Graphic Arts Standards Update - 1997

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Abstract

Standards relating to color data definition continue to be a dominant theme in both the US and international graphic arts standards activity. There is a growing understanding of the role that metrology and printing process definition play in helping define stable conditions to which color characterization data can be related.

Standards have been published to define color measurement and computation requirements, scanner input characterization targets, four-color output characterization, and graphic arts applications for both transmission and reflection densitometry. Work continues on standards relating to ink testing, reference ink color specifications, and printing process definition.

In addition, efforts are underway to document, in ANSI and ISO Technical Reports, colorimetric characterization data for those printing processes having broad-based usage. These include various applications of offset, gravure, and flexographic printing processes. Such data is key to the success of color profiles developed in accordance with the specifications being developed by the International Color Consortium (ICC).

The published graphic arts imaging and color-related standards and technical reports are summarized and the current status of the work in progress is reviewed. In addition, the interaction of the formal standards programs and other industry-driven color activities is discussed.

Keywords: Standards, color, graphic arts, photography, printing, color characterization, color management, ANSI, ISO

1. Introduction

For those of you who have diligently followed the many presentations on the topic of graphic arts color definition standards, I thank you for your patience and support. I do suspect that for some of you this is getting to be old hat. For those who are just getting involved, I recommend the summaries in the 1991, 1993, 1994, 1995, and 1996 proceedings of this conference.[1-6]

This year's report will be an update of these prior reports, with a brief review of the background and history to provide a context for the current activities. I apologize for some of the redundancy with those earlier reports but it seems important for each of these to be self-supporting.

Activities and standards of three accredited committees will be discussed along with some comments on the work of the International Color Consortium (ICC) and the Commission Internationale del' Éclairage (CIE). The standards committees are: ISO/TC 42—Photography, ISO/TC130—Graphic Technology, and ANSI/CGATS (Committee for Graphic Arts Technologies Standards).

2. Background

For those not familiar with the standards activities within the graphic arts industry, it is important to briefly summarize the origins of these activities. In the mid to late 1980s the need to move data between electronic prepress systems was the motivation for the United States graphic arts industry to become involved in technical standards—virtually for the first time in its history. Once the basic file formats for data exchange were developed, it became obvious that to make effective use of the ability to move data, the meaning of the data being moved must be better defined. A key element of this data definition includes the relationship of the data and the intended color output. Unfortunately this is not a simple task.

In graphic arts, the final image data used to create the proof or printed sheet is usually expressed as cyan, magenta, yellow, and black (CMYK) dot values. The relationship between these data values and the color that results on the printed page is dependent on many variables, most of them traditionally uncontrolled and often unknown. In the United States the normal process has been to use a proofing system that generally simulates the printing process to be used. The halftone films produced from the electronic data, or the electronic data itself, and a color proof are given to the printer who is responsible for producing a printed sheet that matches the proof.

As the graphic arts moves into a world of open exchange of electronic data, the two meaningful definitions of the "color" of electronic image data are either the color that is expected from a specific printing process or a colorimetric definition of the color desired regardless of the printing process used. For either of these definitions, all of the steps between the data in the computer and the final reproduction must be defined and/or characterized before any real meaning exists between the data and reproduced color. This has required a major change in thinking and practice within the printing industry that has only recently been accepted and is slowly being implemented.

Let's look at the standards already in place and still being developed that support the definition of color within the graphic arts industry. These include standards for measurement, characterization targets, test images, viewing conditions, ink color, process control, and printing characterization.

3. Measurement

A key element in the definition and exchange of color and process control data is agreement on the conditions of measurement for densitometry and colorimetry. For densitometry, several standards have been prepared that provide guidance in the area of measurement, and application of the measurements for graphic arts applications. These are

- CGATS.4-1993, *Graphic technology—Graphic arts reflection densitometry measurements—Terminology, equations, image elements and procedures*;
- CGATS.9-1994, *Graphic technology—Graphic arts transmission densitometry measurements—Terms, equations, image elements and procedures;*
- CGATS.11-199x, *Graphic technology—Certified reference materials for reflection and transmission metrology—Documentation requirements and recommended procedures;*
- ISO/CD 12645, *Graphic technology—Device for tonevalue calibration of transmission densitometers*;
- ISO/CD 13656, *Graphic technology—Process control—Application of measurements made by reflection densitometry and colorimetry to process control in the graphic arts*; and
- ISO/WD 14981, *Graphic technology—Process control—Optical, geometrical and metrological requirements for reflection densitometers for graphic arts use*.

As you can see from this listing, considerable work has been completed and much is still in process. It is important to note that these standards do not replace, but instead build on the work of ISO TC42, Photography, and the committees of ANSI/NAPM.

For colorimetry, CGATS.5-1993, *Graphic technology—Spectral measurement and colorimetric computation for graphic arts images,* provides a set of conditions suited to the measurement of graphic arts images. For reflection images these are: 0/45 geometry, 2E standard observer, D_{50} illuminant, and black backing under the sample. For transmission images the geometry is defined as normal/diffuse with the same observer and illuminant. CGATS.5 has been adopted and approved within TC130 as ISO 13655 with the same title. My paper, "Integrating Sphere vs Opal-glass as the Reference for Colorimetry of Transmission Targets for Scanner Characterization," later in this same session of the conference, addresses a specific issue relating to transmission measurements for colorimetry.

4. Characterization Targets

Two steps involved in the movement of images between capture and hardcopy output, where color is particularly susceptible to misinterpretation, are the scanning of input material and the output rendering process. In both cases, as the industry moves from closed systems to more open interchange, calibration and characterization are essential.

Color input scanners do not see color the same way the human eye does. This means that each scanner/film combination must be tested and characterized before meaningful data can be assured. Standards IT8.7/1-1993, *Graphic technology—Color transmission target for input scanner calibration*, and IT8.7/2-1993, *Graphic technology—Color reflection target for input scanner calibration,* define the characteristics of targets for this application. These two ANSI standards have been combined by TC130 into a single International Standard ISO 12641:199X, *Graphic technology—Prepress digital data exchange—Colour targets for input scanner calibration*. These standards provide a colorimetric definition of the elements to be included and define the specific sizes and locations for the individual components. A detailed description of the background and design of these targets is included in the 1993 proceedings of this conference. It is important to note, however, that these targets have been specified such that some elements will have the same appearance (color) regardless of the material used, while others will have characteristics unique to the product being used.

At the output step, the hard copy rendering of electronic data, the need for a common target is also important. As in any characterization process, the target must be the stimulus or input to the step being evaluated. For graphic arts printing, the stimulus is the CMYK printing values that reside in the computer or the values of the halftone dots in the film that are transferred to printing plate.

Unfortunately, the relationship between CMYK printing (dot) values in a computer file, or on film, and the color that results on a printed sheet for a particular printing process is not amenable to simple computation based on the primaries used. The recommended data set of CMYK values, along with recommended measurement conditions, is contained in IT8.7/3-1993, *Graphic technology—Input data for characterization of 4-color process printing*. ISO 12642:199X is the international version of this same standard. Although the data set is not constrained to any particular layout, the standards committees have used a consistent, and common, layout for their work to simplify data reduction. Electronic files that represent that layout are contained in ISO 12640-199X (which includes a CD-ROM) discussed below.

Work has recently been started in CGATS/SC8 (Color Data Definition) to create a new standard for the definition of a three- component data set to be used for the characterization of printing and proofing devices that use only three colorants. The tentative title of the standard is IT8.7/4, *Graphic technology—Data set for characterization of 3-colorant output devices*. This standard will be similar in concept to the existing IT8.7/3-1993 standard discussed above. Preliminary discussion in the committee suggest that the values presented in the standard should be for devices that have been linearized in L*. This suggests that the standard will also need to provide guidance to facilitate the linearization of output devices in terms of L*. As a result of these discussions, the committee is moving forward with an $8 \times 8 \times 8$ matrix based on values of 0, 5, 10, 20, 40, 60, 80, and 100 where 0 represents no colorant and 100 represents the full amount of colorant.

It should be noted that although the work of ANSI/IT8 has been incorporated within ANSI/CGATS, the IT8 designation is retained on existing IT8 standards and will be used on new standards that are logical parts of, or extensions of, existing IT8 standards.

5. Standard Test Images

Although test patches are important for the measurement of printing conditions, human observers find natural appearing images far more useful for visual evaluation. Consistent use of the same images builds a base of understanding and allows comparison between systems that is not practical when image selection is random or personal. TC130 has developed a set of images as ISO 12640:199X, *Graphic technology—Prepress digital data exchange—Standard color image data (SCID).* Included are a series of eight "natural" images (pretty pictures), as well as ten test and control elements or "synthetic" images. The IT8.7/3 CMYK color data set, described earlier, has been partitioned and is included as four of the synthetic images.

As these images only exist as electronic data, the data files are contained on a CD-ROM that is a "normative" part of the standard. Two versions of the data have been prepared. One has a data spacing of 16 samples per mm and a data range of 28 to 228 representing dot values of 0% to 100%. The other has a data spacing of 12 samples per mm with a data range of 0 to 255.

Although this standard has been approved, the DIS version with CD-ROM included, will remain available until publication of the final document. It is available from various standards sources. The recommended source in the United States is NPES, the Secretariat to the USTAG/TC130 (see bibliography for contact information).

Work has also been started in TC130 to develop a comparable set of images encoded as three component data. Similar to the CMYK SCID images these will include both natural images and synthetic test objects. However, the three-component images will represent a much larger color gamut than is provided by the CMYK color space definition.

6. Viewing Conditions

An often overlooked issue is the reality that the three dyes used in photography and the four pigments used in printing, depend on metameric matching under specific viewing conditions to allow us to visually match one to the other. The proliferation of new technologies used for proofing of graphic arts images adds to the complexity of the issue of metameric matching. The colorants and overprint characteristics of dye sublimation, ink jet, photography, etc. vary widely and can only match, if even then, under carefully defined conditions of viewing—particularly when halftone, error diffusion, and continuous tone imaging characteristics are added to the mix.

Viewing conditions for graphic arts are currently defined in ISO 3664:1975, *Photography—Illumination conditions for viewing color transparencies and their reproductions*, and ANSI PH2.30-1989, *Graphic Arts and Photography—Color Prints, Transparencies, and Photomechanical Reproductions—Viewing Conditions*. A joint TC42/TC130 special task force on viewing conditions has been charged with the responsibility for developing a revised version of the viewing conditions standard. The revised document will be ISO 3664, *Viewing conditions—For graphic technology and photography*. Support from other ISO Technical Committees has been invited and TC6 (Paper, board and pulps) is a formal participant in these activities.

Two of the key changes, from prior versions of the standard, are the introduction of spectral power distribution specifications in the wavelength region of 340 to 400 nm in consideration of fluorescence issues, and the introduction of CIE Publication 51 as the method used to evaluate compliance of the spectral power distribution of a source to that of D_{50}. Also included in the current proposal are two levels of illumination. One, for critical comparison between images, specifies an illuminance of 2000 ± 500 lux. The other, for practical appraisal, specifies an illuminance of 500 ± 125 lux.

The first Committee Draft (CD) version of the standard has been balloted and a revised draft is in preparation. The decision to move to a ballot for consideration of this work as a Draft International Standard (DIS) or have a second CD ballot is still pending. Based on the review of the ballot comments, the task group has decided that the color rendering index (CRI), UV metameric index, and visible metameric index (MI) will all be included as normative requirements, and viewing equipment will be required to meet all three to be in compliance with the standard. In addition, viewing conditions for color monitors will become a normative part of the standard. Conditions for the display of prints in galleries etc. had been addressed in earlier standards. The decision has been made to remove these from the main body of the standard and include a special annex to address this topic.

7. Output Characterization

In the standardization of color output characterization, different definitions are required at different stages of the process. The ink maker and the printer need to be able to define the color of the ink in the can. The pressman cares about the color of the ink on the particular printing stock being used along with the other process control parameters that define the printing process. The color separator needs data that relates the color printed in both the solid and overprint areas to the input CMYK data for a particular ink color and printing process. Each is part of the output characterization, but to some extent can be specified independently.

7.1 Ink Color

The testing of ink, and the measurement and definition of ink color, is a key link in the chain leading to control and standardization of the printing process. When we go back and look at the basic definition of the ink color by the ink maker, we realize that this does not necessarily require the use of any of the normal printing processes, but only a consistent, reproducible way of evaluating ink color. ISO 2846-1:1997, *Graphic technology—Colour and transparency of ink sets for four colour printing—Part 1: Sheetfed and heatset web offset lithography printing*, is the first of a new series of standards that address the color of the ink in the can.

The approach used is to specify a colorimetric aim and an allowable tolerance in CIE $)E_b$. The ink is "printed" on the reference test paper (Phoenix Imperial APCO II/II), using laboratory printability testers, over a range of ink film thicknesses in accordance with the specification. The $)E_b$ between the printed color and the colorimetric aim is plotted as a function of ink film thickness. If the tolerance is

met within the allowable ink film thickness range, the ink is deemed to have met the colorimetric aims. This allows considerable flexibility in ink composition and ink strength, but ensures that the ink will be the correct color at a reasonable ink film level.

Additional parts of ISO 2846, already in process in TC130, include: *Part 2: Coldset web offset lithographic printing on newsprint, Part 3: Gravure printing,* and *Part 4: Screen printing*.

7.2 Process Control

While targets and measurement standards are important for the characterization of an output process, such characterization is of little value if the process being characterized is not defined or repeatable. CGATS.6-1995, *Graphic technology—Specifications for graphic arts printing—Type 1*, carries the notation "The numerical data in this standard was based on an analysis of control targets and printed samples associated with the current industry practice identified as 'Specifications Web Offset Publications' (SWOP)." Similar work is being done in TC130. ISO 12647, *Graphic technology—Process control for half-tone colour separations, proofs and productions prints*, is being prepared as a multipart document. *Part 1: Parameters and measurement methods*, identifies those parameters that are used to define a printing process. The subsequent parts of the document provide the detailed parameters for different classes of printing. Work is completed on *Part 2: Offset processes*. Work is currently underway on *Part 3: Coldset offset and letterpress on newsprint*, *Part 4: Gravure printing*, and *Part 5: Screen printing*.

7.3 Color Characterization

ANSI CGATS TR 001-1995, *Graphic technology—Color characterization data for Type 1 printing*, is the first set of publicly available color characterization data for a major printing process. As noted earlier, Type 1 Printing is directly related to SWOP proofing. This work drew upon ISO 2846-1 for color of the ink in the can, SWOP and CGATS.6 for printing process definition, ISO 12640 for the electronic data representation of the IT8.7/3 data set, and CGATS.5 for the colorimetric measurement definition. This is one of the first examples of the various elements of the standards process working together as intended.

Following this lead, work is also underway to provide color characterization data for other printing conditions. Within TC130, printing samples based on the conditions defined in ISO 12647-2 have been prepared by the German printing research institute, FOGRA, and measured data is being evaluated for use in preparing a set of ISO Technical Reports. In addition, the Japanese National Standards Body has prepared a Japanese standard providing color characterization data for a publication printing condition identified as "Japan Colour". Within the United States, The Gravure Association of America (GAA) is considering color characterization data for gravure printing on three paper grades. In addition CGATS is working with the SNAP (Specifications for Non-Heat Advertising printing) Committee to characterize printing on newsprint. Some work has been started in the GCA (Graphic Communications Association) Print Properties Committee to identify printing conditions that might lead to the characterization of several commercial printing references as a function of paper type.

8. International Color Consortium

The International Color Consortium (ICC) is a strong player in the area of color definition. Although the ICC is not a formal standards organization it is in the business of building specifications that will assist the exchange of color information. In addition, the ICC is in dialogue with ISO/TC130 and hopefully their work will eventually be moved into that standards arena. The ICC membership is currently at 45 members. NPES, the secretariat for the United States graphic arts standards committees, also serves as the Administrative Secretariat to the ICC.

The following statement from the ICC describes who they are: "The International Color Consortium is an organization established for the purpose of creating, promoting, and encouraging the standardization and evolution of an open, vendor-neutral, cross-platform color management system architecture and components. The work of the ICC shall be made available to the public and encouraged for adoption by all relevant suppliers of the 'color' industry. Where appropriate, ICC documents will be forwarded to national and international standards organizations."

Version 3.3 of the ICC Profile Specification has been published and is available from www.color.org.
As there are many other presentations during this conference that will provide an in-depth look at the work of the ICC, I will not elaborate further.

9. Three-Component Color Data Encoding

At a meeting of CGATS/SC8, in Scottsdale Arizona last fall, the work on a default three-component data definition for graphic arts applications was reactivated. It was agreed that a CGATS standard will be developed with the title *Graphic technology - Three-component color data definition*.

The key thinking behind the standard, particularly the RGB default, was that if no other definition were available, what would be the most logical definition to assume for data of the types specified. This becomes particularly important for RGB data in the graphic arts, where many of the desktop publishing systems have no ability to identify or "tag" the RGB data that they send forward to other systems. The proposed document will include defaults for an 8-bit per component RGB and CIELAB and two 16-bit per component CIEXYZ encodings.

The RGB encoding will be identified as "Default Display RGB (sRGB)" and draws heavily on the paper "Proposal for a Standard Default Color Space for the Internet - sRGB", by M. Anderson, R. Motta, S. Chandrasekar, and M. Stokes (version 1.04, Sept. 6, 1996). This default definition will include assumptions about viewing conditions and flare. It is based on the ITU-R BT.709/4 phosphors, a D_{65} white point and a gamma of 2.2.

The graphic arts CIELAB will be based on a D_{50} white point and colorimetry as defined in CGATS.5. Provision will be made for a user-defined encoding range, as well as a default encoding that is compatible with typical applications used with desktop systems.

Provision is being made for two flavors of graphic arts 16-bit XYZ data. The first is identified as "Graphic Arts Linear XYZ". It is based on a D_{50} white point and the other colorimetric definitions of CGATS.5. The data encoding, however, allows X, Y, and Z values up to 200 so that the same data encoding scheme could be applied to other white points in the future. The committee is also considering a proposal to include a companded (extended range) XYZ for future uses. Some suggested applications include recording data in from a color negative or high quality digital camera (capturing a wide exposure range), in such a way that a rendering decision does not have to be made before data encoding.

10. Other Activities

One other item being discussed within the graphic arts standard community is the issue of an input scanner calibration target for negative films. This subject was discussed at the Fall meeting of CGATS/SC8 and some work is being undertaken. The current approach is to allow individual film manufacturers to characterize their color negative film as a specific relationship to a photographic printing paper of their selection.

11. Bibliography of Applicable Standards

The following bibliography of color definition related ISO and ANSI standards is provided as a supplement to assist the reader. They are arranged in numerical order.

1. ANSI CGATS.4-1993, Graphic technology—Graphic arts reflection densitometry measurements—Terms, equations, image elements and procedures
2. ANSI CGATS.5-1993, Graphic technology—Spectral measurement and colorimetric computation for graphic arts images
3. ANSI CGATS.6-1995, Graphic technology—Specification for graphic arts printing—Type 1
4. ANSI CGATS.9-1994, Graphic technology—Graphic arts transmission densitometry measurements—Terms, equations, image elements and procedures
5. CGATS.11-199x, Graphic technology—Certified reference materials for reflection and transmission metrology—Documentation requirements and recommended procedures
6. ANSI/CGATS TBD, Graphic technology—Three-component color data definitions (Preliminary Draft only)
7. ANSI CGATS TR 001-1995, Graphic technology—Color characterization data for Type 1 printing
8. ANSI IT8.7/1-1993, Graphic technology—Color transmission target for input scanner calibration
9. ANSI IT8.7/2-1993, Graphic technology—Color reflection target for input scanner calibration
10. ANSI IT8.7/3-1993, Graphic technology—Input data for characterization of 4 color process printing
11. ANSI IT8.7/4, Graphic technology —Data set for characterization of 3-colorant output devices (Working Draft)
12. ANSI PH2.30-1989, Graphic Arts and Photography—Color Prints, Transparencies, and Photomechanical Reproductions—Viewing Conditions
13. ISO 2846-1:1997, Graphic technology—Colour and transparency of ink sets for four colour printing—Part 1: Sheet-fed and heatset web offset lithography printing (Revision of ISO 2846:1975)
14. ISO/WD 2846-2, Graphic technology—Colour and transparency of ink sets for four colour printing—Part 2: Coldset web offset lithographic printing on newsprint
15. ISO/NP 2846-3, Graphic technology—Colour and transparency of ink sets for four colour printing—Part 3: Gravure printing
16. ISO/WD 2846-4, Graphic technology—Colour and transparency of ink sets for four colour printing—Part 4: Screen printing
17. ISO/CD 3664, Viewing conditions—For graphic technology and photography
18. ISO 12640:199X, Graphic technology—Prepress digital data exchange—Standard color image data (SCID)
19. ISO 12641:199X, Graphic technology—Prepress digital data exchange—Colour targets for input scanner calibration
20. ISO 12642:199X, Graphic technology—Prepress digital data exchange—Input data for characterization of 4-colour process printing
21. ISO/CD 12645, Graphic technology—Device for - tonevalue calibration of transmission densitometers
22. ISO/CD 12646, Graphic technology—Specifications for the use of a colour monitor for colour proofing of graphic arts images
23. ISO 12647-1:1996, Graphic technology—Process control for half-tone colour separations, proofs and productions prints—Part 1: Parameters and measurement methods
24. ISO 12647-2:1996, Graphic technology—Process control for half-tone colour separations, proofs and production prints—Part 2: Offset processes
25. ISO/CD 12647-3, Graphic technology—Process control for half-tone colour separations, proofs and production prints—Part 3: Coldset offset and letterpress on newsprint
26. ISO/WD 12647-4, Graphic technology—Process control for half-tone colour separations, proofs and production prints—Part 4: Gravure
27. ISO/WD 12647-5, Graphic technology—Process control for the manufacture of half-tone colour separations, proof and production prints—Part 5: Four colour printing by screen process
28. ISO 13655:1996, Graphic technology—Spectral measurement and colorimetric computation for graphic arts images
29. ISO/CD 13656, Graphic technology—Process control—Application of measurements made by reflection densitometry and colorimetry to process control in the graphic arts; and
30. ISO/CD 14672, Technical Report—Statistics of the natural SCID images defined in ISO 12640
31. ISO/WD 14981, Graphic technology—Process control—Optical, geometrical and metrological requirements for reflection densitometers for graphic arts use
32. ISO/NP 15076, Graphic technology—Prepress digital data exchange—International colour profile format
33. Recommended Specifications for Web Offset Publi-

cations, 1993 Edition, SWOP Inc., 60 East 42nd St., Suite 1416, New York, NY 10165-0015 (1997 Edition currently being printed)

Note:

Standards showing a date as 199X are approved but not yet published. NP indicates that a standard is at the New Proposal stage of development, WD represent Working Draft, CD is a formal Committee Draft, and DIS indicates that a standard is a Draft International Standard and is in the final review process for acceptance as an International Standard.

TC130, IT8 and CGATS published and draft standards are available from NPES The Association for Suppliers of Printing and Publishing Technologies, 1899 Preston White Drive, Reston, VA 20191-4367, 703-264-7200. NPES is the Secretariat for CGATS, IT8, USTAG/TC130, and TC130/WG2.

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