SunChemical®

a member of the DIC group

CIE Division 1

Workshop

Leeds University

Date: 4 July 2013

working for you.

Danny C. Rich, PhD

ISO TC 130 Concerns for CIE D1

Introduction

- At the end of the 1960s there was a move to develop industry-wide agreement on best practices for graphic reproduction
  - At the time, graphic reproduction was mainly an art form
  - Images were scanned in continuous tone, matched to halftone screens on copy cameras and R, G, B filters inserted between the image and the copy camera to build plate films.
- These manual processes were slow and error prone as artists uses knives and pens to make corrections to the films.
- Press to press results were further complicated by variations in the colors of the 4 process inks (CMYK)

Introduction

- In the mid 1970s a group of concerned members of the Web Offset Printing Association and the Graphic Arts Technical Foundation met together
  - Their goal was to define a set of industry specifications for offset printing that would improve the reliability and predictability of high quality, high volume printing.
- The result of several years of debate and testing was the Specification for Web Offset Printing published in 1986.
- This industry specification, known as SWOP, became a *defacto* industry standard.
- Its success prompted ANSI to suggest the development of a new standards committee, Committee on Graphic Arts Technology Standards (CGATS)

International Standards on Offset Printing

- In Europe there was already activity around setting up standards for the color of offset printing ink.
  - ISO 2846 was being developed for European inks and it was felt that this standard should include inks from North America and Japan as well
  - ISO 2834 on the preparation of laboratory test prints had already been developed and utilized a very accurate method of determining the amount of ink transferred to the paper and hence the thickness of the layer in a print.
- From North America came a technical report on assessing the transparency of the ink by printing over a very black substrate.

quality.
service.
innovation.

International Standards on Offset Printing

- Next a specific type of paper for the ink testing was identified
  - The paper had no OBA, no wood pulp and hence little or no lignin, and was gloss coated so that the ink would hold out.
- The paper was a European stock used for specialty jobs and was produced very consistently, batch to batch.
- The black bar for transparency assessment was given specifications and some commercial examples identified.
- Everything necessary for a proper standard was in place. The process took nearly 10 years to complete but once in place, the standard was validated using inks from around the world, proofed and measured locally and then the data combined.
  - The tolerances on the ink color and transparency were realistic and attainable any where in the world.

International Standards on Offset Printing

- The ISO 2846 Standard was a success by all measures
- The original offset ink standard was then expanded to other types of inks
- 2846-1 Heat set / Oxidative set offset (magazine) inks
- 2846-2 Cold set offset (newsprint / directory) inks
- 2846-3 Publication Gravure inks
- 2846-4 Screen printing inks
- 2846-5 Flexo graphic inks

quality.
service.
innovation.

Introduction to ISO TC 130 Graphic Arts

- ISO TC 130 Continues Developing Standards for Materials and Process Control in 4-Colour Process Printing
- Process Printing is used in All Forms of Graphic Reproduction
  - Publication, Packaging and Signage
- Process Printing Relies on Consistent Colour Primaries to mix both additively and subtractively
  - The mixtures form metameric matches to common colours encountered in daily life
- Colour Differences and Colour Rendering Must be Assessed Accurately for Accurate Reproduction Control

quality.
service.
innovation.

Graphic Arts is becoming Graphic Engineering

Historical Review of CIE and ISO Relationship

- Statement of Mutual Acceptance Between CIE and ISO
  - CIE is to establish the fundamental technology and guidance
  - ISO is to issue documentary standards on the use of CIE technical recommendations

- Joint Meeting of ISCC/ASTM E12/CIE Div. 1
- Standards: What they are - What will they be? What should they be?
  - Princeton University, Princeton, NJ
  - June 14 – 18, 2010
- Review of Current Standards in Graphic Reproduction

quality.
service.
innovation.

Why do standards fail? – Conclusions from 2010

- Standards like ISO 2846-5, 3664, 23605, 13655 fail because of two reasons:
  - Either the committee does not do the required homework to make certain that the standard can be understood and utilized by community at large
  - Or the committee is so focused on getting the status of “standard” assigned to their work they will compromise the utility of the standard.
    - The latter happens in two situations:
      - When the committee is directed or loaded with academics with a vested interested in the technology being assessed
      - When the committee is directed or loaded with commercial technologists with a single view point or commercial interest.
- When standards are so badly written (not speaking of grammar here) that they verge on being a restraint of trade there is a clear problem in the standards process.

quality.
service.
innovation.

Examples of standards that failed and why

- When ISO 2846 was drafted the average agreement between handheld 45:0 spectrocolorimeters was about 1.0 CIELAB unit
  - When 13655 was issued the agreement was still 1.0 CIELAB unit.
  - In 2010 after the revision of 13655 it is still 1.0 unit.
  - More that 10 years of field use in colorimetry of print and we may as well not had the standard on the books.
  - Recently, a study by IDEAlliance showed that 4 vendors of 45:0 instruments conforming to the latest version of 13655 agreed to an average of 0.6 CIELAB unit
- ISO 5 on Densitometry was one of the earliest international standards.
  - It was drafted by ANSI and sent on to ISO in support of the use of filter densitometers in photographic films and prints.
  - It identified the sources, intermediate optics and sensors very carefully using the notion of a Spectral Product.
  - It took nearly a decade to revise the standard to allow for spectral densitometry

Examples of standards that failed and why

- CIE Publication 15 – the recommendation on basic colorimetry that once contained the fundamental definitions of the CIE approach to colorimetry has a whole series of standards
  - ISO 11664 Parts 1, 2, 3, 4, 5 which are based on CIE standard S 014-x are now required to document the “standard observer” functions, the two illuminants, how to compute XYZ & CIELAB, CIELUV. But 1 & 2 are duplicated in ISO 10526 and 10527
  - So recommendations that were used for nearly 80 years now have to be recast into standards templates – thrice. Are they more useful because they have been standardized three times?
- CIE Publication 51 was a good recommendation on how to assess daylight simulators. But there were some issues.
  - After a minor revision it was submitted for standardization and the result ISO 23603 is full of errors and omissions so that it is unusable for its purpose. In updating ISO 3664 we used only a small part of the tabular data and none of the computational information.

Areas Where the CIE Has Failed to Give Guidance

- CIE has “standardized” many of its technical reports and recommendations
- In doing so, it has reduced the size and complexity to make them more encyclopedic
- CIE 51 was a good recommendation lacking only D50 for used by ISO TC 130
  - The standardized version, ISO 23603 was so light that it was not possible to follow and get equivalent results. So ISO 3664 included the guidance on how to compute CIE indices
- Similarly, CIE has now taken Publication 142-2001, cut it down and made it a standard S 014-6, no doubt with the intent of moving it into ISO/CIE joint standard.
  - Where is the guidance on how to replace prior CIE recommendations with this new one?

What the ISO Needs from the CIE

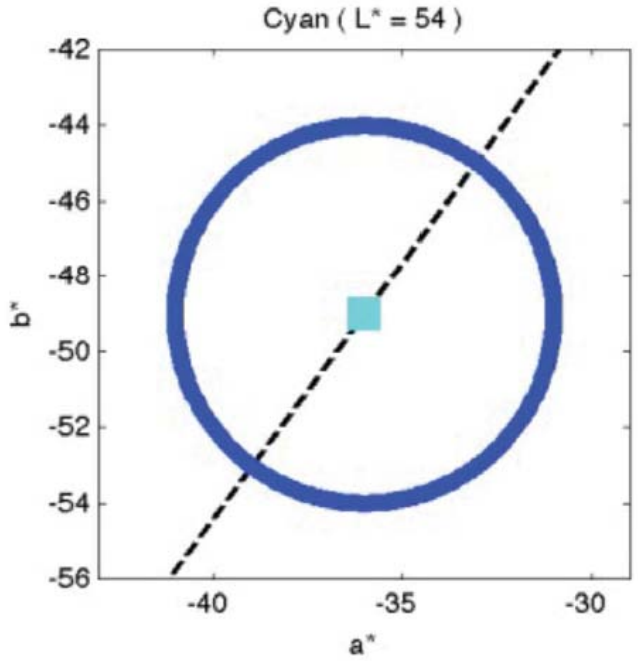
- The Examples given here are focused on Division 1
- But the needs of Graphic Reproduction are not limited to colorimetry
- Modern Graphic Materials are Fluorescent and Publications from Division 2 Have Been Static since 2000
- This lack of activity may also impact Division 1 activities
- ISO 3664 and ISO 13655 are attempts at combining lighting and color
- ISO 12646 and ISO 14861 have to with measurements and predicting colour stimulus functions from displays used to proof publication printing
- ISO 12647 series and 15339 used objective measurements to assess & control the quality of printing.

quality.
service.
innovation.

Implementation of CIEDE2000 as the Replacement for CIELAB76

Replacing CIELAB Tolerances with CIEDE2000 Tolerances

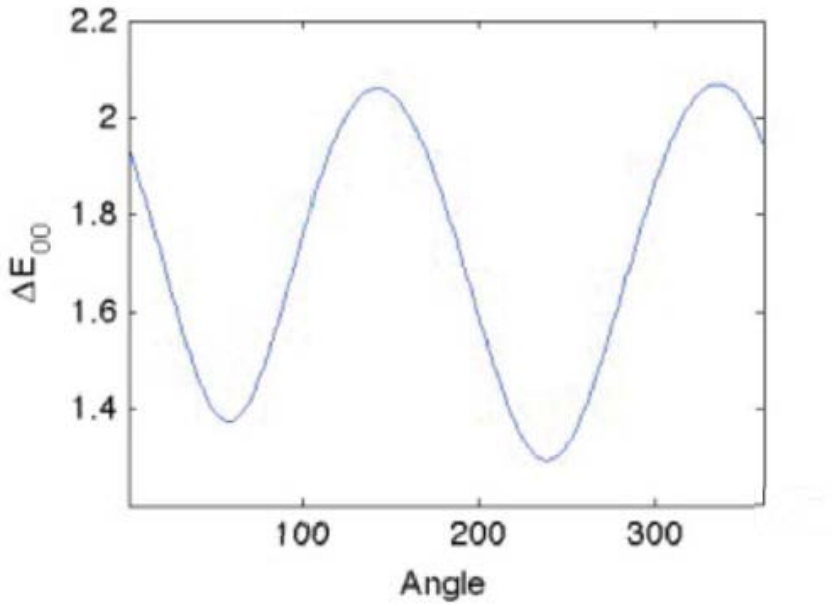
- Color difference metrics include ΔE^*, ΔL^*, Δa^*, Δb^*, ΔH^*, ΔC^*, ΔC_h
- CIEDE2000 (ΔE_{00}) is a color tolerance metric, developed more than a decade ago, and is to replace ΔE^*_{ab} in the revision of all ISO TC130 standards.
- The TC is puzzled on how to take existing CIELAB spherical tolerances and replace with DE_{00} elliptical tolerances.
  - ISO tolerances become national law in some countries

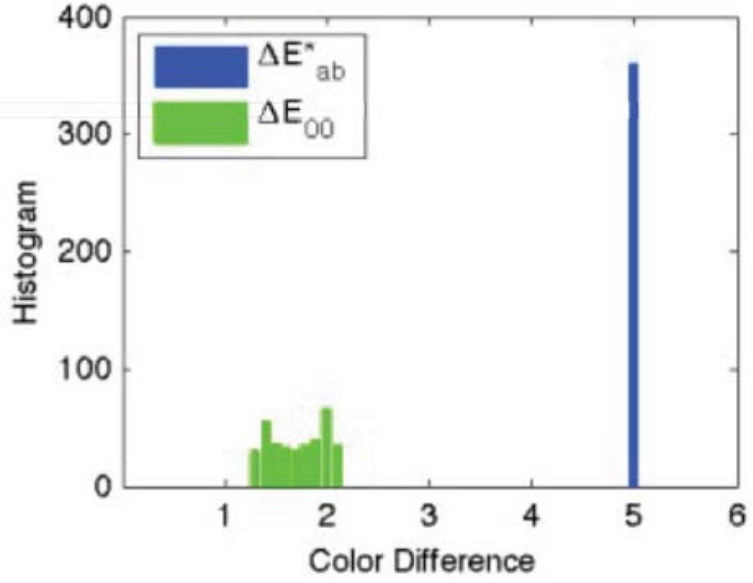


quality.
service.
innovation.

Printing Conformity Parameters

- Using a cyan solid (54L*, -36a*, -49b*) as the center with a 5 ΔE^*_{ab} radius at the constant L* plane, ΔE^*_{ab} is a spike but the ΔE_{00} distribution varies from 1.3 to 2.1 units.
- The magnitude of ΔE_{00} varies as a function of angular displacement around its center and the distance between the color aim and the test specimen.





quality.
service.
innovation.

Color Tolerances Based on Empirical Evidence Only

- Data from only 35 Press Runs.
- Definition of “Pass” and “Fail” based on old CIELAB data
- No clear reason why a press should create “Fail” data
- Tolerance values in ΔE_{00} occur at varying sizes.
- No visual significance other than the structure of CIEDE2000 itself.

- Can CIE provide guidance on replacing CIELAB with CIEDE2000?
  - Visual significance?
  - Optimize or control one parameter over another?

quality.
service.
innovation.

quality.
service.
innovation.

Importance of Near-Neutral Colour Differences in Graphic Reproduction

What is Near-Neutral or Gray Balance

- Terminology:
- Grey is the visual perception of a color stimulus function with no discernible hue contribution
- Grey is paper relative – that is, a grey area should have the same CIELAB coordinates as the substrate would if covered with a thin layer of spectrally nonselective absorbing material (Black ink)
- Grey balance is the condition when a printed area containing layers of Cyan, Magenta and Yellow inks provides the same visual impression as an equivalent layer of a Black only ink.
- If an image exhibits gray balance then all areas of the image (highlights, shadows, mid-tones will have a pleasing, natural appearance.

What is Near-Neutral or Gray Balance

- Near-neutral triplets is a set of pre-defined CMY tone values that appears grey, and its colorimetric values can be derived by means of the A-to-B conversion.
- Grey reproduction is a set of colorimetric values of near-neutral triplets that can be used for conformity testing and for process control.
- Chromaticness difference, ΔC_h, is the difference between two colors of approximately the same lightness
- CGATS TR 015 (2013) defines a set of near-neutral triplets and black tints as prepress input.
  - It also defines colorimetric values of paper color, K solid, and CMY solid as press inputs.
  - It provides a mathematical method for deriving their colorimetric aims.

quality.
service.
innovation.

CGATS TR 015 contains no tolerances on the grey points

Why Tolerances on Grey Points Are Important

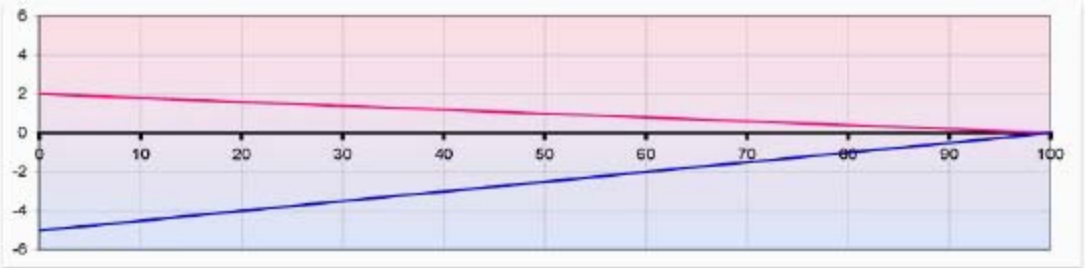
Three different Gray Balance formulae on blue-biased paper.

Three different Gray Balance formulae on yellow-biased paper.

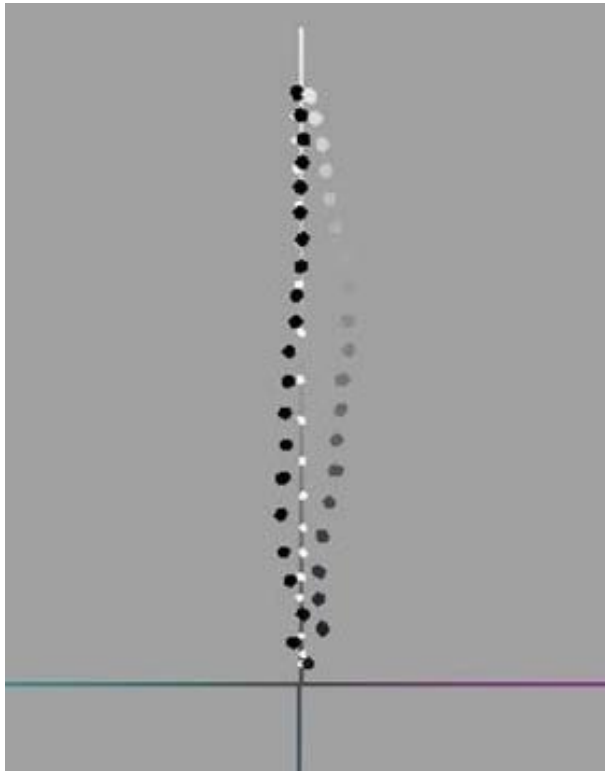
quality.
service.
innovation.

Why Tolerances on Grey Scales are Important

Ideal neutral scale from Tone 0 (white) to Tone 100 (black). Red line is a* and Blue line is b*

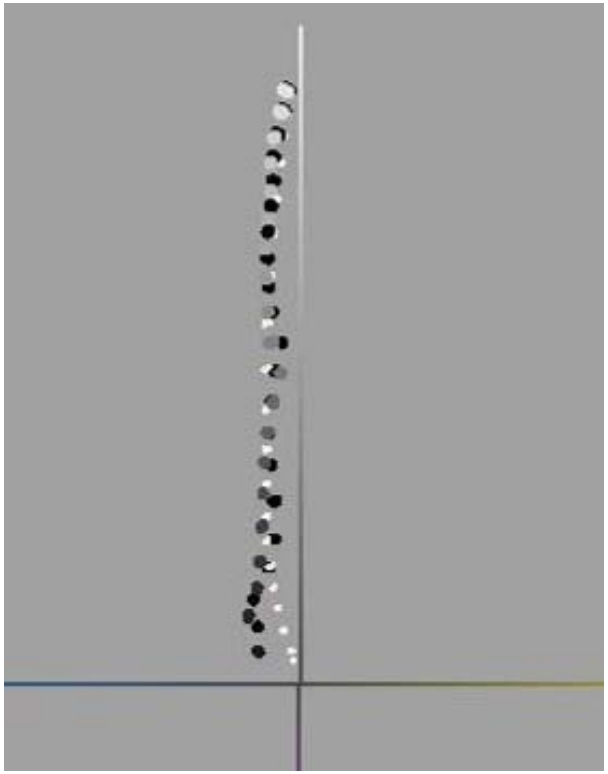


L* axis



a* axis

L* axis

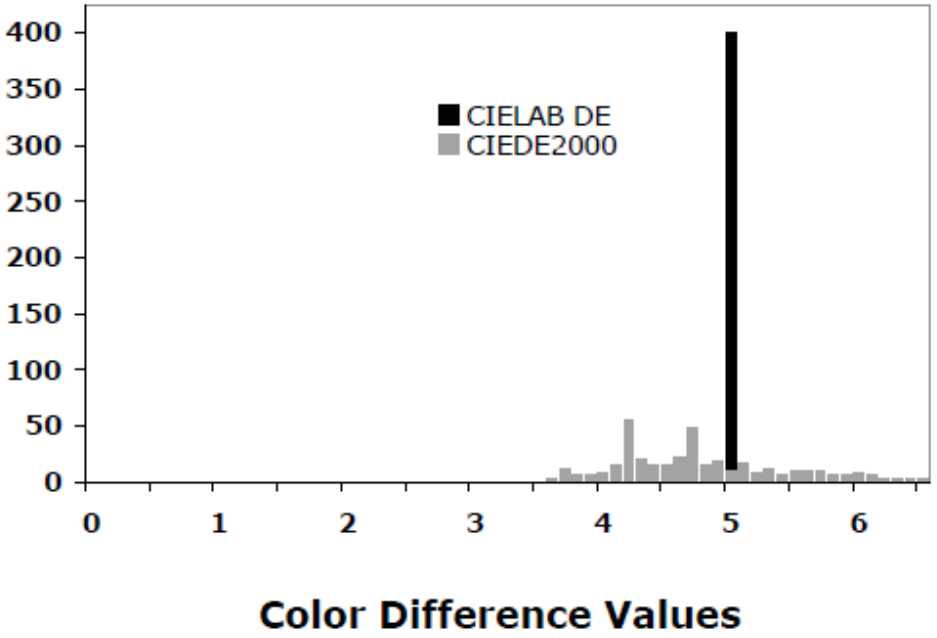


b* axis

quality.
service.
innovation.

Tolerances on Near-Neutral or Gray Colors

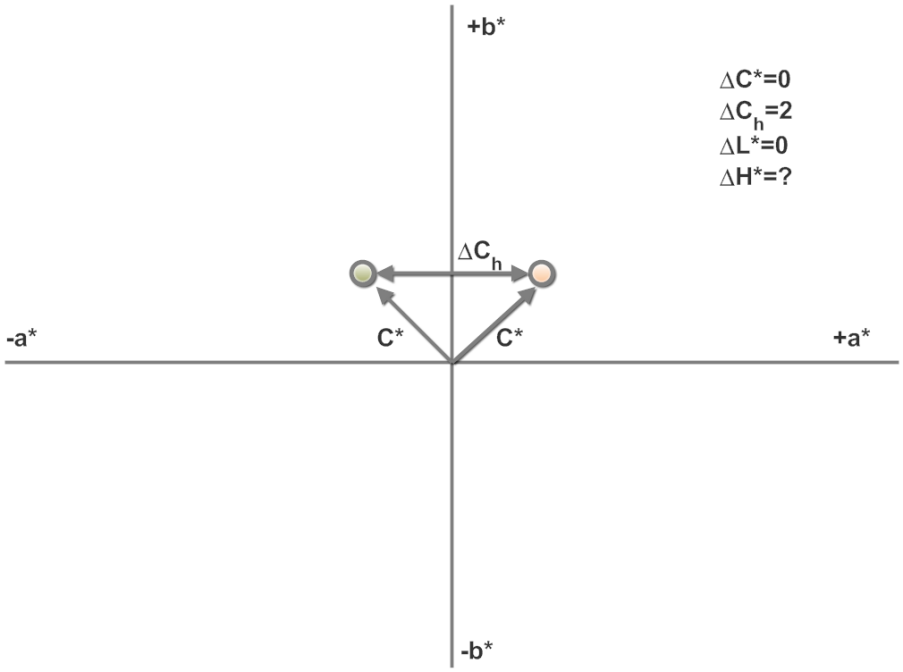
- Using a mid-tone grey (58L*, 0a*, -1b*) as the center and a 5 ΔE^*_{ab} radius, the ΔE^*_{ab} and ΔE_{00} distributions of 400 evenly sampled data points from the CIELAB spherical surface are different.
- Near-Gray Differences are Scattered Around the CIELAB Differences.
- Unlike the High Chroma Cyan – No Clear Pattern Appears



quality.
service.
innovation.

Printing Conformity Parameters – Gray Tolerances

- Look at the same 35 print runs as the Cyan plus an additional 337 data sets from IDEAlliance G7 calibration
- Optimization more complex for two reasons:
  - Neutral scaling in CIEDE2000 is based only a mathematical correction to the original discontinuity.
  - CIE metric Chroma or Chroma difference is not descriptive of the spacing of the two grey patches.

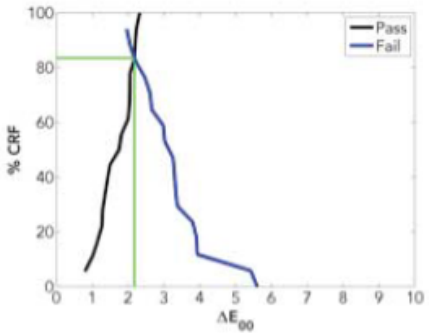


quality.
service.
innovation.

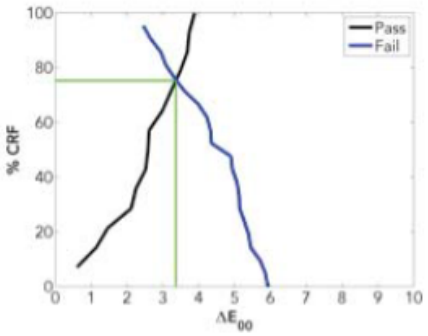
Printing Conformity Parameters – Tolerance Optimization

- ΔE_{00} Optimization and %agreement were performed separately at quarter-tone, midtone, and three-quarter tone near-neutrals.

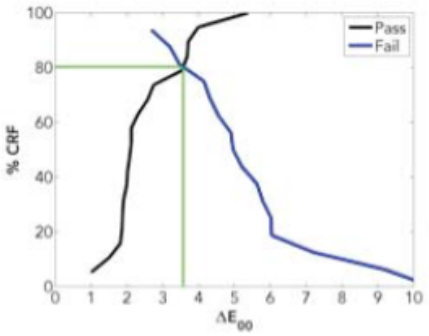
Triplet Type	Conformance criteria	*Optimized ΔE_{00}*	Equal outcome
Quarter-tone	2.0 ΔC_h & 2.5 ΔL	2.2	84%
Midtone	3.0 ΔC_h & 2.5 ΔL	3.4	75%
Three-quarter tone	4.0 ΔC_h & 2.5 ΔL	3.6	80%



(quarter-tone)



(midtone)



(three-quarter tone)

400+ Press Runs reported color target data. Look for the overlap between the Pass and Fail cumulative distributions Tolerance varies with gray level. Implication: Hue errors are more tolerable in dark neutrals than in light neutrals? Is this true? Why?

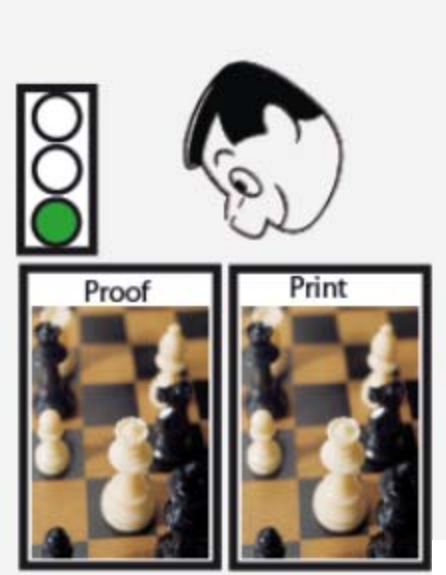
quality. service. innovation.

quality.
service.
innovation.

Requirements for Colour Rendering in Graphic Reproduction

Impact of Lighting on Reproductions and Proofs

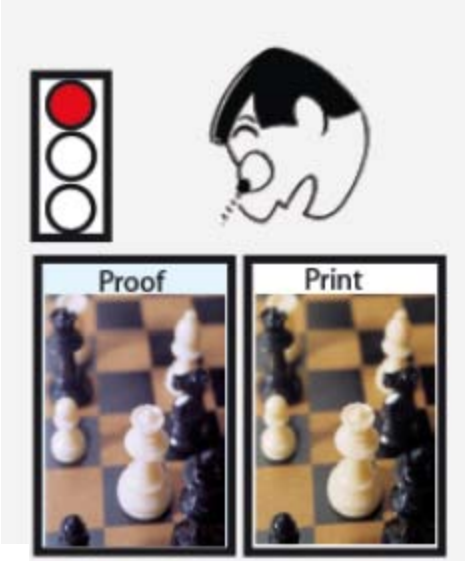
CIE D50

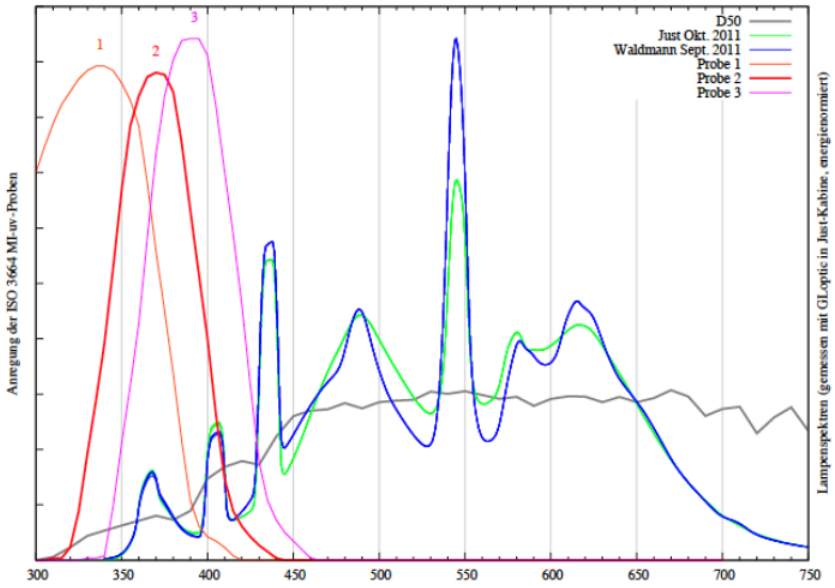


Proofs are a contract that Says, “the print will look like this”. But proofs and prints can be produced on different substrates with different inks and are metameric.

ISO 3664 is based on CIE standards does not provide the full solution.

LED D50





LED lamp spectra from FOGRA – German graphics research institution.

quality.
service.
innovation.

Recent Study From FOGRA in Munich

- Focus on the effect, hence the excitation of typical papers
- Restrict usage on D50 (metamers)
- Variation of UV-amount within tolerances of 3664:2000

⇒ UV-amount$_{GD}$ = 0% ⇒ Δb=4

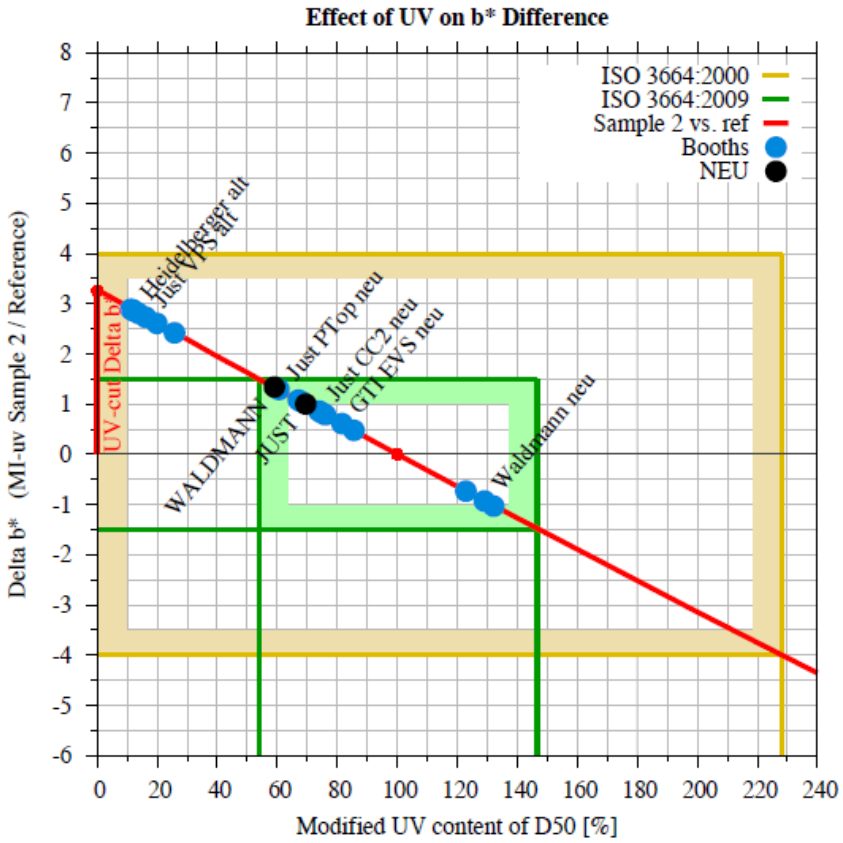
⇒ UV-amount$_{GD}$ = 230% ⇒ Δb=-4

- Variation of UV-amount within tolerances of 3664:2009

⇒ UV-amount$_{GD}$ = 53% ⇒ Δb= 1,5

⇒ UV-amount$_{GD}$ = 148% ⇒ Δb= -1,5

- Visualising typical viewing cabinets and measurement devices



Source: Hoffstadt, 2012

quality.
service.
innovation.

White lights in tolerance by CIE methods allow large variations in UV energy and the color of prints

ECI 2002 Test Target – 1485 Process Printed Colors

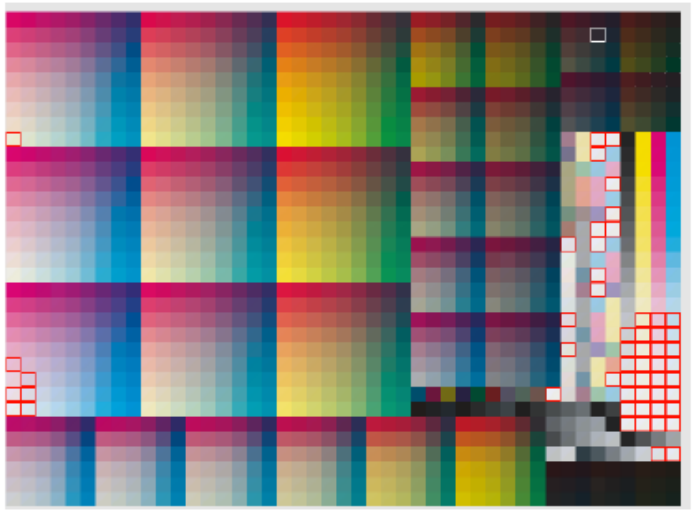
Uncontrolled UV Produces Significant Errors in Color Readings

Modelling is complex and for practical usage (yet) not precise enough

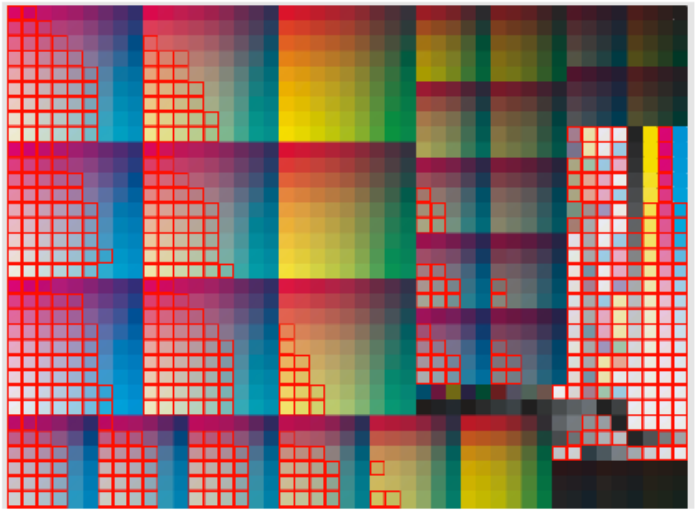
E.g. comparing ISO 13655 M0 and M1 (UV-rich) measurement conditions:

- The largest differences are on the substrate (Paper)
- Yellow is affected at least since it absorbs the UV light (hence no/less UV can excite the OBA "sitting" in the substrate)

$\Delta E^*_{ab} > 5$



$\Delta E^*_{ab} > 2$



Red Outlines Show Large Color Differences

Thanks to ISO TC 130, FOGRA and RIT for use of presentations

QUESTIONS FOR PRESENTER

quality.
service.
innovation.