System Design Considerations for Contract Quality Color Proofing

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Abstract: System design for contract quality color proofing must integrate hardware, software and media to perform a variety of complex functions, which exceed normal press capabilities. Variables that impact the critical image quality characteristics such as consistency, color accuracy, and mechanical artifacts are discussed. Other factors such as productivity, functionality, and connectivity are also explored.

The Purpose of Contract Proofing

The primary purpose of contract quality color proofing is to provide a cost-effective predictor of the printed results in order to contract with the budget holder. Subsequently, the proof is used to communicate the budget holder's requirements for content and color to the press operator and those who must assess quality before materials are committed for manufacturing of a printed product.

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A paramount consideration in this activity is that the proofing system itself must not introduce defects that might cause confusion concerning the quality of the data in the electronic file. Dust and dirt, size accuracy, and handling defects are likely to cause such confusion and require that electronic files be brought up on the screen and inspected. A proof with dust and dirt is likely to require re-making, as are some handling defects such as smudges. This is one of the many ways that a proofing system must be held to tighter design constraints than production printing systems.

Size accuracy is a critical factor for all printing. However, inaccurate size reproduction will make a proofing system particularly unsuitable for the production of printed products such as packaging and greeting cards, in which die cutting and finishing operations must register to print. Size and positioning are also quite crucial in placing advertisements in publications.

An accurate conversion of text and page geometry is critical and dependent upon a common interpretation of the electronic file between the proofing device and the printing system. A proofed file that does not mimic the printing system can lead to costly errors. These types of errors are rarely forgiven by the budget holder and are usually found more objectionable than color errors that can often be considered more of a "judgement call".

Accuracy and consistency are primary drivers for the use of off-press proofing, and get to the heart of the benefits of off-press proofing over press proofing. These system characteristics will be discussed as some length later in this paper.

In order to be at all useful, a proofing system must allow convenient integration with existing workflows. Accurate electronic files must be able to pass from the user's host system environment to the proofing device in a file format that can be effectively used for proof output.

Last, but not least, a contract proofing system must be cost effective. It is critical to understand that cost effectiveness for proofing must be assessed in the light of its function. It protects valuable press time and materials.

Proofing in Practice

In practice, it is quite possible to be confounded when one is trying to implement a contract quality color proofing system. In order to be useful, a proofing system must approximate the printing conditions. We must match the relevant characteristics of the printing conditions with the proof conditions.

When we run the press, however, we must approximate the proofing conditions with the press, in order for the color to match the proof. This is the printing industry's chicken and egg dilemma.

When a proofing system is established, we must identify the reference printing condition and match it with the proofing system. Typically, we create the match through the use of controls which effect the critical matching factors listed in the next section.

We then use the proofing system as a surrogate for the press and create color separations that provide images that meet customer expectations using this calibrated proofing system. We then, in turn, run the press to the reference printing condition by matching the proof.

It is critical to note that in order to match the proof, the press must be run to approximate the proof, recreating the standard printing condition. It is noteworthy that earlier studies have demonstrated that a press operator will achieve the correct printing condition faster by running to the proof rather than "running to the numbers".

However, the numbers are very useful in troubleshooting when the operator has difficulty matching the proof.

Ranked Critical Matching Factors

Building on the work of the Print Properties Committee of the Graphic Communications Association, the SWOP Committee, marketing research work and over twenty years of experience, I have constructed the following list of ranked critical matching factors for a proofing system. Each of these is highly valued by those who must assess the readiness of electronic files and films and is required to fully represent a future printed product using a proof.

1. Dot Gain Control
2. Density Control
3. Overprint Trap
4. CMYK Colorant Set
5. Paper Color
6. Text and Graphics Resolution
7. Special Ink Colors
8. Halftone
9. Metallic Ink Colors
10. Trap (chokes and spreads)

Accuracy Vs Consistency

For purposes of discussion, the distinction between accuracy and consistency is important when we are discussing proofing.

We have seen proofing systems, which are accurate, but not consistent. When the "stars are aligned", they can produce an accurate proof. That is, they are capable of producing a very accurate match, color for color, to the production press if and when all the variables for press and proof synchronize. Often, however, these technologies fail because of the need for proofing consistency.

In a proofing system that does not provide a high degree of consistency, the critical matching factors are not held constant. Therefore, two proofs that are made at different times are made with slightly different conditions.

The press will match the proof only when it has matched the critical matching factors that made the proof.

The press can effectively create only a single printing condition at a time (with the limited exception of limited inking control). This means that the press cannot match both proofs simultaneously unless the proofs were made to the same conditions.

Differences between proofing systems are the primary cause for in-line color problems on press.

Any significant sources of inconsistency in a proofing system must be addressed. For example, variations in paper can create significant differences from proof to proof.

As most sheetfed printers know, paper is simultaneously sheeted from several rolls. This means, for example, that every fourth sheet might come from the same roll. The differences between the sheets of paper may cause an acceptable degree of sheet to sheet difference on press. However, using a different process, such as ink jet, may create wider color swings from sheet to sheet from the same stack of paper.

Some proofing processes are particularly susceptible to this type of problem and require that significant attention be paid to calibration for each paper.

One method of eliminating paper as a variable has been to seal the sheet with a laminate. The final proof surface conforms to the surface texture of the paper, reproducing its texture and gloss level. Subsequent treatment might increase or decrease gloss levels from this standard relationship, depending on the individual customer preferences.

Color Match is Superior with Digital Dot Gain

Although we use apparent dot gain (and print contrast) to measure this primary factor, they are really surrogates used to describe overall tone reproduction. Historically, apparent dot gain on press results from mechanical factors on press, paper and ink interaction, optical dot gain, and other factors.

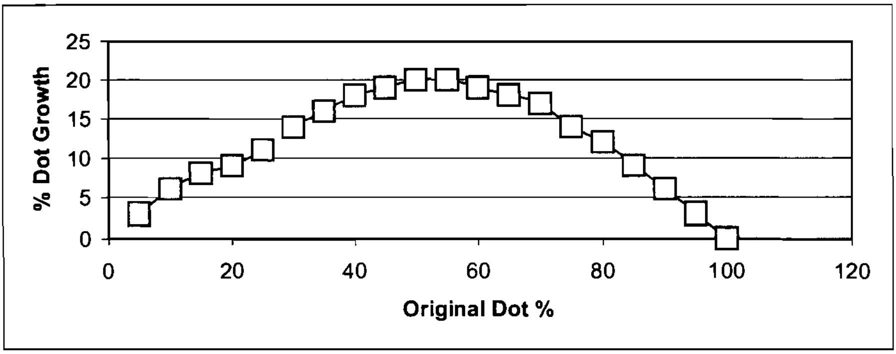
Original Dot Value VS Increase in Dot Value

The most successful off press proofing systems have approximated the press tone reproduction using spacing layers which cause internal reflections of the colorant layer, simulating the apparent dot gain of the press. This has been an acceptable practice, even today, for most printing systems.

One problem with this approach, however, has been a significant difference between the proof and the printed sheet in the quartertone area of the image using this method. The proof tends to darken the quartertone, causing those who are making the color separations to reduce the dot size in these areas, overcompensating for dot growth.

When the job is run on press, the dot size is too small. This creates a reduction in highlight detail and shifts the color of any tone that is made of a dot in the quartertone area.

If we graph the original per cent dot on the horizontal axis and the dot growth on the vertical axis, we get a visible result that has been called the quartertone dip. Because of its familiar shape, it is also known as the Volkswagen hump.



Proof Vs Press: Typical Analog Proof

Because we can control the dot reproduction throughout the tone scale, color matching between the proof and press can be superior to traditional off press proofing methods when using digital proofing systems.

Measuring Apparent Dot Gain in a Filmless Workflow

The technical definition of Dot Gain is the apparent growth in dot size between the film and the printed result. It is usually measured at a 50% level since it is usually greatest at the this level of the tone scale.

In a filmless system, we must use a new measure. Since most users match the film percent dot value to the electronic file, we can use the electronic file as our starting point.

It is critical to note that apparent dot gain (tone reproduction adjustment) is added during the proofing operation. Because of this requirement, the dot values are necessarily different between the proof and printed page if the proof is required to match the printed output.

Accurate Density

Density control of the proofing system is a requirement for custom color matching. Since the industry runs, in large part, to established density standards, the other benefits of controlled, adjustable density might be overlooked.

Eliminating the Impact Coating Variability

Just as no printer would admit to having dot gain back when the SWOP committee started its work, manufacturers of coated products are reluctant to admit that some coating tolerances exist.

Batch to batch variability is part of the process and is a major focus in manufacturing quality. All coating facilities work diligently to make product that is invariant. However, some tolerances must exist or no affordable product could be produced.

The existence of this batch to batch coating variation is a potential contributor to inconsistency of color from proof to proof, leading to the previously described in-line color problems on press. It is inevitable that proofs for the same press run will be made on materials from different coating runs.

The ability to adjust proofing system density allows the user to center their process back to their process aim, eliminating the impact of this variable in their process.

Mixing Spot Colors

An additional benefit of adjustable, controllable density for the proof is the ability to mix spot colors. Using laser power to control the amount of cyan, magenta, yellow, and black, a single spot color plate can be used to create a user defined special color.

For example, purple can be created by using the same screened bitmap file from the RIP to expose the required amount of cyan on top of the required amount of magenta. The ability to print dot on dot, using the same electronic file, creates the same result that would be obtained if a purple donor color were used.

It is impractical for coating manufacturers to coat the number of colors that the market requires. This Recipe Color solution is a cost-effective way for the customer to mix the required spot color.

It should be noted that the color gamut may be constrained by the process color donors used. It is possible, however, to envision wider gamut donors that, when used in these recipes, will allow an expansion of the achievable gamut.

Trap Between Process and Spot Colors

In order to demonstrate trap between process and spot colors, it is required that higher combined densities be reached than either spot or process density would create by itself. For this reason, it is desirable that a density significantly higher than 100% of process color density can be reached using a single colorant sheet in a laser thermal process. This allows the choke and spread areas to demonstrate the full density of the process plus the effect of an overprinting of the spot color where the trap occurs.

Most laser thermal donors have a density limit which only support process color densities. Using these types of systems, it is not possible to demonstrate the trap area (chokes and spreads) unless fresh donor is consumed for the creation of the spot color. Systems that can drive additional colorant, beyond the process color densities, can demonstrate the trap areas between process image areas and spot color areas without using a second set of colorant donor sheets.

Requirement for Noiseless Laser Systems

When choosing between adjustable density systems and binary systems (which transfer all of the colorant) it is critical to understand that the very ability to adjust density could have the impact of creating variability in density. Any variability in the output of the laser systems could translate into density variability in the proofing system.

By designing "noiseless" laser systems, it is possible to avoid this problem while allowing the significant benefits of adjustable, controlled density.

Several system techniques contribute to this "noiseless" laser system. Individual laser control, which is independent of the laser swath, is one. If the entire laser swath shifts up or down in density, it is likely to be seen as a visible artifact on the proof.

Selection of lasers with the lowest specification for output noise levels is also a major factor. These lasers tend to be expensive and are a major contributor to overall equipment cost.

Custom electronics and sophisticated optical techniques control laser power in ways that can eliminate density variability due to this factor.

Dirt and Resulting Artifacts

Dirt has been a significant problem for prepress practitioners since the first piece of film (or glass plate!) was "drawn down" for vacuum exposure. This is true for laser thermal systems as well, since the colorant must be transferred across a precisely controlled gap for deposition onto the imaged surface. This deposition can be significantly disturbed if particles of dust and dirt get between the surfaces.

Several techniques have been used to reduce the impact of dust and dirt in laser thermal systems. Many of these techniques have been used in combination.

An option developed by one manufacturer uses spacer beads that are built into the materials. They are used between the imaged surface and the donor surface. These beads create a controlled gap space that is larger than most of the airborne particulate that is found in the typical prepress environment. Since the beads are somewhat larger than these particles, the uniform gap spacing is not disturbed.

The use of rolls instead of sheeted material is another dirt reducing technique. The materials are never exposed to unfiltered air since they are wound into rolls in a clean room environment at the coating facility. Air inside the proofer is filtered and under positive pressure, ensuring the cleanliness of the proof through the proof-making process.

This was a major factor leading to the design of the roll fed and fully automated proofer.

Another technique relies on a tacky rubber roller to remove dirt in from the materials inside the proofing device.

Accurate Image Structure

Testing has demonstrated that controlling two specific screening parameters is sufficient to detect a moiré pattern. The screen frequency and angles must be identical between the proof and printed sheet in order to detect this defect with certainty. A subtle change in dot size due to the addition of dot gain is of little consequence in the detection of this defect. Similar dot shapes are recommended.

Halftone

The debate about halftone screening appears to be subsiding to a great degree. Printers are not willing to put their precious press time at risk and are insisting that a halftone proof be made prior to inking up a press and committing paper and ink.

In addition to the ability to detect moiré patterns, halftoning significantly improves the consistency of color. A density shift in a solid translates to a significantly less color shift in the midtones, and creates an almost imperceptible color shift in the highlight areas of an image.

Screened Files as an Interface Mechanism

Given the myriad of RIP systems on the market and the need to work effectively with these electronic environments which they create, several levels of interface are required. A common file format is desired. Network hardware and software must allow the devices to transfer information. Then information must be in a file format that is understood and can be acted upon once received.

By using the screened bitmap file which is produced by a RIP system, the newly developed OFE (Open Front End) interface allows the proofing system to achieve a level of interface that is a technology breakthrough.

The OFE is a file format specification that builds on the screened bitmap file that is output by a RIP. Some screening information is added to this screened bitmap file to properly instruct the writing engine.

This allows the writing engine to use a screened bitmap file from the same RIP that is used for plating, film exposure, or direct to press. Using the OFE satisfies the image structure requirements necessary to detect a moiré.

The OFE was developed by and is available from Kodak. OFE simulators are available from a third party in order to accommodate the confidential development efforts of all parties.

The OFE specification provides for spot color creation. In addition, a certification process ensures image quality.

Summary

The requirements of a proofing system are more rigorous than the production conditions in many ways. The trade-offs which must be addressed in designing digital proofing systems must be made with the customers' need for cost effectiveness of the total printing system mind.

With the advent of CTP and Direct to Press technologies, it is clear that proofing systems add value by assuring the quality of prepress work that reaches the production press and by allowing the press to perform to its quality and productivity potential.