Colorimetric Variables Utilized by U.S. Ink Companies

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Colorimetry

- Promises Accurate and Precise Color Communications Among Stakeholders
- When Used Properly Can Drive Variability Out of Workflows
- Multiple User-Selected Variables Need to be Consistent

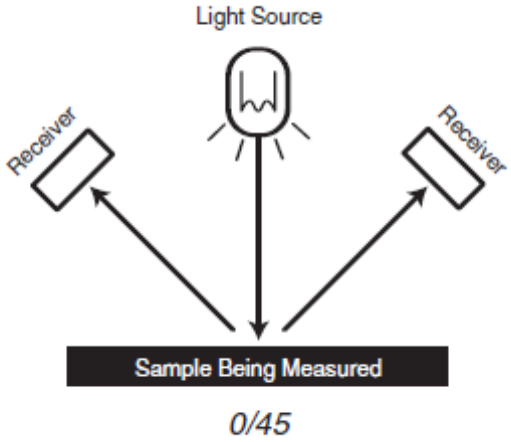
Relevant Colorimetric Variables

- Instrument Geometry
- Illuminant
- Standard Observer
- Color Differencing Equation (Tolerancing Method)

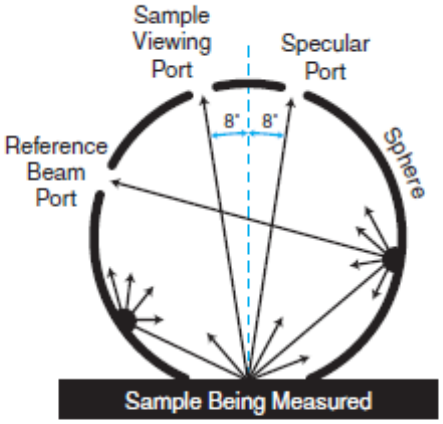
Instrument Geometry

- Directional 0/45° and 45/0°
- Spherical d/8°
- Multi-Angle (also known as “Gonio”)

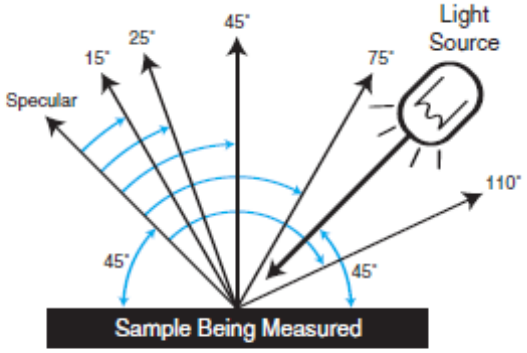
Instrument Geometries



0/45



Spherical



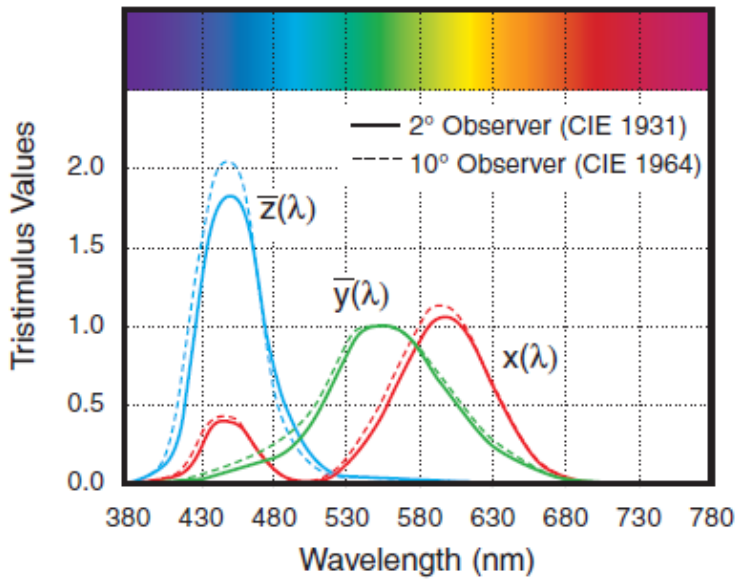
Multi-angle

Illustration reproduced from X-Rite's *Guide to Understanding Color Communication*

Illuminant

- CIE has defined several illuminants to represent certain light sources. The spectral data for these illuminants are stored in color measurement instruments to calculate the color of a sample as it would appear under each light. Examples include:
  - Standard Illuminant D65: Average daylight, with a correlated color temperature of 6504K
  - Standard Illuminant C: Average daylight (not including ultraviolet wavelength region), correlated color temperature of 6774K
  - Standard Illuminant A: Incandescent light, correlated color temperature of 2856K

CIE Standard Observer



- **Two Options that are similar, but not identical:**
  - **2° (1931)**
  - **10° (1964)**

Illustration reproduced from X-Rite's *Guide to Understanding Color Communication*

Colorimetric Values from X, Y and Z Tristimulus Values

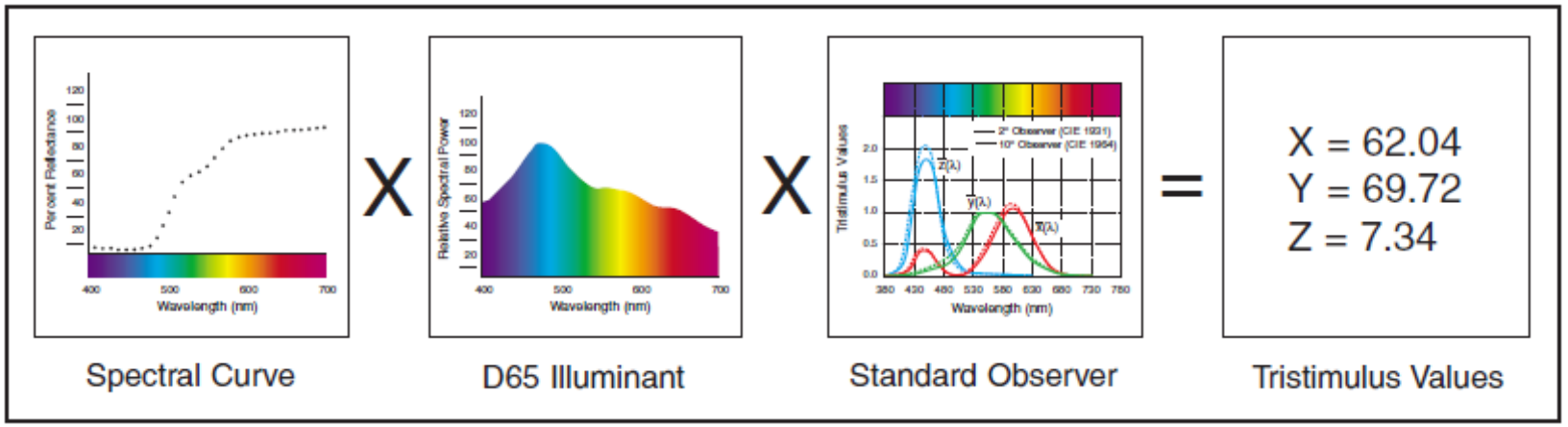


Illustration reproduced from X-Rite's *Guide to Understanding Color Communication*

Color Differencing Equation (Tolerancing Method)

- ΔE^*_{ab} (also known as ΔE^*, ΔE_{ab}, ΔE_{76})
- ΔE_{cmc}
- ΔE^*_{94} (also known as ΔE_{1994})
- ΔE^*_{00} (also known as ΔE_{2000})

Psychophysical Studies Compare Color Differencing

- Which Method Best Correlates to Visual Analysis? e.g.:
  - Habekost, M. “Which Color Differencing Equation Should be Used?” *International Circular of Graphic Education and Research*, 2013.
  - Chung, R. & Chen, P. “Determining CIE DE2000 for Printing Conformance” IARIGAI Conference, 2011.

Which Colorimetric Variables are U.S. Ink Companies Using as SOPs?

- Early Adopters of Colorimetry
- Influence Printers
- Colorimetric Reporting

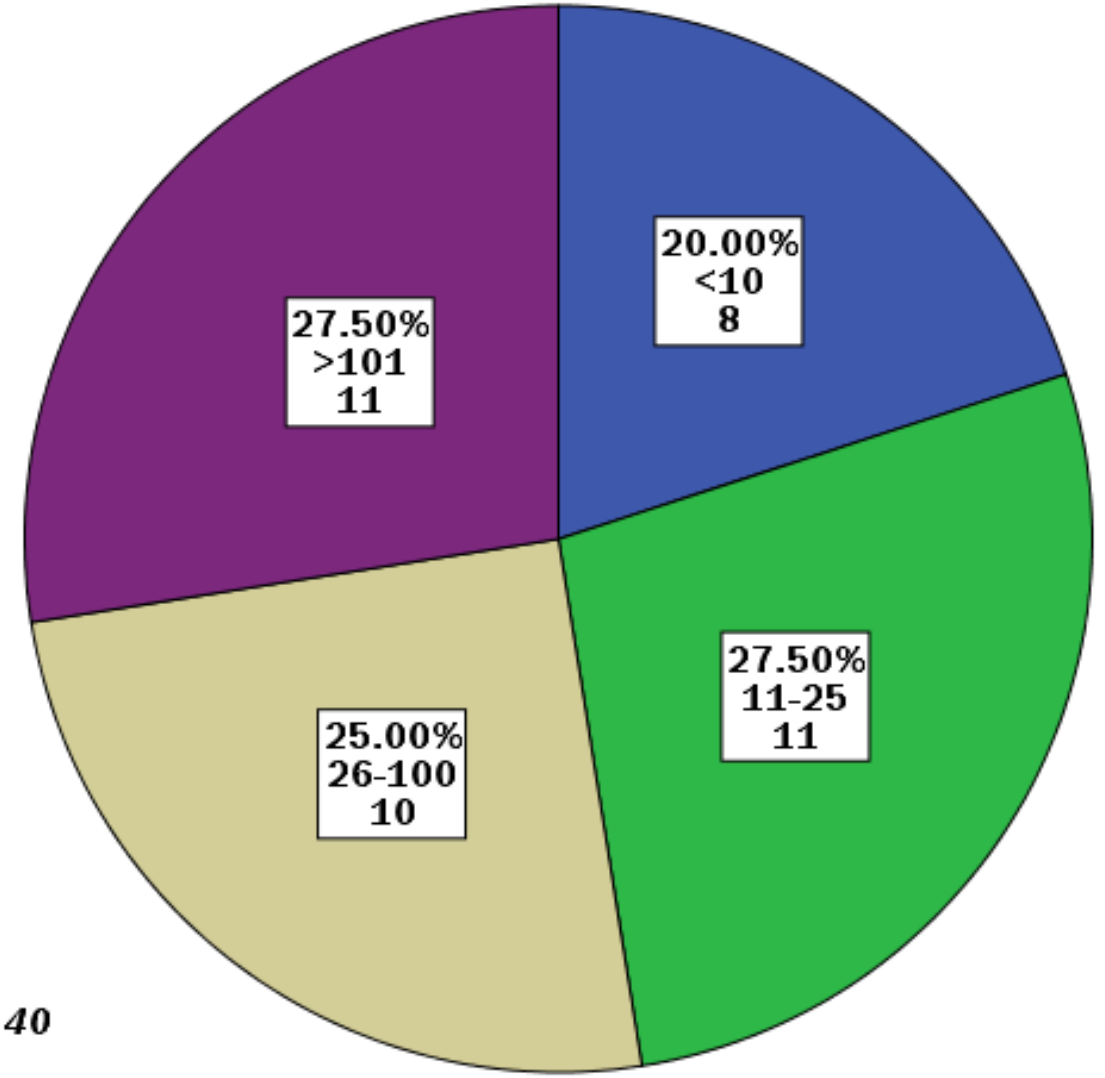
Additional Questions

- Which Software is Utilized for Quality Assurance?
- Which File Format is Utilized for Colorimetric Communication?
- Is There a Correlation Between Software and File Format?
- Is There a Correlation Between Software and Tolerancing Method?

Methods

- Ink World List of U.S. Ink Companies
- 127 Ink Companies Identified
- Mailed Survey with On-Line Response Option
  - Dillman, Smyth and Christian: *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method.* Wiley (2014).
  - One no longer in business
  - One self-disqualification
- 41 Responses ≈ 33% Response Rate

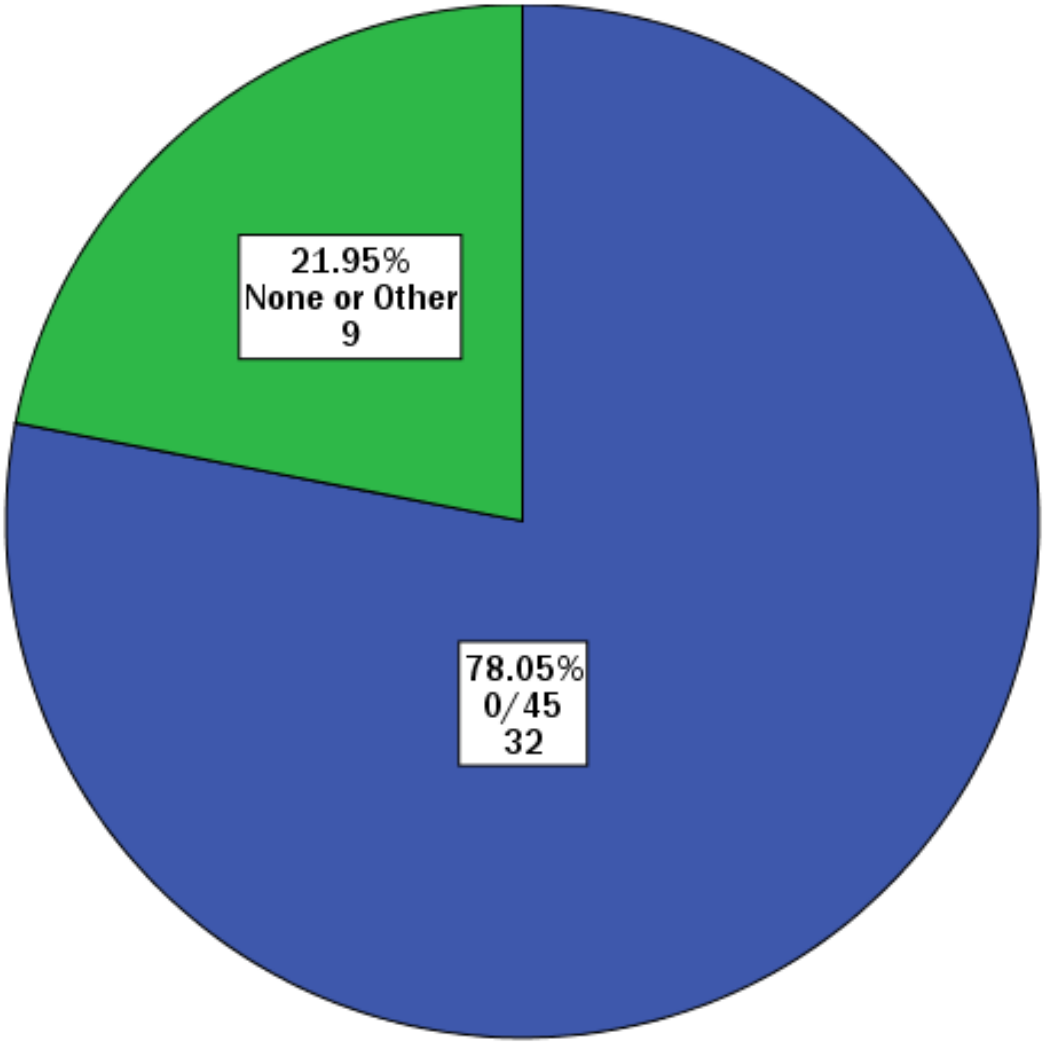
Respondent Demographics



n = 40

One Respondent Declined to Answer

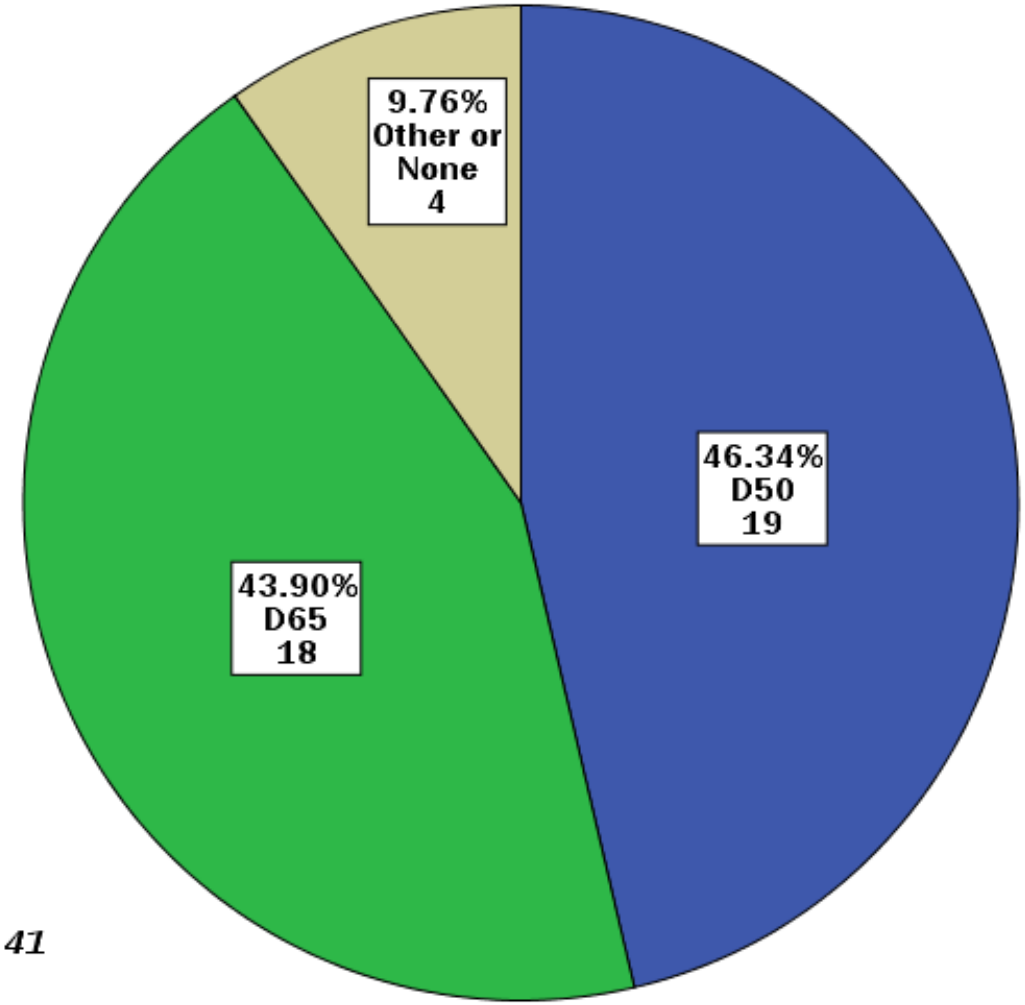
Instrument Geometry



n = 41

Other or None Includes:
Sphere (3), Multi-angle (4), None (2)

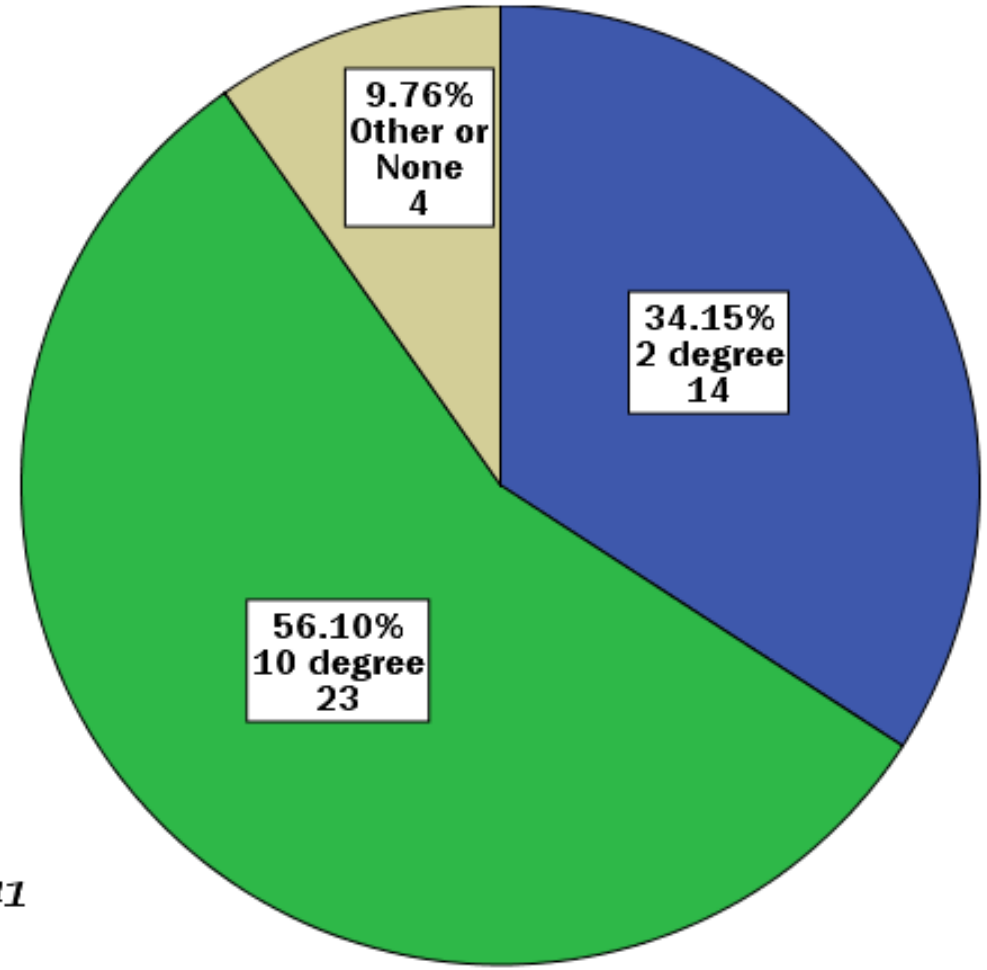
Illuminant



n = 41

Other or None Includes:
F2 (1), None (1), Don't Know/Decline (2),

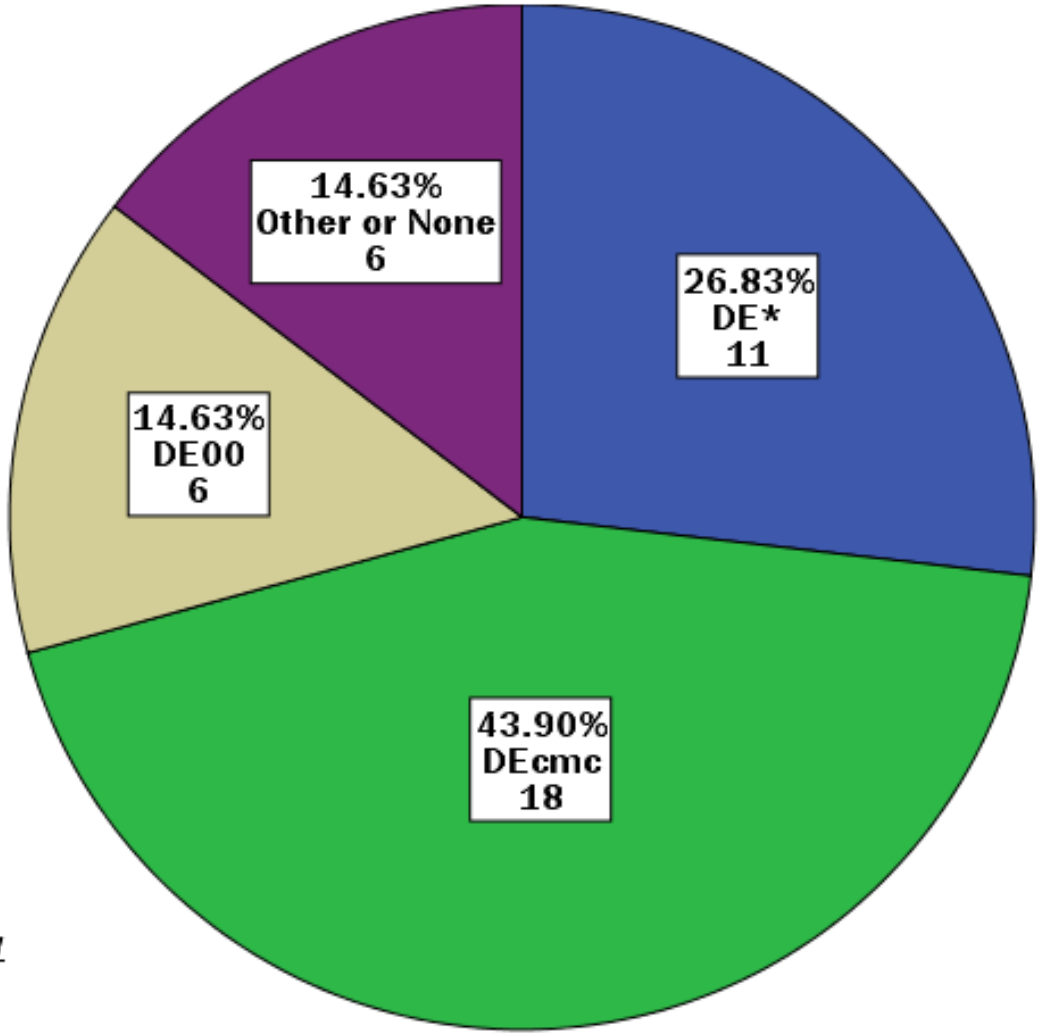
CIE Standard Observer



n = 41

Other or None Includes:
None (2), Don't Know/Decline (1)

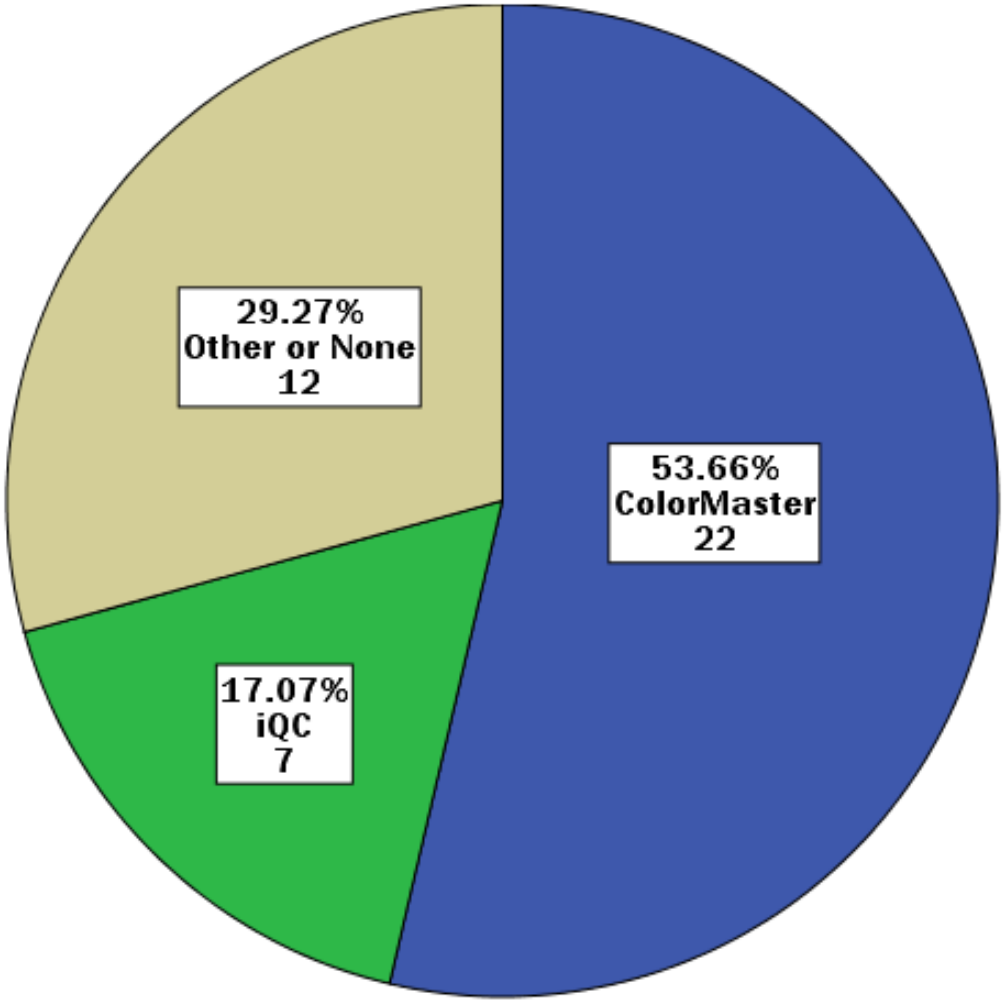
Color Differencing Method



n = 41

Other or None Includes:
CIE94 (1), CIELCh (1), Don't Know (1), None (3)

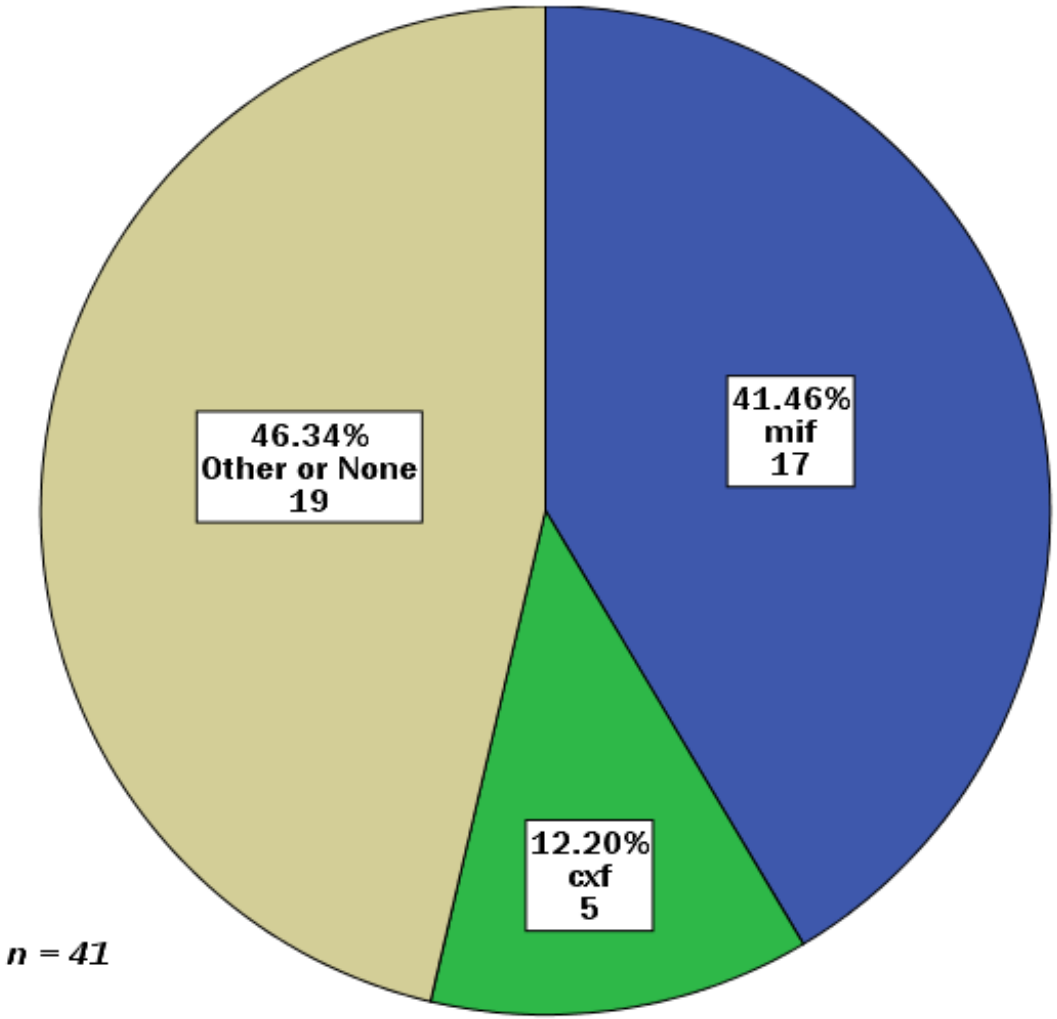
Quality Assurance Software



n = 41

Other or None Includes: X-Rite ColorQuality (4), DatacolorTOOLS (3), BYK Smart (1), BASF (1), None (1), Don't Know/Decline (2)

Digital File Format



Associations: Software and Color Differencing Method

- A chi-square test for association was conducted between software and color differencing method, using ColorMaster vs. Others and ΔE_{cmc} vs. Others.
- All expected cell frequencies were greater than five.
- There was no statistically significant association between software and size of company

$$\chi^2 (1) = 1.58, p > 0.10.$$

Associations: Size of Company and Software

- A chi-square test for association was conducted between software and size of company, using ColorMaster vs. Else and size of company as

  ≤ 50 and > 50.

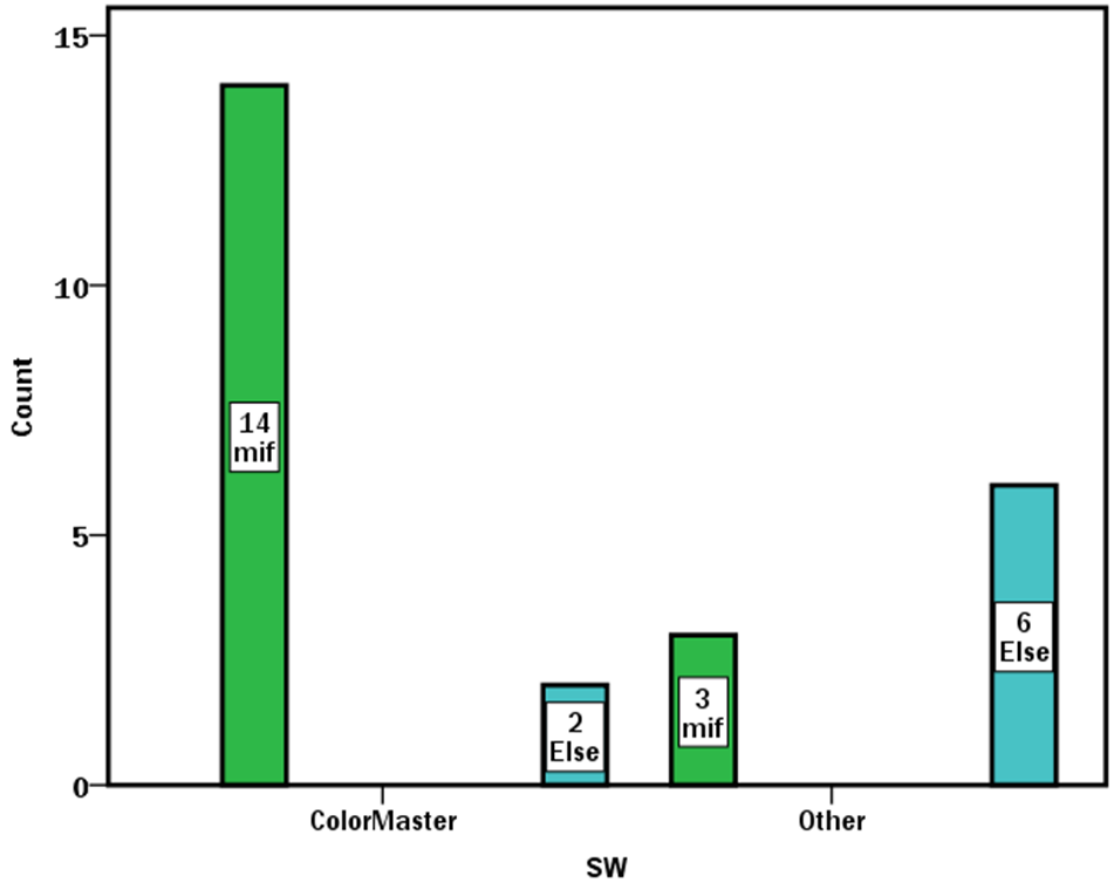
- All expected cell frequencies were greater than five.
- There was no statistically significant association between software and size of company

$$\chi^2 (1) = 1.58, p > 0.10.$$

Associations: Software and File Format

- A chi-square test for association was conducted between QA Software (ColorMaster vs. Others) and File Format (.mif vs. Others).
- One expected cell frequency was less than five, therefore significance of Fisher's Exact Test is reported.
- There was a statistically significant association between software and file format ($p = 0.01$).

Associations: Software and File Format



Conclusions/Implications

- Diversity of Colorimetric Variables Utilized by U.S. Printing Ink Companies
- Many Differ from Standards Committees
  - e.g.: Recent ISO adoption of .cxf file format, moving toward ΔE_{00}
- Stakeholders Must Remain Vigilant
- Interesting Case for Color Differencing Method
- Default Selections in Software Products Critical