Designation: F1945 – 05 (Reapproved 2011)

# Standard Practice for Determining the Lightfastness of Ink Jet Prints Exposed to Indoor Fluorescent Lighting[1]

This standard is issued under the fixed designation F1945; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers an accelerated procedure intended to determine the lightfastness of ink jet prints in office environments where overhead fluorescent light is used for illumination.

1.2 This practice describes two methods based on Method II and Method III from D4674, in which specimens are exposed to cool white VHO fluorescent lamps (Method II) and cool white fluorescent lamps (Method III) under controlled environmental conditions.

1.3 Two criteria are used to determine relative lightfastness: color change and optical density.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 8.

1.5 There is no known ISO equivalent standard.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials

D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

D3424 Practice for Evaluating the Relative Lightfastness and Weatherability of Printed Matter

D4674 Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

2.2 *ANSI Standard*[3]:

ANSI/NAPM IT9.9–1990 Stability of Color Photographic Images–Methods for Measuring

IT2.17–1995Annex A1 Density Measurements–Part 4: Geometric Conditions for Reflection Density, Backing Material

## 3. Terminology

3.1 *Definitions:*

3.1.1 The definitions given in Terminology G113 are applicable to this practice.

3.1.2 *ink jet media*—substrates used by ink jet printers to receive inks. The substrate may be paper, plastic, canvas, fabric, or other ink receptive material. The substrate may, or may not be, coated with one or more ink receptive layers.

## 4. Summary of Practice

4.1 Printed ink jet media are exposed to radiant energy from cool white fluorescent lamps. The exposure duration is based on radiant exposure in kJ/m$^2$ monitored either (1) in the UV region between 250 and 400 nm (Method II of Test Method D4674) or (2) in the UV/visible region between 300 and 800 nm (Method III of Test Method D4674). Radiant exposure is the product of irradiance W/m2 and the exposure time, in hours.

4.2 The duration of the exposure may vary widely depending on the lightfastness of the ink/media and whether Method II or Method III from Test Method D4674 was used.

4.3 During the course of the exposure, the color changes and optical densities of the printed samples are periodically evaluated. The color change after each period of exposure is

[1] This practice is under the jurisdiction of ASTM Committee F05 on Business Imaging Products and is the direct responsibility of Subcommittee F05.07 on Ink Jet Imaging Products.

Current edition approved Oct. 1, 2011. Published September 2012. Originally approved in 1998. Last previous edition approved in 2005 as F1945 –05. DOI: 10.1520/F1945-05R11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, 10036.

determined by comparison of the exposed specimens to unexposed specimens, using either visual or instrumental procedures, and reported as color difference, ΔE. The change in optical density is determined instrumentally and reported as percent retained density. Results are compared with changes in a control specimen exposed at the same time.

4.4 Exposures are conducted for a duration agreed upon by all interested parties. Test and control specimens are periodically removed for color measurement and optical density.

## 5. Significance and Use

5.1 Lightfastness of printed ink jet media for specified periods of time is pertinent to the end use of these materials. Since the ability of ink jet prints to withstand color changes is a function of the spectral power distribution of the light source to which it is exposed, it is important that lightfastness be assessed under the conditions appropriate to the end use application. While ink jet prints may be handled and displayed under a variety of conditions, this practice is intended to produce the color changes that may occur in ink jet prints upon exposure to irradiation from office lighting where overhead fluorescent light is used for illumination by simulating these conditions.

5.2 The accelerated procedures covered in this practice are intended to provide a means for the rapid evaluation of the relative lightfastness of a series of prints or of a print of interest in comparison to the performance of controls with known lightfastness exposed simultaneously under laboratory conditions. Test results are useful for specification acceptance between producer and user, for quality control, and for research and product development.

NOTE 1—Refer to Practice G151 for full cautionary guidance applicable to all laboratory weathering devices. Additional information on sources of variability and on strategies for addressing variability by design and data analysis of laboratory accelerated exposure tests is found in Guide G141.

5.3 Variation in results may be expected when operating conditions are varied within the accepted limits of this practice. For example, differences in the level of irradiance using lamps with the same spectral power distribution can cause significant differences in test results. Therefore, no reference to the use of this practice should be made unless accompanied by a report prepared in accordance with Section 12 which specifies whether Test Method D4674 Method II or Method III was used and which describes the specific operating conditions used.

NOTE 2—A comparison of the two listed methods has not been performed. Therefore, the two methods cannot be considered to give equivalent test results unless tests have been carried out to show that the two methods provide the same stability rankings, i.e., the same relative stabilities for different ink jet prints. Also, exposure times for equivalent changes in color and optical densities by the two methods has not been determined.

5.4 Reproducibility of test results between laboratories using the same method (e.g., Method II or Method III of Test Method D4674) has been shown to be good when the stability of materials is evaluated in terms of performance ranking compared to other materials or to a control. Therefore, exposure of a similar material of known performance (a control) at the same time as the test materials is strongly recommended. It is recommended that at least three replicates of each material be exposed to allow for statistical evaluation of results.

5.5 Color changes may not be a linear function of duration of exposure. The preferred method of determining lightfastness is to expose the prints for a number of intervals and to assess the exposure duration required to obtain a specific color change.

## 6. Interferences

6.1 It is recognized that the rate of photo degradation of ink jet prints will vary significantly due to factors such as initial color density, the area printed (solid versus half-tone), the substrate, the ink type (dye versus pigment inks), and the coating type and thickness. Consequently, test results must be determined individually for each printed ink jet media.

6.2 Variations in exposure time, temperature and humidity may also affect results.

## 7. Apparatus

7.1 Use Fluorescent UV test apparatus that conform to the requirements specified in either Method II of Test Method D4674 or in Method III of Test Method D4674.

7.1.1 For Method III of Test Method D4674, use a test apparatus that complies with Practice G154.

7.2 The spectral distribution of the cool white lamps shall comply with the requirements given in Annex A2 of Test Method D4674.

7.3 *Instrument Calibration*—To ensure standardization and accuracy, the instruments associated with the exposure apparatus (for example, timers, thermometers, humidity sensors, UV sensors, and radiometers) require periodic calibration to ensure repeatability of test results. Whenever possible, calibration shall be traceable to national or international standards. Calibration schedule and procedure should be in accordance with manufacturer's instructions.

## 8. Safety Precautions

8.1 Follow the safety instructions in accordance with the manufacturer's instructions and also described in Test Method D4674, Section 7, Hazards.

## 9. Test Specimen

9.1 The substrate, method of printing, ink, ink laydown, and handling of printed specimens shall be consistent with the anticipated end use of the specimens.

9.2 The test image may be generated with personal computer word processing, drawing/graphics, or page layout software, saved as a print file for each printer/method of printing (contributing its unique ink and ink/receiver interactions that may impact on the image light stability), trial-printed, and evaluated for appropriate ink laydown (purity and amount) and ease of printing and testing. Each print file should have its filename, type, and version identified in the image area and a place for experimental notes (for example, time, printer, environmental conditions, operator). The printer settings and a trial print of each print file version should be archived.

9.3 The recommended test image shall consist of a standardized arrangement of color patches printed using print files containing the appropriate printer setup specific for each application. This test image shall contain color patches at maximum print density (100 % fill) for each of the primary colors (cyan, magenta, yellow, and black), secondary colors (red, green, blue), and composite black (cyan plus magenta yellow). In addition, since lightfastness may vary as a function of print density, low optical density patches are recommended to test the lightfastness of binary images of discrete ink spots. A step wedge containing patches with a range of optical densities (for example 25 %, 50 %, 75 %, and 100 % fill) may be useful for this test.

9.4 For visual examination, the specimen size as indicated in Practice D1729 is a minimum of 3 ½ by 6 ½ in. (90 by 165 mm). For instrumental evaluation, the specimen must be large enough to cover the specimen port; a minimum size of 1.25 in. × 1.25 in. (35 mm × 35 mm) is satisfactory for many instruments.

9.5 For comparison of the exposed specimens with unexposed specimens, prepare and/or measure the latter in the following manner:

9.5.1 For visually evaluated tests, set aside a replicate print or cut off a segment of suitable size; store in a dark, dry place.

9.5.2 For instrumentally evaluated tests, make color measurements on the relevant specimen area(s) prior to exposure.

NOTE 3—The unexposed file specimen should not be a masked specimen. Even though shielded from radiation, some materials may undergo color changes, due to the heat or moisture present during the test.

9.6 Test prints on opaque substrates do not require backing material and shall be tested in accordance with their intended use. Transparencies shall be backed with a white backing material. Translucent substrates shall be backed with a diffuse black backing material with an image density of 1.5 ± 0.2 as described in ANSI IT2.17–1995 Annex A1.

## 10. Conditioning

10.1 It is recommended that samples be conditioned at 25°C and 45 % RH for at least 24 h prior to testing. Specimens should be visually inspected for color uniformity and surface irregularities, which could adversely affect color measurement.

## 11. Procedure

11.1 Perform the test in accordance with Test Method D4674, Method II or Method III.

11.2 *Test Method D4674 Method II.*

11.2.1 Locate the apparatus in an area maintained between 18°C and 27°C. Maintain chamber air temperature between 30°C and 40°C. If the chamber air temperature exceeds 40°C, the device must be shut off and the cause for the high temperature corrected before exposures can continue.

11.2.2 Operate the device for at least 20 minutes, then record the UV irradiance, ($CW_{E(UV)}$) in W/m$^2$, 250-400 nm). Calculate the exposure time ($CW_t$) necessary for the desired cool white UV radiant exposure as described in section 11.5.

11.3 *Test Method D4674, Method III*

11.3.1 Operate the equipment to maintain an uninsulated Black Panel temperature of 50°C.

11.3.2 In devices that automatically control irradiance, set the irradiance level for the cool white fluorescent lamps to 44 W/m $^2$ at 300-800 nm (15 klux). Calculate the exposure time ($CW_t$) necessary for the desired cool white UV/visible radiant exposure as described in section 11.5. For example, for CWE = 44 W/m$^2$ at 300-800 nm and $CW_H$ = 158 × 106 J/m$^2$ at 300-800 nm, the time in hours is 1000 (158 × 106/44 × 3600).

11.3.3 In devices that do not automatically control irradiance, measure irradiance before and after exposure and use the average irradiance.

NOTE 4—Information developed by Committee G03 on allowed operational fluctuations of the set points and guidance for measuring uniformity conditions in the test chamber is published in Practice G151 Annexes.

NOTE 5—Since these tests are timed by radiant exposure, the above formulas specified in section 11.5 for determining exposure time assumes that reciprocity, i.e., the color change for the same radiant exposure at different irradiance levels, applies to all ink jet prints tested.

11.4 *Specimen Repositioning*—Periodic repositioning of the specimens during exposure is not necessary if the irradiance at the positions farthest from the center of the specimen area is at least 90 % of that measured at the center of the exposure area. Irradiance uniformity shall be determined in accordance with Practice G151

11.5 *Duration of Exposure*—Conduct exposures for the radiant exposure a total duration agreed upon by contracting parties based on UV radiant exposure for Test Method D4674 Method II and UV/visible radiant exposure for Test Method D4674 Method III. The exposure time ($CW_t$) is determined as follows:

$$CW_t = CW_H/CW_E$$

where:

$CW_t$ = exposure time in seconds (hours × 3600)
$CW_H$ = radiant exposure in J/m$^2$
$CW_E$ = irradiance in W/m$^2$.

11.6 Periodically remove test and control specimens for color measurement and optical density tests.

## 12. Evaluation

12.1 Evaluate the exposed specimens for changes in color either visually or instrumentally in accordance with Practice D1729 and Test Methods D3424, Section 11. For instrumental evaluations, using the CIE 1976 L* a* b* equation described in Test Method D2244, calculate ΔL*, Δa*, Δb*, and $\Delta E^*_{ab}$ between each exposed specimen and its unexposed counterpart.

12.2 Evaluate the exposed specimens for changes in optical density measured per ANSI/NAPM IT9.9–1996, paragraphs 3.3 – 3.6. Percent retained density shall be calculated as follows:

$$\%\ Retained\ Optical\ Density = \frac{Optical\ Density\ After\ Exposure}{Optical\ Density\ Before\ Exposure} \times 100$$

where:

## 13. Report

13.1 The report shall include the following:

13.1.1 Specimen identification, including the method of printing, print area (% fill), and substrate.

13.1.2 Exposure method used (Methods II or III of Test Method D4674 as specified in sections 11.2 or 11.3, respectively.

13.1.3 Total accumulated radiant dosage and wavelength in which it was measured (e.g., 250–400 nm or 300–800 nm).

13.1.4 Total exposure time, h.

13.1.4.1 Results from the visual or instrumental evaluation of color change.

13.1.4.2 Percent retained optical density.r

NOTE 6—If instrumental color measurements are used, the type of equipment, the method and the color-difference equation used must be stated.