

Shades of White

Communicating the Color of Light

Energy Star Lighting Partner Meeting
April 5, 2005

Pamela Horner, OSRAM SYLVANIA, NEMA
Dale Work, Philips Lighting, NEMA

Topics

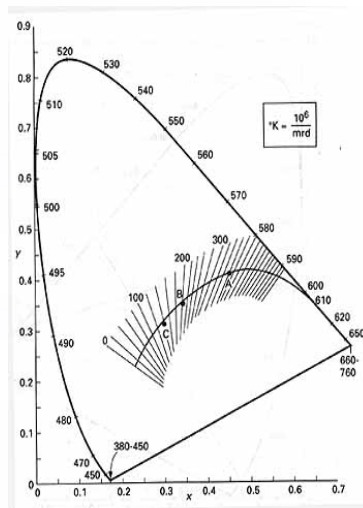
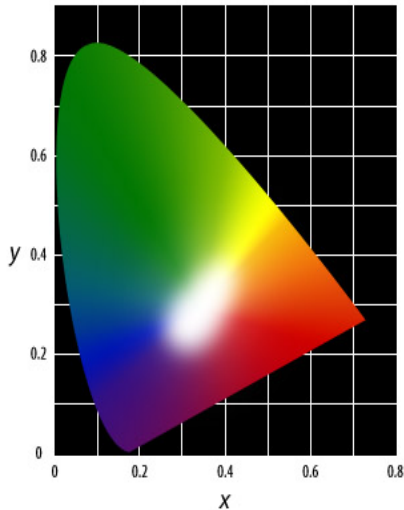
- What is “white”?
- Color appearance of a lit lamp
- Problems communicating light and color to consumers
- Entities with interest in communicating color & light
 - Traditional lighting manufacturers
 - LED manufacturers
 - Energy Star (CFLs and luminaires)
- New color communication ideas for color of a “lit” lamp
- Color rendition
- Government and industry working together

What is white?

- Begin with a short experiment – not describing lit lamps, describing a lit object
- Volunteer(s) from audience
- Task 1: describe the “shade of white” of a tile
- Task 2: which paint color matches it?
 - Based on the description of the tile
 - Based on your memory of the tile
 - Background might matter

Current Metrics for...

- The color “appearance” of a lighted lamp
 - Color temperature (for filament sources)
 - Correlated color temperature, CCT (for fluorescent, HID and solid state/LED sources)
 - Measured in degrees Kelvin, expressed in kelvin, K (numbers)
 - Primarily to distinguish “shades of white”



Color Temperature, CCT

- Generally understood and used by
 - Lamp manufacturers
 - Specifiers
 - Commercial distributors
 - Large commercial/industrial planners
 - Utility specialists
- Not generally understood by
 - Consumers
 - People who change lamps

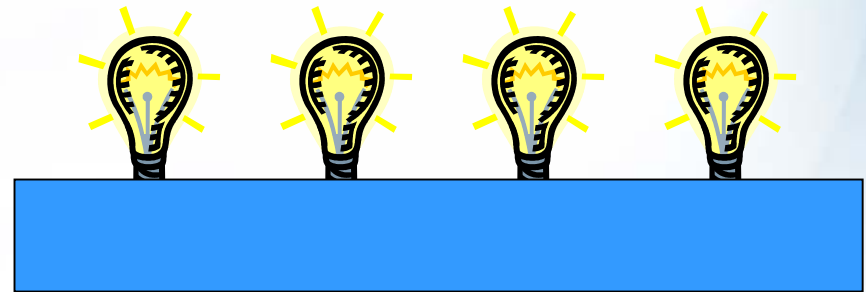


Communicating Color of a Lit Lamp

- The problem isn't chiefly one of metrics.... communication plays a major role
- Lamp manufacturers currently communicate using...
 - Numbers to indicate CCT
 - 2700K, 3000K, 3500K, 4100K, 5000K, etc.
 - Words to describe "appearance" or "whiteness"
 - Cool White, Warm White, Deluxe White, Supermarket White, Natural White, Royal White, Lite-White, White
- Consumers communicate using...words?
 - Let's try an experiment.....

How would you answer these questions?

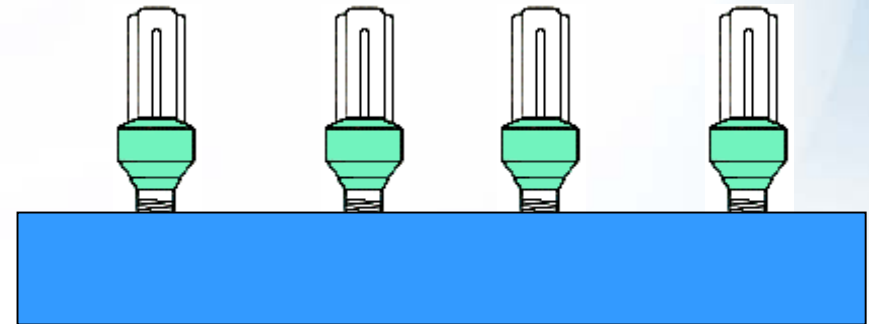
- For this group of incandescent lamps, how would you succinctly describe...
 - The color of each one, beginning with the left?
 - The change you see in color from left to right?
- Which one of these incandescent lamp colors do you prefer for your home?
- How would you succinctly describe the color of the one you prefer?



Lighted Samples

And these?

- For this group of compact fluorescent lamps, how would you succinctly describe...
 - The color of each one beginning on the left?
 - The change you see in color from left to right?
- Which one of these lamp colors do you prefer for your home?
- How would you succinctly describe the color of the one you prefer?



Lighted Samples

How a group in the Northeast answered these same questions.....

Person	Lamp A: 100W 130V Rough Service	Lamp B: 100W 120V A-line Soft White	Lamp C: 100W A- line Halogen Daylight Plus	Lamp D: 100W A-line Daylight coating	Lamp E: 27W CFL Twist 2700K	Lamp F: 27W CFL Twist 3000K	Lamp G: 27W CFL Twist 3500K	Lamp H: 27W CFL Twist 5000K
1	bright	bright soft-tone	yellow	blue-soft	yellow	softer	blue	bluer
2	yellow bright	white bright	grey-softer	blue-soft	soft white	soft white	soft, light pink	soft
3	bright white	ghost white	clear candle	cloudy white	white	white	white	bright white
4	bright yellow	white - soft	white	milky white	soft, yellowish	lovely soft white	white snow	light white
5	yellow green	whiter yellow	blue purple	purple	white	hint of purple	white, crisp	cool
6	creamy white	brilliant white	bright white	milky white	white hot	cool bluish white	soft gray white	blue white
7	yellow white	white	white/yellow	blue or white	white	blue white	bluer white	bluer, cooler
8	warm yellow	brighter white	dull white	crisp white	dull white, cool	cool crisp	bright bluish	very cool blue
9	yellow	white	yellow	white	light yellow	white	whiter	bluish
10	yellowish	whiter	white/not so bright	nice quality	white	whiter	less glaring	blue
11	yellow	white	white	white	yellowish	white	bluish white	blue/purple
12	yellow	white	white w/yellow tint	dull	dull yellow	white	greyish white	bluish white
13	yellow	white	white w/yellow tint	real white	pink	light purple	white	blue white
14	yellow	normal	normal	white, clean	weak yellow	blue drab	blue-green crisp	moonlight
15	yellowing white	yellowish/diffuse	whiter	whiter	yellow	whiter	whiter still	blue white
16	gray/purple	bluish white	neutral white	daylight	greenish	white	daylight white	sky white
17	orange/yellow	white/yellow	whiter	true white	yellow, intense	white	blue greenish	blue
18	light blue	yellow	blue	blue purple	yellow	white	white	blue
19	soft	bright	glaring	perfect/bluish	yellowish	comforting	whiter	bluish
20	bright	white	yellow	blue	white	greyish	light green	soft white

Green fill = preferred incandescent lamp

Pink fill = preferred CFL

How a group in the Northeast answered these same questions.....

Person	Incandescent Array			CFL Array		
	Color Change, Left to Right	Preferred Lamp for Home	Color of Preferred Lamp	Color Change, Left to Right	Preferred Lamp for Home	Color of Preferred Lamp
1	bright to soft	D	blue	yellow to blue	H	blue
2	violet to white to grey to light blue	B	white	violet to white	H	even white
3	dim to bright	B	cloud white	yellowish to bright white	H	bright white
4	C to A to D to B	B	full soft white	yellow white to white	G	snow white
5	little difference	C	blue purple	yellowish warm to bluer purple	F	white
6	bright to fuller cloudiness	D	soft	yellow to white	G	soft brilliance
7	yellow to white to colder to bluish	B	white/uniform	warm to cool	G	not too yellow, not too blue
8	yellow warm to clearer cooler white	B	bright white with splash of yellow	warm to cool, white to crisp	E	warm white
9	yellow to white	D	white	yellow to white to bluish	G	white
10	white to more uniform	B	mellower	yellow to white to blue	G	mellow
11	progressively whiter	D	blue/white	getting whiter	G	white
12	yellow to white	B	warm white	dull white to bright white	G	natural light
13	yellow to blue white	D	closer to daylight	yellow pink to blue white	H	natural light
14	yellow to white, dim to crisp	C	normal yellow white	yellow to blue, dirty to clean	H	clean
15	right one is most white	B	yellowish white	yellow to white to blue white	F	yellow white
16	dim yellow to bright white	C	bright white	green to blue	F	bright, softer
17	warm to true white	C	natural white	warm yellow to blue	G	natural color
18	subtle to brighter	B	yellow	subtle to bright	G	white, clear, true
19	?	D	bluish	N/R	F	less glare
20	more intense at the end	D	pure white	brighter left to right	H	white

Some problems in communicating color appearance of lit lamps

- Numbers
 - Kelvin means nothing to most consumers, and in fact can be construed as “higher numbers are better”
 - To a consumer, numbers are usually mean “watts”
- Words
 - To most consumers “warm” and “cool” are temperature terms, so they think “warm” lamps will actually make the room warm
 - Other descriptors such as “natural white” have different meanings for different people and different cultures
 - Color descriptions can be confounded with brightness descriptions
- Proximity to other light sources
 - The “color” of one lamp depends on what other lamps are nearby
- Shades or globes
 - The color appearance of a lamp can change if the light has to pass through a lamp shade or plastic globe
- Familiarity
 - Most consumers think of incandescent “colors” as the norms

Traditional lighting manufacturers and color...

- Manufacturers of “white light sources” are generally satisfied with current CCT metrics
 - Work well for communicating among ourselves
 - Work reasonably well for communicating with commercial specifiers
- Manufacturers are not generally satisfied with communication of color properties to consumers
 - Recognize that CCT is precise but confusing
 - A simpler, “outside the box” communication method should be possible
 - Particularly with fluorescent products, simpler communication could translate to more sales of these energy-efficient products

LED manufacturers and color...

- What about for “white” LED systems?
 - Appearance issues of “lit systems” are the same
 - Communication issues are the same

Energy Star and Color...

- Energy Star SCFLs

- “Color” suggested as a barrier to sales, but no clear information on what that means
 - Lamps from the same manufacturer don’t match?
 - Lamps from different manufacturers don’t match?
 - New lamps don’t match old lamps?
 - Lamps of different wattages don’t match?
 - Lamp color doesn’t look like incandescent?
 - Colors of objects being illuminated don’t “look right”?

- Energy Star Luminaires

- Lamp color choices should be clearly marked for consumers
- Lamp colors need to be consistent among manufacturers so that customer expectations can be met (tighter specs)
 - However, luminaires influence color appearance of the source
- Lamp color specs for luminaires may eventually apply to SCFLs

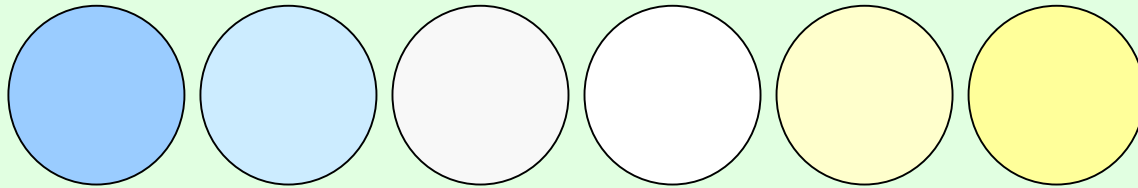
A New Idea for Communicating the Color of Lit Lamps

Focus Groups

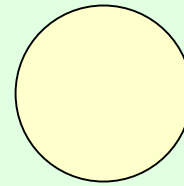
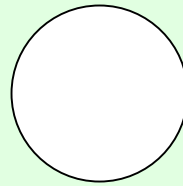
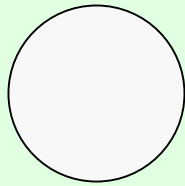
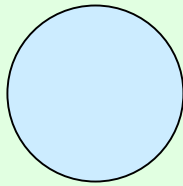
Background

- Industry recognized the problem
- Problem needs an industry-wide solution
- Asked LRC for one idea to get us started
- That idea was consistent with industry view and was embraced as an approach to be expanded
- Industry approached government, who had known concerns in this area – specifically within Energy Star
 - What will consumers think of the approach?

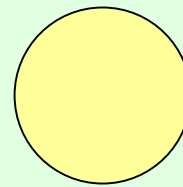
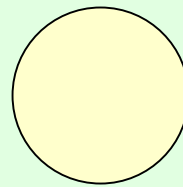
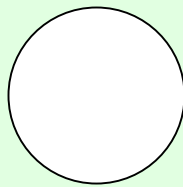
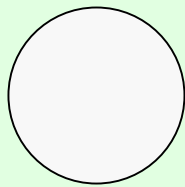
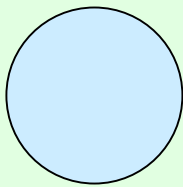
- Color Appearance -
what the lamp looks like when lit



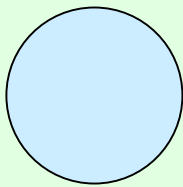
- Color Appearance -
what the lamp looks like when lit



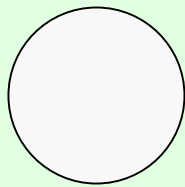
- Color Appearance -
what the lamp looks like when lit



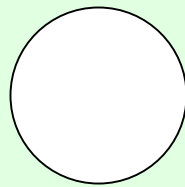
- Color Appearance -
what the lamp looks like when lit



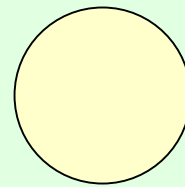
5000



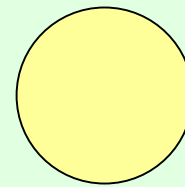
4000



3500

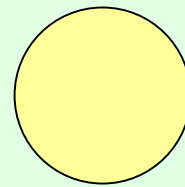
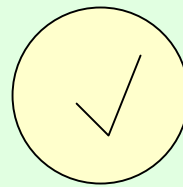
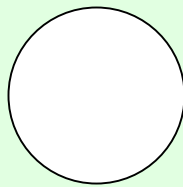
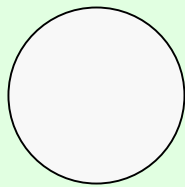
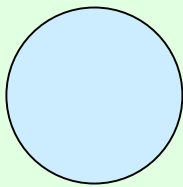


3000

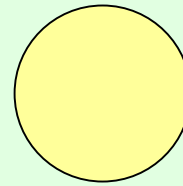
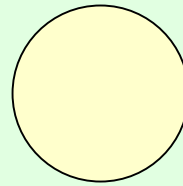
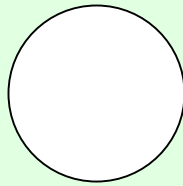
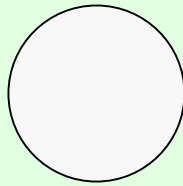
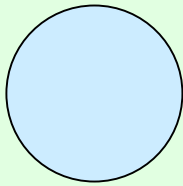


2700

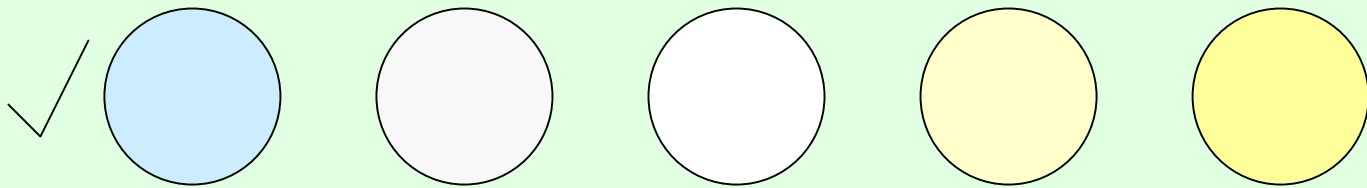
- Color Appearance -
what the lamp looks like when lit



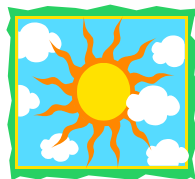
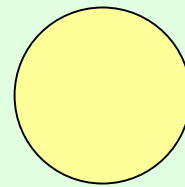
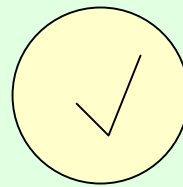
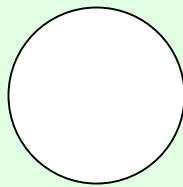
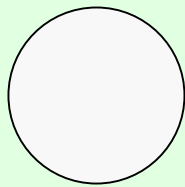
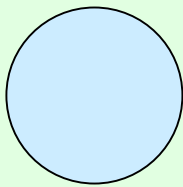
- Color Appearance -
what the lamp looks like when lit



- Color Appearance -
what the lamp looks like when lit



- Color Appearance -
what the lamp looks like when lit

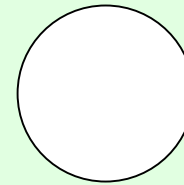
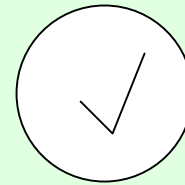
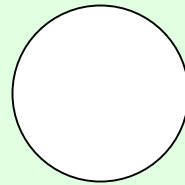
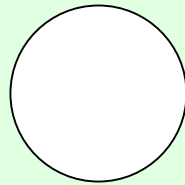
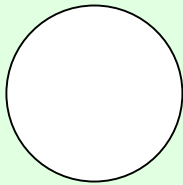


- Color Appearance -

what the lamp looks like when lit

blue-ish

yellow-ish



- Color Appearance -
what the lamp looks like when lit

blue-ish

yellow-ish

1	2	3	4	5	6 ✓	7	8
---	---	---	---	---	--------	---	---

Focus Groups

- Energy Star (DOE and EPA) plus NEMA are sponsoring a study of this idea with focus groups, coordinated by the LRC
- If you were in one of these focus groups, what would you say regarding:
 - Number of circles
 - Helpful icons
 - Checkmark in or out of circle
 - Colored circles vs. white circles with words
 - With or without CCT
 - Circles vs. boxes
 - Other

But there is more to the color
story than color appearance of a
lit lamp...
how do objects look?

Current Metrics for...

- The ability of a light source to “render” an object more or less naturally
 - Color Rendering Index (CRI)
 - Compare sources to a standard of the same CCT that illuminate a set of 8 color “chips”
 - Measure & compare shift in appearance of chips
 - By definition, filament sources score high, at or near 100



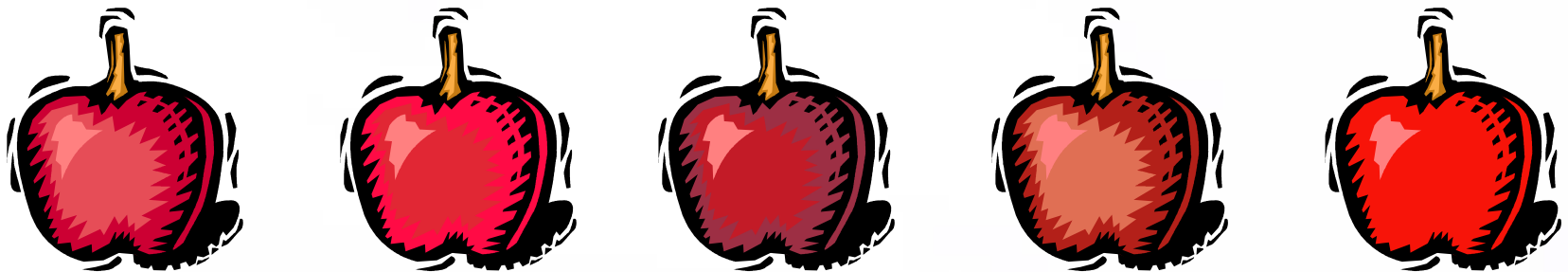
CRI

- Generally understood and used by
 - Large commercial/industrial planners
 - Specifiers
 - Commercial distributors
 - Utility specialists
 - Lamp manufacturers
- Not generally understood by
 - Consumers
 - People who change lamps



The problem of color quality and a “reference”

- Which one of these apples has the “right” red color, according to your apple memory?
- Which one looks “best”?
- Which one is the “reference” apple?
- Should a “good” light source render them all to look like the “reference” apple?



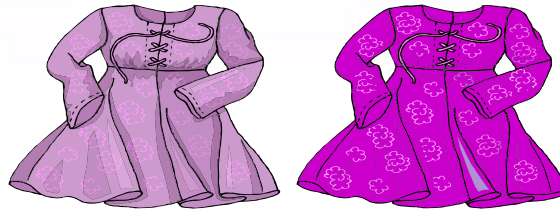
Other problems in communicating color rendering ability of lamps

- Color rendering implies lighting quality, but “color quality” could mean several things...

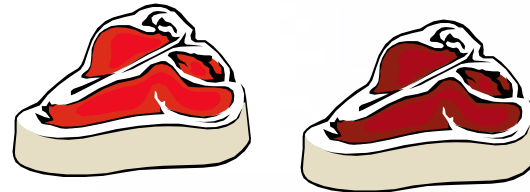
- Discrimination:



- Preference:



- Expectation:



LED manufacturers and color...

- What about for “white” LED systems? It depends.
 - For “phosphor converted” LED systems, the issues are about the same
 - For “R-G-B” LED systems, special problems can arise
 - Some people feel the standard CRI is biased against “narrow band” sources like LEDs
 - The problem seen not only as a communication problem, but also a metrics problem

Color Symposium

- What is to be done?
 - Surely we can do much better
 - Single approach wanted for both traditional lamps and LED systems
- Just what is it that needs communicating?
- In order to communicate what users want to know, do we need new metrics?

Color Symposium

- Energy Star (DOE and EPA) + IES + NEMA are sponsoring a February '06 symposium
 - Need creative ideas:
 - What should be communicated?
 - Must be simple, effective – not perfect
 - Do we need to measure something new?
- Do you have ideas to contribute?
 - Best ideas may not come from “insiders”

The End