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DIGITAL COLOR LABORATORY

Xerox iGen4 Photographic Image Print Quality— One of the Best options available today

Digital presses have come a long way in the two years since we last had an opportunity to evaluate their Photographic Image Print Quality. Print quality has improved still further, making it more difficult to narrow down and pick the best. Out of the several high quality options available in the market today, **the 4-color Xerox iGen4 Photographic Image Print Quality emerged as overall best of the digital presses**, barely edging out our previous best, the 6-color HP Indigo Press 5500.

Using the knowledge of consumer photo preferences gained from well over 1600 participants in two dozen focus group events in three continents over the last six years, _SpencerLab_ emulated those collective consumer preferences in judging these prints. Improving still further on methodology used in prior studies, we tested all representative printing devices and conventional photo processing at two different vendor-recommended commercial or in-house sites, each recently calibrated with well-trained operators.

The first step in our comparative analysis was to compare the print sets from each machine type, and to discard the lesser quality set. Then _SpencerLab_ had the very difficult task of comparing these representative print sets, side-by-side. Applying consumer preferences, we evaluated seven different consumer attributes and determined an overall weighted average. All of the digital press photo output that we evaluated–perhaps the best each system could produce–would be acceptable to consumers in the current photo book market.
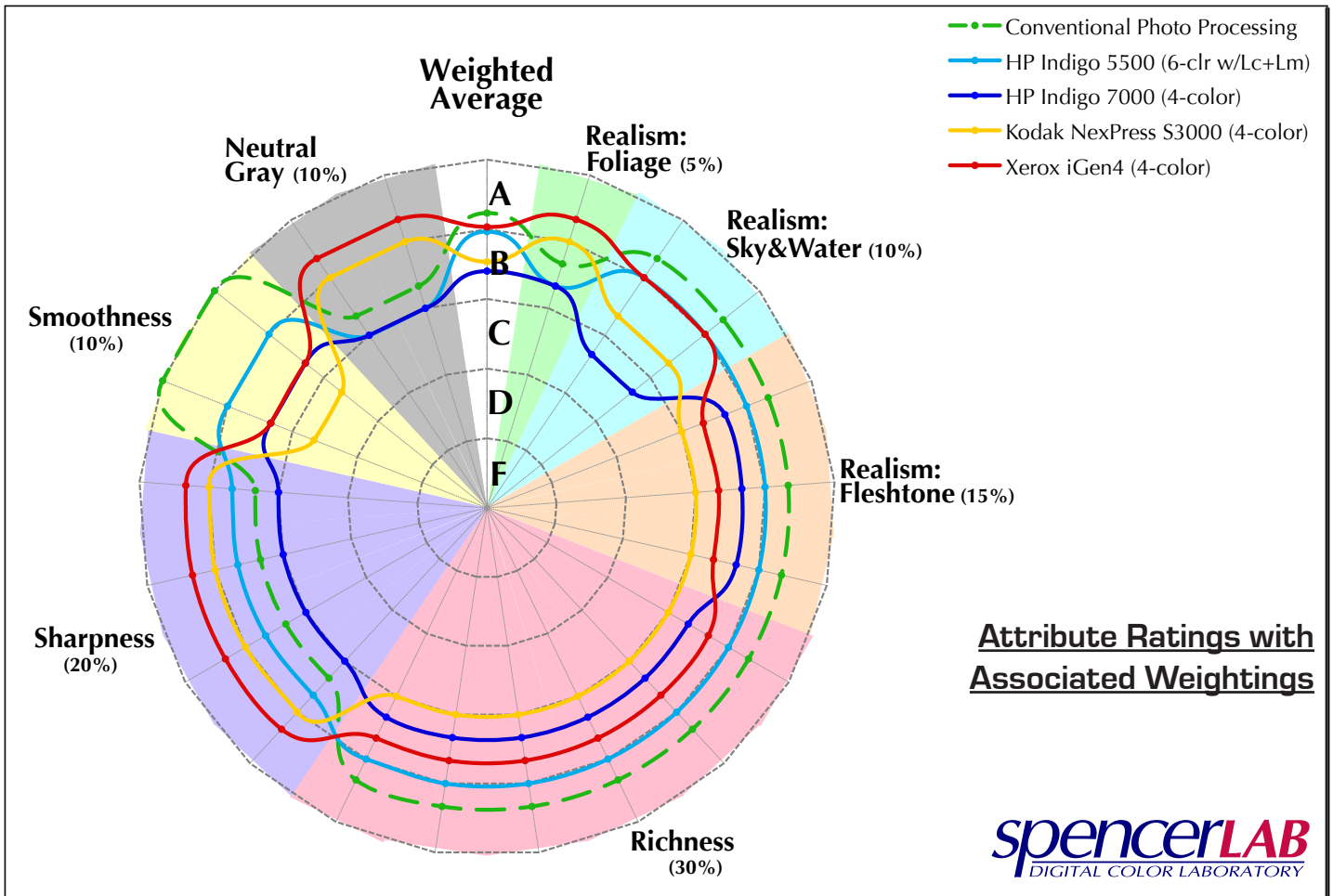
EXECUTIVE SUMMARY

The _SpencerLab_ Digital Color Laboratory was commissioned by Xerox Corporation to perform an independent Comparative Photographic Image Print Quality Analysis of print output from several digital presses and conventional photo processing.

As noted above, photographic image print quality of the 4-color Xerox iGen4 emerged as overall best of the digital presses, barely edging out the 6-color HP Indigo Press 5500, although the two machines' output differed in individual attributes. Conventional photo processing (silver halide, or AgX) reestablished its reputation via the Fujifilm Frontier 570 as the benchmark to beat, but not in all rated attributes.

In order to accurately study the differences among such high-quality printing devices, methodology must be extremely well thought out and carefully executed. For this project we contacted all of the manufacturers and they each identified

a pair of high-level commercial or in-house sites that they believed would provide the best representative output for this study. Compatible vendor-approved media–one Matte and one Glossy–were selected and supplied to all vendors for printing. Using our _SpencerLab_ Printer Test Suite experience, over four dozen test images were carefully selected to represent a comprehensive set for photo print quality evaluation, incorporated in 12x18" test files and printed at each site under _SpencerLab_ on-site supervision. We then selected the higher quality of these output sets from each device type for the comparative analysis.

A comparative Photographic Image Print Quality analysis was performed by a team of experienced _SpencerLab_ staff, applying consumer photo preferences and relative emphasis on the attributes of color Realism (Foliage, Sky & Water, and Fleshtones), Richness, Sharpness, Smoothness, and Neutral Grays. Our detailed analyses focussed on the modest differences among the range of test prints.

Weighted Average

Attribute Ratings with Associated Weightings

Legend:
- Conventional Photo Processing
- HP Indigo 5500 (6-clr w/Lc+Lm)
- HP Indigo 7000 (4-color)
- Kodak NexPress S3000 (4-color)
- Xerox iGen4 (4-color)

Axis labels: Neutral Gray (10%), Realism: Foliage (5%), Realism: Sky&Water (10%), Realism: Fleshtone (15%), Richness (30%), Sharpness (20%), Smoothness (10%)

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KEY FINDINGS

Our summary finding is that *the Xerox iGen4 offered the overall best photographic image quality among the tested digital press solutions for photo book applications, and is a competitive option to conventional photo processing.*

The overall best digital press printing performance of the Xerox iGen4 was highlighted by very impressive Sharpness and Neutral Gray rendition, and exceptional Realism of both Foliage and Sky & Water colors. Richness was good, while some opportunity for improvement was noted in Smoothness and Realism of Fleshtones.

Compared to the very high quality standard set by conventional photo processing among currently available options for consumer photo book production, the iGen4 provides competitive overall output quality at a significantly lower price.

When all of these digital presses are serviced and operated properly, their image print quality was fully acceptable for photo book use. Lack of operator training and non-optimized RIP/workflow can significantly deteriorate the actual print quality achieved by any device.

METHODOLOGY

We spent considerable time and effort to design and implement a research methodology that would provide consumer-representative print quality results, while being equitable to each of the competitive devices from which the output was evaluated.

• In order to minimize the possibility of using non-representative output for analysis, the manufacturers were contacted and each recommended two sites that they believed would provide photo book quality prints representative of the respective devices.

• We prepared a suite of test files (shown on the following page) representing a broad range of consumer photographs, augmented by test files from the *SpencerLab* Printer Test Suite, which has been used extensively by many major printer manufacturers under license as well as in our own testing. The test file layout was designed to emulate a typical photo book application. Both sRGB and AdobeRGB images in at least 300 dpi resolution JPEG and TIFF formats were composed into 12x18" test files and provided in PDF format for digital presses and

A Range of Consumer Photographs augmented by *SpencerLab* Printer Test Suite files

as sRGB TIFF for conventional AgX. While AgX prints rendered full bleed 12x18" images on the 12x18" sheet size, the digital presses had varying sized non-printing margins. iGen4 and NexPress S3000 had minor clipping; Indigo 5500 and 7000 prints had the most clipping of the 12x18" image area.

• Test files were printed at two sites for each of the digital press devices: Xerox iGen4 (4-color), HP Indigo Press 5500 (6-color, with Light Cyan and Light Magenta), HP Indigo 7000 Digital Press (4-color), Kodak NexPress S3000 Digital Production Color Press (4-color), and Fujifilm Frontier 570 conventional photo processing (AgX) printers. One of the AgX and one of the iGen4 sites were in-house. All the print runs were supervised on-site by *SpencerLab* personnel.

• HP Indigo Press 5500 prints were made with Light Cyan and Light Magenta as 5th and 6th colors. Xerox iGen4 and NexPress S3000 presses were 4-color only. The Indigo 7000 Digital Press was used in 4-color mode–commercial printers indicated they would only use 6-color HP IndiChrome mode (Orange and Violet as 5th and 6th colors) to provide extended gamut for color matching of PMS colors, and not for photo book applications. Conventional photo processing is a 3-color additive process.

• The prints used for analysis from Xerox iGen4 were printed using Xerox FreeFlow Print Server version 7; HP Indigo Press 5500 using Indigo Press version 7.4.1 DFE; HP Indigo 7000 Digital Press using HP Ultra

Print Server 3.0.0800807A; NexPress S3000 using NXP2163VC DFE; Fujifilm Frontier 570 using latest software version MS012.S5.

• Digital press prints were imaged on vendor-approved matte and glossy media–NewPage Futura Laser Matte 80# Text and SMART Papers Kromekote True-Photo Cast Coat C1S 10pt. AgX was imaged on Fujicolor Crystal Archive Paper, Super Type C, Matte and Glossy.

• All vendors were asked to have their machines running at optimal performance, by having the machine serviced or preventative maintenance conducted by well-trained operators prior to test print runs. In order to obtain consumer representative test prints, vendors were also asked to use the same workflow and system settings in printing of the test files that they would typically use in printing of photo book jobs. For each device, print sets from the two sites were compared and the higher quality set was selected for formal evaluation.

• Attribute analysis was performed for respective Matte and Glossy competitive sets, by an experienced team of *SpencerLab* staff under a controlled viewing environment with 5000°K illumination. Analysis was segmented into seven attributes: Realism: Foliage, Sky & Water, Flesh-tones, and Richness, Sharpness, Smoothness and Neutral Gray. Each attribute was comparatively rated, using an A-B-C-D-F grading scale with + and - options. A+ corresponded to 'exceptional' quality, C- to 'just acceptable' consumer quality, D to 'needs improvement', and F as 'unacceptable'.

• Results were summarized in an overall Weighted Average of these attributes, derived from our experience conducting worldwide consumer focus group activities. This emulates consumer photo preferences with relative emphasis on the areas of color Realism (Foliage, Sky & Water, and Fleshtones), Richness, Sharpness, Smoothness, and Neutral Gray. A computed weighted average was plotted and converted to its closest corresponding letter grade.

DETAILED FINDINGS

In the following discussion of detailed findings, print quality is discussed by attribute–in order of decreasing quality for each. Unless otherwise noted, comparative results for both Matte and Glossy media were similar.

REALISM

Realism includes true-to-life reproduction of memory colors – those with which users are heuristically familiar without requiring an original for comparison. Most common memory colors, such as green grass, trees & foliage, blue skies & water, various flesh tones, etc., test printers' color rendering ability. Some color issues, such as rendering purple skies, yellow or red fleshtones, blue or yellow greens, would produce unrealistic output. A fine balance needs to be maintained between Realism and Richness, as images that are too rich and dark can overpower Realism. Realism was evaluated and rated in the separate categories of Foliage, Sky & Water, and Fleshtones.

Color Realism: Foliage

• Xerox iGen4: The color of green grass, trees, and shrubbery images were found to be most realistic on the iGen4 prints. iGen4 Foliage images on both media types were well saturated and exhibited good color balance, not too blue or too yellow. A slight hue shift was noted in the shadows. Matte & Glossy Ratings: A-

• Kodak NexPress S3000: Prints from the S3000 exhibited good color Realism on Foliage images, although they appeared slightly washed out and lacked saturation when compared to the iGen4 prints. Matte & Glossy Ratings: B+

• AgX: Foliage color Realism of conventional AgX prints was good; however, greens were rendered with a slight yellow color cast. Matte & Glossy Ratings: B

• HP Indigo 7000: Foliage images of the 7000 were rendered relatively lighter than other competitive output and appeared flat. Prints also exhibited a yellow cast. Matte & Glossy Ratings: B-
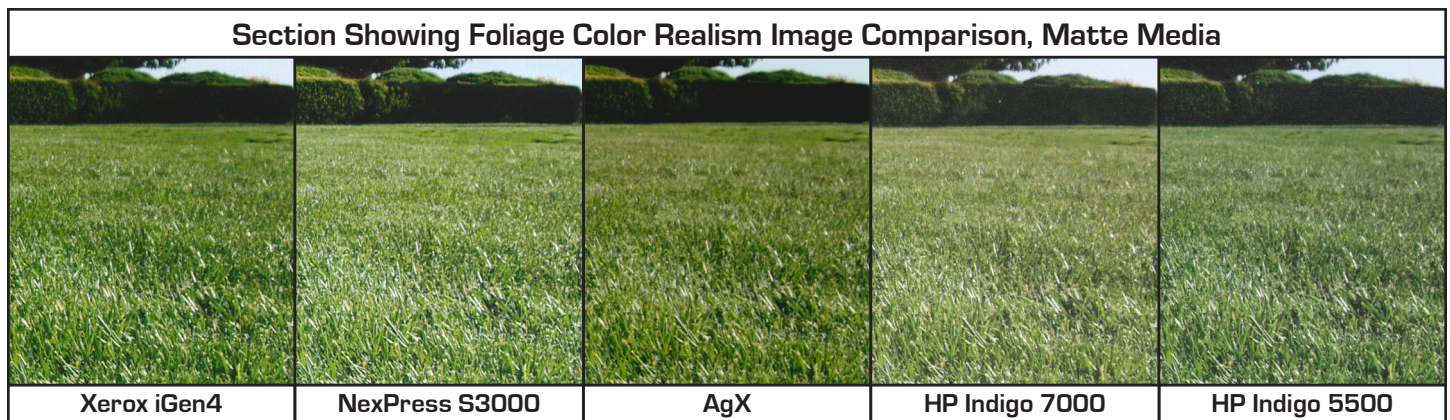
• HP Indigo 5500: Foliage images of the 5500 were shifted towards blue and appeared overall dark and comparatively unrealistic. Matte & Glossy Ratings: B-

Color Realism: Sky & Water

• AgX: Conventional AgX prints had the most realistic Sky & Water image color reproduction. Overall, Sky & Water images looked very true-to-life, however a slight yellow-green shift was noticeable on both media types. Matte & Glossy Ratings: A-

• Xerox iGen4: Prints from the iGen4 were comparatively the closest overall visual match to the Realism of the conventional AgX Sky & Water images. Some sky images were shifted towards purple, however, overall Realism was good on both media types. Matte & Glossy Ratings: B+

• HP Indigo 5500: Although blues from the 5500 were rendered noticeably darker than competitive prints, the saturation did not overpower Sky & Water color Realism, and produced images that were pleasingly realistic. A tendency toward purple was noticeable on both media types. Matte & Glossy Ratings: B+

Section Showing Foliage Color Realism Image Comparison, Matte Media

| Xerox iGen4 | NexPress S3000 | AgX | HP Indigo 7000 | HP Indigo 5500 |

Section Showing Sky Color Realism Image Comparison, Glossy Media

| AgX | Xerox iGen4 | HP Indigo 5500 | NexPress S3000 | HP Indigo 7000 |

• Kodak NexPress S3000: Prints from the S3000 were rendered comparatively lighter. On Matte media, blue Sky & Water images were rendered with a purple/magenta cast. On Glossy media, Sky & Water images appeared too blue and light (excess cyan) to be judged realistic. (The difference between the two media type grades did not change the S3000's overall Weighted Average relative ranking.) Matte Rating: B-; Glossy Rating: B

• HP Indigo 7000: The 7000 prints were rated the lowest for Sky & Water color Realism, as the images were rendered too purple and exhibited a noticeable magenta color cast. Midtones were rendered flat, making images appear comparatively dull. Matte & Glossy Ratings: C
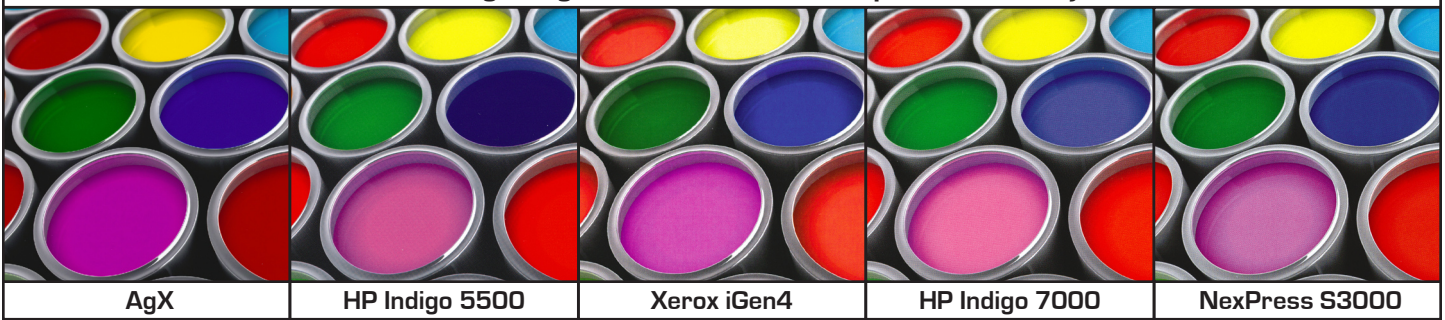
Color Realism: Fleshtones

• AgX: The conventional AgX prints had excellent color balance with extremely realistic Fleshtone color reproduction, although they exhibited a slightly warmer (reddish) tone. AgX Fleshtone images were very true-to-life, and overall had the most pleasing appearance. Matte & Glossy Ratings: A-

• HP Indigo 5500: The Fleshtone images of the 5500 were the closest visual match to the AgX prints, appearing quite pleasing and realistic; however, they had a slightly warmer tone. Matte & Glossy Ratings: B+

• HP Indigo 7000: Realism of Fleshtone images was average for the group. Images were rendered comparatively lighter than the competitive prints, and Fleshtones looked pale when compared to the 5500 output. Midtones were rendered slightly flat. Matte & Glossy Ratings: B

• Xerox iGen4: Fleshtone images were rendered with a yellowish color cast that detracted from overall Fleshtone color Realism, resulting in the prints being judged comparatively less realistic. Matte & Glossy Ratings: B-

• NexPress S3000: As noticed on the iGen4 prints, S3000 Fleshtone images had a yellow color cast. On both media types, Fleshtone images were rendered relatively light and appeared somewhat washed out and pallid. Distracting contouring on some images was also noticeable. Matte & Glossy Ratings: C+

Section Showing Fleshtone Color Realism Image Comparison, Glossy Media

| AgX | HP Indigo 5500 | HP Indigo 7000 | Xerox iGen4 | NexPress S3000 |
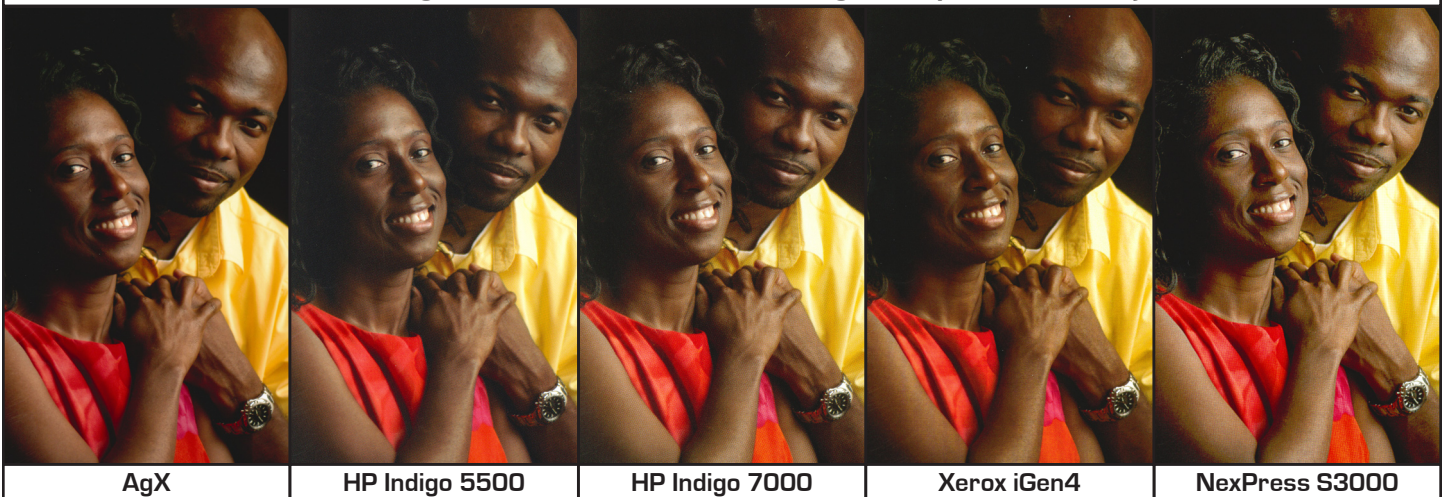
Section Showing Image Color Richness Comparison, Glossy Media				
AgX	HP Indigo 5500	Xerox iGen4	HP Indigo 7000	NexPress S3000

RICHNESS

Richness is a combination of saturation, darkness, vividness and image contrast. In order to appear rich, an image needs to possess good saturation with just the right darkness without appearing dull or muted, while exhibiting a vibrance of colors and image contrast, without appearing light or washed out.

• AgX: The conventional Fujifilm Frontier prints exhibited the highest Richness of the competitive group. AgX prints had good saturation, but with some colors rendered a bit too dark, especially noted on red, magenta and blue colors, and with yellows shifted towards orange. The Richness of the AgX prints may be accentuated by the higher gloss and surface smoothness of the AgX-specific media. Matte & Glossy Ratings: A-

• HP Indigo 5500: Overall, the 5500 prints had good saturation and image contrast; however, solid blues were oversaturated on intensely colored images. Overall image smoothness added to Richness. Matte & Glossy Ratings: B+

• Xerox iGen4: Images from the iGen4 were comparatively less rich than the AgX and 5500 prints. iGen4 output lacked a little in saturation and vibrance, appearing slightly muted on some of the more saturated color images, mostly notably on solid yellow and red. Matte & Glossy Ratings: B

• HP Indigo 7000: The 7000 prints were rendered comparatively lighter than on iGen4, AgX, and 5500 output, and appeared slightly washed out. The lack of saturation was especially noticeable in the midtone range, resulting in overall flat images. Matte & Glossy Ratings: B-

• Kodak NexPress S3000: Like the 7000 prints, S3000 prints were rendered relatively light. S3000 prints failed to maintain adequate contrast balance, thus producing output that was too light and washed out, detracting from overall vividness. Matte & Glossy Ratings: C+

SHARPNESS

Image Sharpness is the combination of detail rendition, image definition and clarity. Unsharp image rendition can detract from overall quality by reducing image detail, resulting in blurry, unacceptable output. Conversely, overly sharp images can introduce related artifacts that can result in images that appear harsh and unnatural.

• iGen4: The iGen4 prints exhibited exceptional Sharpness and rated highest of the tested systems. The iGen4 images exhibited excellent fine detail rendition and image depth, without introducing harshness. Screening reduced some image clarity. Matte & Glossy Ratings: A-

• Kodak NexPress S3000: Prints on Matte and Glossy media from the S3000 exhibited very high detail rendition; however, excessive sharpening created artifacts in some images that appeared unnatural. Matte & Glossy Ratings: B+

• HP Indigo 5500: Although acceptable, the prints from the 5500 had lower Sharpness than the iGen4 and S3000. The images were rendered slightly soft and shadow details were plugged. Minor misregistration of magenta appeared on some prints. Matte & Glossy Ratings: B

• AgX: AgX prints exhibited comparatively less Sharpness than the 5500 prints. Images were very soft, and shadow details were lost due to the overall dark rendition. Matte & Glossy Ratings: B-

• HP Indigo 7000: Images from the 7000 had poor detail rendition and clarity compared to the other tested print systems. The screening algorithm caused noticeably distracting coarse dot patterns that detracted from image definition. Matte & Glossy Ratings: C+

Section Showing Image Sharpness Comparison, Matte Media

| Xerox iGen4 | NexPress S3000 | HP Indigo 5500 | AgX | HP Indigo 7000 |
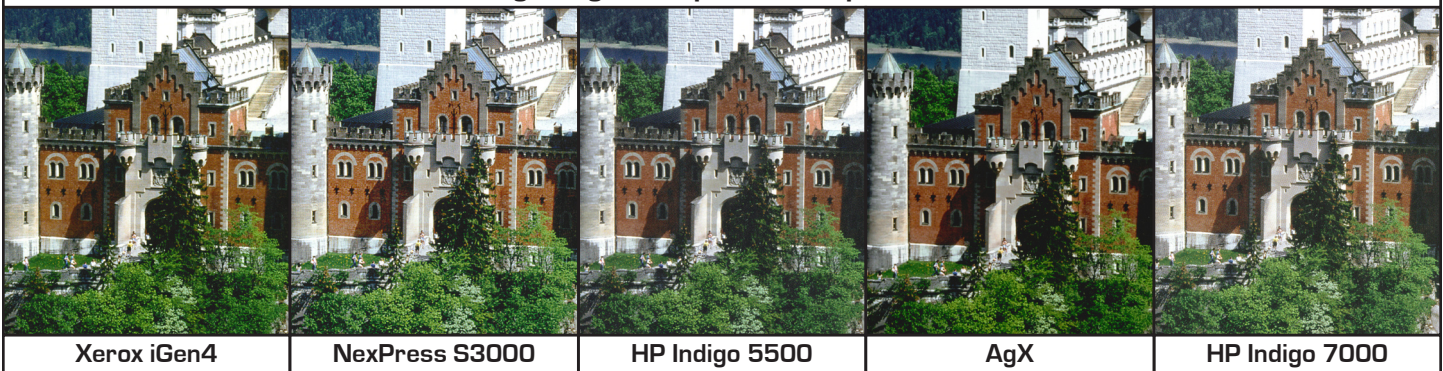
SMOOTHNESS

Smoothness may be thought of as a lack of artifacts, such as grain, screening, process noise, streaking or banding, gloss differentials, etc. Lack of smoothness will be especially apparent in images with little image content variation (low spatial frequency) and/or on isolated sharp transitions.

• AgX: The Fujifilm Frontier produced AgX prints that can be considered the benchmark of Smoothness. With the use of a continuous-tone process that completely avoids the need for screening, exceptional Smoothness is achieved. No significant artifacts were noted. Matte & Glossy Ratings: A+

• HP Indigo 5500: The 6-color prints produced by the 5500 appeared very smooth. The supplemental Light Cyan and Light Magenta allowed for the very smooth images, and screening artifacts were negligible at normal viewing distance. Matte & Glossy Ratings: B+

• Xerox iGen4: Smoothness on the iGen4 prints suffered from visible screening patterns, with noticeable cross hatching. Minor process noise and banding was also apparent. Lack of Smoothness on iGen4 prints was noted at the micro-uniformity level, with noticeable screening patterns. Matte & Glossy Ratings: B-

• HP Indigo 7000: Distracting screening patterns of coarse dots were noticeable at normal viewing distance on the 7000 prints, on both media types, thus decreasing overall Smoothness. Although using liquid toner, the absence of supplemental Light Cyan and Light Magenta yielded output that was less smooth in comparison to the 6-color 5500. Matte & Glossy Ratings: B-

• NexPress S3000: Distracting process noise and banding at the macro-uniformity level on the S3000 prints was noticeable, especially on large solid areas, such as skies.

Contouring contributed to the lack of Smoothness. Matte & Glossy Ratings: C

NEUTRAL GRAY IMAGES

Grayscale image rendition is important in photo book type applications where consumers choose to showcase their images with heightened drama or emotion by rendering in Black & White. Quality expectations increase for these photographs, typically nostalgic snapshots, wedding portraits, or textured landscapes. With the elimination of distracting color, the viewer is inclined to focus more closely on the image.

Higher solid Black Density results in richer blacks, and good linearity results in smooth transitions from highlight through midtones to shadow areas — all helping to maintain image details. Optical density measurements (Status T) were made with a calibrated X-Rite 939 spectrodensitometer.

In color images with near-neutral colors, any lack of realistic rendition is easily noted.

• Xerox iGen4: Grayscale images produced on the iGen4 were rated overall best of the competitive group. Grayscale images and non-raster RGB black were both rendered with black-only (K). Images were rendered with deep blacks and exhibited good contrast and sharpness. While maintaining very good linearity, the iGen4 solid Black Optical Density values of 1.82 ODU on Matte and 1.85 ODU on Glossy media contributed to its high contrast. Near-neutrals had a minor color shift. Matte & Glossy Ratings: A-

• Kodak NexPress S3000: Grayscale prints from the S3000 were rendered with good gray neutrality. Although lighter than the iGen4, S3000 prints were rendered with rich blacks. As with color images, over-sharpening diminished the S3000's Grayscale image

Section Showing Neutral Gray Image Comparison, Matte Media

| Xerox iGen4 | NexPress S3000 | AgX | HP Indigo 5500 | HP Indigo 7000 |
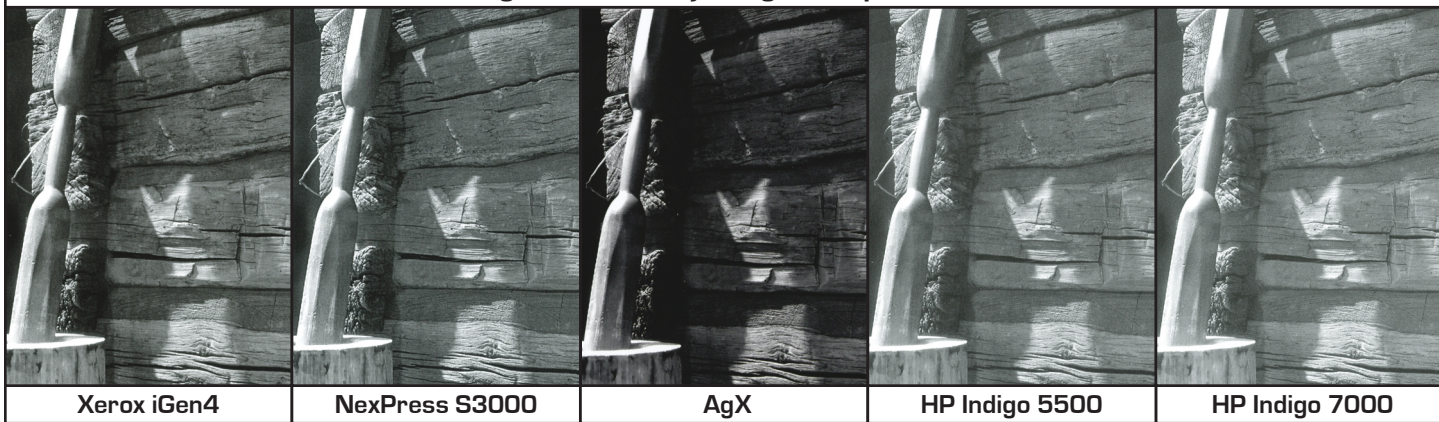
overall smoothness and quality. Grayscale images and non-raster RGB Blacks were produced as black-only, with measured Black Optical Density values of 1.62 ODU on Matte media and 1.77 ODU on Glossy media. The Density response curve was relatively flat through the midtones, resulting in the images that were overall light. Matte & Glossy Ratings: B+

• AgX: Grayscale images on AgX prints were rendered excessively dark, resulting in loss of image detail. Although producing rich solid blacks, the images exhibited a yellow-green color cast, reducing overall image quality. AgX prints recorded the highest solid Black Density values of 2.29 ODU and 2.34 ODU on Matte and Glossy media, respectively. The Density response curve showed a rapid density increase going from midtone to shadow, resulting in overall darker prints and, subsequently, poor shadow detail rendition. Matte & Glossy Ratings: B-
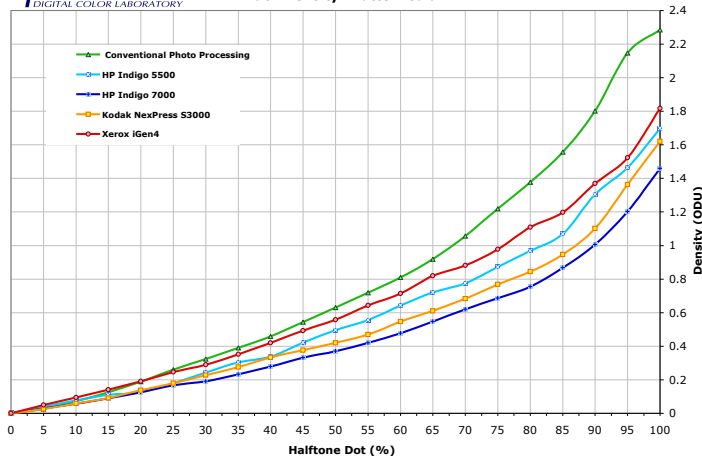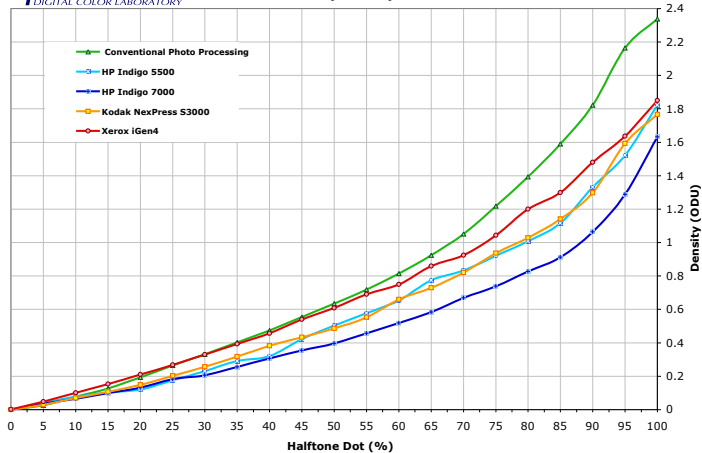
• HP Indigo 5500: Prints from the 5500 were rendered very light and with lower contrast than competitive systems, along with noticeable streaking. While Grayscale images were produced using black only, non-raster RGB black was rendered using composite black (CMYK). The 5500 prints recorded solid Black Density lower than the iGen4 and AgX prints, at 1.70 ODU and 1.82 ODU respectively. The Black Density response curve of the 5500 was most uneven, showing non-linear transitions. Matte & Glossy Ratings: C+

• HP Indigo 7000: Grayscale images from the 7000, like those from the 5500, were rendered too light and appeared washed out in comparison to the competitive set. Solid blacks were less rich than blacks of other competitive prints. Grayscale images and non-raster RGB blacks were rendered with pure black. The 7000 Grayscale prints had the lowest solid Black Density values of 1.46 ODU on Matte media and 1.63 ODU on Glossy media. The Density response curve was overall flat through the midtones, resulting in the images that were light overall. Matte & Glossy Ratings: C+

WEIGHTED AVERAGE

Weighted Average includes all the attributes of photographic prints: the components of Realism (Foliage, Sky & Water, and Fleshtones), Richness, Sharpness, Smoothness, and Neutral Gray. Our experience with consumer photographic image preference studies is reflected in the relative weights of 5%, 10%, and 15% for Foliage, Sky & Water and Fleshtone Realism, and 30%, 20%, 10% and 10% for Richness, Sharpness, Smoothness and Neutral Gray, respectively. Weighting may reflect the negative aspect of one or more of these characteristics (such as smoothness) rather than their positive contribution.

Although minor rating differences were noted between media type sets, the overall weighted average ratings of Matte and Glossy media remained the same for each print systems' two media sets. The computed weighted average was plotted (see page 2) and converted to the closest corresponding letter grade; the following discussion is in order of the computed weighted average.

• AgX: The quality of the Fujifilm Frontier prints obtained for this study were, in our experience, some of the best that we have seen from conventional photo processing systems. (Although AgX prints are typically considered the benchmark for photographic image print quality, "the gold standard", we have observed significant process variation; these Fujifilm prints are a marked improvement from previous test sites.) With an overly dark color rendition, the rating of AgX took a slight hit. Overall Average Rating: A-

• Xerox iGen4: Overall photographic image print quality of the iGen4 was rated as a highest among the digital presses, with excellent Sharpness and Neutral Gray rendition, and very good Sky & Water and Foliage color Realism. Overall Average Rating: B+

• HP Indigo 5500: The 5500 continues to be a high photo image quality producing system. The iGen4 prints were rivaled for overall print quality by the 6-color HP Indigo 5500. Overall Average Rating: B+

• NexPress S3000: The overall quality produced by the S3000 was found to be acceptable for the consumer photo book market. Inferior Fleshtone Realism, over-sharpening, and excessively light images contributed to a lower rating of S3000 prints. Overall Average Rating: B

• HP Indigo 7000: The overall quality of the prints produced by the 7000 was lowest of the tested print systems, with contributions from comparatively coarse screening, color shifts, and an overall flat appearance. Overall Average Rating: B-

Weighting Percentages
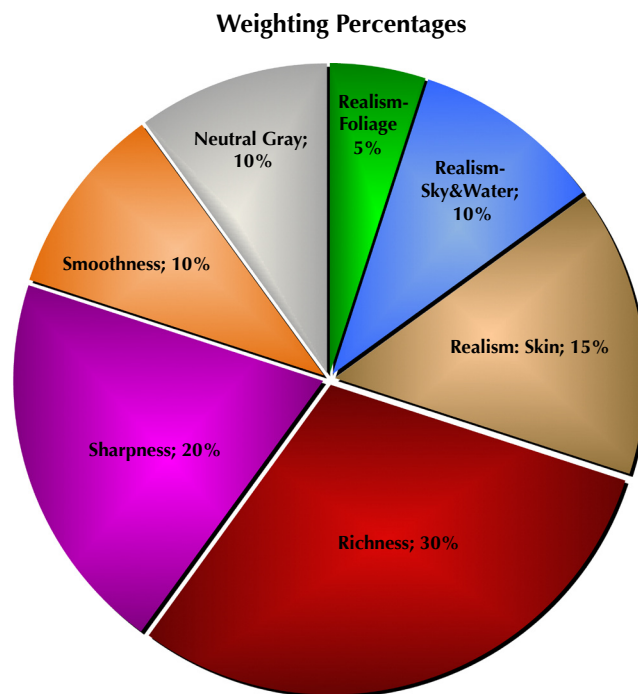
In summary, we reiterate that the Xerox iGen4 offered the overall best photographic image quality among the tested digital press solutions for photo book applications, and is a competitive option to conventional photo processing. We note that all of the digital presses earned overall ratings higher than 'just acceptable' for typical consumer quality photo applications.

THE *spencerLAB* DIGITAL COLOR LABORATORY

The *SpencerLab* Digital Color Laboratory is an independent printer evaluation laboratory that provides services to vendors and corporations for whom digital color printing is mission-critical. The Laboratory follows strict guidelines in the integrity of both methodology and reporting; vendor-sponsored studies do not guarantee favorable results. *SpencerLab* has developed industry-standard test software, and performs print quality, cost-per-page, speed, and ease-of-use analyses in all technology classes, from desktop printers to digital color presses.

SpencerLab is operated by Spencer & Associates Publishing, Ltd., a premier IT consulting boutique specializing in Digital Color Imaging. Since 1989 Spencer & Associates has provided strategic support in product planning, development, and launch to manufacturers, and workflow analysis, usage optimization and print system selection to corporate users.