Automating the Production Process to Provide Standardized Print Quality

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Abstract: A discussion of the crucial role of standardized quality in print jobs and the ways to achieve it in light of the increasing challenge to produce shorter runs while meeting shorter deadlines.

Introduction

Print buyers all over the world are asking for shorter runs, faster turnaround times and a consistent and better print quality. The role of the printer is being redefined by the advent of push-button printing, where many press functions are automated and where crucial decisions as to ink balance and density – formerly the sole province of skilled tradespeople – are made faster and more accurately by electronic sensors. One of the fastest color output options is the digital press, which requires no film or plates and which rasterizes files directly to a high-resolution, fast digital printer. But while this method *does* offer short turnaround, it supports a limited number of substrates, and the color quality it offers has been defined as "pleasing", rather than "perfect". Systems from vendors of digital printers have therefore found a niche in service bureaus for short-run color printing, but have not supplied a solution for the high-end printing market, which requires print quality monitoring and integrity control. This is where digitally-integrated offset comes in. Maintaining the high quality of offset while providing the benefits of automation and integration with prepress in a fully digital workflow, digitally-integrated offset offers standardized quality, consistently, avoiding the variations resulting from conventional offset processes.

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Standardized Quality and its Benefits

Standardized quality means achieving predictable high-quality results by compensating for fluctuating external conditions such as printed substrate and the particular press and ink used, regardless of the operator performing the job. The consistency allows the printer to run more jobs on the digitally-integrated press than can be run on a conventional press. The printer knows that if the file has been prepared properly, it will print as expected. This high predictability enables the printer to schedule more jobs at the entire production site – from prepress to bindery – well in advance.

The ability to set higher expectations and meet them, on time, gives printers a significant commercial advantage. For the customer, increased confidence in the quality of the output reduces the supervision required and results in more opportunities for remote printing. The only aspect that might be conceived as a disadvantage for traditional printers is the elimination of the option to edit on press. The current model for many print buyers is to come on press during the makeready and work with the printer to achieve the desired results. The standardized quality model, which requires a color management system, is less flexible, but far more predictable and consistent.

What is Tolerance and How is it Measured?

Consistent print quality – in terms of uniformity within a page and repeatability among sheets – is measured within a given tolerance. Two points within a given tolerance level should appear visually similar. Subjectively, tolerance is measured by a visual comparison of the proof to the printed sheet, in search of variations. This time-consuming method requires high levels of operator intervention and experience. On the other hand, tolerance can be measured objectively by a number of different methods. These include densitometric measurements – such as solid ink densities, dot gain, contrast, trapping, hue error and grayness – and colorimetric measurements, such as RGB, XYZ or Lab.

Densitometric measurements do not relate directly to color, although they are used in standard methods for defining print tolerances, such as solid ink densitites and dot gain. Density-based tolerances, which are defined separately for each separation, have cumulative effects on color.

More informative are colorimetric-based tolerances; these formal assessments use dE (delta E) as a common tool for measuring color differences between two prints. A commonly used dE is dE_{Lab}, which is defined on the Lab color space by the Euclidean distance between two Lab vectors:

$$dE_{Lab} = \sqrt{dL^2 + da^2 + db^2}$$

where:

$dL^2 = (L_s - L_t)^2$

$da^2 = (a_s - a_t)^2$

$db^2 = (b_s - b_t)^2$

and (L_s, a_s, b_s) & (L_t, a_t, b_t) are the source and destination Lab vectors respectively.

When comparing color on the same target printed under two different scenarios (source and destination), it is necessary to define a good target that fully represents the characteristics of the color space. If n source and destination points are measured and compared, then dE_i is calculated for each pair i, i=1...n, and the most commonly used measure of performance is average dE. More informative measures – which may compensate for the information lost by averaging – are maximum dE and the standard deviation of dE.

The limitations of dE_{Lab} in the correct evaluation of visual color differences have been acknowledged by many researchers and color experts, and numerous correction and alternative methods have been derived (for example, Robertson, 1990; McDonald, 1990; Luo and Rigg, 1986; Melgosa, Hita, Poza and Perez, 1996; CIE Technical Report 116, 1995). But whereas the new methods compensate for certain of the inherent problematic issues of dE_{Lab}, none so far have provided a comprehensive solution to the color difference and tolerance problem.

Existing models fail to match a tolerance definition to its real manifestation. In other words, within the same tolerance range, there may be large discrepancies between the visible variation in color for different points. A need has therefore arisen to define a model that maintains the correct correlation between color variance and tolerance level. Such a tolerance definition model aims to reach agreement between visual and formal assessments of color.

How to Achieve Standardized Quality

Standardized quality is achieved with a reliable color management system that provides consistent color – within a given tolerance – with full automation and with a stable inking system. The 74 Karat press is designed specifically for the needs of today's printing market, including standardized quality. It is thoroughly automated, with no operator intervention in plate loading, imaging, color-calibrating, printing or washing up. A number of technical innovations contribute to its hands-free operation and to the standardized quality it offers:

1. The **Gravuflow inking system**, a keyless, self-calibrating method that makes mechanical ghosting virtually impossible and achieves highly predictable quality color right from the first few printed sheets.
2. **A color management system** that reproduces color with scientific precision and high fidelity on a consistent basis.
3. **Full automation**, minimizing operator intervention and maximizing predictability.
4. **Waterless printing**, which eliminates the variable of changing ink-water balance, thus removing another skill requirement for production. The consistent, repeatable waterless process is also a key enabler of high-quality, proof-matching keyless printing.

A Keyless Inking System

Color space definitions vary not only among devices, but also between presses, papers, inks, and imaging parameters – such as dot shape, angles and screen ruling. The 74 Karat press provides stable press conditions by implementing the unique, keyless Gravuflow inking system, designed specifically to provide consistent, uniform ink densities across the press sheet. The self-calibrating Gravuflow system includes standard elements of the conventional offset inking system, but at the same time it integrates elements from inking systems of other printing processes, including the doctor blade from Gravure and the anilox roller from Flexography.

Conveniently packaged, standard ink cartridges provide the press with a constant, automatically-controlled ink flow. The ink chamber includes sensors that detect the level of ink and automatically keep it at a prescribed level by instructing the ink-dispensing unit how much ink to deliver. The ceramic Gravuflow roller is precision engraved with cells that fill up with ink. The doctor blades in the ink chamber level the surface of the cells to maintain a consistent ink film on the Gravuflow roller, which is then transferred to the form roller. The form roller delivers ink to the plate; its circumference is identical to the length of the plate. Since each plate cylinder holds two plates, the form roller makes two revolutions for each revolution of the plate cylinder, thus coming into contact with the Gravuflow roller twice for each time it meets the plate. After each ink replenishment cycle, the form roller comes into contact with a single plate. Prior to its next contact with the plate, the ink layer on the form roller is entirely replenished, so that it can again deliver exactly the amount of ink required, independently of ink "consumed" during a previous cycle.

This image-independent inking system eliminates mechanical ghosting and ink "starvation", and creates superbly consistent ink densities from the gripper to the tail and from side to side of the press sheet. The Gravuflow system inks each printing dot with complete precision, creating beautiful solids and consistent results, sheet-to-sheet, job-to-job, rerun-to-rerun. It comes up to color rapidly, requires little time to stabilize, and being keyless, eliminates the possibility for making adjustments.

Benchmark Results: Standardized Quality in the 74 Karat Press

Results of tests run on the 74 Karat press indicate that it can produce a higher level of standardized quality than a conventional offset press, in terms of both among-sheet repeatability (throughout the run) and on-sheet uniformity.

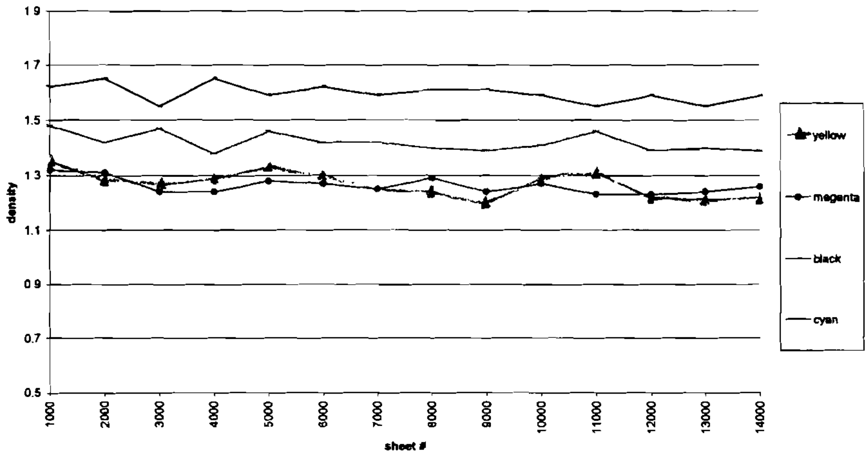

Figure 1. Long-run repeatability, represented by solid ink densities measured every 1,000 sheets

Figure 1 shows that throughout a run of 14,000 sheets, the solid ink density is stable, in all four colors.

Figure 2 demonstrates on-sheet uniformity of the 74 Karat press compared to that of a conventional offset press. Measurements are based on Lab values of three gray patches: light gray (with CMY=[25,19,19]), medium gray (with CMY=[50,40,40]), and dark gray (with CMY=[75,64,64]). Gray patches were chosen in order to account for visual color deviations in C,M,Y, as was suggested by Beatrix B., et. al. (1998), who established that gray is best suited as an indicator for color deviation.

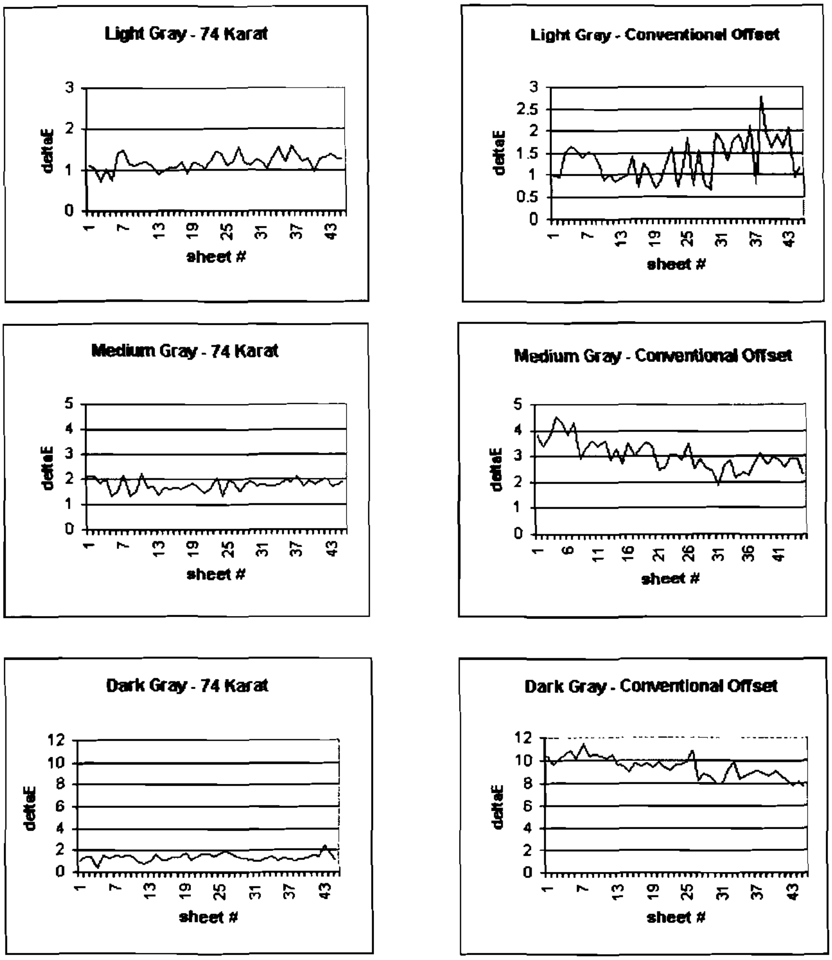

Figure 2. On-sheet uniformity of the 74 Karat press compared to conventional offset (SpeedMaster SM74)

Although the application of dE is limited, as discussed previously, it is very useful as a comparative tool for patches that are visually similar, such as grays. Figure 2 shows measurements of Lab values of two identical gray patches, printed on the right and left sides of the sheet. deltaE (on the y axis) between the two identical patches was calculated for 45 consecutive sheets (x axis). The left column corresponds to deltaE of the 74 Karat press grays and the right column to conventional offset grays. Clearly, the 74 Karat press demonstrates much more uniform behavior, especially for the dark grays.

A Reliable Color Management System

Traditionally, the manipulation of color data to achieve desired results rested with the color scanner operator. Color manipulations were possible after scanning, but these processes were slow, limited in capability, and inaccurate. Color reproduction has always centered around the printing press, with all prepress processes calibrated to obtain desired results with a specific press/paper/ink combination. The required adjustments on a traditional press from job to job in this setup are registration of plates and adjustment of ink flow to match "ink take off" as a function of coverage. Any specific CMYK combination should theoretically produce the same color on the press sheet as long as the press/paper/ink variables remain constant. For maximum efficiency, the sheet on press is supposed to match the proof.

One of the advantages of conventional offset lithography is its ability to easily "cheat the system" to get desired color. By selectively adjusting ink flow in zones across the cylinder, different variations of colors can be obtained with the same CMYK dot area values on the plate. A disadvantage of this method is that changes in ink keys reflect in color changes across the entire strip on the plate, whereas a keyless system can control variations in different zones. As long as the entire process is full of uncontrollable variables – from separations through platemaking and press – the ability to adjust color on press is a necessary feature, even though the process is inefficient and occasionally unsuccessful. But developments in digital prepress and improvements in press controls, as discussed earlier, have enabled an evolution to a predictable, efficient workflow based on stable, uniform press conditions.

Responsibility for color on the 74 Karat press lies with the prepress department, which delivers the proof that the press must match. In order for this to occur, the color fingerprints of the press and proofer must be established and correlated. Once measured, the proofer, like the press, must remain in calibration and stable at all times. The Color Management Module (CMM) of the 74 Karat press creates ICC profiles– standard tables that tie together color spaces of different devices. Based on these measurements, the CMM builds databases that include fingerprints for devices, paper types, ink types and other variables.

Profiling is a key procedure in making color conversions. Profiles are developed based on the assumption that the printing or proofing system is first optimized and stable. A test form consisting of specific CMYK values in the digital file is then printed or a standard transparency is scanned. The color patches of the test form are read by a spectrophotometer to establish the correlation between

CMYK (used in printers and proofers) or RGB (used in scanners) color spaces, and CIELAB – an independent 3D color space – for selected points in the particular system. Color profiles contain tables of corresponding transformations between CIELAB (Lab) and CMYK for a specific input or output system. Color matching is accomplished by interpolating between measured values within a profile and then concatenating one profile to another – a mathematical calculation performed automatically by the system.

With the 74 Karat press, for every combination of press, paper and ink, there is a corresponding set of quantifiable parameters. Not only do color conversions depend on these parameters, but so do press settings. Feeder, delivery, impression pressure, and press speed settings must be adjusted accordingly. Fingerprint information in the form of color profiles, color conversion look-up tables and press/paper/ink parameters is maintained in database libraries within the 74 Karat press.

Subjective color matching and customer color approval begins and ends at the proofing stage. Changes can be made by editing the file (local correction, usually made by the designer) or editing the ICC profile (usually done by the operator). During makeready, the 74 Karat press is matched to the proof and/or to a reference standard print condition – such as Euroscale, Cromalin, SWOP or MatchPrint – quickly and accurately.

By employing advanced color management, the keyless inking system of the 74 Karat press achieves highly predictable quality color right from the first few printed sheets. Guesswork is eliminated, and no expertise is required since automation takes over. Color is not "invented" on press but reproduced with scientific precision and high fidelity on a consistent basis. This is one of the ways in which the 74 Karat press takes printing from art to manufacturing.

A conventional offset press workflow requires a continuous correction cycle during page assembly to match the proof, and another cycle of corrections after the plates are produced and the page printed, to adjust inking keys until a match is achieved. This process is time-consuming, requires great expertise, and is highly inconsistent and unpredictable.

With the 74 Karat press, the only correction cycle is performed by the Color Management Module, which automatically adjusts parameters such as paper, ink, weight and lamination. The press is calibrated to a reference print condition (such as Euroscale, Cromalin, SWOP or MatchPrint), and the proofer (such as Iris) is calibrated to the 74 Karat press. As a result of this calibration, the proofer simulates the 74 Karat press, which in turn acts like the MatchPrint standard, so that the printed sheet perfectly matches the proof, and looks like the MatchPrint reference. This is a very reliable process of real match to proof, where the result is fully predictable. Standardized quality is assured, time after time.

The following diagram graphically compares the production workflow of a conventional offset press with the more streamlined workflow of the 74 Karat press.

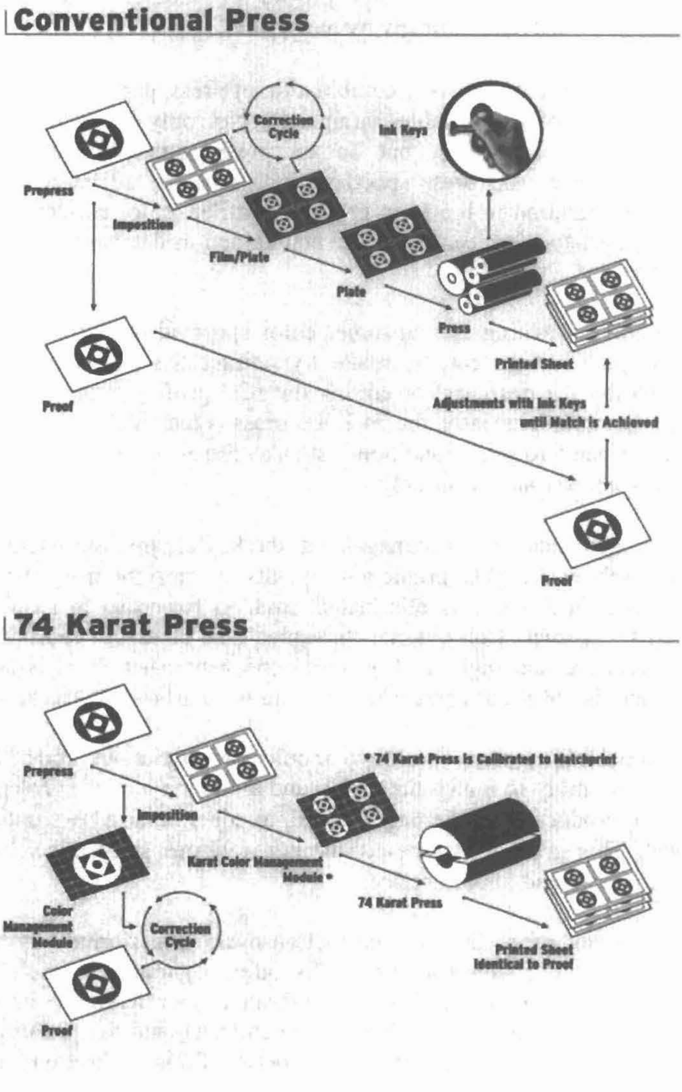

Figure 3. Printing Workflows

Conclusions

Standardized quality is an essential component in supplying the demands of consumers in today's printing market. Achieving consistent color to arrive at standardized quality requires high levels of automation, a stable inking system and an accurate color management system. A successful color management system relies on correct tolerance measurements. One of the key components of standardized quality is, therefore, a new model to match between formal and visual assessment of color differences. Accurate formulas that solve the tolerance problem eliminate the need for subjective assessments, which require expertise and time. Removal of one more human intervention level leads to standardized quality and more efficient production. The new tolerance model developed for the 74 Karat press facilitates effortless, accurate matching of press to proof, enabling consistent, standardized quality.

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