



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Draft ENERGY STAR SSL Criteria

Jeff McCullough, LC

Pacific Northwest National Laboratory

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Overview

- **Key Considerations**
 - **Scope of the criteria**
- **Overall Requirements**
- **Category A Proposed Criteria**
- **Category B Proposed Criteria**



Key Considerations

- **General illumination applications only**
 - Not indication or decoration
 - Not monochromatic light
- **Residential and commercial applications**
- **Based on current and expected white LED performance**
- **Designed to ensure energy efficiency relative to existing light sources**



Terms

$$\text{Lamp Efficacy} = \frac{\text{Rated Lamp Lumens}}{\text{Lamp Input Power}}$$

$$\text{System Efficacy}_{\text{fluor}} = \frac{\text{Rated Lamp Lumens} \times \text{BF}}{\text{Ballast/Driver Input Power}}$$

$$\text{Luminaire Efficacy} = \frac{\text{Luminaire Light Output}}{\text{Ballast/Driver Input Power}}$$



Luminaire Efficacy: Measurement

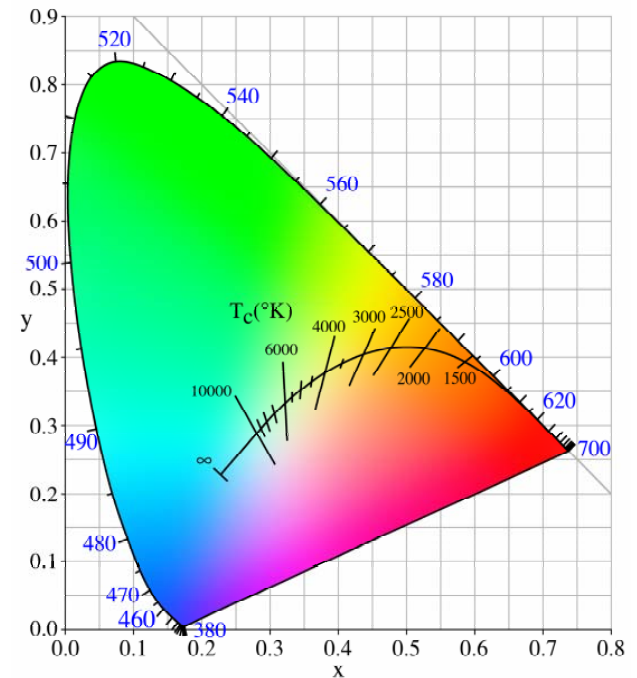
- **Photometric measurement of LED fixture**
 - Based on new ANSI/IESNA LM-79 standard in process
- **Measure total light output**
- **Measure input power**
- **Calculate luminaire efficacy as lm/W**





Chromaticity and Correlated Color Temperature

- **Draft ANSI Chromaticity Standard C78.377A in process**
 - 8 nominal CCTs
 - Flexible color option
 - Uses chromaticity quadrangles





Draft ANSI Chromaticity Standard

<u>Nominal CCT</u>	<u>CCT (K)</u>
2700 K	2725 ± 145
3000 K	3045 ± 175
3500 K	3465 ± 245
4000 K	3985 ± 275
4500 K	4503 ± 243
5000 K	5028 ± 283
5700 K	5665 ± 355
6500 K	6530 ± 510
Flexible CCT (2700-6500 K)	$T^{(2)} \pm \Delta T^{(3)}$

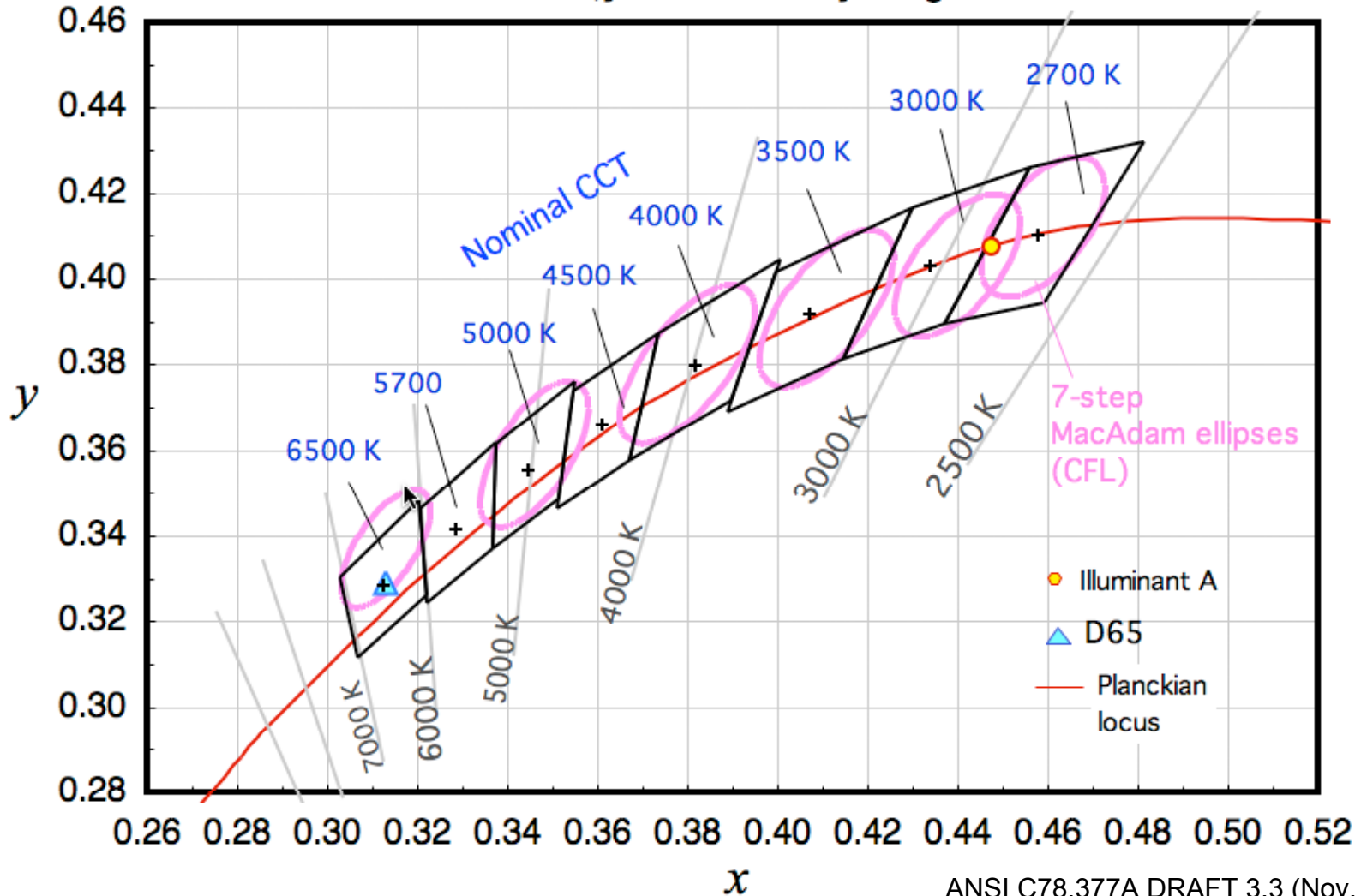
(2) T is chosen to be at 100 K steps (2800, 2900, ..., 6400 K), excluding the eight nominal CCTs listed.

(3) ΔT is given by: $\Delta T = 0.0000108 \times T^2 + 0.0262 \times T + 8$



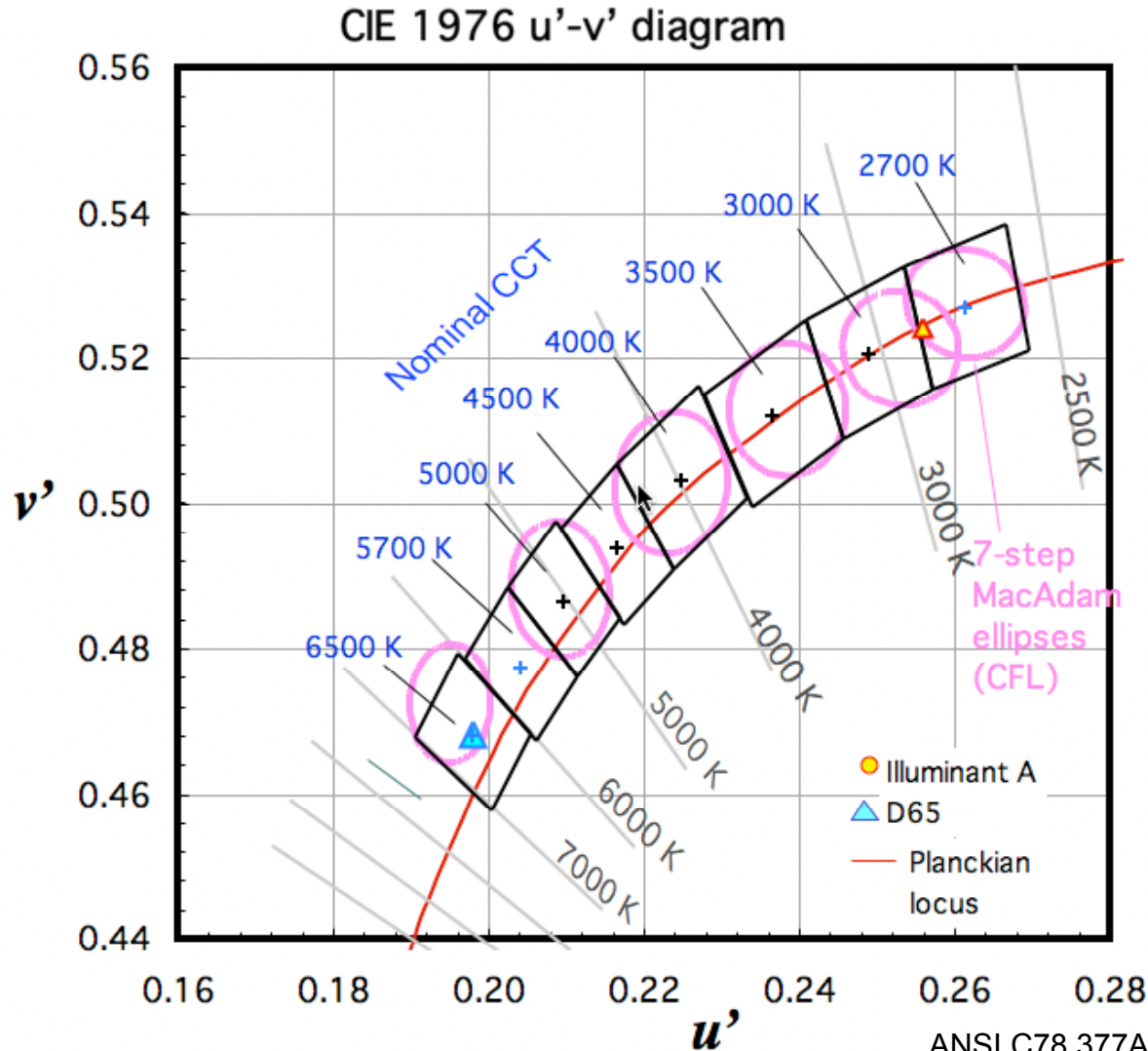
Chromaticity Diagram

CIE 1931 x,y Chromaticity Diagram



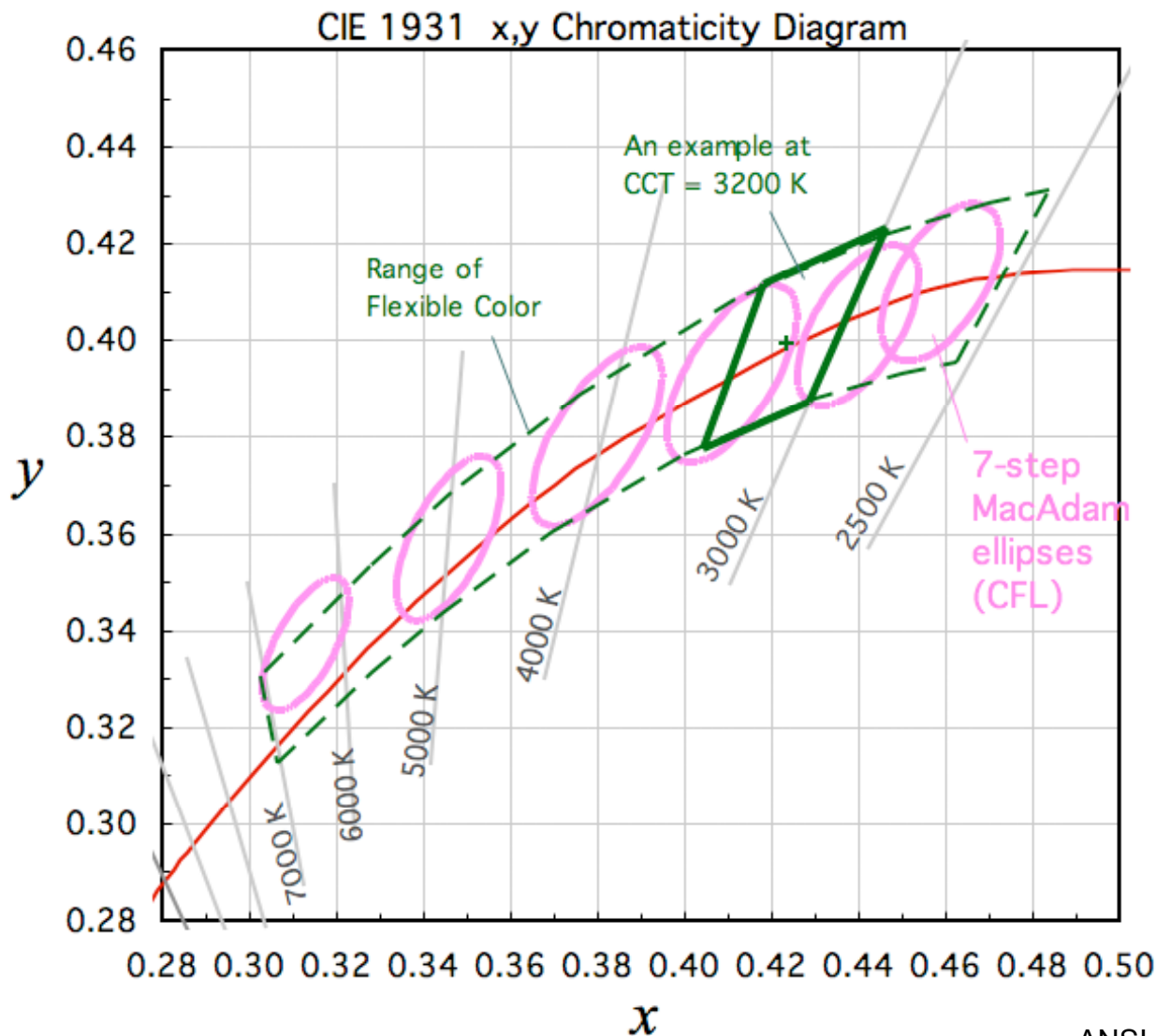


CIE 1976 u' - v' diagram





Example of 3200K product



Nominal CCT
3200 K

Min CCT 2998
Max CCT 3402
Center Duv 0.0002

4 corners (x,y)

x	y
0.4464	0.4234
0.4180	0.4116
0.4046	0.3774
0.4289	0.3871



Color Rendering Index

- **A flawed metric, especially with respect to RGB LEDs**
- **ENERGY STAR will continue to use CRI until the lighting industry develops a new metric**
- **DOE is supporting NIST in standard and test procedure development**

1	2	3	4
5	6	7	8



Overall Requirements

- **Color Spatial Uniformity**
 - Shall be within 0.004 on CIE u'v' diagram
- **Color Maintenance**
 - Shall be within 0.007 on CIE u'v' diagram over its lifetime
- **Useful Life (L_{70})**
 - ANSI/IESNA LM-80 Lumen depreciation LED Light Sources (in process)
 - $L_{70} \geq 35,000$ hours



Overall Requirements (cont.)

- **Warranty**
 - 3 years
- **Thermal Management**
 - Follow device manufacturer guidelines
- **Residential Outdoor Automatic Daylight Control**
 - Luminaires > 13 watts must have photosensor



Overall Requirements (cont.)

- **Drivers**
 - **Power factor ≥ 0.90**
 - **Minimum operating temperature shall be -20°C or lower**
 - **Maximum measured in-situ case temperature shall not exceed driver manufacturer warranty**
 - **EMI/RFI FCC 47 CFR Part 15**
 - **Consumer limits (residential)**
 - **Non-consumer limits (commercial)**
 - **Noise**
 - **Class A sound rating**



Category A: Niche Applications

- **Directed light applications**
 - Energy efficiency potential due to directional light source
 - Minimize fixtures losses
- **Source relatively close to illuminated surface**
- **Application requires relatively modest illuminance requirements**
- **Typically $\leq 50\%$ fixture efficiency**



Category A: Overall Approach

- **Establish minimum luminaire efficacy**
 - **Benchmark to fluorescent**
 - **Consistent with current ENERGY STAR lighting criteria**
 - **Use ASHRAE/IESNA 90.1 Lighting sub-committee consensus system efficacy for CFL**
 - **58 lm/W**
 - **50 lm/W (lower wattage applications and E* min.)**
 - **Use IES recommendations wherever possible: Handbook, RP-33-99, etc.**



Category A: Overall Approach (cont.)

- **Surveyed existing products in the marketplace for:**
 - **Fixture efficiency**
 - **Light Output**
 - **Photometry**
 - **Lamp, lamp/ballast wattage**
- **Establish minimum net light output**
- **Establish zonal lumen density requirement**



Category A: Niche Applications

- 1. Undercabinet Kitchen**
- 2. Undercabinet Shelf-mounted Task**
- 3. Portable Desk/Task**
- 4. Outdoor Wall-mounted Porch**
- 5. Outdoor Step**
- 6. Outdoor Pathway**
- 7. Recessed Downlights**



Formula used for Determining Category A Luminaire Efficacy

$$\text{Luminaire Efficacy} = \frac{\text{Typical Fixture Efficiency} \times \text{CFL Efficacy}}{\frac{\text{Application CRI}}{0.8}}$$

Given comments received to date and the fast pace with which LED efficacy is improving, DOE will drop the denominator, thus the equation simplifies to:

$$\text{Luminaire Efficacy} = \text{Typical Fixture Efficiency} \times \text{CFL Efficacy}$$



Assumptions for Establishing Luminaire Efficacy

Niche Application	CFL System Efficacy	Typical Fixture Efficiency	CRI	Calculated Luminaire Efficacy
Under-cabinet Kitchen	58	40%	80	23
Under-cabinet Shelf-mounted Task	58	50%	80	29
Portable Task	58	50%	80	29
Outdoor Wall-mounted Porch	58	40%	70	27*
Outdoor Step	50	40%	70	23*
Outdoor Pathway	50	50%	70	29*
Recessed Downlight (res)	58	50%	80	29
Recessed Downlight (com)	58	50%	70	33*



Undercabinet

- Residential kitchens
- Commercial offices
- Photometry available for commercial products
- Provide task lighting on countertop or desk





Category A: Under-cabinet Lighting



Albeo Talea

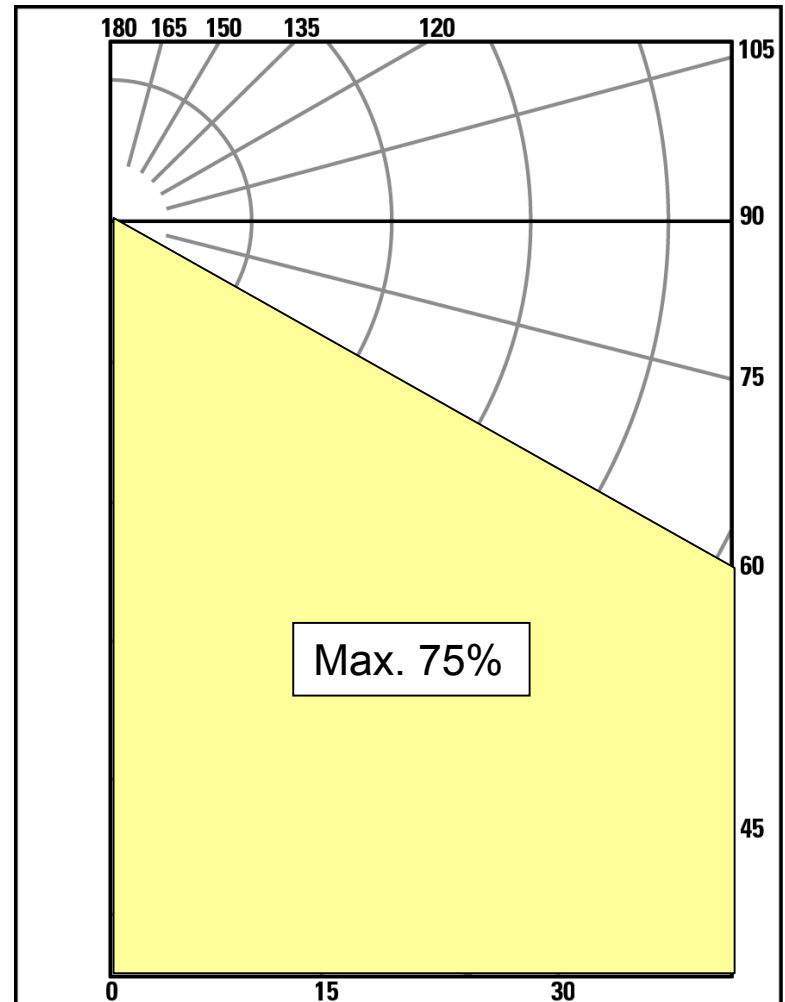


EnbrytenLED ENBU



Under-cabinet Kitchen

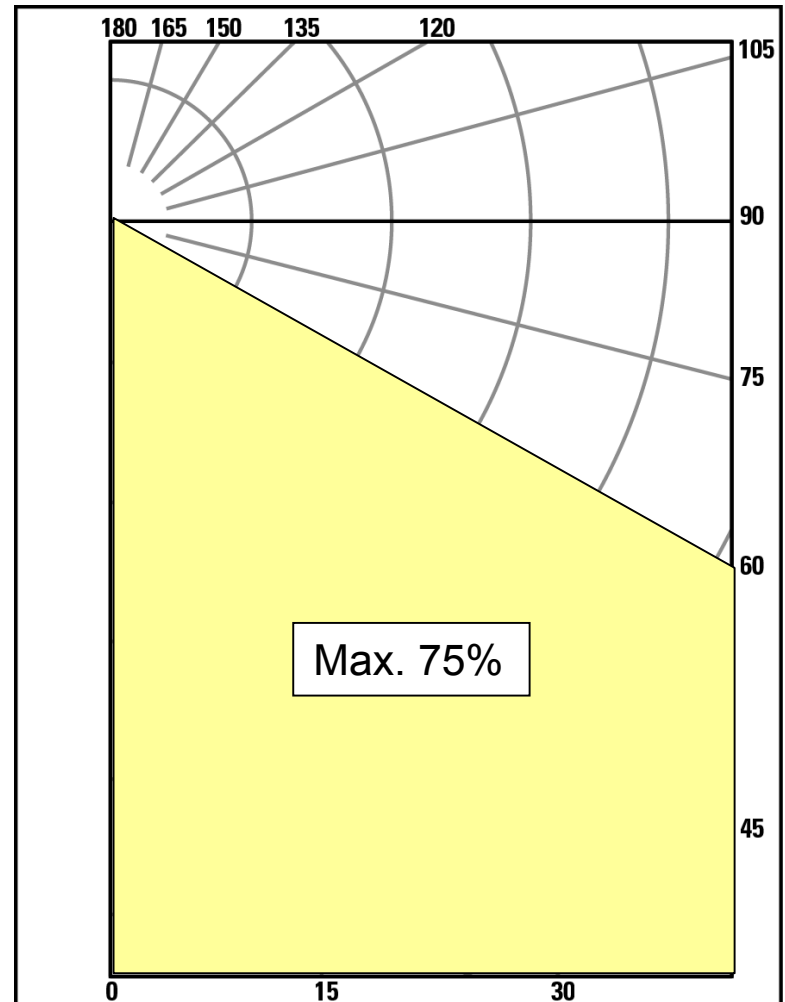
- **Minimum Light Output**
 - 150 lumens per lineal foot
- **Zonal Lumen Density**
 - No more than 75% of total light output within 0-60° zone
- **Luminaire Efficacy**
 - ≥ 23 lm/W
- **CRI**
 - ≥ 80





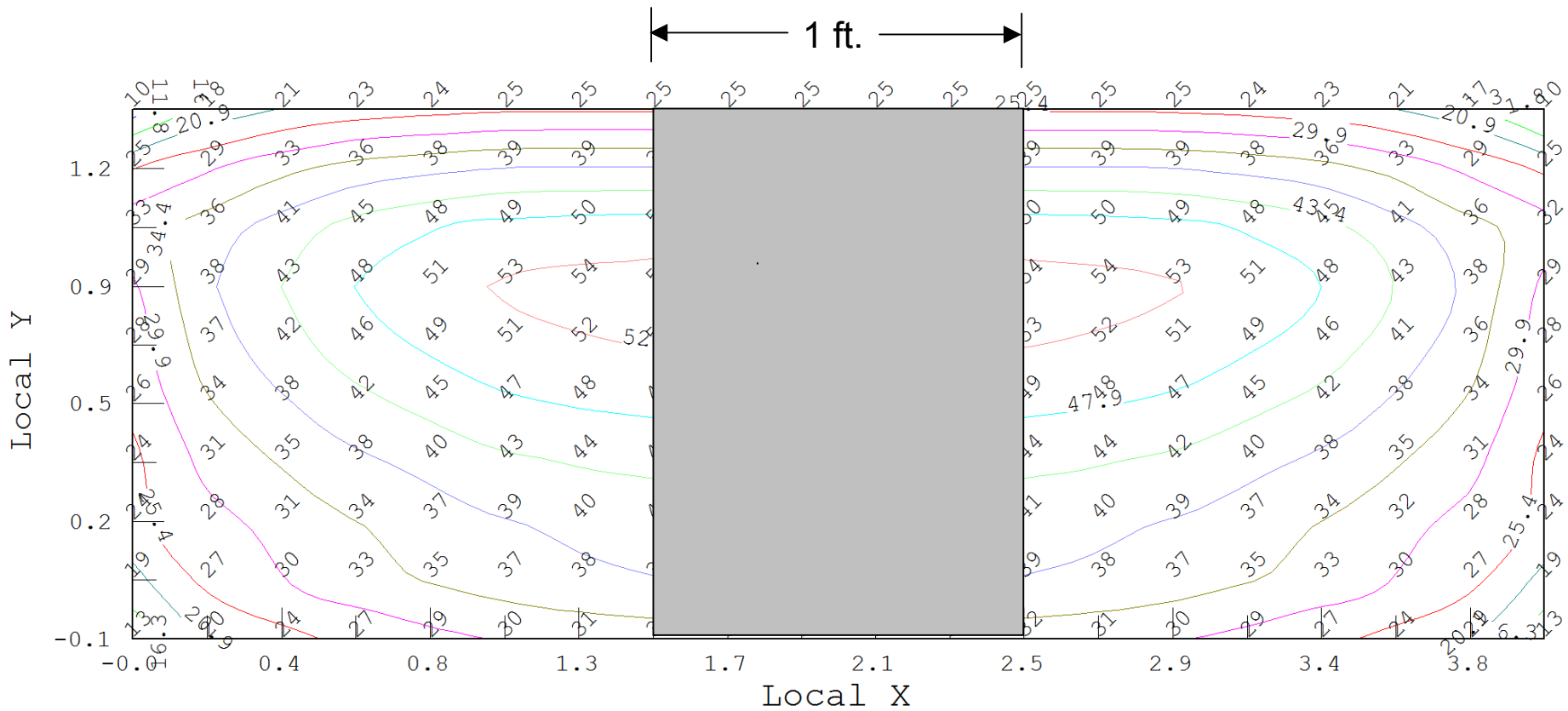
Under-cabinet Shelf Mounted Task

- **Minimum Light Output**
 - 150 lumens per lineal foot
- **Zonal Lumen Density**
 - No more than 75% of total light output within 0-60° zone
- **Luminaire Efficacy**
 - ≥ 29 lm/W
- **CRI**
 - ≥ 80



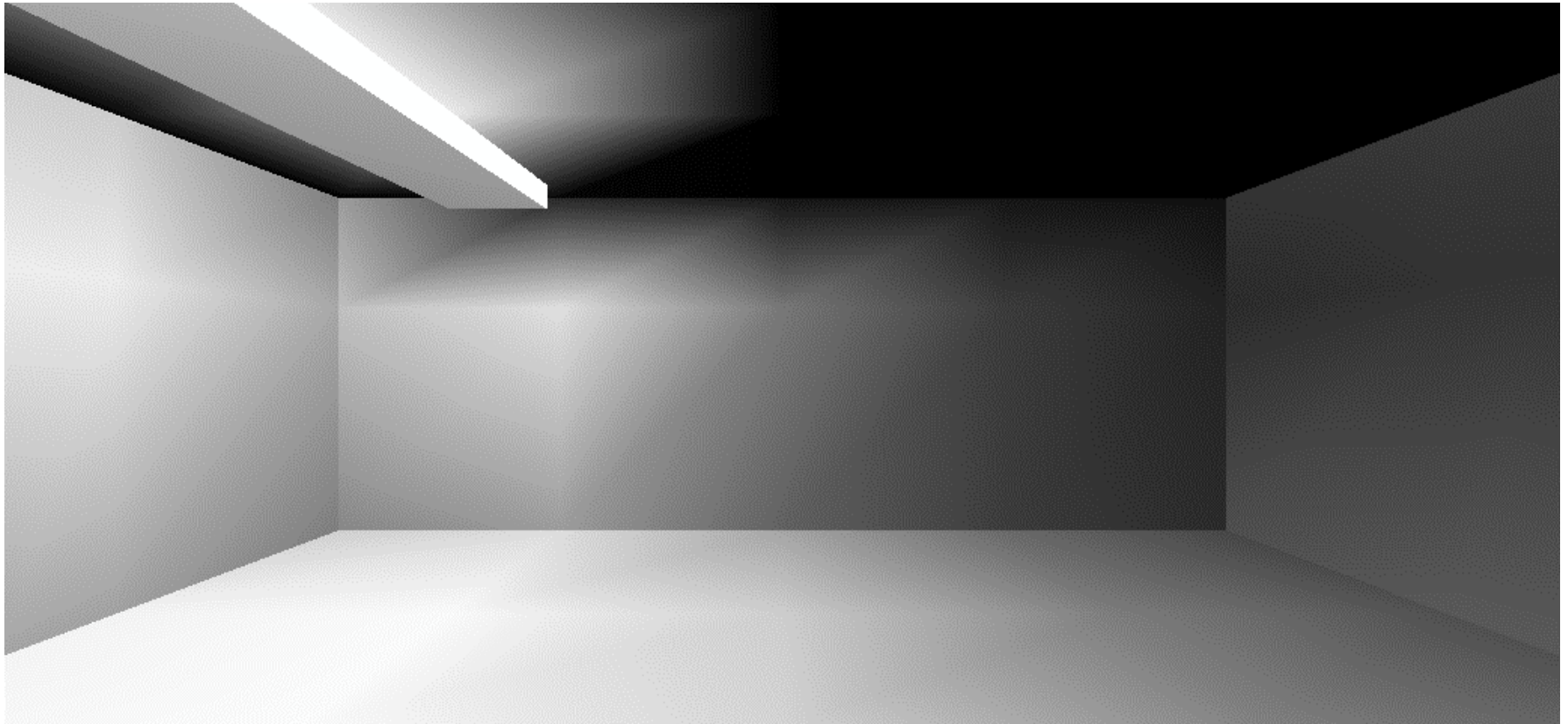


Iso-footcandle Plot





Grayscale Rendering





Existing Undercabinet Performance

	Fixture Input Watts	Lamp Type	# of lamps	Lamp Rated Lumens	Source Rated Lumens	System Efficacy	Fixture η (down)	Net Lumens 0-60°	App. Efficacy	Fixture Length	App. Lumens per lin. ft
Halogen											
ALKCO LIGHTING -- HG23-SGD	60	T-3 Halogen	3	320	960	16.0	53.3%	443.1	7.39	1.91	232
ALKCO LIGHTING -- LH22	75	T-4 Halogen	3	170	510	6.8	58.9%	245.7	3.28	1.8	137
Xenon											
ALKCO LIGHTING -- XN12	50	T-3.25 Xenon	5	91	455	9.1	74.5%	216.1	4.32	0.98	221
T8											
Columbia - UC48-132	30	F32T8	1	2900	2900	96.7	52.2%	1037	34.57	4	259
Fail-Safe -	27	F25T8	1	2150	2150	79.6	67.3%	1222	45.26	3	407
ALKCO - 332	35	F32T8	1	2900	2900	82.9	49.0%	1018.4	29.10	4.01	254
T5											
Lithonia -- TTL 2L8 120 GEB	15	F8T5	2	400	800	53.3	43.6%	241.7	16.11	1.3	186
Lithonia -- UC42	31	F13T5	2	850	1700	54.8	38.1%	481.7	15.54	3.5	138
Lithonia - UC24	19	F8T5	2	400	800	42.1	38.1%	226.5	11.92	2	113
ALKCO - HP113	16	F13T5	1	833	833	52.1	50.5%	308.8	19.30	1.77	174
ALKCO - HP128	33.8	F28T5	1	2900	2900	85.8	59.8%	1283.4	37.97	3.85	333
T2											
ALKCO - SQ113	16	T-2 FM13	1	860	860	53.8	62.1%	381.4	23.84	1.89	202
ALKCO - SQ213	30.5	T-2 FM13	2	860	1720	56.4	63.5%	790.40	25.91	3.65	217



Portable Desk/Task

- **Plug-in portable fixtures**
- **Wide variety of styles and prices**
- **Photometry typically not available**
- **Provide supplemental task lighting on desk or other horizontal work surface**





Category A: Portable Desk/Task



6 Watt LED Desk Lamp

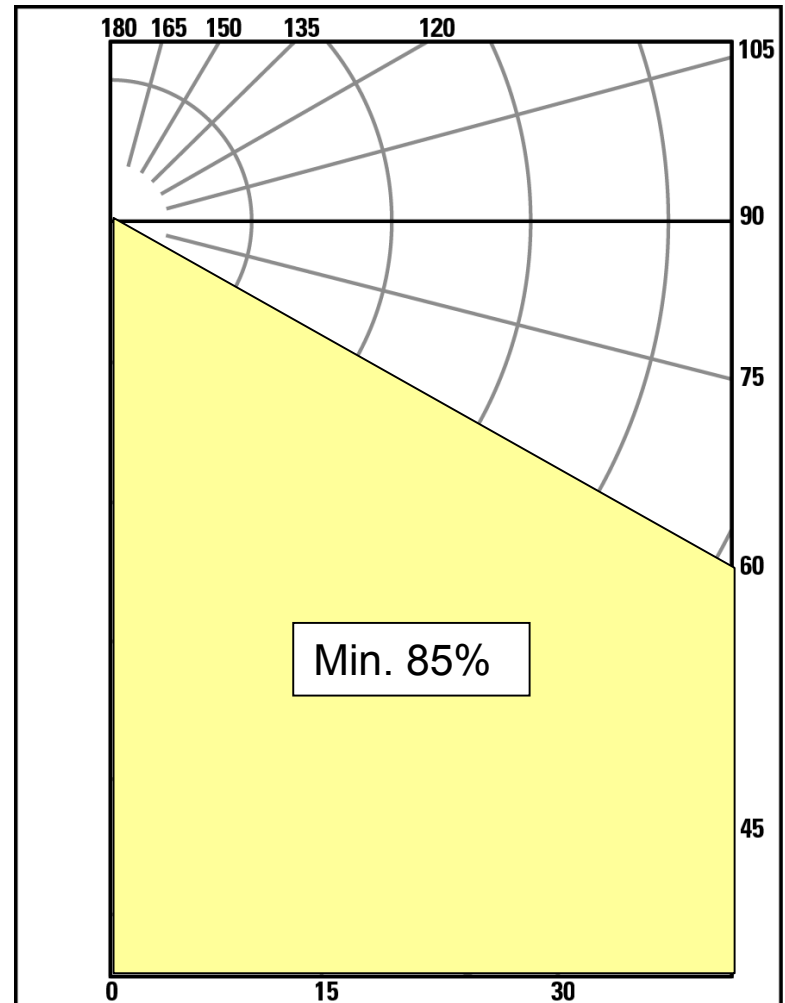


Halley LED Desk Lamp



Portable Desk Task Lamps

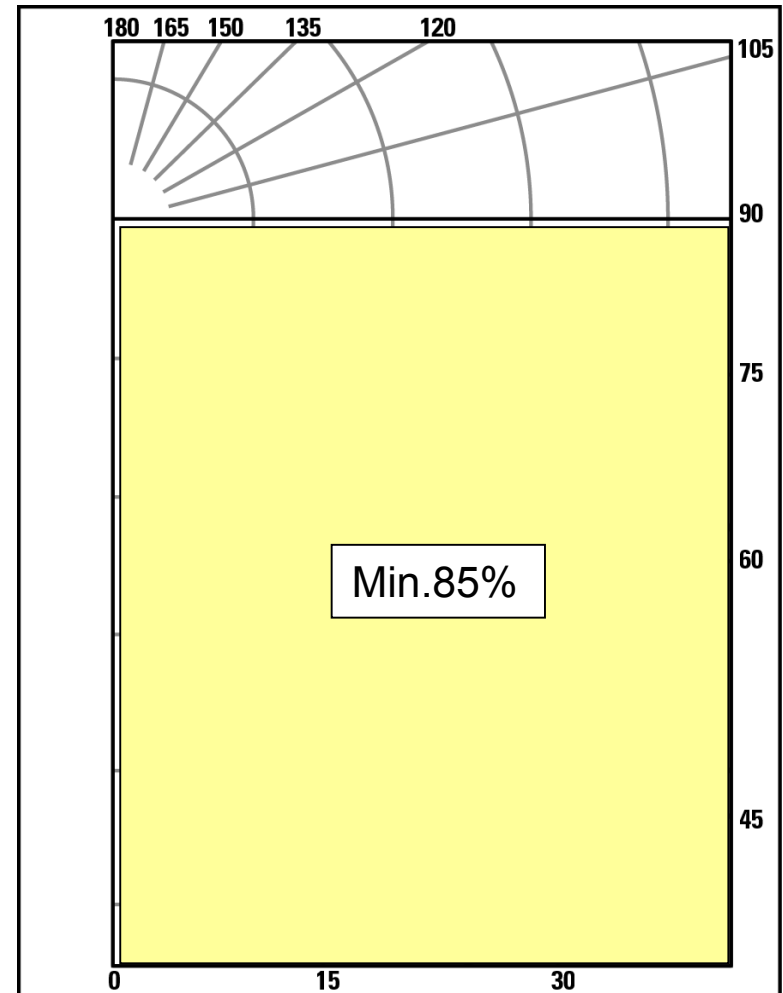
- **Minimum Light Output**
 - 200 lumens
- **Zonal Lumen Density**
 - Minimum 85% of total light output within 0-60° zone
- **Luminaire Efficacy**
 - ≥ 29 lm/W
- **CRI**
 - ≥ 80





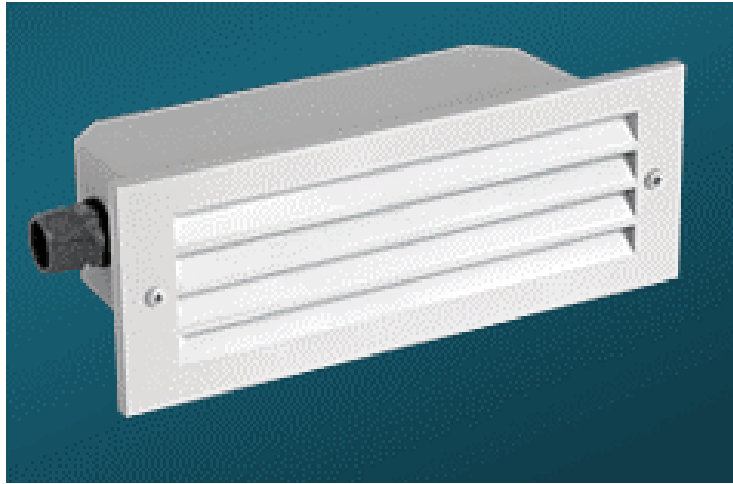
Outdoor Wall-mounted Porch

- **Minimum Light Output**
 - 200 lumens
- **Zonal Lumen Density**
 - Minimum 85% of total light output within 0-90° zone
- **Luminaire Efficacy**
 - ≥ 27 lm/W
- **CRI**
 - ≥ 70





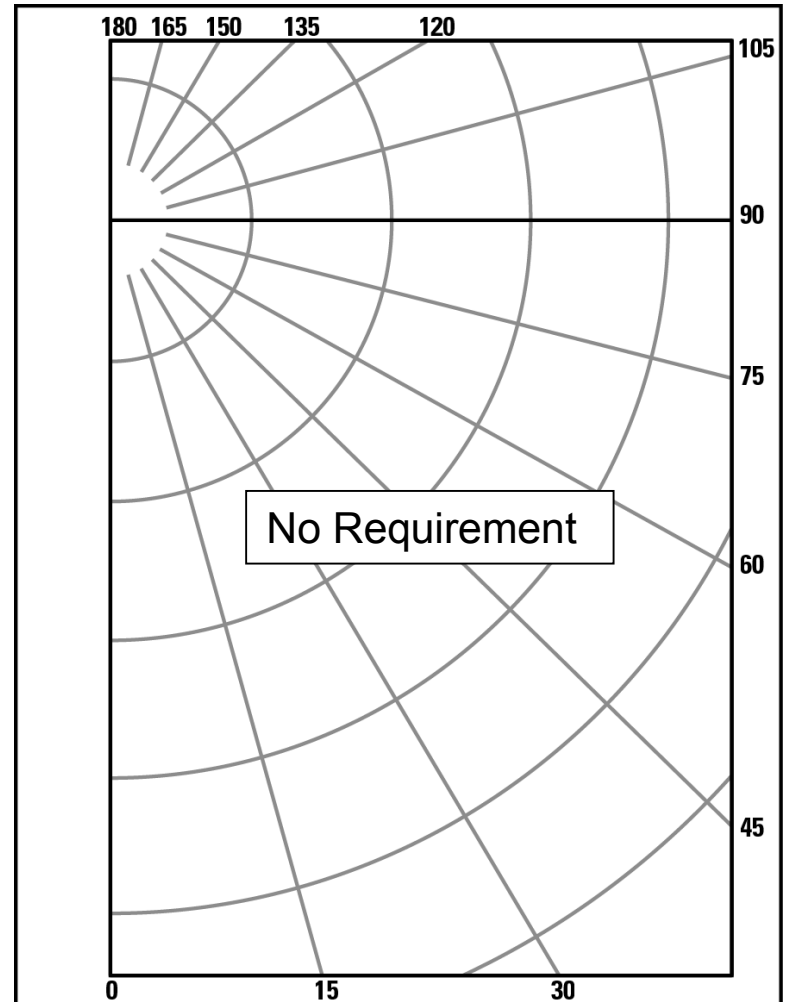
Category A: Outdoor Step





Outdoor Step

- **Minimum Light Output**
 - 100 lumens (initial)
- **Luminaire Efficacy**
 - ≥ 23 lm/W
- **CRI**
 - ≥ 70





Category A: Outdoor Pathway



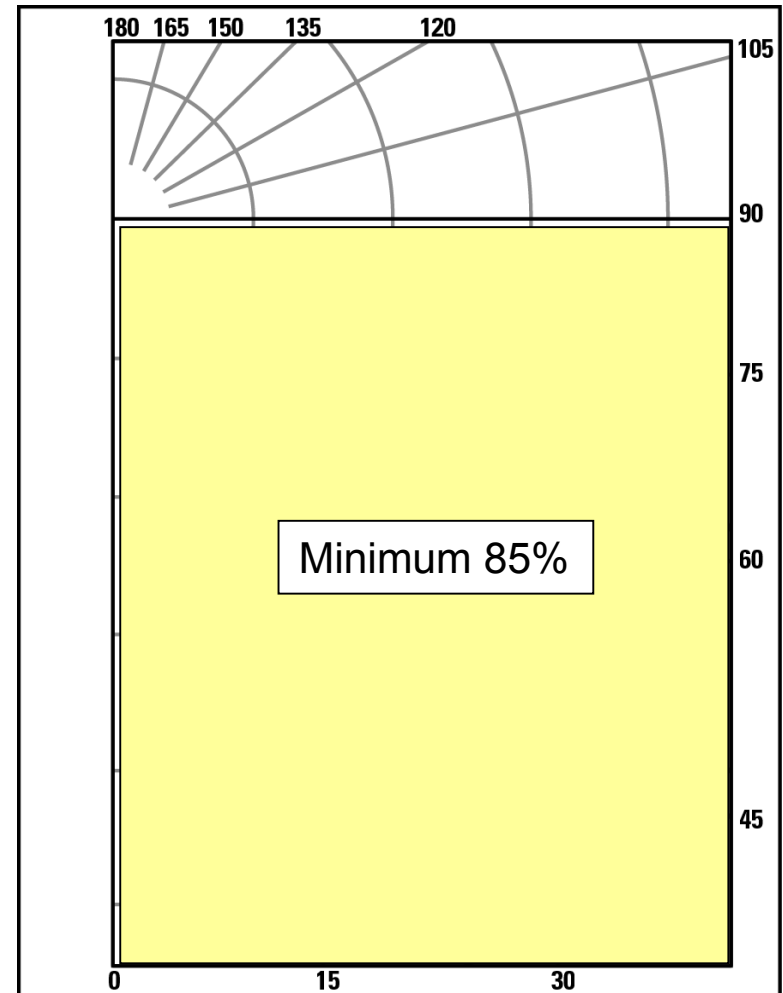
Advanced LED Ltd.





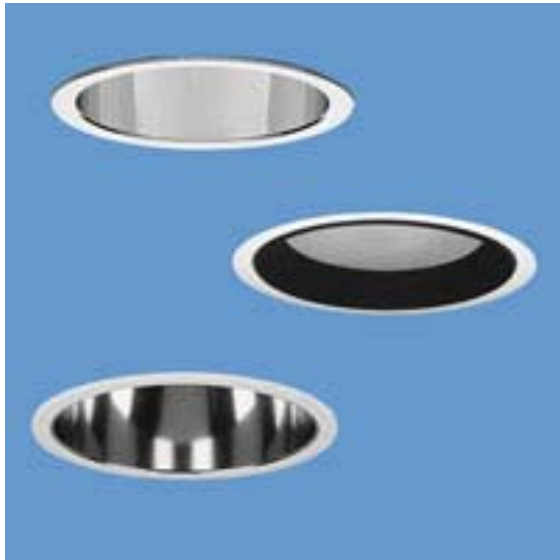
Outdoor Pathway

- **Minimum Light Output**
 - 100 lumens (initial)
- **Zonal Lumen Density**
 - Minimum 85% of total light output within 0-90° zone
- **Luminaire Efficacy**
 - ≥ 29 lm/W
- **CRI**
 - ≥ 70





Recessed Downlights

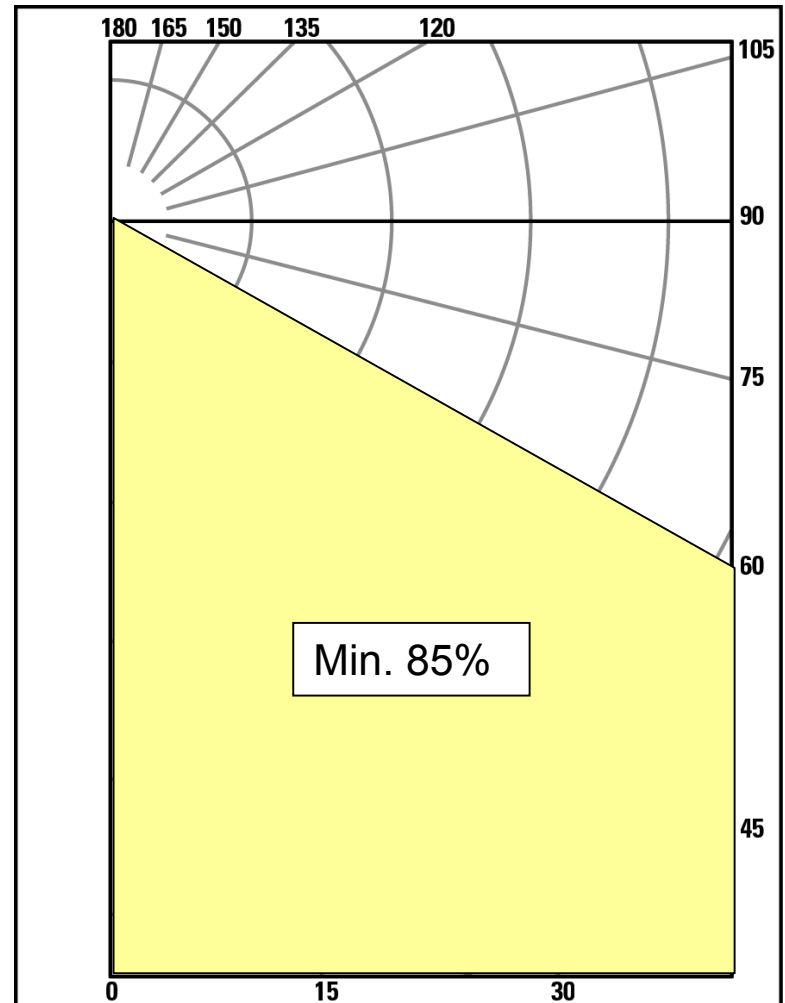


- Most common residential installed fixture
 - Insulated ceilings result in high temp environment
- Also very common in commercial buildings
- Ambient lighting



Recessed Downlights

- **Minimum Light Output**
 - ≤ 4 " Aperture 300 lumens
 - > 4 " Aperture 500 lumens
- **Zonal Lumen Density**
 - Minimum 85% total light output within 0 - 60° zone
- **Luminaire Efficacy**
 - ≥ 29 lm/W (residential)
 - ≥ 33 lm/W (commercial)
- **CRI**
 - ≥ 80 (residential)
 - ≥ 70 (commercial)





Category B: Luminaire Efficacy Based Performance

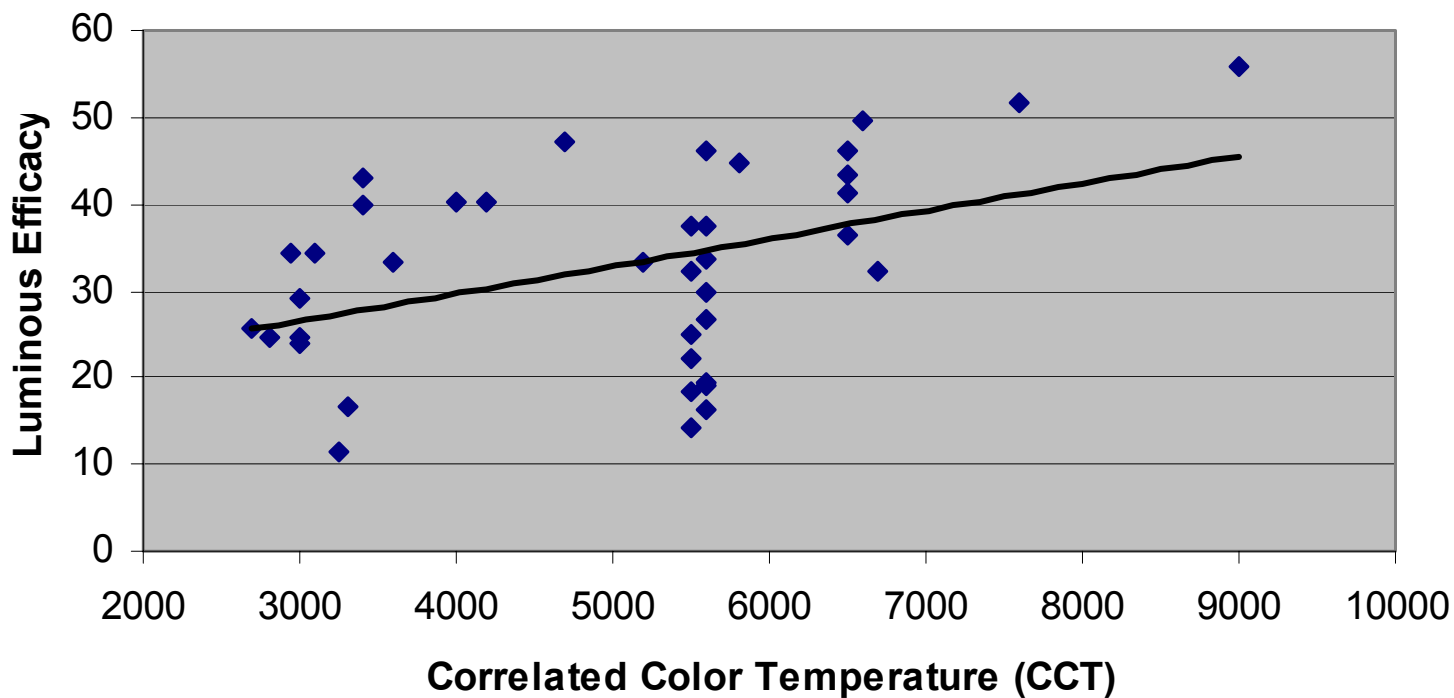
- **Establishes threshold 1-3 years out**
- **Exceed efficacy of best CFLs**
- **No application efficiency requirement**
 - **No minimum net lumens nor zonal lumen density requirements**
- **Based on luminaire efficacy**
 - **Total luminaire lumens/total luminaire watts**



LED Efficacy and Color

Production LEDs

as of 7/06





Category B: Performance-Based Specification

CCT	Luminaire Efficacy
$\leq 3000\text{K}$	$\geq 50 \text{ lm/W}$
$3000\text{K} < \text{CCT} \leq 5000\text{K}$	$\geq 60 \text{ lm/W}$
$> 5000\text{K}$	$\geq 70 \text{ lm/W}$

- CRI
 - Indoor Luminaires ≥ 80
 - Outdoor Luminaires ≥ 70



The Path Forward

- Stakeholder meeting: February 8, 2007
- Issue second draft: March 2007
- Complete final criteria: July 2007
- Effective date: December 2007



Q & A

Richard Karney, PE
ENERGY STAR Product Manager
U.S DOE
richard.karney@ee.doe.gov