Image Permanence of Fujifilm Original Photopaper

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Abstract

In general it is known that over time, the density, colour balance and whites of prints are gradually changing by degradation. The rate of deterioration is depending on the different technologies used for printing, paper quality, type of illumination and the different types of protection (such as framed under glass, UV filtered glass, acrylic, polycarbonate or totally uncovered).

End-consumer don't know "how long will your photo prints last".

The indoor light display permanence test results including the test method will be explained of silver halide technology prints as original photopaper.

Original Photopaper technology

FUJIFILM Original Photopaper consists out of the silver halide emulsion technology. The emulsion is embedded in gelatin which gives the unique benefits. This gelatin protects the paper against image degradation by pollutants (such as Ozone), prevents bleeding and gives physically overall durability. After exposing the silver halide crystals on the photographic paper a latent image is created by an RGB exposing system. Then paper is chemically processed by developer and bleach/fix to get the image on the paper.

Original Photopaper delivers superb print quality (brilliant whites, deep blacks, pleasant dynamic range, wide colour range, image sharpness and continuous tone) and long lasting images to maximize the enjoyment and longevity of an image. The prints quality is superb by the natural gloss and feeling (haptics).

Evaluation method of image stability

Print life is in general calculated from tests on accelerated exposure to light, ozone or high temperature and humidity.

It is important to define the end point criteria for the evaluation of image stability when accelerated tests are carried out. There is no standard for the end point criteria and therefore several end point criteria sets are used.

Light stability is judged by the fading of printed images under illumination for their display [1]. Dark stability is judged by the image fading caused by heat and humidity in case of their storage in an album.

Besides light and dark print stability, it is necessary to evaluate fading of images caused by gases as ozone based on the change of living circumstances (air-tight), thermal and humidity fastness.

Image Permanence Testing

Light stability

In order to simulate the light stability of a print, which is displayed indoors under the illumination of indirect sunlight, a Xenon arc lamp with an appropriate UV-cut filter should be used as light source, since it is similar in luminous spectrum to sunlight which has passed through window glass [1].

Another common method is illumination by cool white fluorescent (CWF) lamps. The CWF lamps do not provide a spectral match to indoor indirect daylight through window glass [2]. Therefore, Xe arc is selected for testing for light stability under indoor light.

The spectrum of Xe and CWF light are shown in Figure 1, Comparing to indoor indirect sunlight.

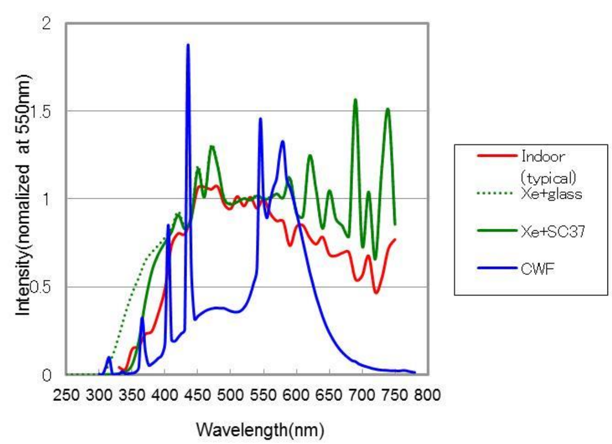

Figure 1: Comparison of the spectrum of Xe, CWF and typical indoor indirect sun light.

The test method stipulated in clause 7.2 of ISO 18937; 2014 was applied. The test condition involved a Xe Arc lamp light source (intensity 79.000 lux); The SC37 UV filter was used as standard but also prints displayed under glass and without protection were tested.

The test target includes Grey (0.5, 1.0 and 1.5 density) CMY (0.5, 1.0 and 1.5 density), RGB (0.5, 1.0 and 1.5 density) and white.

The optical densities and chromaticities of the samples were measured before and after exposure of different amounts of light. The values of the density changes and colour differences (ΔE_{76}) were calculated for each set of fresh and faded samples.

The ΔE approach is important for evaluating the image permanence of photographic prints. It is particularly valuable for evaluating print lives based on human perception, while

density approach is valuable for the research and development of photographic prints and their components [3].
The faded and initial images were placed next to each other for each material type for visual judgement of prints.

In this report, those 3 types of evaluation methods are included.

Criteria for estimation of end point

It is important to define the criteria for its end point to predict the lifetime of printed images the results of accelerated tests. There is no standard for calculating end point, therefor several methods are used: (1) end point criteria based on density measurements (2) end point criteria based on chromaticity measurements (3) end points based on visual judgement.

For density measurements, the end-point was considered to be the point which one patch on the test target print met the criteria. Criteria (1): density loss 40% on monocolor or grey density or colour balance change of 20% on grey. For stain (Dmin) ΔE_{76}=10 was used as end point. Criteria (2): Wilhelm Imaging Research classification set v3.0.

For the chromaticity measurements, the average of the ΔE values of all the analysed patches was used. It should be noted that average ΔE_{76}=10 can be effectively used as endpoint for evaluating the image permanence of photographic prints. Furthermore, ΔE_{76}=20 for one individual patch was also calculated as end point.

The faded images are compared to their corresponding initial images and quality (colour, density and whiteness) was judged by consumers and end point was determined. The judgement was done on noticeable fade (color balance, fade and stain).

Calculation for print lifetime

The estimation of print lifetime in years is depending on the end point criteria and the indoor light level. The estimation of print lifetime was done for 3 use cases: (1) Museum (2) Consumer Home (3) Office.

250 lux for 12 hours is used as light level of consumer homes in daytime, based on consumer homes surveyed by Kodak [4] and Fujifilm survey. 100 lux for 12 hours per day is used as light level of museum and 450 lux for 12 hours per day is used as light level of offices.

Results of fading by indoor light

The results of the indoor light fading test are shown in tables 1 - 4 for the calculated end point criteria based on respectively density measurements (table 1 and 2), chromaticity measurements (table 3) and visual judgement (table 4).

Table 1: Light stability represented by end point (40% density loss or 20% color balance) in Mlux.hours of images under illumination of Xe arc lamps and UV filters

	End point (Mlux.hours) Density	Failure mode
Fujifilm Professional Paper	57	40% color loss Y
Manufacturer A Professional Paper	44	20% color balance C/M
Fujifilm Color Paper (CA)	47	40% color loss Y
Manufacturer A Paper	23	20% color balance Y/M
Manufacturer B Paper	18	20% color balance C/M

Table 2: Light stability represented by end point (WIR Endpoint Criteria set v3.0) in Mlux.hours of images under illumination of Xe arc lamps and UV filters

	End point (Mlux.hours) Density	Failure mode
Fujifilm Professional Paper	44	25% color loss M
Manufacturer A Professional Paper	28	15% color balance C/M
Fujifilm Color Paper (CA)	40	25% color loss M
Manufacturer A Paper	22	15% color balance C/M
Manufacturer B Paper	15	25% color loss M

Table 3: Light stability represented by end point (ΔE_{76}=10) in Mlux.hours of images under illumination of Xe arc lamps and UV filters

	End point (Mlux.hours) ΔE_{76}=10 for as averaged value on 22 patches	End point (Mlux.hours) ΔE_{76}=20 for one patch
Fujifilm Professional Paper	43	52
Manufacturer A Professional Paper	33	45
Fujifilm Color Paper (CA)	36	47
Manufacturer A Paper	19	31
Manufacturer B Paper	12	12

Table 4: Light stability represented by end point (visual judgement) in Mlux.hours of images under illumination of Xe arc lamps and UV filters

	End point (Mlux.hours) Visual Judgement
Fujifilm Professional Paper	66
Manufacturer A Professional Paper	44
Fujifilm Color Paper (CA)	44
Manufacturer A Paper	20
Manufacturer B Paper	20

The visual judgement is based on the visuals as shown in the graphs with the comparison of image fading versus the original print (0 Mlux.hours).

We believe that delta E approach is the best from the extensive study shown in reference [3].

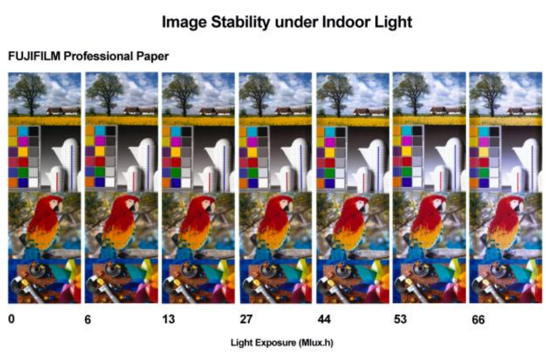

Figure 2: visuals FUJIFILM Professional Paper

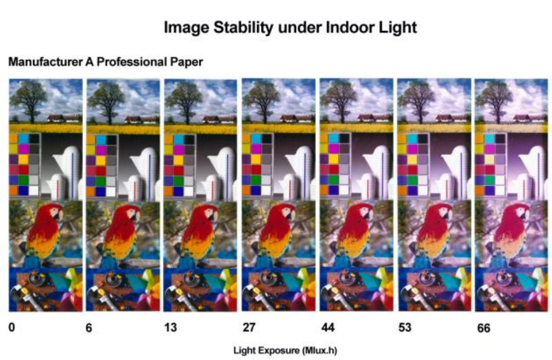

Figure 3: visuals Manufacturer A Professional Paper

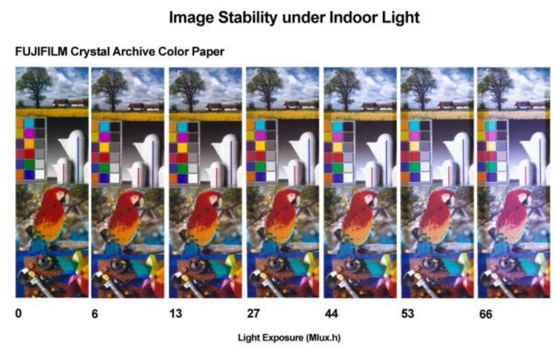

Figure 4: visuals FUJIFILM Crystal Archive Color Paper

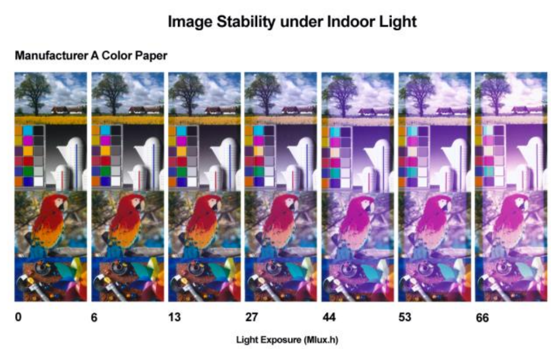

Figure 5: visuals Manufacturer A Color Paper

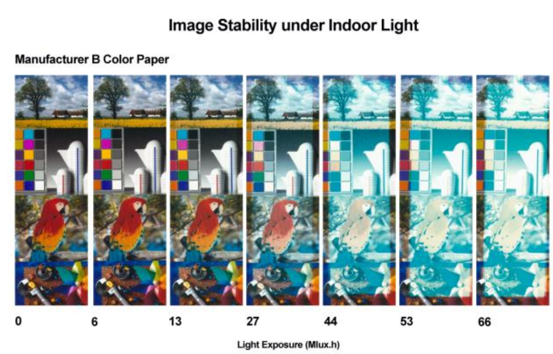

Figure 6: Visuals manufacturer B Color Paper

The Fujifilm professional paper is most stable for indoor light among the silver halide technology prints. Main reason is that Cyan and Magenta are fading with same extend (Figure 7).

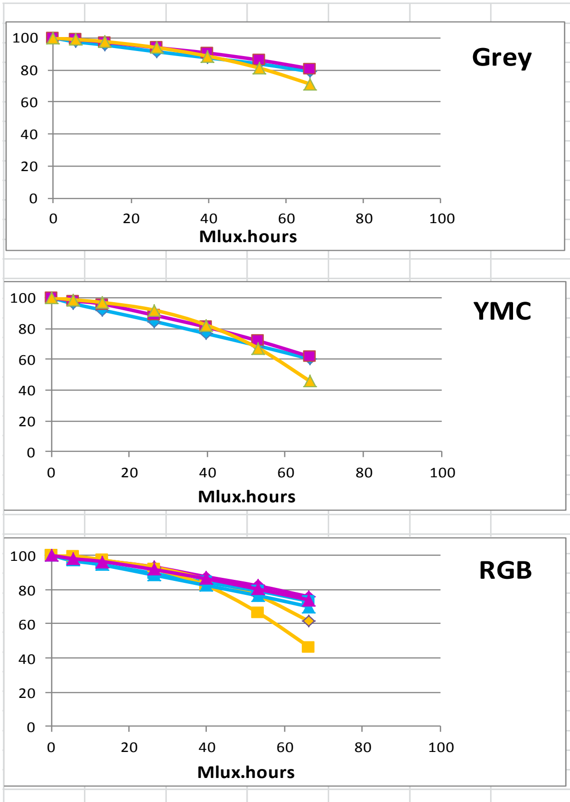

Figure 7: Image Fading (density measurements) for initial density 1.0

Print protection will have a major impact on the indoor light stability results. In Table 5 and 6, the results for end point are indicated.

Table 5: end point (Mlux.h) comparison between the protection of print and Color Paper types

	Fujifilm (CA) print	Manufacturer A print	Fuji/Man A ratio
Bare-bulb	30	9.3	3.2
Window glass	43	19	2.3
UV filtered	47	23	2.0

Table 6: end point (Mlux.h) comparison between the protection of print and Professional Paper types

Print protection	Fujifilm Professional print	Manufacturer A Professional print	Fuji/Man A ratio
Bare-bulb	27	20	1.4
Window glass	45	33	1.4
UV filtered	57	44	1.3

The relative difference in print lifetime between Fujifilm and other manufacturers of silverhalide photopaper prints is not depending on the protection of print by window glass or UV-filtered glass.

Results of life time of print

The so called print life time is depending on the illumination intensity and time of illumination. This is linked to the use-case, such as museum, consumer home or offices.

Table 7: examples of irradiation intensity of several use cases.

Use case	Light level (lux)	Illumination (Mlux.hours/year)
Museum	100 lux	0.438
Consumer home	250 lux	1.095
Office	450 lux	1.971

However, this kind of assumption can mislead the customers, because the light level varies widely even in the each use cases, for example, light level of consumer home varies from less than 10 lux to over 1000 lux. In addition, the ambient temperature and humidity also varies widely. More complicated issue is the reciprocity failure. i.e. the duration of life time is not always proportional to the duration measured with acceleration test.

Table 8: print life time in years for several use cases and based on 12 hours illumination per day.

	Museum	Consumer home	Office
Fujifilm Professional Paper	130	52	29
Manufacturer A Professional Paper	100	40	22
Fujifilm Color Paper (CA)	107	43	24
Manufacturer A Paper	53	21	12
Manufacturer B Paper	41	16	9

Note: the print life time figures in the table 8 are based on irradiation intensity of several use cases (table 7). Those figures are based on average illumination intensity measurements, but each individual use case might differ from the table 8 figures. Estimated print life can vary widely depending on the criteria.

The Fujifilm professional paper is best in class under indoor light conditions among the current silverhalide technology photopapers.

Results of dark stability

The Arrhenius method is well-known to predict the lifetime of a print kept in the dark (such as prints in a shoe box and prints inside a photobook) as a measure for its dark stability.

The test was carried out at 50°C, 62°C, 73°C and 85°C under 50% RH. Calculations were done using chromaticity measurements.

The test results showed that print lifetime as dark permanence exceeds 200 years.

Thermal, Humidity and Gas fastness

The Fujfilm original photopaper prints are robust related to image degradation under gas (such as ozone), thermal conditions and humidity conditions.

The gelatin in silverhalide technology prints protects the paper against image degradation by pollutants (such as Ozone).

Prints made by the inkjet technology can result in relative rapid image degradation by ozone gas [1)].

Conclusions

The tests for image permanence should be based on the light and ambient conditions of the prints. Concerning the spectrum, Xe filtered with SC 37 matches well to indoor indirect sunlight.

Under these appropriate test conditions, The Fujifilm professional paper is best in class under indoor light conditions among the current silverhalide technology photopapers.

References

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4) D. Bugner, J. LaBarca, J. Phillips, T. Kaltenback: a survey of environmental conditions relating to the storage & display of photographs in consumer homes, JIST 50(4), 309-319 (2006)