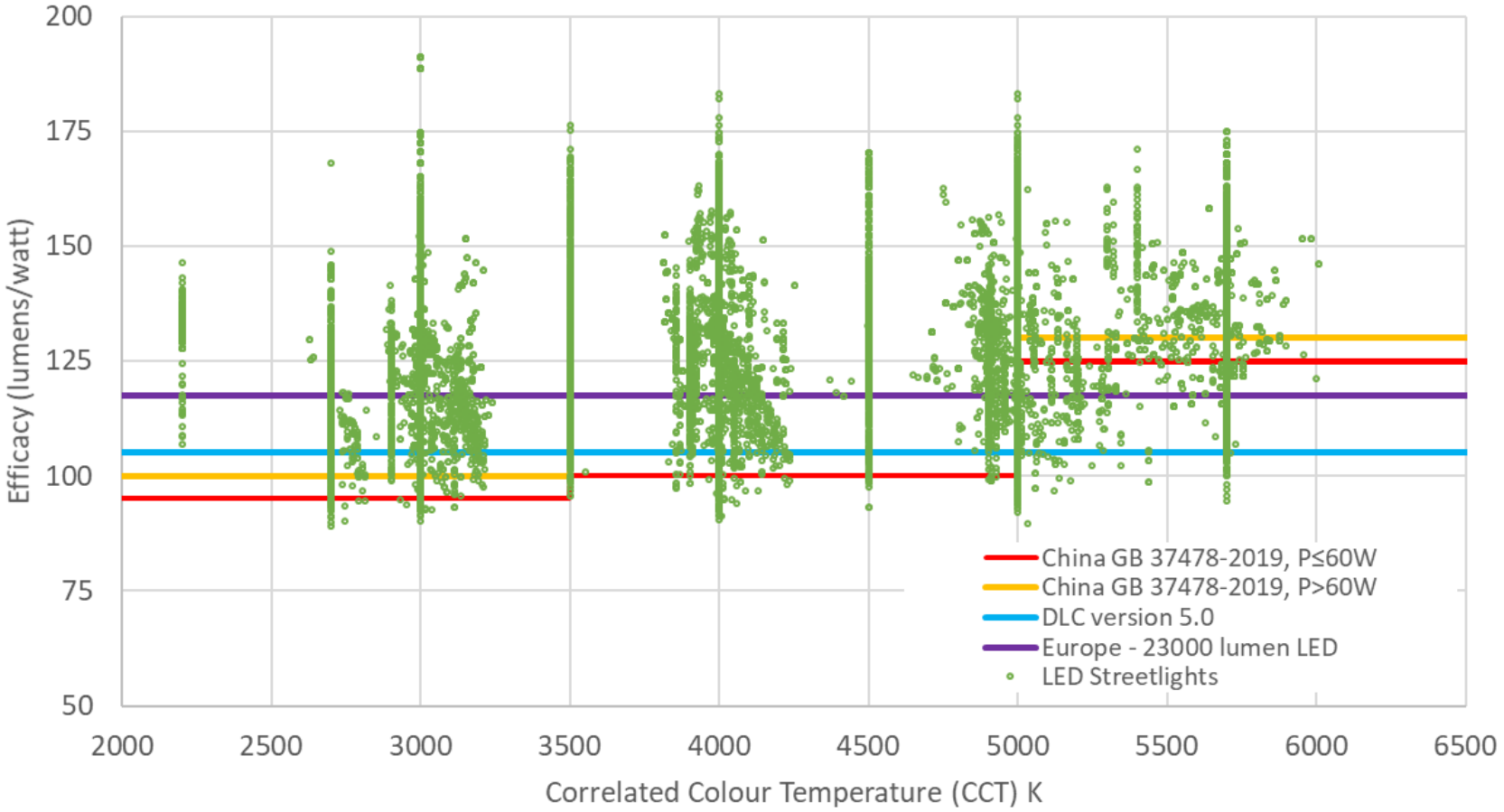
- New installations of streetlights are LED
- Thus, the scope of the Technical Note and the metrics discussed are applicable to LED streetlights

- Discussion on features and aspects of LED street lighting:
  - Light quality
  - Energy Savings
  - Lower Maintenance Costs
  - Controls and Intelligent Networks

- Comparison of Outdoor Lighting Technologies

Metric: Energy Performance - Efficacy

- The metric for regulating lighting products is luminous efficacy – lumens of light / watt of power
- Higher values equate to better performance



Metrics for Color Quality

- Color rendering index – accurate color, but lower because outdoors (70 CRI)
- Correlated color temperature - type of white (cool vs. warm) as specified by the municipality
- Color consistency / chromaticity tolerance – declared CCT must not exceed tolerances set out in ANSI C78.377-2017

Basic Nominal CCT Specification

Nominal CCT Category (K)	Target CCT and Tolerance (K)	Target Duv	Duv Tolerance
2200	2238 ± 102	0.0000	T_x: CCT of the source For T_x < 2870K 0.000 ± 0.0060 For T_x ≥ 2870K $D_{uv}(T_X)^{3)}$ ± 0.0060
2500	2460 ± 120	0.0000	
2700	2725 ± 145	0.0000	
3000	3045 ± 175	0.0001	
3500	3465 ± 245	0.0005	
4000	3985 ± 275	0.0010	
4500	4503 ± 243	0.0015	
5000	5029 ± 283	0.0020	
5700	5667 ± 355	0.0025	
6500	6532 ± 510	0.0031	
Flexible CCT (2300 – 6400)	$T_F^{1)} \pm \Delta T^{2)}$	$D_{uv}(T_F)^{3)}$	

a. T_F is chosen to be at 100 K steps (2300, 2400, …., 6400 K), excluding the first ten CCTs listed in Table 1.
b. $\Delta T_F = 1.1900 \times 10^{-8} \times T_F^3 - 1.5434 \times 10^{-4} \times T_F^2 + 0.7168 \times T_F - 902.55$
c. $D_{uv}(T) = 0$ for T<2870K, $D_{uv}(T) = 57700 \times (1/T)^2 - 44.6 \times (1/T) + 0.00854$ for T≥2870K.

Metrics on Electrical Performance

- Power - shall not differ by more or less than 10% of the total power declared by the supplier.
- Power factor – active power following the load divided by apparent power of the circuit; low PF's can adversely affect electricity distributors by as low PF's result in higher real power.
- Fundamental power factor – (also: displacement factor or displacement power factor) - quantifies the displacement (phase-shift) between the fundamental current and voltage waveforms
- Total harmonic distortion (THD) – the RMS-sum of all the harmonic currents divided by the current at the fundamental frequency; conform to IEC 61000-3-2
- Voltage variation - Shall start and continue to operate at 70% of country's nominal mains voltage. (IEC 61547). Shall meet requirements of IEC 61547 for voltage surges
  Surge protection devices - SPD shall be installed and shall conform with ANSI C136.2-2018 or IEC 61643-11

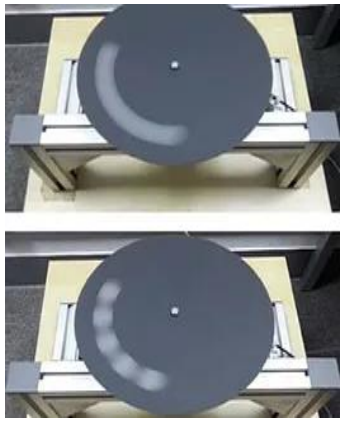
Metrics for Lifetime and Operation

- Luminous Flux Maintenance – L70B50 shall not be less than 50,000 hours
- Warranty - minimum of 10 years warranty from date of invoice
- Control Gear – operating temperature shall not exceed the rated maximum temperature of the control gear

Metrics for Health and Safety

- Flicker and stroboscopic effect – concern about health impacts including eye strain, migraine, seizures, anxiety and fatigue.

- LED lighting is highly responsive to the driver, thus flicker (PstLM[1]) and stroboscopic effect (SVM[2]) are both regulated



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Other Factors for Consideration (1 of 3)

- Electromagnetic Compatibility (EMC) – CISPR 15 requirements
  - EMC emissions – makes sure the LED lamp or luminaire doesn't interfere with other products using the electromagnetic spectrum (e.g., TV, radio)
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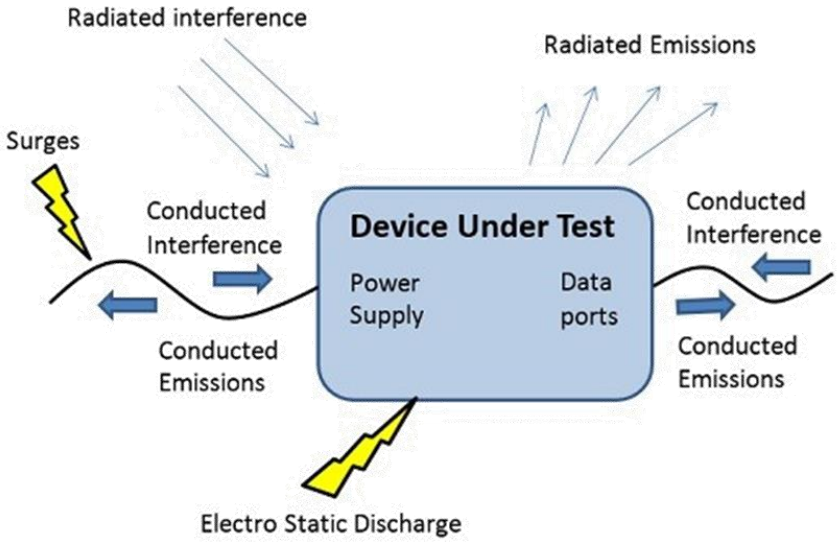

Other Factors for Consideration (2 of 3)

- Control of Light Distribution – the requirements for the nominated luminaire type for control of light distribution shall be met

CONTROL OF LIGHT DISTRIBUTION - CLD		
Type of luminaire		**CLD (%) = (Cd x 100) / Luminous Flux**
Full cut-off	Above 90º	0
	Above 80 º and up to 90 º	≤ 10
Cut-off	Above 90º	≤ 2.5
	Above 80 º and up to 90 º	≤ 10

Other Factors for Consideration (3 of 3)

- Future-proof / Smart-Lighting Compatible - Require luminaires to have NEMA/ANSI C136.41 sockets (NEMA 7-PIN)

- **Serviceable Luminaire –**a luminaire that can be accessed by standard maintenance personnel and have major components replaced, such as the LED light engine, the driver electronics, control and other circuits, and any other components such as gaskets, optical lenses, etc. should they be damaged.

- Adding a requirement will ensure they continue to be serviceable and municipalities will get the long expected service life

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Discussion and Next Steps

- Technical Notes (drafts v.1.0) will be circulated early next week; comments and questions welcome (MS Word versions)
- Do these seem like the right metrics for your region?
- Are some of these metrics covered under other existing regulations such as telecommunications?
- Are there others which you would prefer to emphasize?
- What policy outcomes do you anticipate from this work?

Thank you, any questions?

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