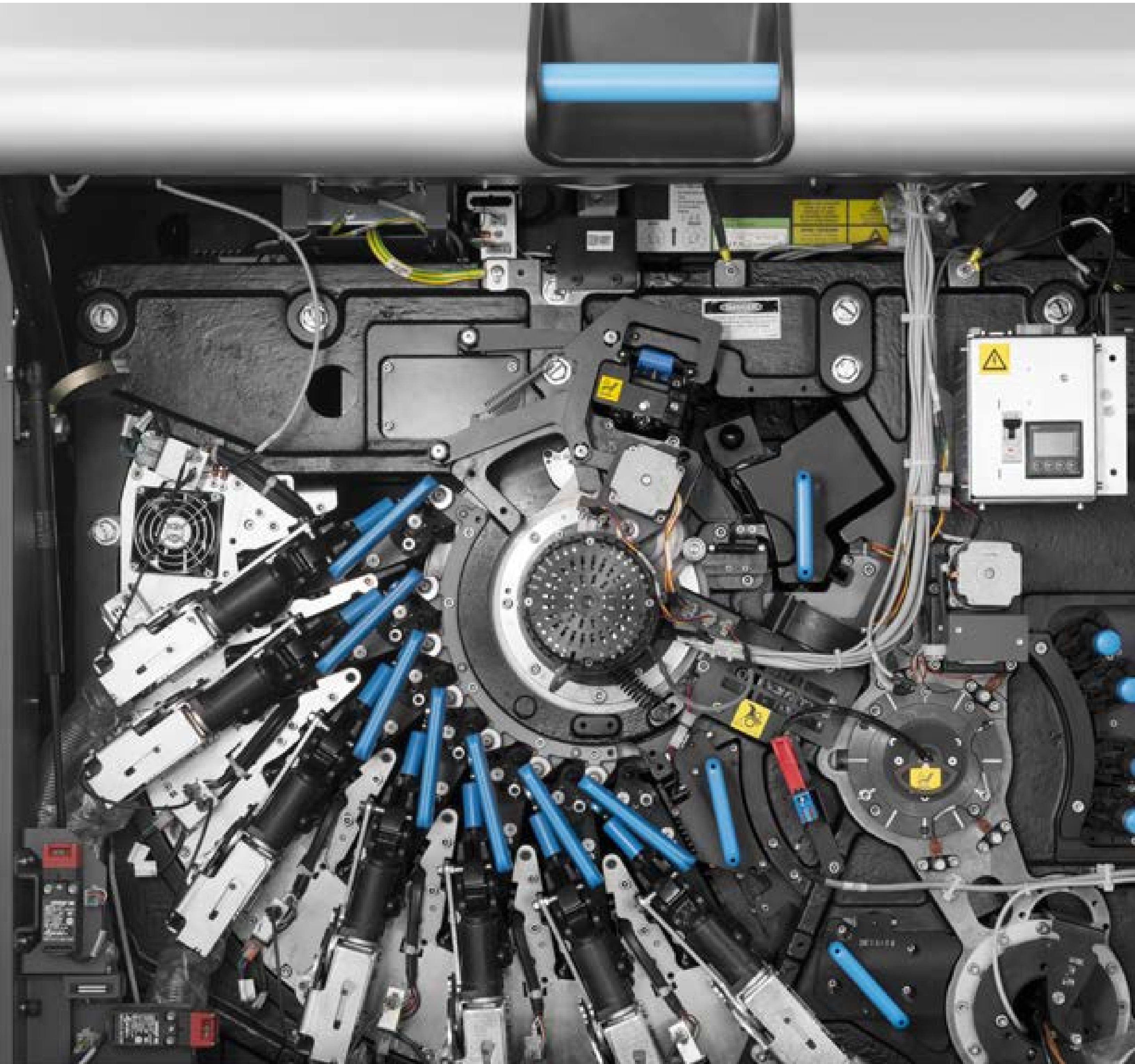
HP Indigo Digital Offset Color Technology



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Introduction

The HP Indigo range of digital printing presses, based on its Digital Offset Color technology and process, offers a unique combination of best print quality in the industry, wide color gamut, substrate versatility, speed, productivity, flexibility, and the ability to vary every printed copy. HP Indigo printing inherently matches and at times, due to its digital local image processing and ink coverage flexibilities, surpasses offset, and is also the best replacement for photo silver halide applications.

This white paper describes the HP Indigo Digital Offset Color printing process and its unique features. It details the latest advances in HP Indigo's liquid electrophotography (LEP) technology released for drupa 2016, including dozens of different hardware, supplies and software enhancements that extend the performance of HP Indigo's underlying core technology. It also compares HP Indigo's liquid electrophotography with dry toner electrophotography (DEP) and inkjet technology-based digital printing presses, as well as with the conventional, non-variable, offset lithography process that has traditionally dominated the printing industry worldwide.

HP Indigo offers a wide range of digital presses for a variety of applications, all based on the basic principles of its Digital Offset Color technology.

Figure 1 HP Indigo 12000 Digital Press

What is Digital Offset Color? Let's break it down word by word:

1. Digital

The printed image is created directly from digital data, avoiding the use of any "analogue" intermediate media. It starts with digitally created pages or print elements containing, for example, text, layouts or images. Then, unlike conventional printing processes, there are no intermediate pre-press processes between the digital document file and the final print. No film, no imagesetters, no plates, no platesetters, no photo-chemicals, and no other "analogue" elements. There is also no press make-ready: no plate mounting, no registration adjustments, no ink keys, and no waste. The HP Indigo process is fully digital from image creation to printing. And, since it is a fully digital process, every image can be a new one, enabling information to be varied as required.

2. Offset

Offset simply means that there is an intermediate cylinder that transfers the ink image from its origin on the plate cylinder to the final substrate (i.e. the paper, plastic or other material) for printing. In the printing industry, the term offset is commonly used as a term for the lithographic process. Indeed, modern lithographic (also called litho) presses do use an offset process.

HP Indigo technology also uses offset printing, by the use of an offset cylinder covered with a renewable rubbery blanket.

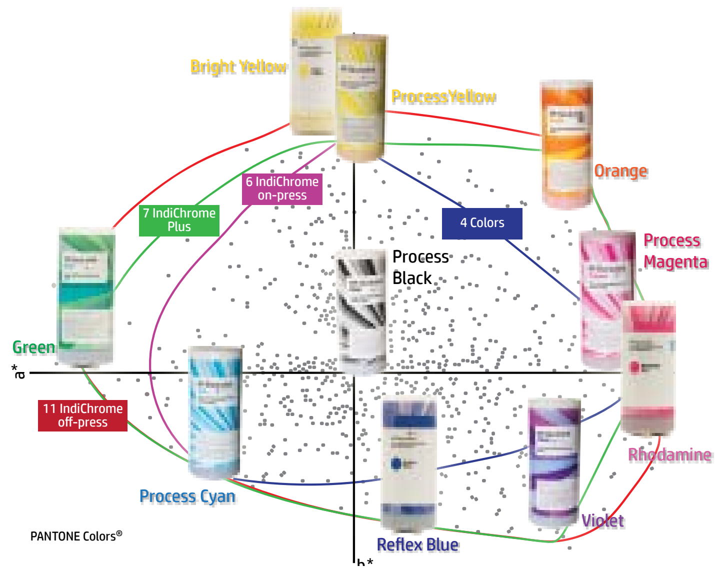
There are two main purposes of offsetting in printing presses. First, it protects the surface of the printing plate from excessive wear due to friction with the substrate as it is printed. Second, since the rubbery blanket conforms to the local topography of the substrate, ink is adhered both to the "peaks" and the "valleys" of the substrate equally. In other words, it acts as a kind of shock absorber and pressure pad, ensuring good ink transfer from printing plate to the substrate. Conventional offset presses can therefore print on a very wide range of substrate surfaces and thickness, and are superior to non-offset processes in this respect. The HP Indigo process uses offset for the same reasons, thus making it capable of printing on a wide range of substrates.

A notable difference between conventional offset and HP Indigo digital offset printing technology is that HP Indigo's ink-ElectroInk-transfers from the blanket to the substrate with virtually none of the ink splitting that characterizes conventional offset printing systems. This enables the creation and transfer of a different image each printing cycle.

A further difference is that HP Indigo ElectroInk is dried on the blanket and the final image is transferred to the substrate in the form of a ready dry film. This process does not depend on the final substrate. Thus, there is almost no limitation to substrate flexibility, and all substrates are printed with the same high HP Indigo quality and at the same speed. Moreover, since no drying is required the substrate does not undergo any further stress. In comparison, other technologies require further drying of the ink on the substrate (as in offset or inkjet technologies) or fusing of toner on the substrate (as in DEP) and require the matching of ink/toner and printing process with media.

The matching requirement, at times, affects productivity due to the need, for example, to wait for drying or to wait for stabilization of the heating mechanism. When an ink-process-media match does not exist, some media has to be excluded.

Figure 2
Schematic comparison of color gamut with 4-, 6-, 7-, and 11-color HP Indigo ElectroInks



- 4 colors (CMYK)
- HP IndiChrome on-press (CMYKOV)
- HP IndiChrome Plus (CMYKOVG)
- HP IndiChrome off-press (CMYKOVG and reflex blue, bright yellow, rhodamine red, and transparent)

The above differences result in superior versatility of LEP, leading to higher productivity, due to the ability to change data, color, and substrate at will and with no time penalty.

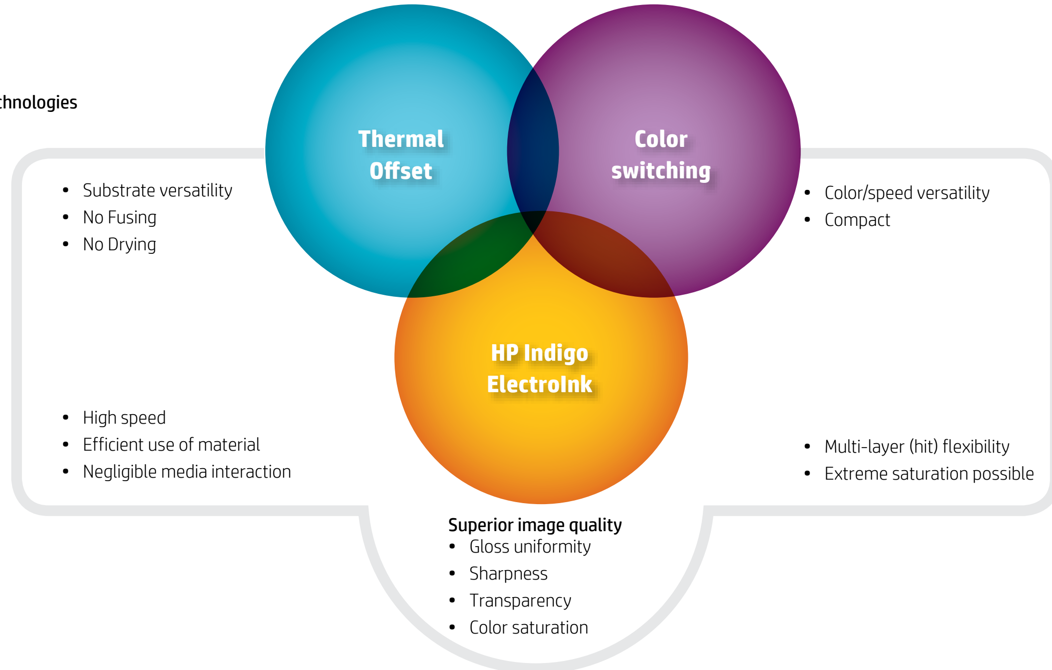
3. Color

As it sounds, HP Indigo technology enables digital printing in full color. However, unlike conventional offset litho color presses, which require one complete printing unit per color, HP Indigo presses print multiple colors for each single pass of the substrate through the press. As described above, in Digital Offset Color technology all the ink transfers from the blanket to the substrate. The HP Indigo digital press transfers with each rotation of the press cylinders, on the single set of blanket and imaging plate, not only a different image but also a different ink. HP calls the method or configuration "on-the-fly color switching." This is all done without physical interaction between the different color separations. Printing with 5, 6 or 7 colors, in addition to CMYK together with the flexibility of adding pre-mixed HP IndiChrome spot colors, and the capability to vary the number of impressions per single color, offers major enhancements in color quality, range, fidelity, and luminosity (see figure 2).

In summary, HP combines digital, offset, and color into a powerful printing process. The three core technologies of the HP Indigo Digital Offset Color process are:

- ElectroInk - HP Indigo's liquid ink
- Thermal offset transfer
- On-the-fly color switching

Figure 3
Digital Offset Color core technologies



HP Indigo ElectroInk

All HP Indigo digital presses use ElectroInk, HP Indigo's unique liquid ink. ElectroInk contains electrically charged ink particles, dispersed in liquid. Similar to DEP, ElectroInk enables digital printing based on the application of strictly controlled electrical fields to move charged color particles. This control enables accurate placement of the printing material. However, unlike DEP, ElectroInk enables the use of very small particle size, down to 1-2 microns. These small particles dispersed in the liquid carrier allow for higher resolution, uniform gloss, sharp image edges, and very thin image layers.

The thin image layer closely follows the surface topography of the paper. This gives a highly uniform finish, complementing the paper and resulting in a similar texture both on the image and on the non-image areas.

For the two other digital technologies, DEP and inkjet, the situation is less favourable. In DEP, the particle size cannot be made too small, as particles then become airborne, and uncontrollable. Therefore, higher printing speeds require larger particle sizes leading to adverse impact on print quality attributes such as color performance, gloss uniformity, and sharpness. Inkjet technology, while still laying a thin layer of ink on the media, suffers from the inherent inaccuracy of the ink jetting. Since the ink must strongly interact and absorb into the media, some of the pigment or dye sinks below the surface rendering it less effective and reducing saturation (or alternatively increasing cost). Part of the absorption follows paper fibers leading ink away from the original droplet thus breaking the edge of the drop in a less controlled and random manner ("wicking"). These effects result in reduced control of the final product and with it loss of sharpness and resolution.

HP Indigo ElectroInk is supplied in a concentrated form. Inside the press it is fed into ink supply tanks, diluted with oil and combined with a charging control fluid, to form a fluid mixture of carrier liquid and colorant particles ready for printing.

The capability to increase the number of ink layers to more than four, which is natural in offset and in ElectroInk, is very difficult, if at all possible, when using the thick layers of DEP or, for inkjet, as it conflicts with the drying requirements of fast heavy coverage printing. This results in a print quality versatility only offered by LEP.

HP Indigo ElectroInk is available in an increasing range of colors, including:

- Standard CMYK (cyan, magenta, yellow, black) process colors.
- HP IndiChrome wide-gamut 6- and 7- color sets. These incorporate orange and violet inks for the 6 colors and also green for 7 colors to extend the color reproduction capabilities far beyond the range possible with CMYK inks only.
- HP IndiChrome spot colors - mixed from a set of base inks, matching spot colors including most of the PANTONE® color range.
- White ink produces an opaque appearance and solid backing for labels and flexible packaging and also supports specialty colored and transparent substrates for commercial applications. Premium white with higher opacity levels (from 59% to 81%) enables the matching of any other white printing technology including screen printing.
- Light cyan, light magenta, light black and light light black deliver smoother tone transitions and saturated colors for photo prints, competing with silver halide quality.
- Transparent Ink applied in multiple layers permits raising the surface of the ink above the image level, creating eye-catching raised print designs and digital watermarks, or, applied directly to the Blanket, it builds up a 'mold' which imparts a textured effect to the substrate similar to an embossed look and feel.
- Invisible Red prints text or barcodes visible only under UV light.
- Fluorescent Pink glows under UV light to create eye-catching effects.
- Fade Resistant Yellow and Magenta Inks are specially designed for outdoor applications and have an excellent lightfastness-rating of between 6 -7, out of a maximum of 8, on the BWS (Blue Wool Scale).

To summarize, ElectroInk enables high quality, wide and accurate color gamut, sharp images, and color with gloss closely matching the media, similar to and at times surpassing conventional offset printing, and exceeding the quality achieved by competing digital printing technologies.

Thermal Offset

The HP Thermal Offset process uses a heated blanket causing the specially shaped pigment-carrying particles within the ElectroInk to melt and blend into a smooth film. When it contacts the cooler substrate, the ElectroInk strongly adheres to the substrate, immediately solidifies and transfers with almost no change in dimension or shape. Since the image is completely defined on the blanket, issues such as ink media interaction or ink-ink interaction which are common in nearly all other printing methods are virtually nonexistent in LEP. The result is an image with a true offset look and feel, accurately replicating the gloss and texture of the substrate on which it was placed.

Since the fusing and drying is done on the blanket and the transfer is by contact, in contrast with DEP printing, there is little need for environmental control of the media prior to printing or to expose the media to extreme heat which limits the media types and may warp the media. LEP does not require the image to be dried on the media, as in offset printing and in inkjet printing. The print is effectively dry as soon as it leaves the press, eliminating the risk of ink set-off marking other copies. Thus, print finishing may be performed immediately. This is a major benefit over conventional lithography which requires either assisted drying systems, or a natural drying time of several hours, before any print finishing processes can be applied.

In summary, HP Indigo's Digital Offset Color technology enables the look and feel of conventional offset printing, the ability to print on a virtually limitless substrate range, and the capability of immediate drying, which enables duplex printing or finishing with no waiting period.

Color switching

As the HP Indigo LEP technology employs only contact transfers and since the HP Indigo ElectroInk does not tend to become airborne as DEP toner, the result is a process which can inherently be much faster than the DEP process and provide much higher quality than inkjet at the same speed. Currently the process speed, or image generation speed, is up to 2.35 m/sec or 462 ft/min with the release of the new HP Indigo 10000 Digital Press platform. This inherent speed is combined with the fact that HP Indigo's Digital Offset Color printing technology enables the printing of all color separations by a single engine. After one color separation has been created and printed, the next one (usually a different color) is created and printed on the same engine. This is possible since the blanket completely transfers the previous image, and none of the image stays on the blanket.

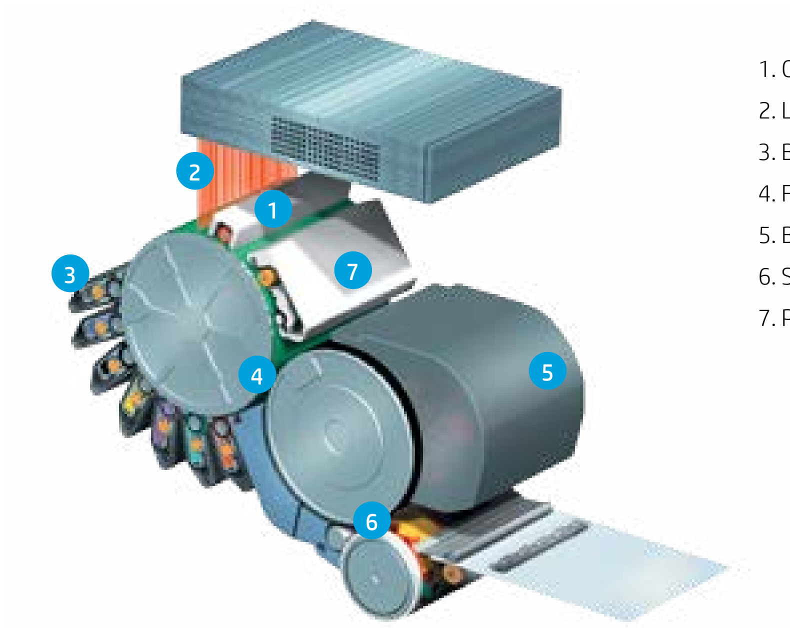
Single engine printing has several obvious advantages, including compactness, lower cost of hardware, and better mechanical accuracy, but beyond that it offers the flexibility to balance quality with color content and color accuracy on the same press and even within the same run.

The inherent flexibility of on-the-fly Color Switching technology means that using the same single engine, the press is free to vary the number of color separations to achieve the desired outcome. Whether it is adding extra colors to widen the color gamut, introducing multiple passes of the same color to increase opacity or create special effects, or even reducing the number of separations to increase productivity in Enhanced Productivity Mode, each of these outcomes can be achieved seamlessly on the same single engine, offering unparalleled flexibility.

To summarize, the color switching technology offers an optimal balance between speed and enhanced quality and at the same time minimizes press footprint and cost of hardware.

Figure 4
Various applications printed on an HP Indigo digital press

Step-by-step description of the HP Indigo Digital Offset Color printing process



1. Charging station
2. Laser exposure
3. Binary Ink Developer units (BIDs)
4. First transfer (PIP to blanket)
5. Blanket heating
6. Second transfer (blanket to substrate)
7. Photoconductor cleaning station

Figure 5

HP Indigo digital press printing cycle

The printing cycle

The HP Indigo printing engine performs the following operations sequentially:

1. Electrostatic charging of the electrophotographic Photo Imaging Plate (PIP) which is mounted on the imaging cylinder.
2. Exposure of the PIP by a scanned array of laser diodes. These lasers are controlled by the raster image processor which converts instructions from a digital file into "power" instructions for the lasers.
3. Image development performed by the Binary Ink Developer (BID) units.
4. Transfer of the inked image to the blanket cylinder.
5. Heating of the inked image carried by the blanket forming the final image in form of a thin tacky film.
6. Complete transfer of the final image film to the substrate held by the impression cylinder.
7. Removal of any residual ink and electrical charge from the PIP and cooling of the PIP after engagement with the hot blanket.

These operations repeat themselves for every color separation in the image. They are described below in more detail:

1. PIP charging

The first step in LEP is the deposition of a uniform static electric charge on the photoconductor. This is achieved by a charge roller which produces charged particles (atoms, molecules and free electrons) by a glow discharge effect (i.e. the ionization of the air) through the application of high-voltage.

The negatively charged particles are directed by electric voltage toward the PIP while the positive charged particles are attracted to the charging device and neutralized.

In order to maintain the process stability, the voltages applied to control the transfer of the charges to the PIP are routinely automatically calibrated to accommodate for changes in the photoconductor's discharging level.

2. PIP exposure

As the PIP cylinder continues to rotate, it passes the imaging unit where as many as 32 laser beams in parallel expose the image area, dissipating (neutralizing) the charge in those areas. When the exposed PIP rotates toward the next station it is carrying a latent image in the form of an invisible electrostatic charge pattern conforming to the image to be printed.

3. Image development

Inking is performed by the Binary Ink Developer (BID) units, one for each ink. The BID units prepare a thin film of highly electrically charged ElectroInk on their roller surface.

During printing the appropriate BID roller engages with the PIP cylinder. The electrical fields between the PIP and the BID result in attracting the ink paste to the image area and repelling it from the non-image areas, shearing the ink film accurately and instantaneously.
The result is the replication of the electrical latent image with a clean and sharp inked image.

4. First transfer

The PIP then rotates into contact with the electrically charged blanket on the transfer cylinder, and the ink layer is electrically transferred to the blanket.

5. Film formation (blanket heating)

The inked image is heated by the rotating thermal blanket and from an external heat source. This causes the ink particles in the ElectroInk to partially melt and blend together. At the same time most of the carrier oil is evaporated, to be collected and reused as part of fresh ink in the tanks. The result is a ready finished image in form of a hot, nearly dry, tacky plastic film.

6. Second transfer

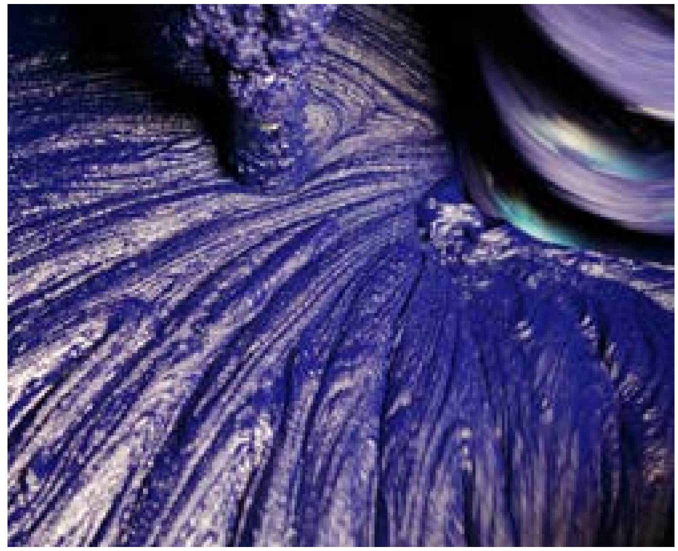
As the ink comes into contact with the substrate, the temperature which is significantly below the melting temperature of the particles, the ink film solidifies, sticks to it, and completely peels off from the blanket, ensuring 100% transfer from blanket to substrate. The blanket is therefore clean and ready to accept the next impression with its new ink layer.

The second transfer method differs according to printing mode. In Multi-Shot the substrate stays on the impression cylinder as it receives each separation from the blanket one after the other. As the final separation is printed, the substrate is either moved for duplex printing or delivered to the output tray. In One Shot mode, the PIP cylinder transfers a succession of separations to the blanket before they are transferred to the substrate in a single pass. One Shot is standard for Labels and Packaging presses, whereas most Commercial presses have the option for using either mode, depending on the substrate.

7. Cleaning station

Returning to the PIP, after transferring the image to the blanket, it rotates past a cleaning station which removes any residual ink and cools the PIP from heat transferred during contact with the hot blanket. At this point this part of the PIP surface has made a complete rotation and can be recharged ready for the next image.

As mentioned before, HP Indigo presses print multiple colors from the same offset blanket. The cycle repeats itself for each color separation and the only difference between the cycles is in the ink application and the image data corresponding to the printed color separation.



Digital Offset Color advantages

After describing the technology and the process, let's touch on the advantages which stem from them.

Quality characteristics

1. Edge sharpness and definition

Figures 8 and 9 display microscope images of dots printed with HP Indigo ElectroInk, conventional offset technology, and DEP technology. All prints have been calibrated to produce the same final color value. Viewed at high magnification, ElectroInk forms much sharper features than any other printing method. For small dots, the conventional offset creates "smudges" due to the ink splitting, while DEP looks like a pile of powder with regions flattened by the fusing and uncontrolled dust between the dots.

The sharpness of ElectroInk is particularly noticeable at the edges of halftone dots, or fine type characters (see figure 6 and figure 7). Noticeable is the contamination-free background of ElectroInk images. This is first due to the small size of the ink particles and also to the way ElectroInk particles are transformed when they are on the press. As opposed to both DEP and inkjet, ElectroInk is not transported by flight though air, but rather a thin ink paste is placed on the PIP and "cut" to the correct size. This produces very accurate edges and almost no background contamination. In the printing process ElectroInk paste is transferred by contact to the heated blanket, because the ink particles melt and blend, the strong surface tension of the liquefied heated ink, while becoming a film, facilitates the formation of a sharp, clean edge. When transferred from the blanket to the final printing substrate (paper or plastic), the heated plastic film cools down to form a thin colored plastic layer on the substrate surface. When printing on paper, the cooled ElectroInk does not soak (or wick) into the paper fibers. Thus, printed dots, linework, and text stay sharp and well defined on the surface of the paper.

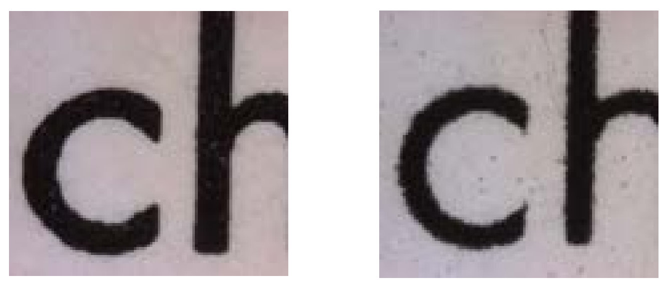
Like ElectroInk, DEP toners don't penetrate the paper either, but they do suffer from large particle size and stray toner particles scattered outside the image edges, leading to poor edge definition no matter what substrate is used.

Figure 6
Comparison between dense lines

HP Indigo ElectroInk

DEP

Figure 7
Comparison of text printed with HP Indigo digital offset (left) with text printed by DEP (right)



Comparison of text printed with HP Indigo digital offset (left) with text printed by industrial inkjet press (right)

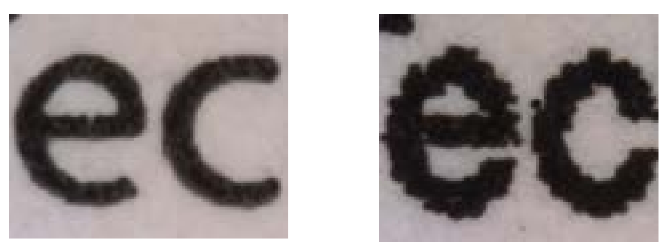
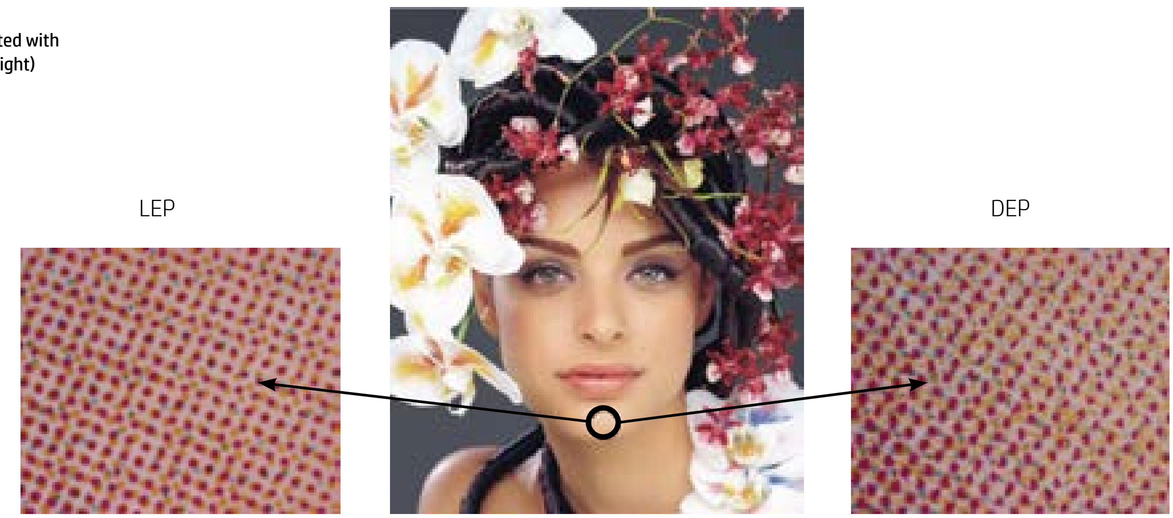


Figure 8

Compare ElectroInk (left), offset (middle) and DEP (right).

Figure 9
Comparison between color dots printed with HP Indigo ElectroInk (left) and DEP (right)



2. Optical density, dot gain color and image consistency

Optical density—the amount of light which the ink absorbs, or its darkness is defined by the thickness of the ink on the media and the concentration of light absorbing material (pigment in our case) it contains. Dot gain is the difference in dimension between the dots and lines as they were designed in the original digital file and their final dimension on the final print. In combination, these two elements are the basis for print stability. For HP Indigo digital presses, both optical density and dot gain are periodically monitored and press parameters are automatically adjusted to minimiz`e fluctuation. The result is color and linework that are consistent and predictable over time and between presses. HP Indigo presses automatically adjust the optical density (i.e. appearance in terms of lightness or darkness) and dot size so that they always appear the same, copy after copy, regardless of small changes in press parameters and even in uncontrolled changes in media batch. On top of this HP Indigo presses have built-in dot gain compensation which corrects the exposed dot size and thickness so that it prints to the color profile with the media included in the equation.

With a conventional offset lithographic press, there are wider fluctuations during a run caused by factors that include: fluctuating ink and water temperature; water/ink balance and their tendency to emulsify; plate and blanket wear; and atmospheric humidity altering the absorbency of the paper. Neither automatic nor manual adjustment can completely iron these out, because there is always a time lag between the problem appearing and the adjustment taking effect, during which many copies are printed. With HP Indigo presses, there are fewer operating variables, and the optical density of the printed image can be electronically set by the operator within a wide operational range.

The capability of printing to a specific color profile is a necessary requirement in order to achieve print consistency. A special capability of the HP Indigo presses is the ability to print linework and fonts with nearly zero dot gain. This is achieved by combining a per-pixel variable laser power capability together with the previously discussed inherent sharpness and accuracy of the ElectroInk process. The combined result of accurate color and linework is a print which is consistent from print to print and press to press.

Just as importantly, the parameters which created the print, such as optical density, color profiles and screen, are kept for repeat runs in future, meaning that a repeat job will be identical to the original regardless of the press or media batch. This is difficult to achieve with lithography, which depends to a great extent on operator skill.

Figure 10
Gloss comparison for various printing systems

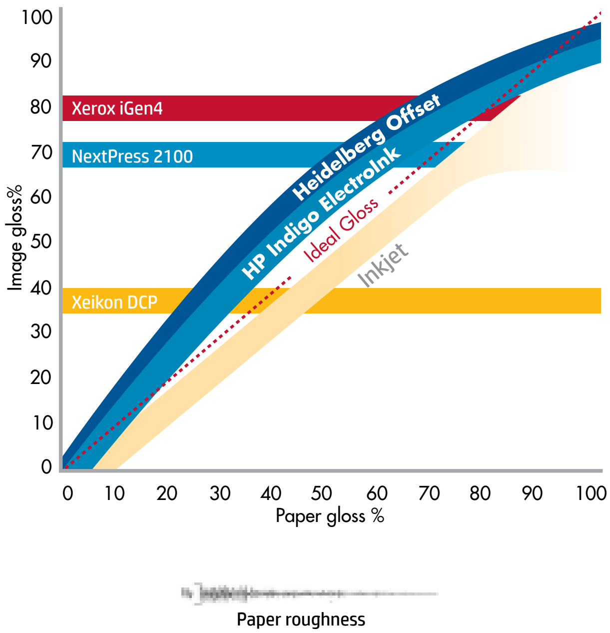
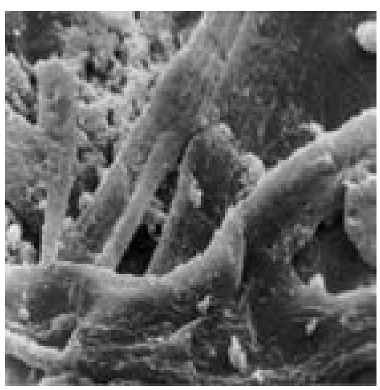
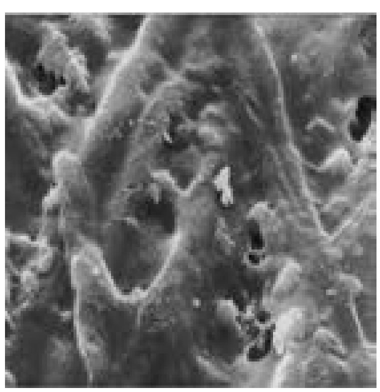


Figure 11
HP Indigo ElectroInk complements the topography of the media



Paper



Paper covered
with HP Indigo ElectroInk

3. Imaging flexibility

HP Indigo presses have been created to offer, by design, full flexibility. The setting of crucial elements such as optical density, color curve, screen and even dot gain may be done before the RIP (Raster Image Processing), but may also be done just before printing by a touch of the keyboard or touch screen and the image will be reprinted with the new required conditions, without re-RIP or time lag. Since the printed ink layers are thin and do not interact, there is little need to change color profile when changing screen. This allows quick proofing cycles when proofing is required, in turn shortening time and minimizing waste of media.

Obviously most of these capabilities are lacking with lithography, but even DEP is limited by the fact that the thick toner layers strongly interact (or trap) each other and thus any change in screen, optical density, dot gain or color curve will require a new RIP to receive a reasonable color output.

4. Image gloss

Many people believe that the key to the quality of offset litho printing is its glossy appearance. This isn't quite true - what is important is the uniformity of the gloss and matching with the media. For instance, many magazines and company brochures have varnished front covers to give a high quality feel, but either gloss or matte varnishes may be used. In addition, some of the most expensive looking substrates have intentional textures which should not be glossed over.

The uniformity of the finish is the key issue rather than just its surface gloss. HP Indigo ElectroInk gives a highly uniform finish complementing that of the underlying substrate - whether the substrate is a high gloss coated paper or a rough matte paper.

ElectroInk images match the gloss of the underlying printing substrate, from rough to dull to high gloss, just like conventional offset prints. Paper stocks have a typical surface roughness ranging from about 1 to 10 microns in height. The ElectroInk layer is only about 1 micron thick, and therefore it follows the "hills and valleys" of the substrate surface texture, rather than filling them in. The result is that there are no large variations in gloss between the inked image areas and the bare paper substrate (see figure 11).

Even the finest DEP color toner is limited to a particle size no lower than 5 to 9 microns, otherwise it is too small to be controllable and forms a powder cloud or dust. Since powder toner particles are so large, they create thick images - which cannot replicate the surface roughness of the paper. Powder toner images therefore have their own unique gloss which contrasts with the gloss of the paper. This gloss non-uniformity is perceived as poor quality printing. Plotting the gloss characteristics of the various digital and lithographic processes on a graph demonstrates that ElectroInk has practically ideal reflective characteristics, nearly matching the paper gloss for all but the very smoothest coated surfaces. DEP toners plot as straight horizontal lines on the graph, indicating they have their own gloss no matter what the substrate.

5. Color gamut

HP Indigo ElectroInk primary colors are similar to the ones defined in ISO 12647-2. This similarity allows the transfer of jobs between offset presses and Indigo digital presses with either minimal or no color transformations. The conformity with offset, in turn, enables the combination of digital and offset pages and the possibility to replace long offset runs (and the accompanying storage requirements) with a few short digital runs. The nature of the ElectroInk process earned HP Indigo digital presses GRACoL proofing and Fogra production certification, confirming their ability to create accurate color prints and work with well defined color standards for color printing.

ElectroInk is easily calibrated for out-of-standard thickness and dot gain supporting the use of different color profiles and removing the need to change ink per application. Therefore ElectroInk can use one CMYK color set for all applications, unlike lithography which requires many different CMYK ink formulations.

Beyond the four process colors (CMYK), HP Indigo digital presses may utilize up to three additional colors in the HP IndiChrome set (CMYK, orange, violet) or IndiChrome Plus set (CMYK, orange, violet and green) increasing available color gamut.

For very discerning applications which require accurate spot color, the unique HP Indigo Ink Mixing System (IMS) provides great flexibility to customers wishing to match specific PANTONE® spot colors. The system allows users to mix, on site, a wide range of special colors from a set of 11 base inks, with fully automated software guiding the user through the measurement, analysis, and mixing steps. (See color gamut schematic on page 3).

6. Instantaneous image drying

Because ElectroInk solidifies as soon as it transfers to the substrate, the finished print emerges dry from the HP Indigo printing press. Further image hardness is acquired in the first few hours post printing.
HP Indigo printed material can withstand considerable handling activities immediately, unlike conventional offset lithography, not equipped with assisted drying, which requires a drying period of several hours before further processes, such as cutting or folding, can be performed. Print drying is considered by GATF (The Graphic Arts Technical Foundation) as the number one problem of conventional lithographic printing, responsible for many image artefacts and defects, as well as print operation issues.

Both DEP and inkjet also produce ready to handle products, nevertheless the extreme heat needed for DEP to fuse on the paper or the requirement to absorb the ink of inkjet into the paper and then to dry it on the paper strongly limit the media selection for these technologies.

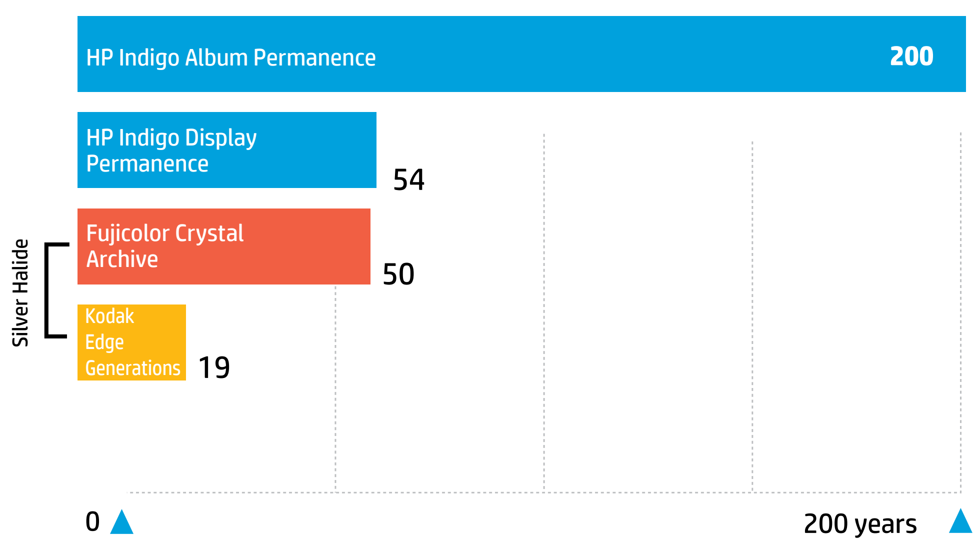
7. Lightfastness

The encapsulation of the pigment sub-particles within the ElectroInk plastic resin helps preserve the chemical properties of the pigments against oxidation and humidity effects, especially under strong ultra-violet daylight conditions. This means that color durability of printed images, either in the form of fading or deepening, is superior compared to conventional offset printing.

Photo consumers are also seeking alternatives to traditional photo printing with silver halide chemicals. In new testing* conducted by Wilhelm Imaging Research (WIR), HP Indigo prints exceeded or matched the display image permanence ratings of the best-rated silver halide product. The WIR testing also validated the album permanence of HP Indigo photobook pages, which received the highest possible dark permanence rating of > 200 years. In comparison, the WIR gave all the silver halide photos a much lower album/dark storage rating of > 100 years.

* Results published on March 7, 2011

Figure 12
HP Indigo print permanence maximum longevity compared with silver halide



Substrate compatibility

1. Variety

HP Indigo's Digital Offset Color process is compatible with a wider variety of substrate types, surfaces and thickness than any other digital printing process. These include paper, card stock, plastic, film, paperboard, and metals. Only one formulation of HP Indigo ElectroInk is needed to print on any stock that the press can handle. This means that HP Indigo press users can rapidly switch between substrates without having to worry about changing inks. With conventional offset printing, different inks for papers and non-absorbing plastic films are required; the latter usually need UV polymerizable inks. When printing on paper stocks with different absorbencies, it may be necessary to adjust the viscosity of the ink by means of thinning or thickening agents, or even use specially formulated inks. Particularly absorbent papers can also increase offset ink consumption by up to about 50%, which contrasts with ElectroInk where consumption has almost no dependence on the substrate properties.

DEP technology is heavily dependent upon the electrostatic properties of the paper substrate, and small changes in the environmental relative humidity may result in noticeable variations in print quality. Moreover, the high fusing temperature needed for DEP puts serious limitations on the choice of coated paper stock or plastic films that can be printed.

Inkjet suffers from even a stronger limitation due to the requirement to absorb the ink into the media. Plastics are out of the question unless dealing with UV inks or coating the media with a coating that will, in effect, absorb the ink.

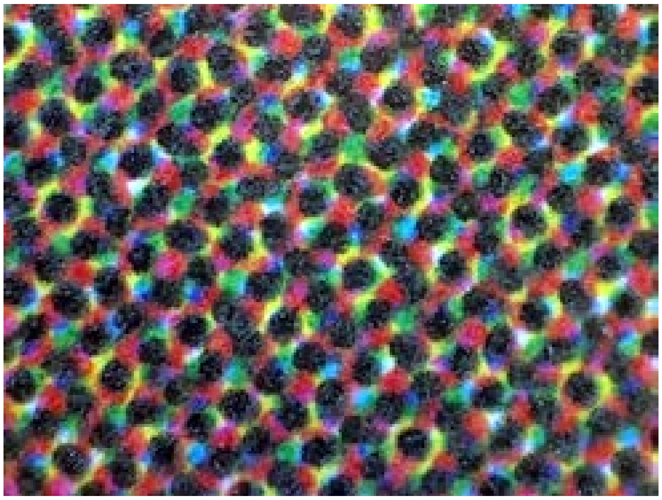
This flexibility in media is what led HP Indigo industrial presses to be the leading source for digitally printed labels and also serve as a replacement technology for flexography. For commercial printing, if there is a need to print on very rough surfaces or off-the-shelf offset papers, this can be achieved by the application of HP Indigo ElectroInk Primer. The primer uses a special additive that chemically binds to the paper on one side and the colored ink on the other, thus strengthening the link between the two. The primer is contained within a transparent ink that can be installed in a normal ink station on the press. As it is applied as an ink, the DFE simply creates an additional separation that selectively applies the ElectroInk Primer to only those areas of the substrate where the image appears. The result is an almost limitless range of substrates, including standard offset stocks and specialty media.

2. Lamination and over-varnishing

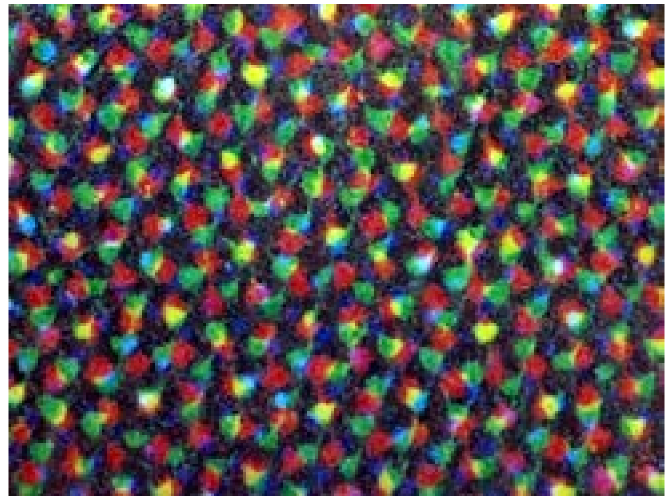
Stock printed with ElectroInk is compatible with standard coating processes such as lamination or varnishing. Lamination of thin plastic films over the printed stock can be done in the conventional way, using a variety of solvent-born, water-based, UV-based or solvent-free adhesives.

A varnish coating, either UV or water-based, can also be used and ElectroInk plastic resin withstands a large variety of chemical solvents. No significant image degradation occurs when using most of the standard coating materials.

Applications printed in Enhanced Productivity Mode, maintaining HP Indigo's high print quality at higher productivity and lower cost.



CMYK



EPM

Figure 13 Compare CMYK color dot prints to Enhanced Productivity Mode printing in three colors.

Productivity and versatility

Enhanced Productivity Mode (EPM) takes advantage of the inherent flexibility of the HP Indigo Digital Offset process to deliver improved productivity for only a modest, likely unnoticeable, reduction in the color gamut (primarily in the very dark areas of the spectrum). As all color separations on HP Indigo digital presses are produced on a single engine, color jobs can be printed 33% faster in CMY while eliminating the black (K) separation. Complex algorithms in the Print Server's color management process translate the black (K) separation information in to the remaining CMY separations, generating the black effect by overlapping the three remaining colors. The result is indistinguishable to the eye from standard 4 separation CMYK (small differences may be noticeable in thin black lines and very small black text), and is suitable for any but the highest quality print jobs.

Rules-based pre-flight solutions can automatically filter print-ready PDF files to select those best-suited to EPM, communicating with the HP Indigo DFE to insure that the files are printed in the correct printing mode, making its deployment simple and effortless. EPM also determines whether any sheets in a job contain only black, in which case they are processed separately as black-only (K) with no additional colors. This allows EPM to be efficient even when pages in the job are black-only.

In addition, eliminating black (K), has been shown to result in some improvements in print quality (increased smoothness, reduced graininess). These improvements can be enhanced even further in combination with light colors light inks (light black, light light black, light cyan, light magenta) which deliver smoother tone transitions and saturated colors. This is particularly advantageous in Photo applications, to achieve silver halide quality.

Color management

Indigo has developed a suite of integrated tools designed to simplify and automate the color management process. These tools ensure that the exceptional Indigo color accuracy remains consistent and uniform across presses and sites and over time, without laborious manual calibration.

The Indigo Color Management system starts with the media; an Inline Spectrophotometer scans a color chart to describe the individual color space of a specific substrate (the "Media Fingerprint"). The DFE (Digital Front End) then automatically generates a dedicated ICC profile, ensuring accurate color matching of that specific substrate against a given FOGRA, GRACOL etc. tool based on standard such as ISO 12647-2.

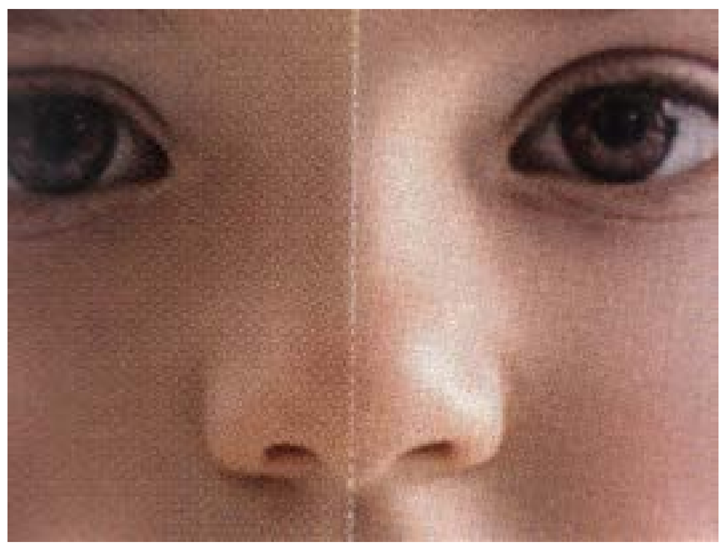
Accurate matching to these industry standards also enables seamless emulation of output from other print technologies (such as offset).

A three-dimensional LUT is then used to regularly calibrate the press, automatically compensating for any variations in press conditions to return it to the baseline established by the Media Fingerprint, ensuring that color output always remains consistent. On web-fed presses this process happens at a pre-determined interval, whereas onsheetfed presses the operator is free to determine the frequency of calibrations.

Media Fingerprints can be saved and shared between presses and sites, and over time, to ensure a consistent output regardless of where or when the file is printed. HP PrintOS allows the easy and rapid sharing of substrate files via the cloud.

Future capabilities

HP Indigo continues to develop and enhance the technical implementation of its core Digital Offset printing processes to maximize its potential. Developments such as the new High Definition Laser Array (HDLA) writing head, due to be launched in 2017, are taking Indigo's already exceptional print quality to a new level. The new Writing Head increases the number of lasers in the array from 28 to 40, angles their deployment to halve the space between the image of each laser on the photoconductor, and increases Polygon speed by 140% to keep up with the process requirements. The result is a doubling of the precision with which each dot can be placed on the substrate for an improved addressability of 1600 dpi. This doubling of addressability enables both smoother screens with 180 lpi, a standard in Indigo printing, and new screens at 220 lpi, with smaller, nearly invisible rosettes. The main benefits are an increase in image smoothness, the elimination of graininess, and sharper, more accurate features. The impact can best be visualized as the equivalent of a four-fold improvement in digital camera resolution (e.g. 1.5MP – 6MP). Tests of Indigo's print quality with 220lpi at 1600dpi have indicated that it now surpasses offset lithography.



HDLA technology enables finer printing with 220 lpi screen (right).

Summary

The HP Indigo Digital Offset Color printing process is the only variable imaging printing technology that can equal or exceed the quality, color range, and substrate compatibility of conventional offset lithographic printing, as well as flexographic printing, and is also the best choice for replacing silver halide technology photo printing.

While competing with offset printing for print quality, the digital technology offers important benefits, both economic and environmental. Since each product may be targeted at a final recipient, waste is reduced and warehousing is minimized as pages may be printed just in time and on demand. Moreover, the HP Indigo digital process offers cost effectiveness and is environmentally friendly as it both reduces waste and eliminates the use of hazardous chemical materials.

Apart from the HP Indigo Digital Offset Color process, the other main variable imaging digital color press technologies are the DEP process and inkjet presses. The limitations of dry toner printing have been detailed above, but to recap briefly: fine detail and acceptable colors can only be achieved with very small pigmented particles. Dry toner particles have to be above a critical size of at least 5 to 9 microns otherwise they form a dust cloud and cannot be controlled in the press. Some DEP processes can produce high gloss toner images, but they cannot match the gloss of the substrate surface, thereby producing high “gloss contrast” which is perceived as poor quality. HP Indigo’s liquid ElectroInk uses oil to bind and distribute its pigment-carrying particles, which are about 1 micron in size, and consequently capable of creating much finer detail and thinner printed films. DEP presses, with their inherently limited process speed, require multiple printing units where the only flexibility is the decision of whether a unit engages the media or not. Therefore an important consideration when making comparisons between these and the single unit HP Indigo presses is simplicity. HP Indigo’s color switching technology enables single station printing presses, which results in flexibility, more compact presses, less parts to maintain, and less potential for things to go wrong.

For inkjet technology, the comparison parameters are different. inkjet technology requires both that the ink absorbs into the media and that vast amounts of liquid are evaporated from the media after the ink is placed. This severely narrows the substrate range and the image coverage of high speed inkjet devices. When combined with the inherent inaccuracy of the jetting and wicking, the result is a technology which, though very adequate for certain applications, is less versatile and less flexible and cannot compete for overall quality or for overall media range with the HP Indigo Digital Offset Color process.

To summarize, the HP Indigo digital printing process offers a unique combination of quality, versatility, and productivity unmatched by any other existing digital technology. The key considerations for organizations investing in digital color printing are quality, speed, total costs (fixed and variable), versatility, and product range, and though for some niche markets other solutions may be equally advantageous, HP technology places it as a leading contender in all these respects.

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