The CIE Colorimetry Standards

Alan R. Robertson

3 October 2011

Abstract

Paper #1

The CIE Colorimetry Standards

Alan R. Robertson

alan.robertson40@gmail.com

The CIE series of six Standards covering the basics of colorimetry is now almost complete. This talk will describe the rationale for writing the Standards, summarize the contents and discuss some of the trials and tribulations involved in writing them.

Status in 2000

- S002: Colorimetric Observers
- S005: Standard Illuminants
- Publication 15: Colorimetry
- Publication 142-2001: Colour difference evaluation

TC1.57 Standards in Colorimetry

Terms of Reference:

To prepare a series of CIE/ISO/IEC Standards that describe:

1) The method of calculating CIE tristimulus values and chromaticity coordinates

2) A uniform color space and its associated metrics

3) A formula for industrial color difference evaluation

Rationale

- To state CIE recommendations concisely and unambiguously
- To use language appropriate for an international standard
- To provide documents that can be quoted in other international and national standards

TC1.57 – Members

- **Chairman:** A R Robertson CA

- **Members:**
  - P Alessi US   M Brill US
  - J Campos Acosta ES   E Carter US
  - R Connelly US   J-F Decarreau FR
  - R Harold US   R Hirschler HU
  - B Jordan CA   C Kim KR
  - D McDowell US   P McGinley AU
  - M Melgosa ES   Y Ohno US
  - MR Pointer GB   K Richter DE
  - G Rösler DE   J Schanda HU
  - R Sève FR   K Witt DE
  - H Yaguchi JP   J Zwinkels CA

Re-numbering

- CIE S014-1 Colour-matching functions (D2)
- CIE S014-2 Standard illuminants (D2)
- CIE S014-3 Calculation of tristimulus values (TC 1-57)
- CIE S014-4 CIELAB (TC 1-57)
- CIE S014-5 CIELUV (TC 1-57)
- CIE S014-6 CIEDE2000 (TC 1-57)

Order of work

- S014-4 CIELAB
- S014-5 CIELUV
- S014-3 Calculation of tristimulus values
- S014-6 CIEDE2000

Documentation

- Initial concern that all TC discussions should be properly documented
- Currently have 89 numbered documents plus extensive records of e-mail discussions
- Will be sent to CB when TC closed

Liaison

- Concern that input should be as broad as possible
- User community is spread over many industries
- Need to reduce chance of problems with the eventual ISO/IEC "fast-track" process
- Wanted to avoid excessive formality such as parallel voting in many committees
- Solution was to set up informal liaisons with relevant ISO/IEC committees

TC 1-57 - Liaison members

- IEC TC100/TA2 (Audio, video & multimedia) Vacant
- ISO TC 6 (Paper, board & pulps) B Jordan
- ISO TC35/SC9/WG22 (Paints & varnishes) G Rösler
- ISO TC38/SC1/WG7 (Textiles) (UK) M Pointer
- ISO TC38/SC1/WG7 (Textiles) (US) R Harold
- ISO TC42 (Photography) D. McDowell
- ISO TC61 (Plastics) Declined
- ISO TC130 (Graphic technology) D. McDowell
- ISO TC171 (Office documents) Declined
- ISO/IEC/JTC1/SC28 (Office systems) K Richter

Liaison procedure

- Initial drafts developed within TC
- Three-month period for liaison members to consult with their ISO/IEC committee and solicit comments
- No official ballots in ISO/IEC committees

CIELAB issues

- Alternate formulae for calculating ΔH^*_{ab}
- Should subscript ab be italic?
- Hue difference when one chroma is zero
- Hue difference when two hues are in different quadrants
- Other mathematical anomalies
- Reverse transformation
- Applicability to object colours simulated on a self-luminous display
- Dated or undated normative references
- Compatibility with CIE 15:2004
- etc

13

CIELAB Standard

- Seven TC drafts prepared 2001-2006
- Published as CIE Standard in 2007
- Published as Joint ISO/CIE Standard in 2008
- ISO 11664-4:2008(E)/CIE S 014-4/E:2007: *CIE Colorimetry — Part 4: 1976 L*a*b* Colour Space.*

CIELUV issues

- Is CIELUV standard necessary or should it just be *u',v'*?
- Standard simply says; "If you want to use CIELUV, here is the proper way to do the calculations."

CIELUV Standard

- Three TC drafts prepared 2006-2007
- Published as CIE Standard in 2009
- Published as Joint ISO/CIE Standard in 2009
- ISO 11664-5:2009(E)/CIE S 014-5/E:2009: *CIE Colorimetry — Part 5: CIE 1976 L*u*v* Colour Space and u', v' Uniform Chromaticity Scale Diagram*

Calculation of tristimulus values

- Definition is an integral over all wavelengths
- Standard method is summation from 360 nm to 830 nm in 1 nm steps using data measured with 1 nm bandwidth
- Abridged method (380 nm to 780 nm in 5 nm steps or less) is allowed if the errors are insignificant
- 10 nm or 20 nm steps are not covered by the Standard

10 nm or 20 nm steps

- Not covered by the Standard
- An informative note explains the pre-calculated weighting function method for reflecting or transmitting objects
- An informative note states that 10 nm or 20 nm steps are not recommended for most self-luminous light sources

Supplementary treatment of input data

- Guidance is given on interpolation or extrapolation of smooth input data to meet the required wavelength range and interval

- Guidance is given for bandwidth correction of smooth input data

- Rules are given for the choice of bandwidth for un-smooth spectra such as those of discharge lamps, fluorescent lamps, LEDs etc

Tristimulus Values Drafts

- First draft prepared June 2003
- Second draft prepared January 2008
- Fourth draft approved by TC in June 2009
- Fifth draft submitted to DD1 in August 2009
- Approved by BA and D1 in December 2009
- Submitted to NCs in December 2009 for comments under 6-month rule
- NC comments received by TCC in December 2010
- NC ballot completed 15 June 2011
- Editorial changes approved by TCC, VPT and VPP 4 July 2011
- Published 11 July 2011

Tristimulus Values Standard

- Published as CIE S 014-3/E:2011: *CIE Colorimetry — Part 3: CIE Tristimulus Values*
- Must go through ISO fast-track approval process before publication as Joint ISO/CIE Standard

21

CIEDE2000 Standard

- Based on CIE Publication 142-2001
- Uses Sharma's algorithm for computing h'bar
- Includes an "informative annex" on Nobbs' method for lightness, chroma and hue splitting

CIEDE2000 Standard

- Draft 1 prepared in October 2010
- Draft 2 passed ISO/IEC liaison stage in June 2011 with no comments
- Draft 3 passed TC ballot on stage in June 2011
- Draft 4 now with CB for BA and D1 ballots

Summary

- Preparation and discussion of drafts by TC
- Comments by ISO/IEC liaison committees (3 months)
- New draft
- TC ballot (1 month)
- New draft
- D1 and BA ballots (1 month)
- New draft
- NC comments (6 months)
- New draft
- NC ballot (3 months)

Conclusion

- TC 1-57 has been in existence for 11 years and will last at least one more year
- It has produced four standards concisely documenting CIE procedures in colorimetry
- The process has been long and tedious but, hopefully, worthwhile