Quality, Flexibility and Predictability in Graphic Arts Printing

April 2021

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An Inkjet Insight White Paper
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Introduction

Advancements in LED Toner Compete with and Complement Inkjet

Inkjet Insight focuses on evaluating and optimizing inkjet solutions for printers, but as an unbiased source of information we also must recognize and communicate that *inkjet is not automatically the best solution for every scenario*. Even taking offset out of the mix and comparing only digital solutions, there are markets where the technology decision is not as straight-forward as most inkjet pundits would have you assume. This is particularly true in high-coverage, high- quality graphic arts markets.

When evaluating full color, perfecting presses for graphic arts applications some gating considerations are:

- Media compatibility & performance
- Print quality
- Productivity

Presses that meet these fundamental performance thresholds then can be evaluated in terms of their acquisition and running costs, application flexibility, workflow fit and, of increasing importance, environmental footprint.

This white paper considers the positioning of the Xeikon SIRIUS SX30000 LED dry toner press in the context of perfecting inkjet presses with an average price of under 2 million USD and the ability to print reliably on offset coated gloss stocks[1].

Media Compatibility & Performance

Often media compatibility is looked at as a check box in the buying process – but a deeper dive is warranted. The breadth of media compatibility and the weight or thickness of the media are both important factors– but look deeper at the level of quality and speed performance that can be delivered on each type of media and weight.

If you need to run on very thin or very thick papers you will find that sheet-fed inkjet devices don't handle media lighter than 50 gsm but excel at heavier weights of 350 gsm and a couple will support up to 400 gsm. Continuous inkjet, on the other hand, can often handle papers as thin as 40 gsm but the physics of wrapping media on a core and drying liquid at high-speed

[1] Devices priced under US 2 million printing high color reliably on offset coated gloss stock: Canon ProStream 1000 and 1800, HP PageWide T250, Kodak Prosper, Ricoh Pro VC70000, Screen TruePress Jet520, Canon VarioPrint iX, Komori Impremia IS29, Konica Minolta Accuriojet KM-1, Xerox Baltoro

begin to challenge most presses approaching 250 gsm with only a few able to handle up to 300 gsm. See the distribution of gsm handling below in Figure 1.

Figure 1: GSM Distribution. Solid colors represent gsm handling at full speed and lighter colors represent reduced speed for toner and/or coverage for inkjet

Overall media compatibility is also a discussion point. For many years, high-speed aqueous inkjet presses only ran on papers specially formulated for inkjet, and those papers were in scarce supply. In the past 5 years, media compatibility has expanded with most presses supporting offset uncoated media and even some offset matte coated grades, but non-porous media such as offset coated gloss is still challenging for most aqueous inkjet presses. There are fewer than 10 aqueous inkjet presses that will support gloss coated grades to differing degrees. UV presses have always been the exception and handle a very wide media range in type as well as thickness, extending beyond non-porous offset grades into textured stocks and some synthetics as well.

A few things to think about when considering aqueous inkjet for production on different types of media:

- Thinner stocks or certain offset grades may require ink to be limited significantly in order to avoid show-through, paper damage from excess liquid or to enable proper drying. This can make color appear “washed out.”
- A pretreatment fluid may be required to create compatibility with offset stocks or for optimal performance. Additional fluid (precoating) means additional cost and additional drying power or specialized dryers.
- Running on certain stocks may require the press to slow by as much as 50 percent from its top speed to ensure proper drying and to avoid humidity buildup inside the press.

Even when inkjet presses are compatible with particular classes of substrates, individual media must be OEM approved, linearized, and profiled for the specific press

Even when inkjet presses are compatible with particular classes of substrates, individual media must be OEM approved, linearized, and profiled for the specific press. Sometimes OEMs have only approved one or two options in a category which limits choice without further, costly testing.

The Xeikon SIRIUS SX30000 supports an array of media choices and weights from digital and uncoated through offset coated gloss and even some synthetics at weights ranging from 40gsm to 350gsm (27 lb. text to 130 lb. cover.) This outstrips all aqueous roll and sheet-fed devices and is second only to UV inkjet. With the Xeikon SX30000, color coverage alone has no impact on speed. The press can deliver full coverage and full color on any uncoated media up to 200gsm and slows by less than 20% to address coated media up to 100gsm and uncoated up to 250gsm. Speed is further reduced to handle coated and uncoated stocks up to 350gsm.

Print Quality

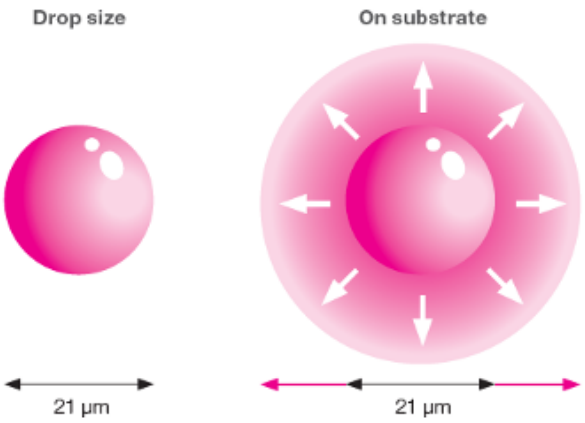
Print quality is not a single metric. It is made up of numerous measures describing the crispness and clarity of fine images and text, the sharpness of fine lines, the range and depth of color, the consistency of production and the resulting smoothness of the printed media.

Drop and Dot Size

Delivering clarity requires the ability to place dots accurately within an addressable grid, this applies to toner dots as well as inkjet drops. Finer dots in a tighter grid will deliver greater clarity with the goal of creating a bitmap of pixels that represent the exact intended image.

With inkjet, it's important to differentiate between the volume of a drop of ink and the size of the dot it makes on the media. The amount that ink will spread when it hits the media surface depends on the type and viscosity of the ink and the type of media. In the high-quality graphic arts range of presses covered here, the size of the minimum drop volume for most clusters around 2 picoliters with the smallest at 1.8 picoliters. In some cases the size of a drop could more than double in size. For example, a 2 picoliter drop volume will result in a drop diameter of approximately 40-55 microns depending on the substrate, ink chemistry and the resulting drop spread on the surface (dot gain.)

Figure 2: Example of inkjet drop size before and after wet-out on substrate (dot gain)



In contrast, dry toner devices can deliver a dot size regardless of the substrate of under 10 microns. That's a quarter of the size of even the smallest inkjet drop size. See the comparison table below. The electrophotographic process creates dots from minuscule toner particles that are attracted by a strong high-voltage electric field. This process happens over a tiny distance, virtually in direct contact with the media. Unlike inkjet, a 21 µm dot can be composed of multiple toner particles and will remain at 21 µm on the media with no gain.

Figure 3: Example of uniform toner dot circumference before and after fusing

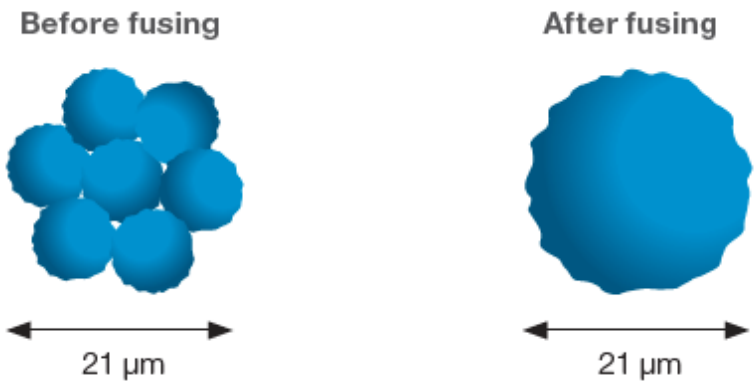


Figure 4: Comparison of dry toner and aqueous ink particle/drop and resulting dot sizes

	Ball diameter of particle or drop	Calculated volume of particle or drop[2] (pL)	Diameter of dot on substrate[3] (µm)
Dry Toner[1]	8	0.268	8-10
Inkjet 2 pL	16	2.1	40-55
Inkjet 3pL	18	3.1	55-65
Inkjet 5pL	22	5.6	60-80
	1. Size of dry toner particles range from 6-9 µm 2. Volume derived from perfect ball diameter 3. For inkjet, the final size on the substrate is determined by the amount of dot gain which varies based on ink type, surface energy, drop speed and absorption characteristics of the substrate surface		

In addition to controlling the size of the dot, there is also the matter of uniformity and placement of the dots. Even with the advanced presses serving the graphic arts market, since inkjet presses jet drops from nozzles at high speed from a distance onto a moving target, the process itself means that accuracy of dot positioning and dot uniformity can be at a disadvantage relative to toner devices which have virtually direct contact with the substrate.

Text quality is also a critical factor with recommended minimum text legibility for this market segment at 4pt or smaller. The dot size and accuracy of the Xeikon SX30000 allows it to clearly print text as small as 1pt, something that is impossible for the inkjet presses covered here. The smallest text clarity information available for a comparable inkjet press is over 2.5 pt.

One press technology is not inherently better than another. They are different and must be assessed on their merits

When talking about the quality of graphics, and particularly photographic or continuous-tone images, the conversation becomes more complex. Different technologies use completely different ways of managing dot placement within a grid. One is not inherently better than the other, they are different. In fact, many of the often cited differences between the processes is based on an understanding of the technology that is out of date.

AM and FM Screening

For context, consider that offset lithography uses AM screening or half-toning to reproduce photographic images. Ink used to be processed by a physical screen to create different dot sizes that are placed at specific angles creating a rosette pattern. If the angles are not correct, moiré or a wavy appearance can appear – a downside often attributed to offset. Since most offset is now computer-to-plate, angle problems and resulting moiré are no longer an issue unless the press has problems with registration.

With AM Screening, dot sizes placed on the grid can vary from 1% to 100% to adjust image density from highlight to shadow. Dots will vary in size, but not in placement. The addressable grid in this instance is composed of lines per inch known as the “screen ruling” which translates as LPI in offset speak. AM Screening is very strong in reproducing mid-tones but fine details in darker areas can be challenging. As a dry toner press, the Xeikon SX30000 has the flexibility to take an AM Screening approach similar to offset, varying color placement from 1% to 100%. The tiny dot size and absence of dot gain with toner provide exceptional control of fine details.

Small dots are an advantage for both toner and inkjet processes

Inkjet presses use Frequency Modulated (FM) Screening. Of course, there is no physical screen involved. Software uses a stochastic algorithm to randomize the placement of drops within a grid. Unlike AM Screening, all of the dots are assumed to be the same (or similar) size, but the distance between the dots is varied to produce lighter or darker tones. Randomizing the placement of drops smooths tones and avoids noise. With FM Screening midtones are harder to control due to dot gain. When dots connect or overlap, mottle and noise can result.

The illustration below shows an image printed using AM Screening on offset on the left and using FM Screening on inkjet on the right. Notice the smoothness in the AM Screening ranging from the midtones to the shadow areas of the picture below is not as smooth as the FM Screening. Midtones and shadow areas are more prone to plugging in offset due to plate impression. In contrast, AM Screening will provide less graininess when printing highlight areas than FM Screening. To remove the aspect of visual graininess in the inkjet drop, highlight areas in FM Screening require a drop size is 3pL or less.

AM Screening FM Screening

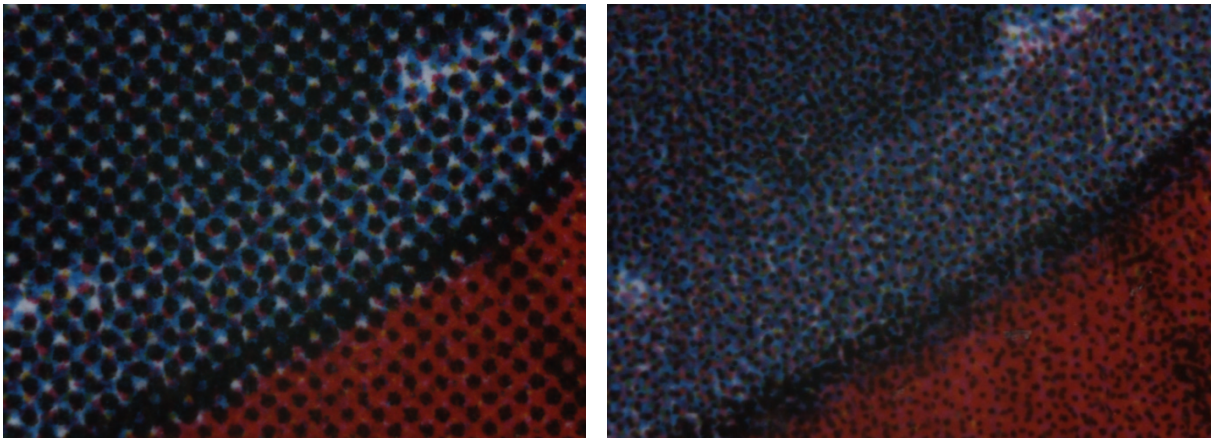


Figure 5: AM vs FM Screening. Image captured at ~2.5µm/pixel

Small dots are an advantage - if the dots are small enough, and the resolution high enough, the FM algorithm can create the optical illusion that there are no dots at all. However, unlike AM Screening, the placement of small dots with more space between them to deliver lighter tones relies on the color of the substrate. This means that lighter tones with fewer ink drops can pick up the color of the media – for better or worse.

FM Screening describes a process with a uniform drop size. However, most inkjet presses today are not binary, they can create 2 or more drop sizes (or deliver 2 drops to the same location to create a larger dot). This enables a multi-level screening approach. While they do not produce the number of differentiated drop/dot sizes of an offset or toner press, multi-drop (grayscale) presses equipped with advanced screening software can apply randomized screening in the highlighted and shadow areas and a non-randomized screening in the mid-tones to transition more smoothly. Because the dot size, as well as the relative positions of the dots, can be varied, inkjet presses with multiple gray levels can create smoother halftones and continuous images than those with a single drop size.

Both toner and inkjet have the potential to deliver results that rival offset. Print quality must be assessed by the measurable characteristics delivered, not assumptions about the underlying technology. Characteristics of line density, text density, show-through and of course color are easily quantified.

Color

Color gamut is an incredibly important factor when evaluating a press for graphic arts. Aqueous and UV inkjet presses targeting the graphic arts market can achieve a color gamut close to or even exceeding offset; however the gamut will vary based on the media being used. Since toner does not penetrate the substrate like ink does, all the colorant remains on the surface delivering more consistent results across media.

Inkjet excels in maintaining consistency of color from run-to-run, often maintaining color deviation of under 3 dE. This is largely because inkjet has fewer components that age and wear out than toner. Toner equipment typically requires more frequent calibration and service than inkjet devices to maintain color and image quality between runs and throughout long runs.

Print Defects

Inkjet presses can also suffer from cross-process density shifts leading to the appearance of banding. With inkjet, the slightest variance in the intended drop size jetting onto the page from one head can become easily visible when stitching hundreds of print heads across the sheet. When inkjet is not delivering the same visual optical density from all the heads, as shown below, cross- process directional banding will result.

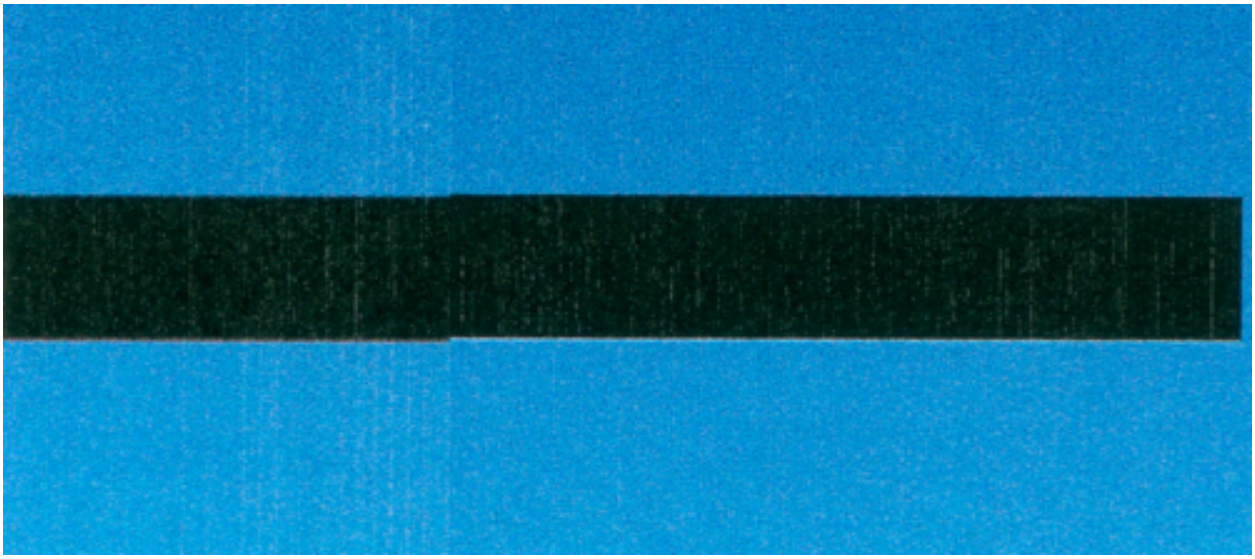


Figure 6: Example of Banding Defect.
Sample shows right to left, cross process directional banding

All printing processes are at risk for certain types of print defects or artifacts that can occur during production. With aqueous inkjet, print defects often come from the process of removing excess water from the substrate and the potential for mottle, cockle and curl if coverage and drying are not appropriate for the media. Inkjet is also subject to the dreaded “jet out” where a clogged or misfiring nozzle causes a visible line in the print. Many of the latest graphic arts

presses have real-time quality control and nozzle compensation systems – but jet outs and banding are still possible.

Toner does not suffer from the jet out or fluid extraction problems, but as noted earlier, with more aging parts toner is more subject to print defects caused by wear. This could include print mottle due to incorrect transfer current settings, picking due to poor toner adhesion and streaking or curl. Heavy coverage output from toner presses may also be subject to cracking over a score because the scoring process weakens or thins the toner as it cuts partially through the surface. UV inkjet have the same problem. Because aqueous ink partially absorbs and bonds with the surface it will not crack during scoring. This is less of a problem for all processes today as many finishing systems use "compression creasing" which creases by creating an impression score from the top as well as the bottom of the sheet rather than traditional impact scoring which is applied to one side of the sheet. This approach compresses the toner (or UV ink) firmly onto the media instead of weakening the bond.

Consistency and Durability

Many toner and inkjet presses are also challenged to keep the print consistent from one side of the sheet to the other in duplex printing. For toner, this is because the hot fusing process dries out the paper when the first side of the paper is printed changing the moisture level, surface of the paper and due to overall shrinkage when the second side is to be printed. For heavier media, the problem is magnified because higher fusing temperatures are required.

The Xeikon SX30000 has novel approaches to overcoming many of these potential quality issues. First, the press prints and fuses both sides of the page at the same time, improving color consistency, ensuring registration, minimizing paper deformation and driving higher production speeds. Xeikon adds further quality control through a closed-loop quality management system with onboard spectrophotometers and registration cameras to ensure color consistency, density and accuracy without the need for operator intervention or frequent calibration. Most graphic arts inkjet presses have also added inline quality control systems.

Once the image is printed and dried, cured or set, the next challenge comes with durability. UV curable inkjet is the gold standard for durability and resistance from scuffs, scratches, heat, water and chemicals. However, when UV varnish post-coat is applied to a print from a dry toner digital press (or an aqueous inkjet press), it becomes as scuff and scratch resistant as its UV inkjet competitor. The same idea applies for heat resistance and chemical resistance; laminations can be applied to remedy most potential issues.

The Xeikon SX30000 offers a web finishing module (WFM) to improve the scratch and scuff resistance of the print that also eliminates static charges that could lead to finishing problems.

Productivity

Productivity is an area where continuous inkjet excels. With speeds of 400 to 500 feet per minute, a 2-up roll-fed printer can generate over 2,000 images per minute. However, for many devices that speed is cut in half for top quality production or when printing on specific media. Even at half speed, these presses are powerhouses and are priced accordingly. The range of available sheet-fed presses for graphic arts top out at around 300 images per minute.

The productivity of the Xeikon SX30000 sits between roll-fed and sheet-fed inkjet. With a speed of up to 30m/min or 98ft/min, producing 2,545 B2 sheets 4/4 per hour or 428 US Letter pages per minute, the press is 50% faster than the top sheet fed inkjet press and approximately half the speed necessary for top quality on continuous inkjet presses in the segment under review. However, at top speed those presses are 3 to 4 times faster than the SX30000.

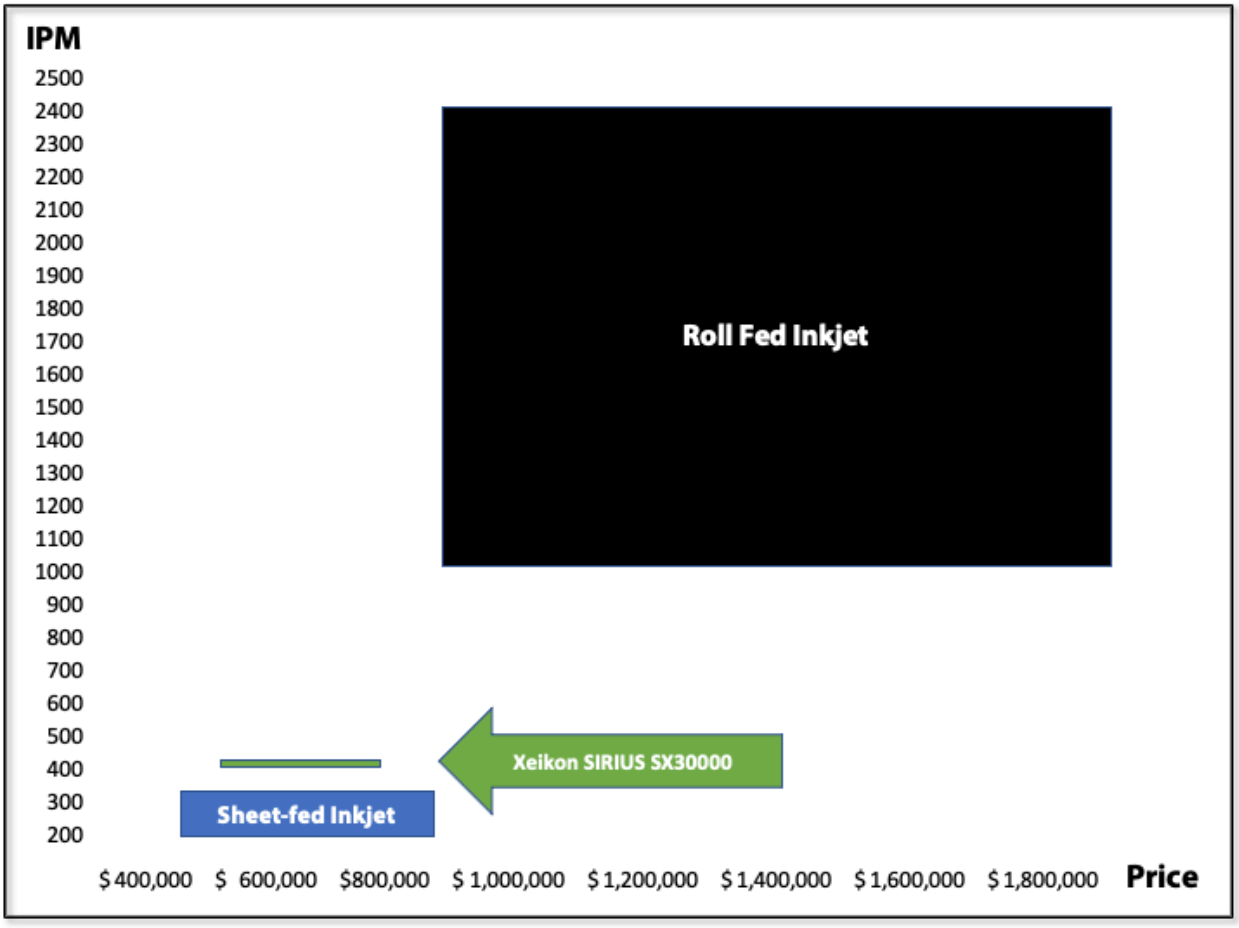


Figure 7: Xeikon SX30000 Productivity and Acquisition Cost vs. Graphic Arts Inkjet Presses

Of course, if you don't have the volumes to keep a continuous press running, that additional speed is moot. When comparing the productivity tradeoffs between the SX30000 and sheet-fed

inkjet acquisition suggest that there are opportunities for toner to shine that start with lower initial investment cost, but extend to flexibility and application flexibility.

Cost Considerations

An inkjet purchase is usually justified over toner based on total cost of ownership (TCOP) for monthly page volumes over 4 million and sometimes as low as 2 million. However, calculating TCOP for digital presses is very complicated and varies widely based on the nature of the work. Some of the factors that will shift the efficiency crossover point for toner versus inkjet include:

- Ink usage: The slower speeds required on many presses to achieve high TAC/coverage can also decrease the flexibility of turnaround capability.
- Press format: sheet-fed inkjet presses in this category are slower than roll-fed
- Workflow efficiency: compatibility with existing finishing capabilities impacts acquisition and running costs
- Job variability: frequency of media changes, support for offset stocks without precoating and ability to adjust coverage levels on the fly impact cost efficiency
- Ink type: UV inks are more expensive than aqueous, aqueous ink prices vary widely, and sheet fed ink costs are higher per liter than roll-fed inks
- Toner type: LED toner will fare much better in cost comparisons with inkjet than Laser toner because a fixed array of LEDs is much less expensive to purchase and maintain than the moving mirror system required for laser.

As an illustration, the zone of profitability when comparing the Xeikon SX30000 to roll-fed graphic arts presses could end at monthly volume of less than 2 million pages per month, or extend to almost 3 million pages per month depending on the variables above, the average running speed of the presses and the value of the completed work in a single, 8-hour shift (see below)

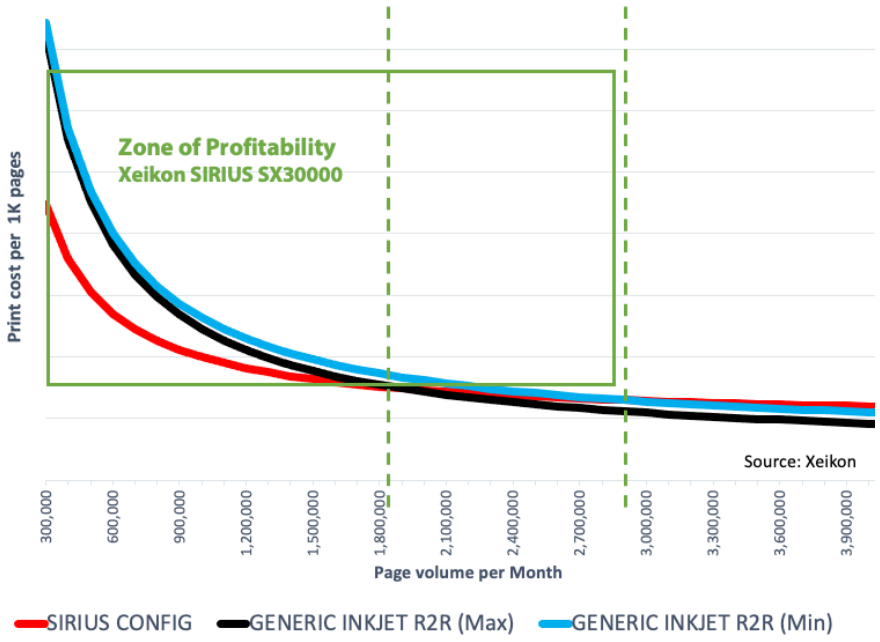
Figure 8: Zone of Profitability

TCOP will also differ for each company based on their negotiated machine, maintenance and materials prices, as well as their mix of business and running volume. However, there are broad comparisons that can be made as a benchmark on particular use cases.

Some companies prefer to mitigate risk by having two lower speed devices rather than a single high-speed device. This approach allows greater flexibility for shops that have a mix of large and small jobs on a wide range of stocks as well as providing business continuity assurance. Naturally, floor space and the size of the press(es) also plays a role in decision making.

Another factor that varies operation by operation is the cost per square foot of real-estate. Of course the cost per square foot may be less of a factor than the ability to fit a new press in the existing space. The images below show roll-fed inkjet press sizes and sheet-fed inkjet press sizes compared to the Xeikon SX30000. Note the fairly dramatic differences in the relative footprints of the presses.

Figure 9: Footprint 1, Roll-fed graphic arts inkjet press compared to XEIKON SIRIUS SX30000



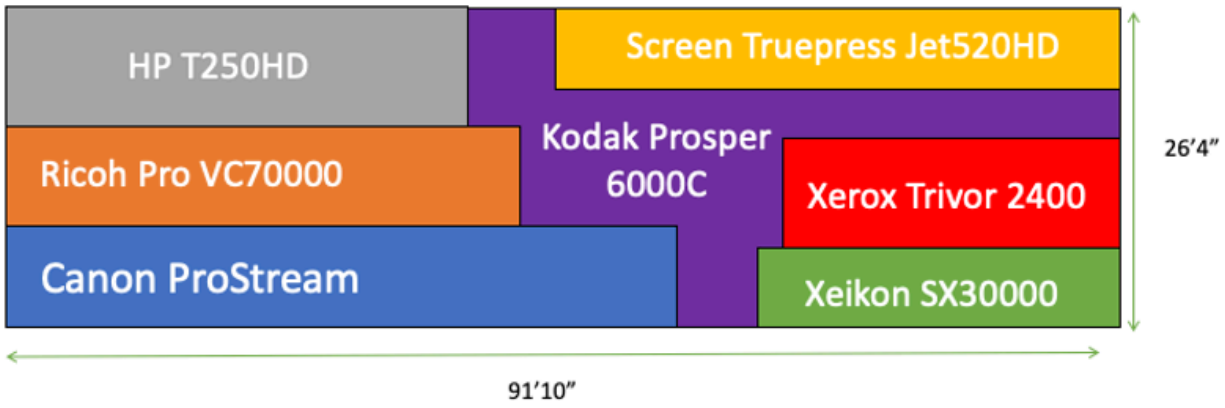
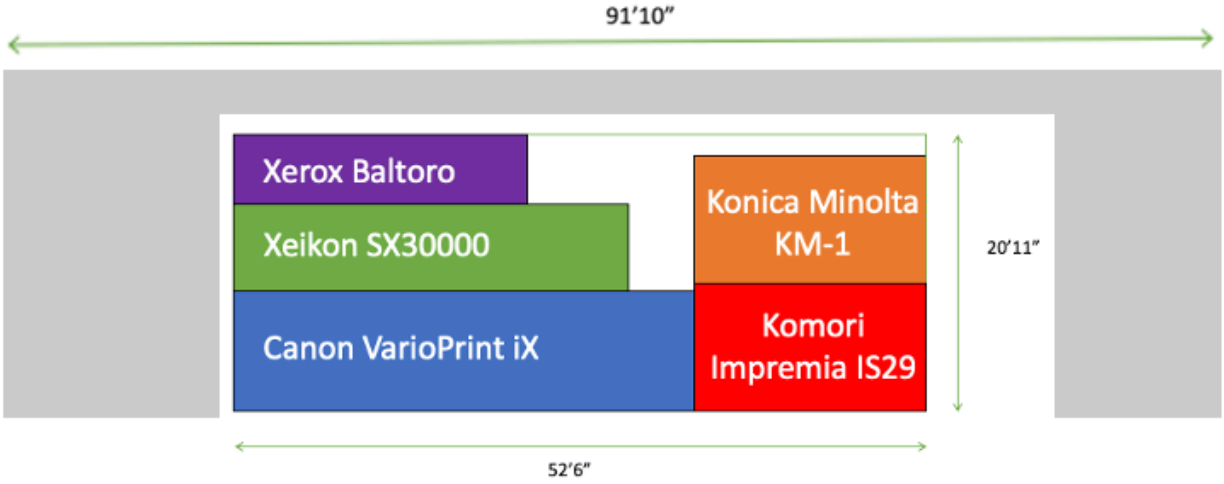


Figure 10: Footprint 2, B2 and B3/SRA3 sheet-fed graphic arts inkjet press footprints compared to XEIKON SIRIUS SX30000 (and relative to footprint of largest roll-fed press)



Considerations Beyond Cost

While reduced running costs are a strong justification in many scenarios, there are still places in the graphic arts segment where the flexibility of toner in general, and the productivity of the SX30000 specifically make sense; particularly for companies that don't have consistent volumes and want to have predictable costs.

Pricing for inkjet jobs can be complex because ink usage is variable and can represent anywhere from 20% to more than 50% of the cost of a job. To make matters more complicated, ink usage to deliver color targets will vary from substrate to substrate and additional costs may be incurred for precoating fluids. This can be a complex concept for sales teams to grasp and failure to do so can have consequences to job profitability. Recent research "Inkjet Insight Production Market Survey of Ink Estimating Solutions," indicates that many inkjet users in graphic arts segments often don't have access to files in order to perform ink estimating prior to quoting a price. Toner costs are typically included in the click charges so estimating is much easier and less risky. Xeikon offers multiple pricing models for the SX30000 including a fixed,

per click model and variable cost models. To add more insight to a variable model, Xeikon provides calculation tools to help customers estimate correct job costs and predicted toner consumption per job.

Risk Avoidance and Flexibility

Many print markets have shown an unpredictability in monthly print volumes as shorter print run lengths become more popular and customers increase demand for versioning and personalization (mass customization). This has driven growth in digital print either as a replacement for or complement to analog presses.

When volume is unpredictable, choosing a press with maximum flexibility to adjust to different job types is key. This includes the ability to print full coverage on thin and thick media support for a wide array of media types as described earlier. But the flexibility of how the printable space is addressed also drives flexibility. Sheet-fed presses are limited by their physical sheet size, where as many roll-fed presses limit down-web single image print length to around 50 inches. The Xeikon SX30000 with a down-web single image print limit of 50 meters (~164 ft) instead of inches is massively more flexible. This impacts applications such as banners, and complex multi-part mailings such as Health Insurance Annual Notice of Coverage (ANOC) documents. Toner devices are typically limited by fuser width to 20 inches which is narrower than a typical inkjet 2-up device at 20.5 to 22.5 and of course there are continuous inkjet a double that width.

An additional opportunity for success in varying job types is the ability to add a 5th color. Several inkjet devices have the opportunity for a custom color, a special black ink or UV reflective ink, but not white ink. Xeikon offers options for white, extra magenta, Xeikon blue, red, green, orange and UV reflective which can support security applications as well as Point-of Purchase (POP) and wall coverings. Xeikon also develops specific brand colors and custom security inks. Unlike inkjet presses where a 5th color station is typically dedicated to a particular purpose (or changed over only with significant time and expense) color options with the SX30000 can be easily swapped and even the color sequence can be modified at the job level.

Another factor to consider is the sustainability of the press. For inkjet inks, aqueous inks being mostly water are inherently less toxic than UV inks, however the level of volatile organic compounds (VOCs) varies widely even among aqueous inks. The chemistry of many new generation of inks have expanded the use of solvents or polymers to expand media compatibility.

Beyond the chemistry of inks, their processes have sustainability aspects as well. UV inkjet inks arrive in plastic bottles that leave ink residue and require rinsing and flushing which must be done within safety guidelines. (Aqueous presses do not have the same issues.) UV inkjet processes produce the toxic material ozone which requires filters to mitigate problems with smell or intoxication.

In addition, the printing process used has an impact on the ability to recycle. Deinkability is more difficult with inkjet presses than with toner because the ink penetrates the substrate surface. The Xeikon SX30000 delivers pages that are 100% deinkable using no water, oils or VOCs. In addition, Xeikon's toner production plants run on 100% green energy, making the SX30000 one of the most sustainable press choices in the market.

Summary

When considering options for digital presses to replace or complement offset, don't rely on outdated assumptions about general categories of technology. Make decisions based on data for cost and quality that are specifically relevant to your business needs.

Make sure to understand the tradeoffs between media, coverage and speed rather than just looking at lists of "compatible" or "approved" substrates. Also understand the process and chemistry needed to achieve compatibility and whether it increases production costs.

When all of the assumptions are taken into account, along with the consistency of assumed volumes and the risk tolerance of the buyer, often there are multiple suitable options.

By simultaneously reducing the cost barriers between inkjet and toner and overcoming many of the consistency and productivity barriers associated with toner, Xeikon has introduced a highly viable solution into the mix. For volumes of under 2 million to as high as 4 million letter images per month in a single shift, with the potential for 3 times higher in a multi-shift environment, the Xeikon SIRIUS SX30000 is a strong competitor in the graphic arts market place.

About

Xeikon, a division of Flint Group, is a long-standing leader and innovator in digital printing technology. Grounded in the principles of quality, flexibility and sustainability, Xeikon designs, develops and delivers web-fed digital color presses for label and packaging applications, document printing and commercial printing. These printing machines work with different imaging technologies, open workflow software and application-specific consumables.

In 2015, Xeikon joined Flint Group to create a new "Digital Printing Solutions" division for the leading global print consumables and solution provider to the packaging and print media industries. Flint Group develops and manufactures an extensive portfolio of consumables for the printing industry. These include a vast range of conventional and energy-curable inks and coatings, press room chemicals, printing plates and equipment,

printing blankets and sleeves, and pigments and additives for use in inks and other colorant applications. The Flint Group is based in Luxembourg and employs around 7,900 people. On a worldwide basis, the company is the number one or number two supplier in every major market segment it serves.

About Inkjet Insight

Top industry experts combined their resources, creativity and brainpower to offer a deep dive into the world of production inkjet. The result is InkjetInsight.com, the most complete, unbiased and valuable source of information for companies evaluating and using production inkjet. Find specifications for inkjet presses, important software and workflow products and compatible finishing and media along with downloadable tools for evaluating products and measuring quality.

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