GATF Color Management Conference 2005

Color Science 101

The importance of lighting when evaluating color

Presenter: **Dan Reid**

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Please be courteous to your peers

- Turn off your cell phone or select silent mode

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The last frontier in color management

- Lighting is by far the least controllable element of a color managed workflow
- Rarely, if ever, does the eventual print buyer view or display prints under the recommended light source.
- There are international standards available for recommended lighting conditions when evaluating color reproduction

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Why Lighting is Important

- No light source = no perceived color, lol!
- The light source color temperature undoubtedly impacts our color perception.

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Why Lighting is Important

Image in Tungsten Lighting

Image in F11 (TL84) lighting

Why Lighting is Important

Computer monitor
in F11 (TL84) Lighting

Computer monitor
in subdued lighting

Why Lighting is Important

- The need for a standard light source, an illuminant, to critically evaluate color reproduction, D_{50}
- ISO 3664: Viewing Conditions - for Graphic Technology and Photography

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Reality Check

- Print buyers never view or display printed material in D_{50} lighting.
- Generally speaking, most print buyers view and display images under fluorescent or tungsten illumination; Illuminant F11 and A

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Reality Check

- So why is D_{50} illuminant bantered about in color management discussions if our clients don't view our products under D_{50} lighting?
- Graphic Arts professionals need a consistent method for evaluating color so a bias is not introduced.
- If you evaluate color reproduction then you should do so under D_{50} lighting

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Color Management's untold secret

- D_{50} is the assumed light source for color matching
  - When LAB is used as the profile connection space it assumes a color match for D_{50} lighting.
- We are never in D_{50} lighting
- We can never expect the final print will be viewed in D_{50} lighting.
  - A color mismatch can occur if actual viewing light source is appreciably different from D_{50}.

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D_{50}

- D_{50} is more of theoretical illuminant than one that is encountered in typical viewing environments
- Chosen because of equal energy in the red, green, and blue spectrum.

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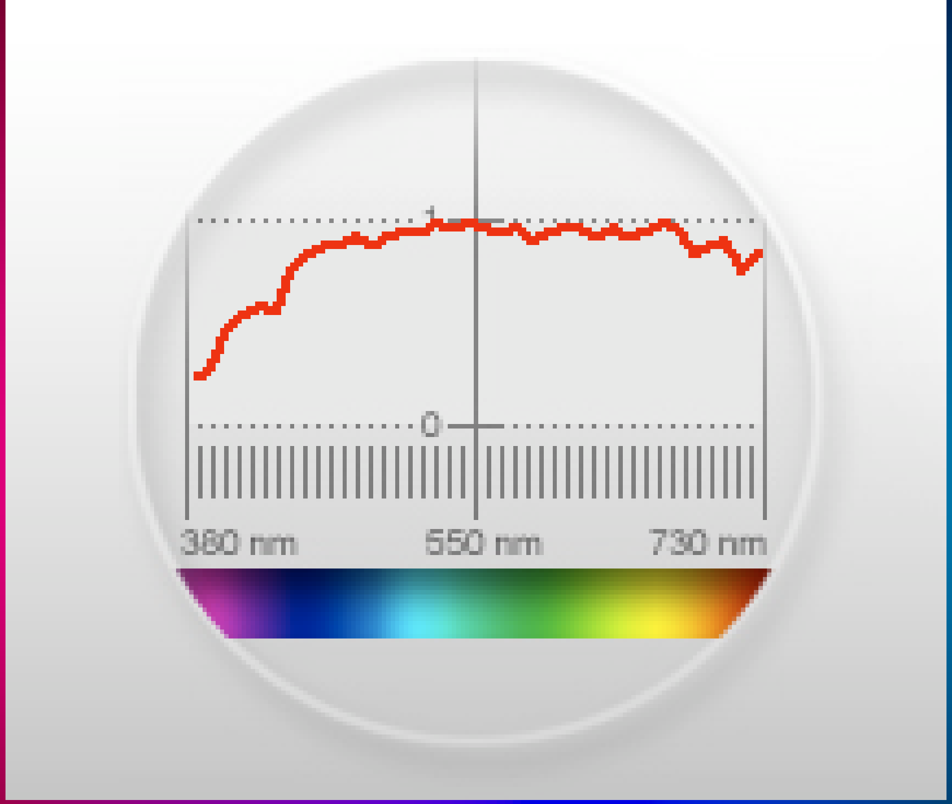
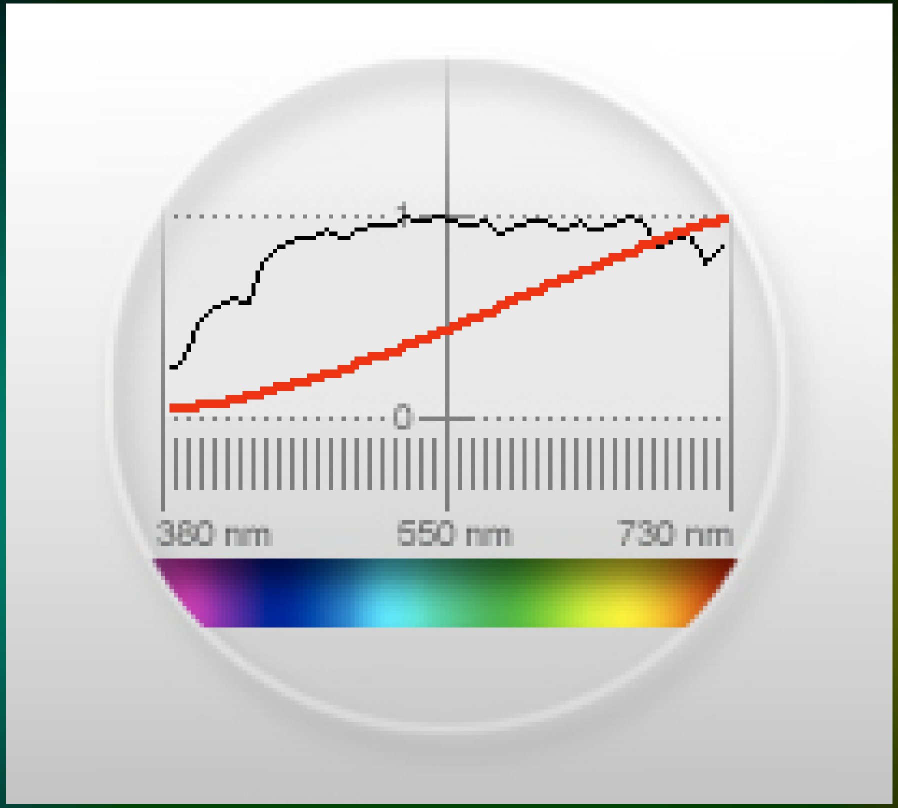
D_{50}



Theoretical
D_{50} illuminant



Illuminant A
(Tungsten)

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Graphic Arts Light Booths

- There are several booths available from companies, GretagMacbeth, GTI, Just Normlicht, and Solux
- Some are configured for comparison to a monitor proof while others simulate different illuminants.
- Look for a booth that conforms to ISO 3664.
- Dimable option is ideal to calibrate the booth intensity to match ISO 3664 recommended illumination levels.

Graphic Arts Light Booths

- Assess how big of a print do you need to evaluate in the booth? Do you want the print horizontal (flat) or vertical orientation like on a wall?
- Do you need to see how different illuminants affect print color?
- Do you need to calibrate the light intensity to match an ISO recommendation?

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ISO Viewing Standards

- ISO 3664: Viewing conditions - Graphic Technology and Photography
- ISO 12646: Color Proofing using a color display

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ISO 3664:2000

Viewing conditions - Graphic Technology and Photography

- Specifies tolerances for variables that influence your color perception
  - Intensity of light source and ambient light
  - color light source, and acceptable deviation
  - color of surround in which a print will be viewed

ISO 3664:2000

- Recommends the surround in field of view for evaluating prints should not have chroma value (LCH) larger than 2; should be neutral
- The surround should extend at least 1/3 of the print dimensions on all sides.
- Easy to achieve with a self contained light booth that has side walls and is painted neutral gray.
    - If side walls are not available for the light booth ensure the surrounding area does not have color objects in the field of view.

ISO 3664:2000

- Intensity of light source for critical comparison to a reference, **P1** illumination
    - 2000 lux, +/- 250 lux
    - No less than 60% fall off at the edges compared to center measurement
- Intensity of light source for practical appraisal of prints, typical viewing conditions, **P2** illumination
    - 500 lux, +/- 125 lux

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ISO 3664

- P2 illumination:
  - Designed to be realistic intensity for tonal appraisal
  - Biggest differences between P1 and P2 is shadows appear compressed under P2 illumination
  - Not used for comparison to another print
  - Used for comparison to a computer display proof

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ISO 3664

Annex A
(informative)

Summary of ISO viewing conditions specified in this International Standard

Table A.1 is deemed to be informative since it is included for convenience and introduces no new specifications. It simply summarizes the main normative requirements specified throughout this International Standard.

Table A.1 Summary of ISO viewing conditions

ISO viewing condition	Reference illuminant and chromaticity tolerance [a]	Illuminance/ luminance	Colour rendering index (according to CIE 13.3)	Metamerism index (according to CIE 51)	Illumination uniformity (min:max)	Surround luminous reflectance/ luminance/ illuminance
Critical comparison						
Prints (P1)	Illuminant D_{50} (0,005)	2 000 lx ± 500 lx (should be ± 250 lx)	General index: ≥ 90 Special indices for samples 1 to 8: ≥ 80	Visual: C or better (should be B or better) UV: < 4	For surfaces up to 1m x 1m ≥ 0.75 For surfaces greater than 1m x 1m ≥ 0.6	< 60 % (neutral and matt)
Transparencies Direct viewing (T1)	Illuminant D_{50} (0,005)	1 270 cd/m^2 ± 320 cd/m^2 (should be ± 160 cd/ m^2)[b]	General index: ≥ 90 Special indices for samples 1 to 8: ≥ 80	Visual: C or better (should be B or better)	≥ 0,75	5 % - 10 % of the luminance level (neutral and extend at least 50mm on all sides)
Practical appraisal of prints (P2)	Illuminant D_{50} (0,005)	500 lx ± 125 lx	General index: ≥ 90 Special indices for samples 1 to 8: ≥ 80	Visual: C or better (should be B or better) UV: < 4	≥ 0,75	< 60 % (neutral and matt)
Transparencies Projection viewing (T2)	Illuminant D_{50} (0,005)	1 270 cd/ m^2 ± 320 cd/ m^2	General index: ≥ 90 Special indices for samples 1 to 8: ≥ 80	Visual: C or better (should be B or better)	≥ 0,75	5 % - 10 % of the luminance level (neutral and extend at least 50 mm on all sides)
Colour monitors	Illuminant D_{65} (0,025)	> 75 cd/ m^2 (should be > 100 cd/ m^2)	Not applicable	Not applicable	Not applicable	Neutral, and dark grey or black [c]

Notes

a This specifies the relative spectral power distribution of the reference illuminant, except for colour monitors in which case it specifies the chromaticity of the white point of the monitor. Permitted tolerances in chromaticity, from that of the reference illuminant, are given in parentheses. These are specified at the plane of viewing, according to the 1976 u'_{10}, v'_{10} UCS system.

b When comparing a transparency to a print, the ratio of the luminance of the transparency illuminator to the equivalent illuminance of the print viewing surface shall be 2 (± 0,2):1.

c The ambient illumination for colour monitors should be less than or equal to 32 lx and shall be less than or equal to 64 lx.

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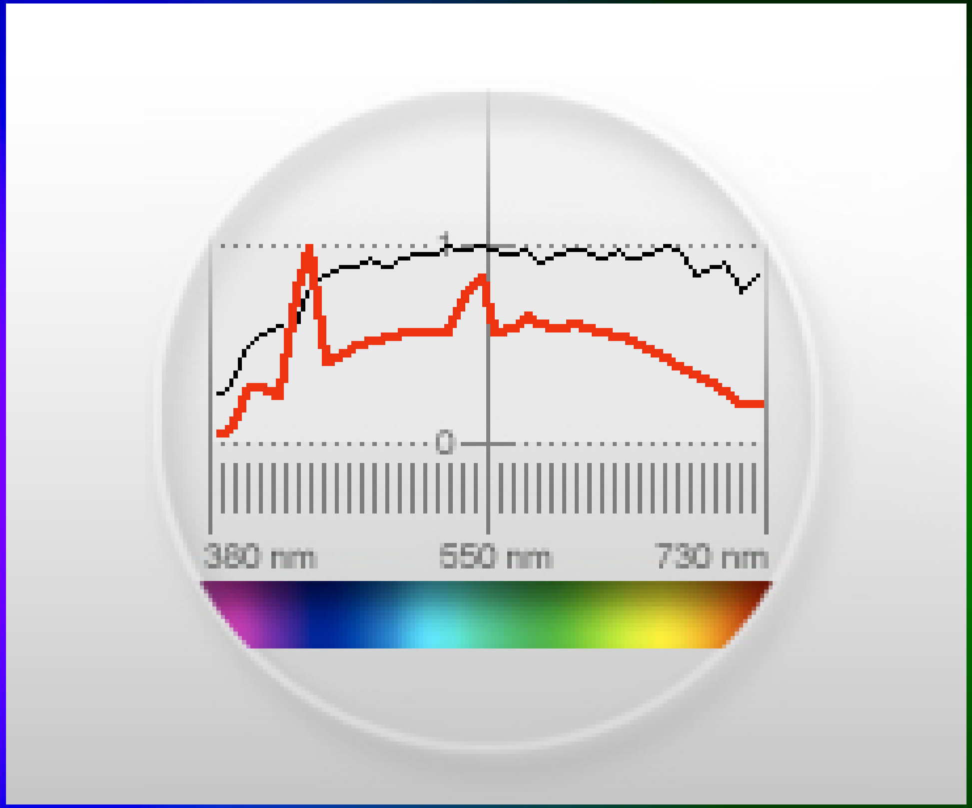
Kelvin Degrees and Spectral Power Distribution

- Kelvin degrees describes the color of white by a numerical value.
- Spectral Power Distribution (SPD) describes the color of white across a color spectrum.
- Two light sources can have the same Kelvin white point but very different SPD curves.
- Illuminants use SPD designations and not Kelvin degrees

Both 5000K Light Sources



GTI light booth

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Illuminants

- Descriptors of light source characteristics. Like an ICC profile for a light source.
- We can measure light sources
  - Use this information we can adapt a ICC profile for a particular light source, i.e. Tungsten, or fluorescent lights.

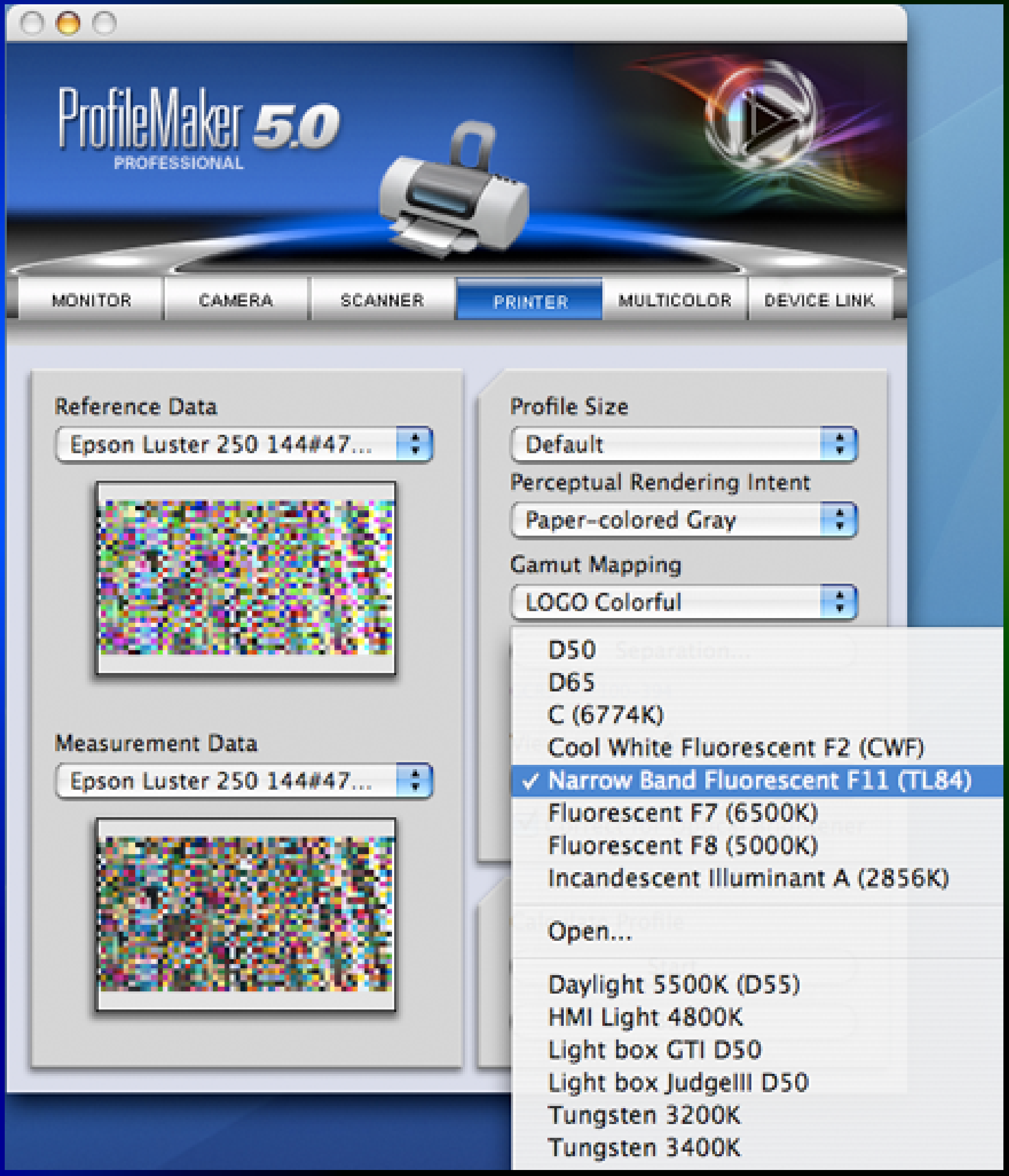
Illuminants

- A illuminant is a tungsten bulb
- D illuminants are Daylight spectral properties
- F illuminants are Fluorescent lamps
  - F2- Cool White Fluorescent tubes
  - F8 - 5000 Kelvin fluorescent lamp, D_{50} simulator lamps
  - F11- (TL84) Typical Fluorescent tubes

Targeting prints for non-D_{50} illuminants

- Spectral measurements of print output can be adapted for a different light source.
- Ideally you can measure the actual light source for adaption. Otherwise you can use a standard illuminant instead.
- Measure light source by holding measurement device parallel to the viewing plane where a print would be placed facing towards you.

Targeting prints for non-D_{50} illuminants



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Targeting prints for non-D_{50} illuminants

- Save using a v4 ICC spec. to ensure correct encoding
- Chromatic Adaption Tag is used to adapt back to D50 for color matching consistency.

Targeting prints for non-D_{50} illuminants

Epson Luster 250 1440 D50 2.icc

#	Tag	Data	Size	Description
	Header		128	
1	'cprt'	'mluc'	94	Multi-localized strings
2	'desc'	'mluc'	82	Multi-localized description strings
3	'DevD'	'text'	50234	ASCII Text String
4	'CIED'	'text'	396636	ASCII Text String
5	'Pmtr'	'text'	993	ASCII Text String
6	'chad'	'sf32'	44	Chromatic adaptation matrix

	=				
Xpcs		1.000000	0.000000	0.000000	Xsrc
Ypcs	=	0.000000	1.000000	0.000000	Ysrc
Zpcs		0.000000	0.000000	1.000000	Zsrc

Epson Luster 250 1440 F11 (TL84).icc

#	Tag	Data	Size	Description
	Header		128	
1	'cprt'	'mluc'	94	Multi-localized strings
2	'desc'	'mluc'	92	Multi-localized description strings
3	'DevD'	'text'	50234	ASCII Text String
4	'CIED'	'text'	396636	ASCII Text String
5	'Pmtr'	'text'	869	ASCII Text String
6	'chad'	'sf32'	44	Chromatic adaptation matrix
7	'wtpt'	'XYZ '	20	Media white-point tristimulus
8	'kTRC'	'curv'	1034	Tone response curve
9	'A2B1'	'mAB '	95164	Intent-1, device to PCS conversion table
10	'B2A1'	'mBA '	132304	Intent-1, PCS to device conversion table
11	'A2B0'	'mAB '	95164	Intent-0, device to PCS conversion table
12	'B2A0'	'mBA '	132304	Intent-0, PCS to device conversion table
13	'A2B2'	'mBA '	95164	Intent-2, device to PCS conversion table
14	'B2A2'	'mBA '	132304	Intent-2, PCS to device conversion table
15	'gamt'	'mft2'	35414	16-bit, PCS to gamut check table
16	'gmps'	'data'	196	

Xpcs		0.959442	-0.042084	0.061462	Xsrc
Ypcs	=	-0.030151	1.014709	0.024567	Ysrc
Zpcs		0.001404	0.003860	1.283752	Zsrc

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Metamerism

- Friend or foe?
- Without metamerism color matching would not be possible
- Many have experienced a metameric mismatch or failure

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Q&A

- Questions?

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JUST NORMLICHT

VISUAL COLOR MATCHING SYSTEMS

Thank you!

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- Free articles available for download too;
  - Review of Monitor Profiling products
  - Hexachrome print process
  - Monitor to Print agreement

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