ISO Image Permanence Standards Update

Joseph E. LaBarca, Pixel Preservation International, 60 Briar Wood Lane, Rochester, New York, 14626, USA
Dr. Peter Z. Adelstein, Image Permanence Institute, Rochester Institute of Technology, Rochester, New York, 14618, USA

Abstract

ISO Technical Committee 42 (Photography), Working Group 5 (Physical Properties and Image Permanence of Photographic Materials) is responsible for developing standards on image permanence and durability. Over the past two years there has been considerable progress by the committee on the development of test method standards for image permanence and durability testing and reporting. Four new methods standards and a test target standard have been published in the last year, and two more method standards are on their way to completion. These seven new standards will be discussed. In addition, work continues on a specification standard that would use the test data to form print life estimates. This proposed standard will be discussed briefly along with the difficulties and complications of making print life predictions. Finally a new standard for testing of photo books has been started and will be discussed briefly as well.

Introduction

There has been much activity in ISO TC42, Working Group 5 in the development of new standards for physical properties and image permanence. Older standards for image permanence testing, such as ISO 18924 Imaging Materials – Test method for Arrhenius-type predictions and ISO 18909 Photography – Processed photographic colour films and paper prints – Methods for measuring image stability, still exist, though these were originally published specifically for silver halide photographic materials, that is, photographic film and paper. While these standards are still useful, a new set of standards was needed to reflect the new digital output technologies in use today. These technologies include inkjet of various types, dye diffusion thermal transfer (commonly called "dye sub"), electrophotographic, as well as silver halide photographic paper, now often digitally exposed. While the new standards were urgently needed, their development has been time consuming because the output technology has been evolving at the same time as the standards were being developed. As technology changed, several standards in development had to be modified to reflect the evolution of the materials. While the new digital output technologies are susceptible to both the common degraders of images (light and heat), they may also susceptible to degradation from atmospheric pollutants and humidity. Thus not only was it necessary to update current standards for light and heat, but to create new standards for these additional environmental factors impacting the stability of digital hard copy output materials. While serving as methods for testing, these new standards mark a change in philosophy of Working Group 5 in that there is now a separation of test methods from predictive specifications. This means that the new standards can be used in a stand-alone mode and be applied more broadly than just generating data for stability assessments. This paper will review the recently published standards for digital color photographic output and provide an update on standards development work still in progress.

Standards Commonality

Before discussing the new standards individually it is important to recognize common features and requirements of the four new test method standards. So-called "boiler-plate" sections are included in all of the method standards that define areas of commonality among these test methods.

One very important area is ambient ozone requirements in the test lab. Because the new digital technologies may be sensitive to atmospheric pollutants (and sometimes extremely sensitive) all the method standards with the exception of the ozone test method, require pre-testing and stringent control of ambient levels of pollutants during the test. As first reported by Eastman Kodak Company in 2001 [1, 2], an "apparent reciprocity failure" observed in long term light fade testing turned out to be colorant loss by very low levels of ozone in the lab. Because of this, the new methods require limits of 2 PPB or lower average ozone concentration over the time period of the test.

The common sections of the test methods also include environmental conditions and reporting requirements. Environmental requirements include definition of standard testing conditions (where common) of temperature and relative humidity as well as environmental conditions during sample preparation and measurement. Reporting requirements include equations for the calculation of density loss and color balance differential, as well as a set of definition of terms and normative references to be used across all the standards. The committee's goals in requiring adherence to all of these common requirements across the four method standards are to maximize the precision in testing, control external variables as much as possible, and minimize the possibility of errors due to interference by external factors.

One final common point is also worthy of note. Each method standard contains the same caution on the use of the test method standards against making life estimate predictions. The test method standards were designed as stand-alone methods to make comparative assessments of the stability of imaging materials, and quantitative assessments of colorant loss due to the specific tested environmental factor. Because of the complexity of making life estimates, the data from these tests shall not be used to make life

This paper was presented at the 4th International Symposium on Technologies for Digital Photo Fulfillment, held Jan. 6-7, 2013, at Bally's in Las Vegas, Nevada.

ISSN: 2169-4672

expectancy claims, such as time-based print lifetime estimates, except in conjunction with an appropriate specification standard, should such standard be developed.

Recently Published Standards

ISO 18930:2011 – Imaging materials — Pictorial colour reflection prints — Methods for evaluating image stability under outdoor conditions

Published in September 2011, this standard provides standardized test procedures to evaluate image stability both in real-time outdoor weathering tests and in accelerated laboratory simulations of the weathering process. During the development of the standard, testing was conducted both in the laboratory and in the field, and good correlations were found between the two. In outdoor testing, critical factors that cause image degradation include light, water, heat, ozone, and local and diurnal variations in climate. In accelerated testing, the standard requires that the most critical factors of light, water and heat are included. The use of xenon arc lamps with "daylight" filters has become an industry standard procedure for the most accurate and uniform simulation of the spectral power distribution of sunlight. The coupling of the xenon arc lamps and "daylight" filters with a water spray and elevated temperatures forms the basis for testing with accelerated laboratory weathering instruments. Recommendations for day-night cycling and water spray cycling are provided in the standard for laboratory testing.

ISO 18936:2012 – Imaging materials -- Processed colour photographs -- Methods for measuring thermal stability

Published in April of 2012, this standard provides the methods and procedures for measuring the long-term dark storage, i.e., thermal stability, of color photographs. In the long term, the vast majority of photographic images ultimately end up stored in the dark so the importance of this standard cannot be understated. Often the ultimate use of a particular photograph may not be known at the outset. For museums, archives and others responsible for the care of color photographic materials, as well as the general public looking for technology-independent, long-term preservation of a digitally captured image, an understanding of the behavior of these materials under various dark storage conditions is essential if they are to be preserved in good condition for long periods of time. The standard looks at the two common paths of thermal degradation of an image, colorant loss and D-min increase. For both, tests for predicting stability are based on an adaptation of the Arrhenius method described in ISO 18924:2000. The new 18936 method includes the cautions and caveats of using the Arrhenius method including competing chemical reactions, as well as physical reactions such as material phase changes.

ISO 18941:2011 – Imaging materials — Colour reflection prints — Test method for ozone gas fading stability

Published in November 2011, the ozone standard covers the equipment, methods and procedures for generating a known ozone exposure, and the subsequent measurement and quantification of the amount of change produced within a photographic image due to that exposure. The standard covers both hard copy materials for digital printing and traditional analog photographic color print images. With newer technology digital output materials often being more sensitive to atmospheric pollutants than traditional silver halide based technologies, this standard provides the means to test for this environmental factor that here-to-fore was not a major concern. The standard describes known variables in an ozone test setup that can affect the rate at which an image will degrade in the presence of ozone. These include airflow direction and velocity over the sample, the nature of the chemical reaction that is occurring, the relative quantities of the reactants (ozone and colorant molecules) and the humidity content and the pH of the image recording layer. Each of these variables can affect the reciprocal response and needs to be understood for an accurate analysis of the accelerated data. Guidance on equipment design is provided, including ozone generation methods, air impingement, closed loop and open loop systems, as well as cautions regarding the need for thorough air/ozone circulation within the test chamber. Because of these complicating variables, a very important requirement of the standard is that any accelerated testing taking place above 1.0 PPM requires reciprocity testing at a concentration at or below 1.0 PPM.

ISO 18944:2012 – Imaging materials — Reflection colour photographic prints — Test print construction and measurement

Published in April of 2012, this standard specifies requirements and recommendations for the digital test file content, number of print replicates, printer setups and printing procedures that are used to generate target prints for test method standards and specifications for image stability in the context of reflection color photographic prints. This standard specifies constraints on factors pertaining to target print preparation and resulting target print measurement which can cause confounding test and process-induced variation of measured color values and densities. By constraining these factors, subsequent test variability is reduced. One important specification is that the size of each square color patch area to be measured shall be at least 2 mm greater in length and width than the measurement instrument aperture, plus twice the measurement instrument positioning accuracy specification. This helps to reduce measurement variability. The image print stability test requires target prints with selected optical densities in a) neutral patches, b) cyan, magenta, and yellow-colored patches, c) red, green, and blue-colored patches and d) Dmin patch (i.e. paper white) area. In addition, a procedure for selecting the appropriate patches to measure is included.

ISO 18946:2011 – Imaging materials —Reflection colour photographic prints — Method for testing humidity fastness

Published in December of 2011, the humidity standard covers the methods and procedures for testing the humidity fastness of reflection color photographic prints. Low and high humidity exposures are covered and this test method is of particular relevance to dye-based ink-jet prints or dye diffusion process prints. The observed changes relate to color, tone, and loss of sharpness caused by horizontal and vertical diffusion of colorants from exposure to elevated humidity levels. A checkerboard pattern is used that allows assessment of humidity induced blur by means of a relatively simple colorimetric measurement. It has also been observed that low relative humidities can accelerate the yellowing of certain types of inkjet papers. Indoor low humidities are common in colder climates as a result of heating air drawn in from outdoors with very low dew points, and also in hot, dry climates in combination with air conditioning. The standard covers both hard copy materials for digital printing and traditional analog photographic color print images. With newer technology digital output materials often being more sensitive to humidity levels than traditional silver halide based technologies, this standard provides the means to test for this environmental factor that here-to-fore was not a major concern.

This standard stipulates three test methods, Methods A, B, and C. Method A demonstrates the degree of the deterioration (average E of the printed image) quantitatively in a fixed humidity condition, Method B demonstrates the limitations of printing systems and materials by analyzing data from tests at various levels of humidity and Method C demonstrates the propensity of the image receiving layer or underlying substrate to yellow upon exposure to low relative humidities.

Standards Near Publication

18937 – Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability

This Draft International Standard which should publish in 2014 describes test equipment and procedures for measuring the light stability of images of color photographic reflection prints designed for display when subjected to certain illuminants at specified temperatures and relative humidities. Indoor illumination conditions described in this International Standard include: 1) simulated indoor daylight typical home display, 2) simulated direct sunlight in-window display, 3) fluorescent illumination using "cool white", and 4) other types of illumination sources, such as other fluorescent lamps, tungsten halogen, LED, OLED, and metal halide lamps. The standard covers both hard copy materials for digital printing and traditional analog photographic color print images. The method can also be used for black and white print images. Issues such as reciprocity and catalytic fade are discussed. Because of the wide range of intensities that can be used the standard includes an extensive discussion on reciprocity and reciprocity failure issues that potentially can result in serious mis-predictions if not properly accounted for. Specifications for controlling test conditions such as light intensity, spectral power distribution, humidity and temperature are included to help reduce testing variability. Because of radiational heating from the light sources, especially xenon sources used for daylight simulation, temperature control, as well as the absolute temperature of the test samples, has been found to be critically important to minimize confounding of test results.

18947 – Imaging materials — Photographic reflection prints — Determination of abrasion resistance of photographic images

The abrasion standard specifies tests to determine the abrasion, scuff, and smudge resistance of photographic images and is applicable to digital and analog prints including photo books. This method is one of a series relating to image durability. This standard was approved for publication in November of 2012 and we expect it to be published in early 2013.

In contrast to image permanence standards that cover ever-present environmental factors such as light, heat, ozone and humidity, the durability standards cover factors that are not necessarily present in the environment. Although consumers may have less control over the environmental factors in which a print is stored or displayed, they may have more control over durability aspects such as careful handling and good quality storage enclosures. "Accidental" exposures and resulting damage, such as water or food spills on a print, as opposed to always-present environmental factors, can, with care on the part of the consumer, be reduced. Obviously this is not always true and in some cases, such as rubbing caused by turning pages in a photo book or natural disasters caused by flooding, the end user has little control. This International Standard provides standardized requirements to evaluate and quantify the abrasion resistance of photographic images in their various formats such as hard copy prints and photo books and looks at both accidental and repeating factors resulting from handling of the image. Some examples of sources of abrasions include: dirt particles rubbing on printed surface; sheet-to-sheet abrasion (sliding motion of sheets relative to each other); prints sliding on tables or other flat surfaces; interaction with dirt or components inside of printers; and magnets or other items used in the display of images.

Future Standards

18940 – Imaging materials – Reflection colour photographic images – Indoor stability specifications for consumers

The goal of this standard is to provide specifications for making consumer indoor life-expectancy estimates for digitally-printed hardcopy images and traditional analog photographic color print images using test data from the four method standards discussed above. Early drafts of this standard assumed display and storage conditions in typical consumer homes. Display conditions found in museums, offices, commercial, and other non-home environments are excluded from this standard.

The goal of this standard is a very difficult one. The results obtained with any single test method may be useful for comparing the related image stability of different products and systems, but may not match the actual behavior in the long term, real world conditions. Further, the accelerated tests must be conducted under conditions that minimize the image degradation caused by processes not under test (e.g. thermal degradation is performed in the absence of light and ozone). Moreover, no methodology has been devised as yet for calculating the real world results of combined modes of image degradation (e.g. light, heat, humidity and ozone all acting together). Although, to a first approximation, the overall life-expectancy may equal that of the most rapid degrading reaction, it may be either less than or more than that prediction, due to interactions of all image degrading phenomena. The complications increase further when the standard attempts to define specific ambient conditions for light, heat, ozone and humidity in a "typical" consumer home. A prediction based on a single set of assumptions will be invalid if any of the conditions vary from the assumption. Because the conditions in consumer homes around the world vary significantly, it becomes impossible to define exactly what a typical consumer home's conditions are. For these reasons, a proposal to change the goals of the standard to avoid predictions based on years and move towards comparative assessments is being discussed. This would avoid the need for defining ambient conditions and the resulting mis-predictions when consumer homes do not meet those specific conditions. To complicate the work even further, small variations caused by random test noise can be amplified into large prediction errors during extrapolation, especially if the kinetics are non-linear. Needless to say, much time and additional work is needed for completion of this standard.

18948 – Imaging Materials – Photo Books – Test Methods for Permanence and Durability

The photo book standard is in early development stage with the goal of defining a collection of test methods to be used to test the longevity of photo books. Photo books are bound books with printed pages comprised of integrated personal photos, artwork, and possibly text designed by and usually dedicated to a limited group of people. The manufacturing of photo books through "mass customization" differs from traditional book production in that the process must accommodate the production of books where each copy may contain different printed images and a different number of pages, and the number of copies produced are few, perhaps even one.

As the number of digital cameras has increased, photo books have replaced the traditional photo album and scrapbook for many consumers and there is an increasing interest in their inherent longevity and durability. Photo book longevity depends on the image stability of the printed pages and on the durability of the binding. Some books may have good image print stability but lack in binding durability.

The standard test methods being developed assume that the photo book will be stored in typical home environments, which may or may not be climate controlled. For this reason, it includes requirements designed to limit the adverse effects of humidity and temperature that may be outside of typical recommended storage conditions. A key requirement for the successful completion of this effort is to include actual product usage experience from the market to insure that the standard is relevant to the products being delivered by the digital photo industry.

Conclusion

This paper has reviewed recently published method standards used for testing the permanence based on the four environmental factors that impact digital hard copy output materials. These new test method standards represent significant progress. In addition, the separation of method standards from specifications for predictions means that the new standards can be applied more broadly than just generating data for stability assessments. They can be used, for example, to specify image permanence characteristics of materials. Further, they can be used in conjunction with several other standards and be revised independently of these standards. The paper has also highlighted standards that are nearly complete in the standards development process and has briefly mentioned two standards in development and some of the difficulties behind them. Print life estimation, in particular, is a very difficult area and discussion continues on how best to move forward in this area. Clearly the ISO TC42 Working Group 5 has been extremely busy. This is reflected by the fact that this working group has been one of the most active in ISO in terms of standards advanced and published in the last two years

References

[1] D. E. Bugner and C. Suminski, "Filtration and Reciprocity Effects on the Fade Rate of Inkjet Photographic Prints," Proceedings of NIP16: International Conference on Digital Printing Technologies, 90-94 (2000).

[2] D. E. Bugner, D. Kopperl, and P. Artz,"Further Studies on the Apparent Reciprocity Failure Resulting from the Accelerated Fade of Inkjet Photographic Prints," Proceedings of IS&T's 12th International Symposium on Photofinishing Technology, 54-57 (2002).

Author Biographies

Joseph LaBarca is a 15-year member of the ISO Technical Committee on Photography and is directly involved in the ANSI/IT-9 and ISO Working Group 5 Committees on color print stability and physical properties. After retiring from Eastman Kodak Company with over 34 years of continuous service Joe formed JEL Imaging Services in 2010 and Pixel Preservation International in early 2011, to provide consulting services to the imaging industry on image preservation, ISO standards, and image quality. He graduated from Bucknell University in 1976 with a Bachelor's of Science Degree in Chemical Engineering and spent a large part of his career at Kodak in the research, development, and commercialization processes for Kodak Ektacolor papers and processing chemistry. This included extensive involvement in the image stability of color papers beginning in the early 1980s and continuing for the remainder of his career at Kodak. In 1997, Joe was appointed Senior Research Lab Manager, directing a laboratory with systems responsibility for professional color negative films and papers. In 2004 Joe assumed the role of Technical Director, Image Permanence with responsibilities that included silver halide, inkjet, thermal dye transfer, and electrophotographic imaging systems. During this time Joe began extensive research in the use of film and hard copy print as preservation media for digital files and this effort continues today with Pixel Preservation International. Joe has been a member of IS&T for over 25 years and was awarded Senior Membership in 2012. He has also been a member of the American Institute for Conservation since 2008. In mid-2011 he was appointed to the position of Visiting Scholar in the College of Imaging Arts and Sciences at Rochester Institute of Technology.

Dr. Peter Z. Adelstein retired from Eastman Kodak Company and joined IPI as a senior research associate. He is an authority on film base and its deterioration and has published over 80 papers. For the past 25 years, he has been chairman of ANSI and ISO committees dealing with the permanence of imaging media. In 1998, he was awarded the Fuji Gold Medal by the Society of Motion Picture and Television Engineers, and in 1999 he received a Civic Award from the Rochester Chamber of Congress. In 2003, he was given a certificate of recognition by the International Imaging Industry Association for his contributions to international standards.