Metrology Standards – An Update

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Keywords: Characterization, Colorimetry, Densitometry, Instrument, Measurement, Spectrophotometry, and Standards

Abstract: Over the past several years, there have been advancements and applications changes in the field of optical measurement metrology, specifically densitometry and spectrophotometry. Various standards have been modified or developed that establish the design specifications for these instruments allowing the graphic arts and photography industries to continue to enjoy a cohesive series of measurement instrumentation. Additional standards have been or are being developed to standardize new areas of importance such as the proper application of measurements for characterizing printing materials and system output as well as process control.

This paper provides an update on the current status of activities in ISO TC 42 Photography and ISO TC 130 Graphic Technology reviewing standards in the field of measurement including documentary standards/revisions on instruments, spectrophotometry, densitometry and the application of these measurements in graphic arts.

Introduction

Standards related to color data definition continue to be a focus in both the US and international graphic arts activities. The need for these activities is highlighted by the increasing use of electronic data exchange for moving press-ready digital materials between prepress service providers and production print manufacturing companies.

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Work in these areas is currently being done by the American National Standards Institute Committee for Graphic Arts Technologies Standards (ANSI CGATS), ISO Technical Committee 42 (ISO TC 42), Photography, and ISO Technical Committee 130 (ISO TC 130), Graphic Technology. In order for these standards related to color definition to be meaningful it is necessary to also have in place standards that focus on how one measures images, namely metrology. The growing use of colorimetric-based characterization data also requires accurate and consistent metrology for successful implementation of color management.

The *International Vocabulary of Basic and General Terms in Metrology* defines metrology as "science of measurement" and further notes "metrology includes all aspects both theoretical and practical with reference to measurements, whatever their uncertainty, and in whatever fields of science or technology they occur."

Over the past few years there have been a number of revisions to standards that address specifications for measurement instruments in the field of densitometry. We have also seen the development of standards that establish how measurements and computations from measurements should be made. International standards and US standards are reviewed on a five-year cycle. Metrology includes an understanding of definitions of what is to be measured, the instruments best suited for a particular measurement and the procedures to be used when making a measurement. Here, we are focusing on measurements of materials and output from photographic, graphic arts and other imaging industries.

This paper will discuss the status of the standards activities of several US and international standards committees and the direction of the future work.

Where Do Standards Come From?

Within the US there are two standards committees under the American National Standards Institute that focus on photography and graphic arts.

The Photographic Imaging Manufacturers Association (PIMA) Image Technology 2 committee develops photography-based standards in the US. ISO Technical Committee 42 (ISO TC 42) covers the same photographic industry standards activity at the international level. The scope of the activity for ISO TC 42 covers "Standardization primarily, but not exclusively in the field of still picture imaging – chemical and electronic – including, but not limited to:

- definitions for still imaging systems;
- methods for measuring, testing, rating, packaging, labeling, specifying and classifying the dimensions, physical properties and performance characteristics of media, materials and devices used in chemical and electronic still imaging;
- specifications and recommendations of logical and physical characteristics, practices, interfaces and formats for still imaging capture, processing, and output systems; and
- methods to measure, test, rate, physical properties and performance characteristics of media, materials and devices.

The American National Standards Institute Committee for Graphic Arts Technologies Standards (ANSI CGATS) develops graphic technology-based standards in the US. ISO Technical Committee 130 (ISO TC 130), Graphic Technology covers the same graphic arts industry standards activity at the international level. The scope of the activity for ISO TC 130 is "standardization of terminology, test methods and specifications in the field of printing and graphic technology from the original provided to finished products" and includes in particular:

- composition
- reproduction;
- printing processes;
- finishing (for example binding), and
- the suitability of inks, substrates and other materials used in graphic technology.

Further noted is "printing is defined here as a process of reproduction involving the transfer of a medium either coloured or not (ink, etc.) to a substrate, using a relief, planographic, intaglio, stencil or other image element."

CGATS has a dual standards role. It is charged with the overall coordination of graphic arts standards activities and the development of graphic arts standards where no applicable standards developer is available.

Densitometry Standards

The most important activity underway this year is the revision of the ISO 5 series of standards that deal with the definition of densitometry. The ISO 5 series (titles shown below) was derived from ANSI PH 2.15, 2.16, 2.17, and 2.18 documents developed by the IT2-28 Densitometry Committee under PIMA. The series dates back to at least the middle 1970s. Even though they were developed by the photographic standards writing committees, the changes they have undergone have had a great deal of input from the graphic arts community.

- ISO 5/1:1984, *Photography — Density Measurements — Part 1: Terms, symbols and notations*
- ISO/FDIS 5/2:200x, *Photography — Density Measurements — Part 2: Geometric conditions for transmission density*
- ISO 5/3:1995, *Photography — Density Measurements — Part 3: Spectral conditions*
- ISO 5/4:1995, *Photography — Density Measurements — Part 4: Geometric conditions for reflection density*

Recently, ISO TC 130 has begun the development of a new standard for reflection densitometry that identifies some features primarily used in some graphic arts applications and specifications for allowed tolerances. ISO/DIS 14981, *Graphic technology — Process control — Optical, geometrical and metrological requirements for reflection densitometers for graphic arts* is nearing completion and is expected to become a standard during 2000 – 2001. An outgrowth of this activity was the expressed concern and commitment from US experts to review the differences between ISO 5-4 and ISO 14981, both standards for reflection densitometers. It was - and still is - the belief that if the two standards remain in place without resolving the differences, manufacturers would either be forced to make two different instrument geometry configurations or forsake one of the industries for the other. In addition, the different geometry specifications might lead to confusion for the consumer or extra costs for instruments with the different specifications.

A careful review of ISO 5 series revealed that the present standards intermix the definition of densitometry and the tolerances and features allowed in the design of practical instruments. Discussions within both ISO TC 42 and ISO TC 130 have lead to the formation of Joint Working Group 21 (ISO/TC 42 JWG 21). The goal of the JWG 21 is to separate the definition of densitometry and the tolerances on equipment design and also incorporate most of the requirements expressed in ISO 14981 into the appropriate parts of ISO 5. JWG 21 had its first meeting in Mesa, Arizona on March 27, 2000 (aligned with the ISO TC 130 working group meetings taking place that same week).

The following sections will attempt to provide information on some of the more important issues being addressed in ISO 5-4 covering reflection densitometry.

ISO 5-4 - Definition versus Practical Tolerances

The unambiguous definition of density requires that geometric conditions, along with other parameters, be exactly specified. However, the practical design and manufacture of instruments requires the use of reasonable tolerances due to physical limitations (that reasonable tolerances are allowed for physical parameters).

The definition of reflection density should be based on the value specified for each parameter. The tolerances shown will represent allowable variations in these parameters, which the technical experts believe will have a negligible effect on the density values resulting from measurements made with practical instruments. The absolute specifications will still be considered preferred.

ISO 5-4 - Influx and Efflux Geometry

Changes will be made that address the definition of the influx and efflux geometry. These include:

- better definition of the cone of illumination or pickup;
- more realistic tolerances on sample aperture;
- inclusion of single azimuth geometry for non-directional samples;
- under and over illumination;
- inclusion of measurement with a polarizer; and
- inclusion of a polarizer test method.

ISO 5-4 - Sampling Aperture & Irradiated Area

Since their initial inception, the sampling aperture and irradiated area definitions have been the ideals to follow. Unfortunately, what is ideal is not always practical. A case-in-point is the definition of the sampling aperture. The current definition of a 2-mm over illumination on each side would translate to a measured 4-mm area needing an 8 mm irradiated area, without obstructions. In the practical sense, it would be extremely difficult to target a device with such a configuration on a 5-mm color bar patch!

On the other hand, the proposed specification of 0.5 mm on each side would make it easily possible to target a 4-mm sampling aperture on a 5-mm patch.

Also, under illuminating and over sampling would now be acceptable. It has been shown through various studies of under and over illumination that there is no significant effect on the measured value as long as the over sampling is sufficient. Both methods of illumination and pickup have their theoretical advantages, but in the practical sense the differences are insignificant.

One of the problems inherent in reflection instrument measurements is translucent blurring or as it is sometimes called lateral diffusion error. David L. Spooner has presented many papers on the subject including "How Surrounding Color Can Affect Measured Color of a Sample" given at this TAGA 2000 conference. Some of the issues include:

- samples under illuminated must be sufficiently over sampled to reduce or eliminate this effect;

- samples over illuminated must be sufficiently under sampled to reduce or eliminate this effect; and
- if done properly, no differences in the measured values should be noted.

Spectral Conditions and Conformance

Additionally, there are areas missing in the ISO 5 series that need to be addressed. The illuminant used is not defined in ISO 5-4, but is shown in ISO 5-3, Spectral Conditions.

Spectral response of the receiver is also not defined, only the overall system response characteristics are specified. Neither linearity nor polarization, which is finding increased usage in graphic arts, is defined in either part 3 or 4.

With the proliferation of low cost spectral devices coming into the market, it is now economically viable to obtain spectrally based instruments for use as process control devices, e.g., densitometers. Unfortunately, the method to convert spectral data to density data has not been standardized, which could lead to differences similar to those one would see if they used different densitometer responses should different computational methods be used. Reflection density calculation from spectral data will be addressed in ISO 5-3.

The following formula is being drafted into annex A of ISO 5-3:

$$D_P = -\log \frac{P(\lambda) \cdot \Pi(\lambda)}{\Pi(\lambda)}$$

where:

D_P	is the propagation density, which may be either transmission density D_T, or reflection density D_R;
$P(\lambda)$	is the propagance factor at wavelength λ (400-700 nm minimum);
$\Pi(\lambda)$	is the appropriate spectral product at wavelength λ
log	is the logarithm to base 10

Colorimetry and Process Control Standards

Several standards have been developed in the past several years that focus on how we should be measuring and computing color characteristics, how we should determine the uncertainty in our measurements and what parameters are necessary to describe a material or the output of a process.

CGATS.5 & ISO 13655

CGATS in the US developed CGATS.5-1993, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*. This standard is in the revision process for the mandatory five-year review cycle.

One of the major issues being addressed is determining whether or not an update is necessary to the weighting factors for computing X, Y, Z as well as the issue of backing material to be used behind images during measurement. CGATS.5 was also used in the development of the ISO equivalent standard, ISO 13655:1996. Updates made to CGATS.5 will be forwarded to ISO TC 130 WG3 for use when that standard comes up for review.

CGATS.11/PIMA IT2.11 and ISO 15790

In late 1999, the standard, CGATS.11/PIMA IT2.11-1999, *Graphic technology and photography — Reflection and transmission metrology — Documentation requirements for certified reference materials, procedures for use, and determination of combined standard uncertainty*, was approved in the United States. This standard addresses the need to better understand the accuracy of reflection or transmission measurements made with various instruments. At first this standard was written for the graphic arts community but it was realized that it could be equally implemented in the photographic industry. During the completion of the standard the decision to co-designate with PIMA IT2 was made so that it could be applied to both industry segments. During this same time the document was introduced to ISO TC 130. ISO TC130 and ISO TC 42 have agreed to form Joint Working Group ISO/TC 130 JWG 6, to move this standard, which is at the Draft International Standard (DIS) level, to completion.

Two of the more significant areas addressed by this standard and its equivalent under development at the international level are:

1. The need to report not only the resultant measurement values but also the "combined standard uncertainty"

$$D_R(45; S_A : 0; T_R) = 1.25 \text{ with } u_c = 0.01$$

2. The need to determine the "combined standard uncertainty" of a measurement system based on some reasonable estimates of the variations.

$$u_c(y) = \sqrt{u_r^2 + u_{crm}^2 + u_{x_1}^2 + u_{x_2}^2 + \ldots + u_{x_n}^2}$$

This standard resulted from many reviews of the scientific documents including the "Guide to the Expression of Uncertainty" and a group of standards that address statistics in measurement.

ISO/FDIS 13656
This standard was an outgrowth of standards such as CGATS.4 and CGATS.9 that address reflection and transmission densitometry measurements. These standards were developed in the early 90's and have been reaffirmed since their first printing.

ISO/WD 15994
ISO 15994 is at the working draft stage of development. It represents a new measurement of the surface characteristics of paper materials that may better correlate with the perception of gloss across the wide range of materials used in the printing and publishing industry.

Future Work

The ISO/TC 42 JWG 21 activity will be focused on revising ISO 5/2, 5/3 and 5/4. updating their content with information that is not only an improved definition of densitometry but also provides that information in a more logical flow. Once all of the parts addressing the instruments and spectral conditions are completed Part 1 for terminology will be revised.

Watch for completion of the ISO 5 series update to occur by 2001!

The ISO/TC130 JWG 6 activity on ISO 15790 covering CRM usage and the computation of combined standard uncertainty should be completed in 2000.

Future activities will include not only the revision of existing standards when necessary but also the development of new standards in areas such as soft proofing and the control of digital workflow.

Conclusions

What we have attempted to accomplish here is to update the TAGA members on what is happening relative to the measurement of graphic arts materials specifically, but also applied to other industries.

The new digital world that we work in will require even more focus on providing data throughout the various phases of image reproduction as an image progresses from the camera to the printed page. To effectively allow this, continued emphasis will be made to improve current standards and develop new ones as necessary.

Contact Information

If you wish to track or get involved in any of these activities please contact either of the following two people. All the standards work related to graphic arts and photography are maintained through the central resources of the committees they represent. You can also contact either author as well.

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Shown here are the various web site addresses that relate to graphic arts and photography standards development. These can be used to research and monitor the standards under development at any particular time.

CGATS	http://www.npes.org
ISO	http://www.iso.ch
ISO TC 42	http://www.pima.net/standards/tc42.htm
ISO TC 130	http://www.din.de and select "English" version

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ISO 5/3
1995 "Photography — Density Measurements — Part 3: Spectral conditions", ISO, Geneva.

ISO 5/4
1995 "Photography — Density Measurements — Part 4: Geometric conditions for reflection density", ISO, Geneva.

ISO 12645
1998 "Graphic technology — Process control — Certified reference material for opaque area calibration of transmission densitometers", ISO, Geneva.

ISO 13655
1996 "Graphic technology - Spectral measurement and colorimetric computation for graphic arts images", ISO, Geneva. (ANSI/CGATS.5-1993 is equivalent).

ISO/FDIS 13656
200x "Graphic technology — Application of reflection densitometry and colorimetry to process control or evaluation of prints and proofs", ISO TC130

ISO/CD 14807
200x "Photography — Method for the determination of densitometer performance specifications", ISO TC42, PIMA.

ISO/DIS 14981
200x "Graphic technology — Process control — Optical, geometrical and metrological requirements for reflection densitometers for graphic arts", ISO TC 130.

ISO/CD 15790
200x "Graphic technology and photography — Reflection and transmission metrology — Documentation requirements for certified reference materials, procedures for use, and determination of combined standard uncertainty", ISO TC130.

ISO/CD 15994
200x "Graphic technology — Testing of prints and printing paper — Visual lustre number", ISO TC130

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