The Impact of Changing Fountain Solution Chemistry and Press Consumables on the Runnability of a Web Offset Press

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Abstract

There are many different materials and consumables that are used within a web offset environment, including the fountain solutions. As with all consumables there are trends that are seen in their evolution over time. Currently there is a move towards higher pH levels in the North American market and also to the inclusion of additives that will aid with the corrosion resistance of the fountain solution. This paper addresses these issues by carrying an experimental program.

The study evaluated the impact of the fountain solution changes on, paper, ink, printing plates and dampening rollers on several different print characteristics. These were the latitude of the water window on the press, the waste levels generated through the start up procedure, the steady state runnability of the press, the amount of piling formed on the printing blanket and ink feedback into the dampening system.

The trial procedure was developed to best utilize the time on press, using DOE procedures in 42 trials. The run length for the water window was approximately 5,000 impressions while the transient start up and runnability used 35,000 impressions.

The results indicated that "corrosive-resistant" fountain solutions can be used without an unacceptable degradation in performance. These fountain solutions have been shown to produce very little or no piling and dampening system feedback and excellent runnability and print quality when combined with the proper dampening rollers, plates, paper, and ink.

PIA/GATF
Printing Industries of America / Graphic Arts Technical Foundation

Introduction

This report will discuss the impact of "*corrosive-resistant*" fountain solutions on print quality and runnability. The "*corrosive-resistant*" fountain solutions that have been introduced into the North American market have been designed to cut down on corrosion of the press caused by fountain solution. In addition, they operate at a higher pH level. This can change the interaction with other consumables, such as paper. Finally, the globalization of the print market creates the situation where materials used in North America are being sourced from all around the world. These changes in materials can also have a great impact on the runnability and performance of the web press.

Corrosion on heatset web presses has been a concern for both printers and press manufacturers for many years. Corrosion generated can lead to many hours of lost production. This is not something that is new in the industry but has been around for many years. To help alleviate this problem, the press and fountain solution suppliers have worked together to produce fountain solutions that by design reduce the corrosion characteristics of these materials.

Since these new fountain solutions have come onto the market, there has been concern that these fountain solutions do not perform as well as a standard fountain solution. The findings of this report, based on the results obtained from a large multi-vendor project carried out on the heatset will address these performance concerns.

The parameters that were addressed were many of the consumables that may react differently with the "*corrosive-resistant*" fountain solutions.

"Corrosive resistant" Fountain Solutions

The evolution of "*corrosive-resistant*" fountain solutions came into full swing around January of 2001. The development of these fountain solutions were driven by the press manufacturers as a method to help minimize corrosion of the presses that would occur due to the extremely aggressive dampening concentrates used (U.S. heatset market).

The method of measuring the "*corrosive-resistant*" properties of fountain concentrates was developed by a joint effort from FOGRA, DECHEMA, and MPA Darmstadt. This method focuses on the corrosive properties of concentrates in a laboratory environment based on a fixed source and treatment of water.

Testing of the different fountain solution concentrates follows a procedure that evaluates six properties of these materials**.

- Registration of the anodic current density-potential curve of rolled nickel and the examination of both the maximum current density in case of activity and the break-through potential.
- Registration of the anodic current density-potential curve of steel at polarization in anodic and cathodic directions.
- Determination of the weight loss per unit area of rolled nickel at free corrosion as a function of time and the calculation of the weight loss per unit area.
- Determination of weight loss per unit area of the hardenable steel at free corrosion as a function of time and calculation of the weight loss per unit area.
- Determination of the redox potential of the FC.
- Determination of the anodic current density-potential curve of platinum.

**FOGRA "Testing Scheme for the Corrosion Test of Fountain Concentrates, 12/2004

The test method has been adopted by several press manufacturers with the support of many fountain solution suppliers. As these fountain solutions become available the press manufacturers are considering writing the use of these materials into sales contracts as a stipulation of the warranty.

Since the release of the test method the majority of fountain suppliers have released one or more formulations that conform to the method. According to one press manufacturer's website, the approved list of "*corrosive-resistant*" fountain solutions includes 36 suppliers worldwide totalling over 160 formulations for sheetfed, heatset, and coldset.

The functionality differences between typical fountain solutions used in the U.S. and those proposed with the "*corrosive-resistant*" properties include significantly different pH and conductivity ranges.

Currently, fountain solutions used in the U.S. have a pH buffered around 4.0 with conductivity values ranging anywhere from 1500µS to well over 3000µS. The proposed "*corrosive-resistant*" formulations generally have much higher pH values around 5.0 with significantly lower conductivity values.

Compatibility of the "*corrosive-resistant*" fountain solutions is a major concern for a lot of heatset web printers as these companies generally spend a significant number of man-hours dialling in their consumables for optimum performance. This was one of the main driving factors for PIA/GATF taking on this project. PIA/GATF's goal in facilitating this project was to determine if these new fountain solutions are a viable option for our industry. The results of our testing are not based on laboratory work, but real on-press observations of the performance characteristics of the fountain solutions.

Investigation Overview

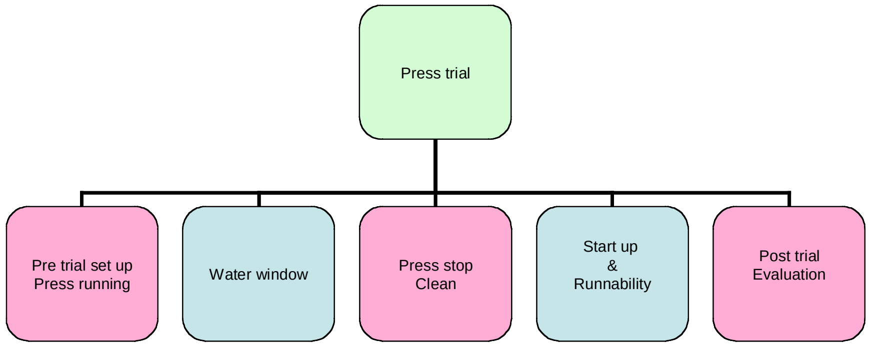
The goal of this project was to investigate if "*corrosive-resistant*" fountain solutions could be run in the U.S. heatset market while achieving the productivity and quality expectations. To perform such a task, a multi-vendor project was facilitated by PIA/GATF. This project was designed to evaluate the runnability and print quality of these new fountain solutions in combination with several other press materials to include:

- **Dampening rollers—**Two manufacturers supplied one set each of water form and water pan rollers.
- **Plates—**One supplier or plates provided two different plates with different water carrying characteristics.
- **Paper—**Three paper companies supplied one paper each, ranging from a heavy weight coated to an uncoated.
- **Ink—**Two separate ink suppliers each supplied two inks that were slightly different in strength and rheology.

Fountain solutions for this project were supplied by two companies. Each company supplied a standard fountain solution currently in use in the North American heatset market and one that was a derivative of this that met the "*corrosive-resistant*" properties.

Due to the extensive number of variables used in this study, a design of experiment (DOE) approach was required in order to manage the information and materials. The DOE not only allowed for the management of materials and results but also allowed for the consolidation of press trials without compromising the results. In order to verify the results of this study several repeat pressruns were performed. The results of these pressruns had excellent agreement with the previous runs confirming that the results of this study were valid.

The design of experiment (DOE) was developed and tailored for the amount of each material delivered by the various suppliers and time restraints due to the press availability. The DOE utilized forty-two different material combinations which would give the participants a solid understanding of the effects of these new fountain solutions on the printing process. Each trial followed the same procedure as to how the press was run and what data was collected. Each trial was broken down into four sequences of events that had to happen in order for a trial to be considered successful. These sequences of events are described as the pre-trial setup (1^{st}), water window (2^{nd}), press stop (3^{th}), transient start-up and runnability (4^{th}).



Pre-trial setup

This section of the trial was used to establish the minimum water for each of the units. Minimum water was achieved at SWOP densities for all three papers, even the uncoated stock, as requested by the supplier. Each trial was run at 40,000 impressions per hour, but possibly reduced to conserve paper during the make-ready process. Water settings were reduced until scumming was apparent. Scumming was assessed by the lead operator who determined the minimum water level. Once achieved, the water was increased 2 units or until the sheet was considered free of scumming by the lead operator. This ensured a consistent starting condition for each of the trials and will be considered the zero point. Once the zero point was achieved the water level was increased by 2 additional units. This guaranteed no scumming, and the pre-trial was considered complete. These water settings, plus 5 units, were used as the start point for the runnability trial. Prior to starting the pre-trial a fountain solution sample was taken so that pH and conductivity can be measured.

Water window

Once the image was considered clean, the water window evaluation was considered active and the net counter was started. The water was increased in 5% intervals for 1500 impressions, at which point 50 samples will be collected. During this process the WPC colour control system was in monitor mode. This process was repeated four times for a total water range of 20 units or until fountain solution was maxed out at 100% on one of the units. Upon completion of the trial, samples were collected and measured for the change in printed ink density.

Press stop

After the water window step was completed the press was stopped. Prior to stopping the press the blankets were washed and the ink rollers were rinsed twice. Upon stopping the press the web was split and the dampening system drained and manually cleaned. After the completion of the cleaning procedures and data collection the press was re-webbed and prepared to start the next step in the trial procedure.

Transient start-up and runnability

Prior to inking in the press the units were allowed to dry spin for a period or five minutes to ensure the rollers were free of solvent which was introduced during the shutdown procedure of the water window step. The process of inking in the press was carried out for a period of 30 seconds at the pre-established ink key profiles. The ink key profiles and water settings from the pre-trial were used for the transient start-up procedure. The press was run up to density during this procedure with the Web Printing Controls (WPC) system in monitor mode. The samples produced during this period were collected and analyzed for the change in density required to meet the targeted SWOP values. This process was estimated to take 3,000 impressions. At the end of the transient period (3,000 impressions) the WPC was engaged into automatic mode and the changes required for maintaining ink density were monitored at regular intervals during the remaining 32,000 impressions noted as the runnability portion of the investigation.

During the runnability, at the first sign of scumming in the image area, the water levels were increased. These changes were recorded by the lead operator. Using these measures, the runnability will be assessed. Fifty consecutive press sheets were collected at a net impression count of 5,000, 18,000, and 31,000 as part of this assessment. Upon completion of 32,000 impressions, the press was shut down without rinsing the ink roller train or washing the blankets so that piling and dampening system feedback could be analyzed.

These trial procedures were developed to minimize the amount of each material required by the various participating organizations and to best utilize the time on press. Running sequence of the trials also took considerable time and consideration as interchanging the various materials could have been very time consuming.

For this reason the sequence of press trials proposed by the DOE software was modified. The first modification of the trial order was to sort the trials based on dampening rollers. The installation of the dampening rollers was estimated to require a considerable amount of time and also required an alignment that best remained unchanged. In addition to adjusting the run sequence by dampening rollers a second modification to the sequence was based on ink as the time to interchange inks was also considered time consuming and had to potential to generate a substantial volume of waste.

Once the trial sequence was sorted by dampening rollers and ink, the time estimated to complete this project was within the parameters set by the committee. Since the time schedule agreed upon was achieved sorting of the other materials was considered irrelevant.

Prior to the start of each day the press was run until the measured temperature of the blankets achieved the targeted operating temperature. This procedure was followed each day so that the first trial would not be run under a cold start condition which has shown to impact the findings of a press trial. A cold press start typically requires less water to clean up a plate. This may result in a rapid build-up of material on the blanket surface or in the dampening system. This would then be compounded by the increase in temperature throughout the pressrun forcing the operator to continually adjust the press in attempts to compensate for these issues. To minimize the possibility of a cold press jeopardizing the integrity of this study, the blanket temperatures were not only measured during the initial warm-up of press but throughout each trial as well.

Press and materials

In this section, an overview of the press and materials used during this study will be discussed to include the press configuration, peripherals, and some of the characteristics of the materials used. The press configuration remained consistent throughout the forty-two press trials. The peripherals on the press were also kept constant and were operated the same throughout.

As part of the assessment of consumables used, laboratory testing of certain characteristics were carried out. Of those materials tested were Ink, paper, and fountain solution, and they are discussed in this section of the report. Not all materials used were tested in the laboratory; certain materials were only assessed on press. These materials included the plates and rollers.

The plates used were not assessed for physical characteristics, but they were measured with a dot area meter to ensure the image was exposed properly. The test image for this project was composed of several elements designed to evaluation the print quality and runnability of a majority of the other materials. These elements and description of the test form will be discussed.

Press

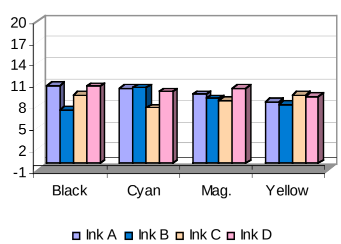
The forty-two press trials performed as part of this joint research project were carried out on the MAN Roland ROTOMAN heatset web press capable of producing sixty-five thousand 22.75×38-in. signatures per hour. Colour and register control on this press is the Web Printing Controls (WPC) system which allows for real-time densitometric measurements. This four-unit press is equipped with a 31-ft. three-zone Megtec dryer who is followed by six chill rolls and is capable of delivering sheets or several folded methods depending on the roll width. For this study the press was operated at a running speed of 45,000 and 50,000 impressions per hour. Ink sequence was black, cyan, magenta, and yellow. Attached to the ink fountains were thermocouples used to monitor the ink fountain temperature. Fountain solution was monitored through the AWS control panel on the fountain solution recirculation tank to a temperature of 67°F.

Ink

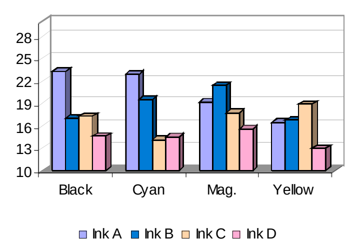
For this study two separate ink suppliers were asked to participate. These two suppliers' proposed two separate formulas that are evaluated during these trials as the inks varied in strength and rheology and may react differently on press. Laboratory measurements show that these inks are typical of inks used for the publication heatset market, both in the United States and Europe.

Strength of the inks were measured by mixing a small amount of ink with the NIPIRI X1025 bleaching white and comparing the inks to a set of SWOP certified inks. All of the inks were equal to or weaker than SWOP by as little as 10% or as much as 40%. In certain cases comments were noted by the laboratory technician that the shade was off compared to SWOP.

Physical attributes of the inks were evaluated by measuring the tacks and viscosity. Tack measurements, taken with an inkometer were observed at one minute and ten minutes. The one-minute measurements show the inks to vary by supplier as well as series. Tack sequencing also appears to vary as two sets are clearly tacked sequentially and the other two appear mono-tacked. In situations where downstream piling may occur, a tack-rated set of inks is preferred. Ink stability over time was assessed by evaluating the ten-minute tack measurement. If an ink tacks up too much as it travels through the press, it may become prone to produce adverse effects on press.



1' Tack Readings



10' Tack Reading

Viscosities of the supplied inks were measured on a TA rheometer where the shear rate and viscosity were recorded over time. The cone used for these measurements was a 40-millimeter, 2º, with a 57-micron truncation. As the main focus of the study was based on the units 1 and 4, viscosity of the black and yellow were measured.

The shear rate profiles indicate that all the inks are shear thinning, i.e., when shear rate increases the measured viscosity decreases. The responses of the inks are markedly different rheologically at low shear rates. This will affect the flow from the ink duct.

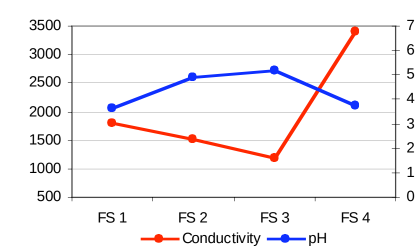
Fountain solution

Two fountain solution companies participated supplying both a typical fountain solution used in the heatset market as well as a fountain solution that has been considered to meet the "*corrosive-resistant*" properties set forth by FOGRA.

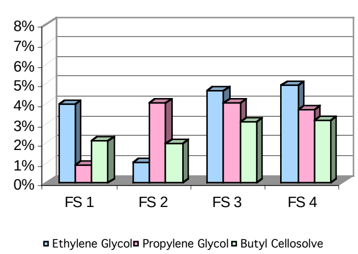
For the press trials run as part of this study, the fountain solution concentrates were mixed with RO water. Prior to the start of each trial the fountain solution circulation system was flushed and filters were replaced. Fresh fountain solution was used for each trial with samples taken at set intervals.

For the laboratory assessment of the fountain solutions, samples were prepared with the same dosage of concentrate to RO water. At this fixed dosage, the fountain solutions referred to as standard products had a pH of around 3.5 to 4.0. The "*corrosive-resistant*" samples had higher pH values close to 5.0.

Conductivity of these samples varied as did the pH. The conductivity of the "*corrosive-resistant*" fountain solution on average had much lower conductivity values, and was less than 1600 micro Siemens/cm. The standard fountain solutions averaged slightly higher than the "*corrosive-resistant*" fountain solutions with values ranging from 1700 ųS to over 3000 ųS.



pH and Conductivity



Solution Components

Gas chromatography analysis of the samples showed varying amount of the main components of the fountain solution. The main components focused on were ethylene glycol, propylene glycol and butyl cellosolve.

Fountain solution sample 2 had the lowest amount of ethylene glycol at just over a percent, whereas samples 1, 3, and 4 had about four times that amount. Sample 1 had a very low amount of propylene glycol at just under a percent worth. Samples 2, 3, and 4 had significantly more at almost four times the amount. The volume of butyl cellosolve varied amongst the four samples, ranging from just under two percent to over three percent.

Paper

Paper for this project was supplied by three manufacturers. Among the supplied papers were a heavyweight coated, a light weight coated, and an uncoated paper. Each paper as you would expect varied in basis weight, brightness, colour and other characteristics. Paper colour/ appearance characteristics were determined by evaluating the brightness, whiteness, gloss and CIELab values.

	Basis Wt.	Brightness	Whiteness	Gloss
Uncoated	34.5	76.75	81.57	36.5
HWC	60	86.5	85.9	64.0
LWC	32	70.0	57.6	39.5

Paper properties

Plates

Two different plates were used as part of this study, both of which came from the same manufacturer. These plates were selected because they would transfer fountain solution differently due to the structure (grain) of the plate surface.

Both plates were imaged on PIA/GATF's Trendsetter with the same test image and curve. Two platesetter calibration curves were generated to produce a linear curve. The two curves were required as each plate's emulsion reacted slightly different to the platesetter's laser power.

By outputting both sets of plates linear, a comparison of the tone reproduction characteristics could be carried out for each trial. Tone reproduction in this study will be described as mid-tone tone value increase and print contrast.

Rollers

As the main focus of this study was fountain solution performance, it was important to evaluate the mechanism used to transfer the fountain solution through the press. For this reason two roller companies submitted fountain pan rollers and form rollers. Roller's physical dimensions were specified by the press manufacturer, but the rubber coating itself was up to the roller supplier.

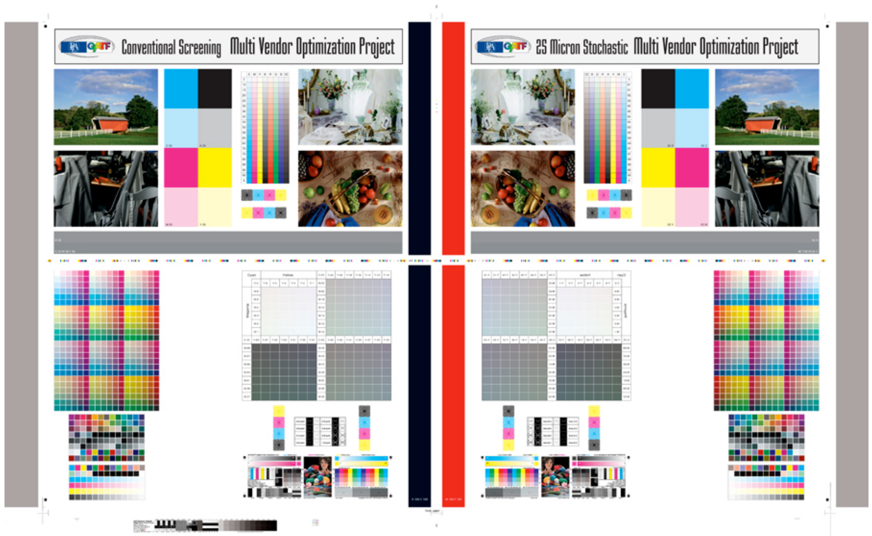
Each supplier's personal rubber coating may have the ability to transfer fountain solution differently due to the characteristics of the compound. It may also generate heat differently as well, which may impact how fountain solution flows through the system. For this reason, the contact between the fountain solution pan roller / ceramic roller and ceramic roller / form roller were considered extremely important and required additional attention and were measured and maintained throughout all forty-two trials.

The contact between these two rollers, commonly referred to as "squeeze" was set to the manufacturer's recommended setting of 7mm across the entire length of the roller.

Test image

The test image for this study was composed of several visual and measurable targets. Among the visual targets were several PIA/GATF stock images that are commonly used on other test forms. These images included the "Covered Bridge" image which is ideal for visual evaluation of the memory colours (red, green, and blue). The "Wedding Dress" is used for the assessment of highlights and gray balance. The "Fruit" image is ideal for evaluating shadows, gradations, and pastel colours. The final image selected, the "Sewing Machine" image, was used for the evaluation of mid-tone and shadow gray balance as well as shadow detail.

Among the measurable targets were several items used to assess the quality of print throughout the forty-two trials. One of the most important targets used was the WPC colour control strip found running through the center of the test form. This target, composed of small solid and screened patches, was used during each trial to control the ink film thickness (density) being delivered to the press sheet. This target was strategically placed in the center of the test form so that piling and ink starvation would have minimal effect. This allowed for consistent printing throughout the twenty plus days of printing. Other targets used on the test form were large solid and screened blocks, which were used for measuring density and CIElab. Tone scales that ranged from a 5% dot to a solid are typically used for plotting tone reproduction across the entire tonal range. Large bands of 50% black next to a screen build of 50% cyan, 40% magenta and 40% yellow running across the width of the web were used to measure mid-tone gray-balance. A modified version of the IT8.7/3 target was used for mapping the colour gamut of each press condition.



Test image

Another target included on the test image used in the analysis of each press trial was the title bar running across the top of the form which was used for the assessment of piling. The "Proof Comparator" is used for the assessment of highlight and shadow dots, quarter-tone, mid-tone, three-quarter-tone gray balance and overprint trap.

As part of the design of the test form, the layouts were divided into four regions and are labelled as follows:

- Upper Gear Side
- Upper Operator Side
- Lower Gear Side
- Lower Operator Side

Each region, identified by location on press, was screened with one of two screening methods. The two regions labelled as "upper operator side" and "lower operator side" were screened at 150lpi with a euclidean dot shape, whereas the regions labelled as "upper gear side" and "lower gear side" were screened with a 25-micron stochastic spot.

Post-trial evaluation

The main focus of the post-trial evaluation was on the runnability portion of the trial. During this time data was collected on several key press characteristics that would impact the productivity of the press as well as the quality of print coming off the press. Due to the extensive nature of analysis to be performed, teams consisting of a press operator and PIA/GATF researcher were tasked with assessing the same characteristic throughout the forty-two press trials. The main characteristics assessed were piling, dampening system feedback, and colour stability.

Piling, the build-up of ink, paper, and fountain solution on the printing blanket, can occur at any position and will vary with time and materials. There are three general types of piling: image area, non-image area, and downstream piling, all of which will adversely affect the efficiency of the press.

The assessment of piling during this study looked at all three types of piling as a function of the process. To assess piling three separate methods were used as one single method does not truly address the full impact. These methods were a visual/touch observation performed by a press operator, profilometry, and tape pulls. Photographs of the blankets were also taken for historical purposes.

Within each unit, both the upper and lower blankets were evaluated as well as the operator and gear sides of the cylinder as these two locations were printing with different screens (operator= 150lpi/ gear= 25micron).

Piling profilometry

The use of profilometry to measure piling was performed only on the black (unit 1) and yellow (unit 4) units. By measuring piling with profilometry on unit one, piling could be evaluated based on a single colour going down on virgin paper. The measurements from unit 4 allowed for the observation of the impacts of not only image area and non-image area piling, but downstream piling as well. Within these two units twelve measurements were taken. Eight of the measurements were from the upper blanket and four from the lower. Of the eight measurements on the upper blanket, four were from the conventionally imaged side and four from the stochastically imaged side. On the lower blanket, just like the upper unit, half of the measurements were from the conventional side and half from the stochastically imaged side.

Piling manual

The manual assessment of piling was carried out by the lead press operator. The assessment (based on a scale from one to ten, one being little and ten being severe piling) was performed on all four units. Within each unit the operator rated the piling on the lead edge and around the cylinder on both the upper and lower blankets. Comments were also noted as to observations not taken into consideration in the rating scale.

This method is only good for being able to characterize significant changes on the surface of the blanket and could possibly vary day-to-day due to the human factor. For this reason, several other methods of characterizing piling were also used: profilometry, tape pulls, and photographs.

Piling tape pulls

Tape pulls are a common method used to document piling. To perform this method, a large piece of tape is placed over an area of interest on the blanket. This could be an area that has a significant amount of piling or an area where a piece of debris was observed. Once the tape is in place, gently apply pressure to the tape to ensure that the adhesive has sufficiently adhered to the material on the blanket. The next step is to gently remove the tape ensuring the material in question adhered sufficiently to the tape. After removing the tape it is suggested to stick the tape with the material on it to some type of clear material such as a piece of acetate.

Dampening system feedback

The build-up of ink on the dampening system rollers, commonly referred to as feedback, occurs when ink transfers from the printing plate onto the water form roller and then upstream to the water pan roller. As the water pan roller becomes covered in ink, there is the potential for the decline in print quality which will directly relate to the productivity of the press itself.

Feedback can be influenced by several factors during the printing process to include how well the press is maintained, materials, and the image being printed. Once feedback starts it can be difficult to control. In many cases to resolve the problem the press has to be stopped and cleaned manually.

The assessment of feedback can be difficult as there is no device that can measure the magnitude during a pressrun or thereafter. For this study, it was agreed upon by the participants to evaluate feedback based on a visual assessment and to document it by photographing the fountain solution pan roller as this roller often shows the severity of the feedback.

The visual evaluation of feedback, similar to piling, was evaluated by a team composed of a skilled press operator and a PIA/GATF researcher. This characteristic was rated on a scale from one to ten with a score of ten meaning extreme feedback.

The visual evaluation of feedback was carried out only on the black (unit 1) and yellow (unit 4). Within each unit feedback was observed on both the upper and lower water pan rollers of the unit and rated. Comments were made as to the location of the feedback across the roller as well as severity.

Colour stability

During each trial the ink film thickness (density) applied to the paper was monitored/ controlled via the Web Printing Controls (WPC) closed-loop colour control system. This system functions by measuring individually coloured patches within a specified colour control strip (located in the center of the test form) with a video capture system located directly after the chill rolls. The WPC system measures the colour patches in real time and displays the results on one of two displays located at the press console. These displays allow the operator to make adjustments manually to the ink film thickness, or the system can control the press automatically.

The WPC measurements are saved to a file and can be retrieved after the pressrun for analysis. The measurements stored from the forty-two pressruns includes the density every thousand impressions across the width of the web on both sides.

Fountain solution stability

The stability of the fountain solution throughout each run was monitored and controlled. The AWS fountain solution tank is equipped with a pH and conductivity control system which notifies the operators if either of these characteristics exceeds the pre-determined limit. Samples of the fountain solution throughout each trial were also taken and analyzed. Samples taken throughout each trial were measured for pH and conductivity. Colour of the fountain solution was also noted as contamination has the potential to change the appearance of the fountain solution.

Piling results

Different levels of piling occurred during each trial. The magnitude varied based on a combination of press materials and in many cases was isolated to specific regions. However, the same types of piling were seen in the same locations during the different trials. The repeatability of producing the same amount of piling was validated by running several repeat trials. During these trials, piling occurred within the same regions and to the same magnitude. The ability to reproduce piling in the same manner during two separate trials validated the conclusions drawn during this study.

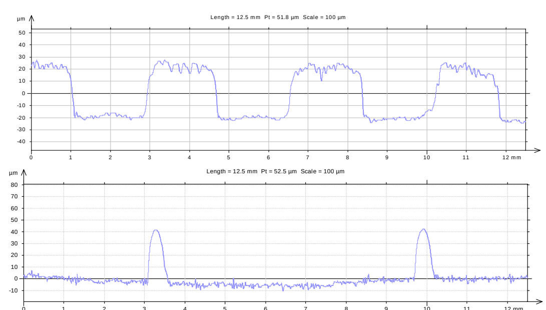
Piling was not measured during the water window section of these investigations, however it was documented that ink and water balance settings did have a direct impact on the volume of piling and the magnitude of piling.

The magnitude of piling was measured several different ways that included targeted measurements using profilometry, as well as an overall observation from a skilled press operator. The same operator was used throughout the duration of the investigation. These two methods of measurement provided a true understanding of the piling as well as an overall view of the piling formation. The results to be discussed within this section are based on a combination of the profilometry measurements, manual assessment as well as tape pulls taken from several target locations.

Special design elements on the test image allowed for the measurement of image area piling, which occurred within the title block that had a 5% screen tint in the background. Non-image area piling was measured within the modified section of the IT8 7/3 target.

Various amounts of piling did occur during each trial. The magnitude varied based on a combination of press materials and in many cases was isolated to specific regions. There were measurable differences as documented by the profilometry measurements.

The figure below shows common profilometry profiles taken from image area and non-image area piling measurement location. The top image depicts the letter “M” found in the title box at the top of the image. Below, the gaps between the colour blocks can be seen as giving rise to non-image area piling.



Profilometry profiles

The magnitude of piling when comparing units one and four did show significant differences. Unit one generally had less piling as this unit was only affected by a single colour. The piling on this unit did not show significant differences between the image area and non-image area as each region piled to a similar volume.

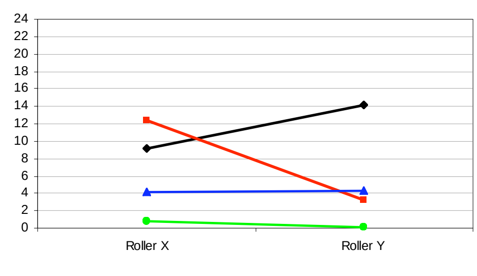
Unit four typically produced more piling, as would be expected. This printing unit was the last unit in the sequence and was directly impacted by the previous units. The effects of deposited ink, paper, and fountain solution from previous units (downstream piling) did produce a higher magnitude of piling compared to unit one. Tape pulls taken after the each pressrun confirmed that the excess piling on this unit was from the previous units.

Piling based on screening produced unexpected results as the areas printed with the stochastic screening produced less piling on unit one and more piling on unit four when compared to the areas printed with conventional screening. The differences based on screening confirm that the screening methods do have an impact on the severity of piling.

When considering the influence of the individual materials assessed on piling it has been shown that the different fountain solutions on unit one did not have a significant impact on the volume of the piling. Fountain solution did however interact with all of the other materials assessed producing significant interactions on both the conventional and stochastic sides of the test image, both upper and lower portions of the unit.

The analysis of unit four showed the impact of the fountain solution to be a significant main effect and also there to be several interactions to occur with other consumables. The interactions of importance all occurred as image area piling and included all of the materials assessed. Comparison of the fountain solutions show the "*corrosive-resistant*" fountain solutions to perform as well as, if not better than, the standard fountain solutions.

An example of an interaction that took place with fountain solution included that with dampening rollers. This particular interaction shows that fountain solutions 3 and 4 to perform similar. The interaction takes place with fountain solutions 1 and 2. Here it can be said that less piling was produced with dampening roller X when printed with fountain solution 1. The direct opposite occurred with fountain solution 2 as this fountain solution piled less with roller Y. This highlights the importance of closely matching all the consumables used on the press.



Interaction of fountain solution and rollers

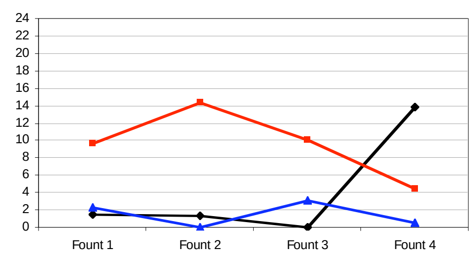
Dampening rollers influence on piling was also unit dependent. On unit one, both sets of dampening rollers were considered to have a minimal impact on piling. Interactions of importance to include dampening rollers on this unit were in conjunction with plates and ink. The dampening rollers did have a significant influence on the level of piling on unit four and varied based on screening, location, and interaction with other materials. On unit four, all of the significant main effects and interactions occurred in the areas producing image area piling.

Plates had a small effect on the piling. On unit one there was only a minimal effect with no significant interactions. On unit four plates did not have a main effect, but did interact with fountain solutions and paper. The interactions occurred in the areas of image area piling, in the header region.

Piling based on the analysis of the three different papers clearly showed one paper to pile more than the other two, regardless of unit, screening method and combination with other materials. The HWC piled more in both the image area and non-image area locations compared to the other two papers. This paper was the heaviest weight of coated paper tested as part of this investigation. The uncoated and LWC papers performed similar in regards to piling, producing virtually equal amounts.

The paper showed significant interactions. On unit one these included those of fountain solution and ink. On unit four, fountain solution also had a significant interaction as did dampening rollers and plates. These interactions were determined to occur in the header region and in certain cases out towards the edge of the printable areas as noted by the piling observer.

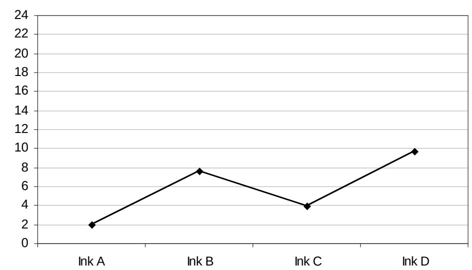
An example of an interaction involving paper and fountain solution took place on the conventional side of unit four. This interaction shows the uncoated paper to piling in a similar manner with fountain solutions 1, 2, and 3, but when printed with fountain solution 4, the uncoated paper had a much larger degree of piling.



Interaction of paper and fountain solution

Ink's influence on piling was similar for both units one and four, and on both units the ink was considered to have a significant main effect regardless of the type of piling (image / non-image).

There were also differences in the magnitude of the piling produced by the different inks. Following is an example taken from unit four showing that inks B and D produced more piling than inks A and C across the letter "M" on the stochastic side of the test image. This structure of performance was not the same for all units. On unit one, it was the case that inks A and C produced less piling than inks B an D, but piled equal to or worse than ink A and C.

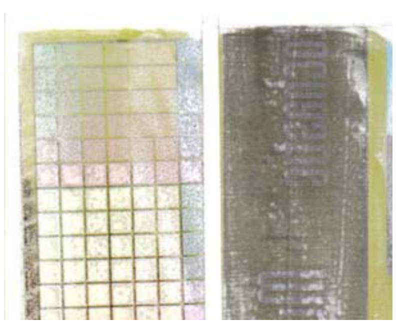


Unit for piling based on ink

On unit four, the volume of piling was generally greater due to downstream piling. Tape pulls indicate that ink from units one through three left some deposit on unit four. In particular, black ink was removed by tape pulls from unit four in the area of the title block which is made up of black text.

Interactions to involve ink were similar for units one and four. The materials to interact with ink and be considered significant were fountain solution, dampening rollers and paper.

Tape pulls taken from the press trials were used to document the severity of the piling as well as the contents of the piling. Observations from the tape pulls reflect the findings previously discussed as to which materials influenced piling and the magnitude of piling based on unit and location.



Tape pull from unit four

Though the volume of piling produced did not adversely affect the print, there were discernible differences based on unit and the type of piling produced. As many interactions occurred it is clear that piling is caused by not just a single material, but a combination of materials.

Dampening system feedback results

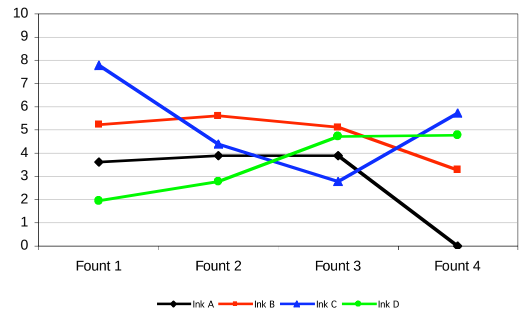
The analysis of dampening system feedback was carried out on units one and four and the analysis has been separated by the upper and lower dampening systems. Dampening system feedback did occur during several of the press trials and varied in magnitude. The overall magnitude from any given trial did not exceed a volume that would require the press to be shut down and cleaned due to quality issues. The magnitude and location of feedback was dependent on the test image. The most severe build-ups appeared as bands around the water pan roller and / or water form roller in line with little or no image on the plate. This included the outer area of the image beyond the printable area as shown below.

Unit 4 feedback example

The fountain solution relationship to feedback showed that there were differences based on the formulation and the unit assessed. The analysis of feedback on unit one, both the upper and lower units, showed that fountain solution 1 had a tendency to generate more feedback than the other three fountain solutions. When printed on unit four, the effect of fountain solution 1 was much smaller as all four fountain solutions producing similar results.

Significant interactions took place between the fountain solution and the paper and ink. These interactions only took place on unit four. Analysis of unit one did not show any significant interactions.

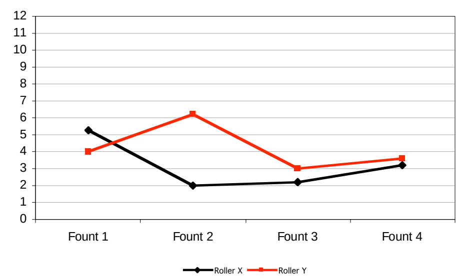
The figure below shows the interaction that took place on unit four with fountain solution and ink. In this interaction it can bee seen that inks A, B, and D performed similar with the four fountain solutions. Ink C, however, did not respond in the same manner. When printing with ink C, feedback was not consistent with each of the fountain solutions, each piling at a different volume.



Feedback interaction of fountain solution and ink

The influence of dampening rollers on feedback was only considered significant on the lower portion of unit one and the upper portion of unit four. On the lower portion of unit one dampening rollers X fed back less than Y. On unit four upper, the results were directly opposite as Y feedback was less than X. Interactions based on dampening rollers occurred with all of the materials assessed and were unit specific. An example of this would be dampening rollers interaction with fountain solution which occurred on unit four lower, but not on unit four upper or any part of unit one.

An example of dampening rollers interaction with fountain solution shows roller X to have similar results with fountain solutions 2, 3, and 4. When printed with fountain solution 1, roller X had a tendency to produce more feedback. Roller Y reacted slightly different as fountain solutions 1, 3, and 4 performed in a similar manner with fountain solution 2 producing more feedback.



Feedback interaction of dampening rollers and fountain solution

Feedback based on paper showed one paper to be directly related to less feedback than the other two. On both units, upper and lower, the uncoated paper generally fed back less than the coated papers. The uncoated paper was unique in the fact that this was run to the same solid ink density values as the two coated papers.

Feedback based on ink was only significant on the lower portions of units one and four. There were however significant interactions to take place on the upper portions of both units. On the upper portion of unit one ink and dampening rollers had a significant interaction. This interaction shows ink B to have a lesser tendency to produce feedback with roller X when compared to Y. The other inks in conjunction with dampening rollers produced similar volumes of feedback.

On the lower portion of this unit the only interaction to occur was with fountain solution. Interactions with ink on unit four were with paper on both portions of this unit. Fountain solution also interacted with ink, but only on the lower portion of unit four.

Plates, regardless of unit did not show one plate to outperform another. Though the plates by design carry fountain solution differently, the optimized ink and water balance setting for this portion of the trial negated its impact.

Water window results

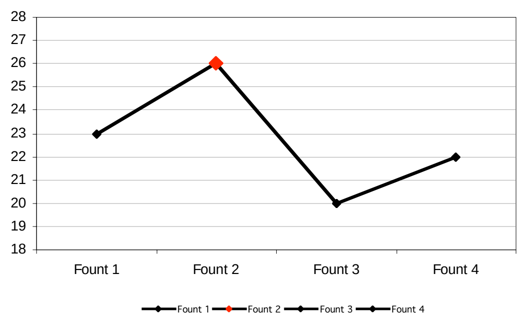
During the investigation of the water window it was determined that the two different screening methods reacted in a different manner to the materials used in this investigation. The difference between the different screening methods was a common thread in the investigation. This was due to the difference in the size and structure of the dots from each of the screenings. These screening methods clearly require different material combinations in order to efficiently transfer the dots at the desired ink film thickness.

There initial objective was to increase twenty units per trial the fountain solution settings. This was not always achievable. As during certain trials the starting water settings were at a level that would constitute water setting above 100%. As increasing the fountain solution level over 100% is not possible, the trial was stopped when one of the units reached 100% fountain solution.

Water window characteristics of the upper and lower units differed slightly, but followed the same trends based on screening. The differences could have been contributed to a number of factors to include the roller configuration, the roller settings, temperature, and the condition of the rollers.

The initial water setting for each trial varied as did the material combinations. The interactions of the various fountain solutions, dampening rollers, plates, paper and ink all required different press settings in order to maintain the targeted ink film thicknesses as well as keeping the paper free of scumming.

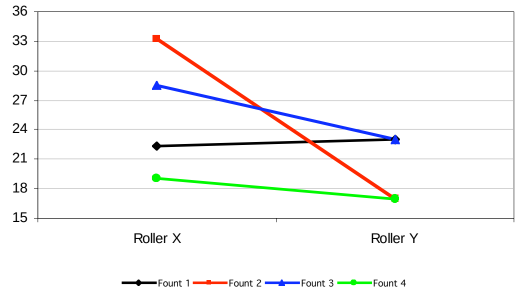
Each of the materials assessed did have an impact on the water window based on either the screening method or printing unit. Analysis of the fountain solutions showed that the *"corrosive-resistant"* fountain solutions were able to operate in the same range of water window as the fountain solutions which were common to the U.S. heat-set printing market. One *"corrosive-resistant"* fountain solution had a slightly wider operating range, based on conventional screening.



Fountain solutions impact on water window

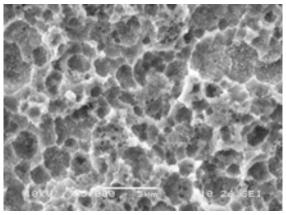
The impact of dampening roller on the water window operating range showed that the main effect differences based on unit and screenings were considered insignificant. Though the main effects did not have an impact, the dampening roller interactions with paper and ink were considered significant. This further emphasizes that choice of materials used is important. Paper's interaction with dampening rollers took place on unit one and the interaction with the inks not only took place on both units.

The results from unit four show the most significant part of the interaction to take place between these two dampening rollers with fountain solution 2, which happens to be classified as a *"corrosive-resistant"*. This interaction clearly shows that in this situation, fountain solution 2 had a wider water window when printed with dampening roller X. The other "*corrosive-resistant*" fountain solution 3 performed similar to fountain solution 2. The standard fountain solutions, in this instance, performed similar with both sets of dampening rollers.



Interaction of dampening rollers and fountain solution

During the initial project design the hypothesis was proposed that the two different plates used would have a significant impact on the water window as these two plates by design would transfer fountain solution differently. The two plates did have a significantly different initial water setting. The depth of the grained surface of the plate based on the findings within this investigation clearly affected the transfer of fountain solution from the water form roller to the printed signature. However, the analysis shows that the two different plates did not have a significant impact on the water window as each plate in combination with the other materials did react in a similar manner. Shown below are two different plates with two different grain structures. With these two different graining methods one would expect that they would carry water differently based on the depth and size of the pores.



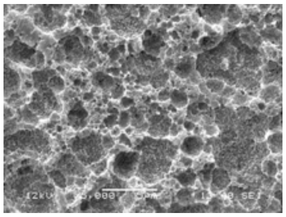
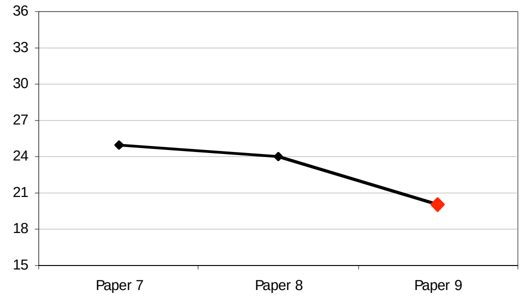


Plate surfaces at 500x, plate "M" left, plate "N" right

Paper's influence on the water window showed the operating range to be different based on the grade and finish of the paper stock. The lightweight coated paper had a smaller water window than the other two papers. The other two papers, the uncoated and heavyweight coated, had water windows that were similar. The only significant interactions to occur based on paper took place on unit one. These interactions with paper included dampening rollers and plates.



Papers influence on water window

Ink’s influence on the water window was determined to be significant as a main effect with inks B and C on unit one having the smallest water window. On unit four, inks B and D had the narrowest water window. Ink’s interactions with other materials was only considered significant on unit one on the conventional side. Within this region inks significant interactions included those with fountain solution, dampening rollers and paper. Unit four and the stochastic side of unit one did not have significant interactions to occur.

The water window operating range during this investigation had main effects based on fountain solution, paper, and ink. Several interactions based on the various materials did occur, but were limited to the conventional side of unit one.

Limited interactions did occur based on paper and were only considered significant on unit one. These interactions included those with dampening rollers, plates, and ink.

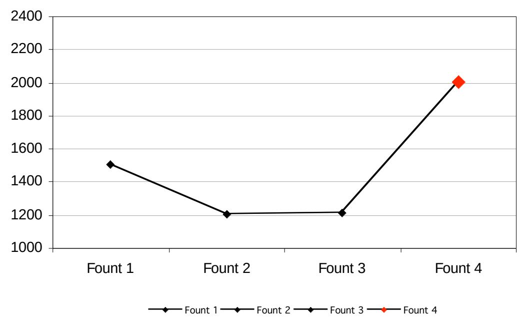
Transient start-up results

Transient start-up time and use of materials is deemed extremely important to the productivity of any printing press and for this reason, the impact of consumables on achieving a quick transient start-up was deemed important by all parties involved.

The initial ink key and dampening settings for the transient start-up were determined during the pre-trial investigation. As discussed earlier in the description of the pre-trial, the optimum ink key setting and dampening setting are critical to a quick transient start-up. Each transient start-up performed during this investigation began at these optimum settings. This allowed the independent assessment of the consumable materials to be quantified with respect to their effect on the speed of the transient start-up.

The effect of the individual materials on the transient start was determined by the number of impressions required to achieve the targeted solid ink film values, specifically units one and four. Completion of the transient start was determined by the off-press evaluation of the printed sheets carried out shortly after the pressrun. Densitometric measurements were taken to determine when the targeted density values were achieved from the large colour blocks located directly above the densitometer, in the illustration below.

In terms of fountain solution, there were no significant differences in the number of impressions required to achieve the targeted values on the conventionally screened side of the image. This was not the case on the stochastically screened side of the image, as fountain solution 4 on average, required slightly more impressions to achieve the targeted values than the other three fountain solutions.

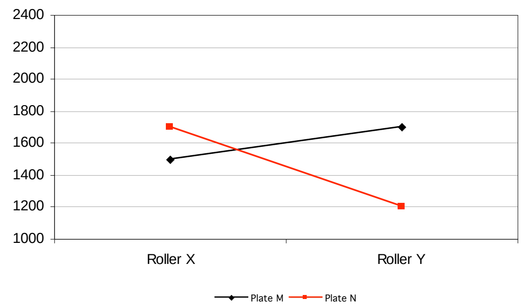


Fountain solutions impact on transient start-up

Regardless of screening method, there were no significant interactions to take place based on fountain solution. Transient start-up efficiency based on *"corrosive-resistant"* or standard fountain solution did not appear to be a factor. Both of the *"corrosive-resistant"* fountain solution either performed similar to or better than the standard products.

On the conventional side of the test image, the only parameter to have a main effect was paper. These results show uncoated paper to meet the requirements quicker than the coated papers, with the LWC paper requiring the most number of impressions to complete the start-up.

Though the main effects were limited, there were interactions to take place on the conventional side which consisted of plates and dampening rollers. Within this interaction, plate N and dampening roller Y required fewer impressions to achieve the targeted density values. The impression difference with plate M was considered insignificant according to the analysis.



Interaction of dampening rollers and plates

Interactions on the stochastic side of the test image involving dampening rollers occurred with ink. Plates also produced an interaction on this side of the test image with paper.

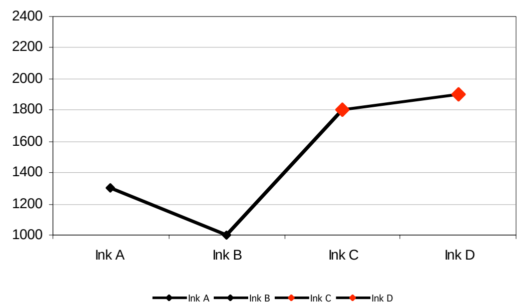
On both the conventional and stochastically screened sides of the test image, paper was a major contributing factor in the transient start-up efficiency. The conventionally screened side achieved the fastest make-readies with uncoated paper followed by HWC paper. On average the slowest make-readies were contributed to LWC paper.

The stochastic results conflict with the conventional results as the LWC paper produced a more efficient transient start-up. The uncoated and HWC papers were slightly less efficient, but performed similar. The reasons behind this difference were unable to be determined with the data supplied, but there is speculation that the difference was caused by the different ink and water balance requirements for these two screening methods.

Interactions involving paper were only significant on the stochastic side of the test image. These interactions included fountain solution and plates. In terms of paper and fountains solution, the analysis shows when printing with paper 8 and fountain solution 4, far more impressions were required to meet the target densities.

Paper's interaction with plates produced mixed results. When printing with HWC paper, plate N required fewer transient start-up sheets than plate M. The other two papers produced just the opposite result requiring fewer impressions with plate M.

The transient start-up efficiency of the different inks was significantly affected by the screening used. Analysis of the data from the conventional screening showed that all inks produced similar transient start-up times. However, when printed using stochastic screening, inks A and B generally produced a faster transient start-up when compared to inks C and D. The reason for these differences is related to ink and water balance as well as the composition / formulation of the different sets of ink.



Impact of ink on transient start-up, stochastic

These results of the transient start-up show there to be discernible difference between screening methods. The differences are clearly related to ink and water balance. Based on these findings it can be said the proper ink and water balance is not only important for maintaining stable colour throughout a run, but is extremely important in order to produce quick make-readies.

Runnability results

During the runnability portion of the study the press operator was asked to maintain the targeted densities for 32,000 impressions. During this run the operator was also tasked with monitoring the fountain solution adjustments required to maintain the target densities.

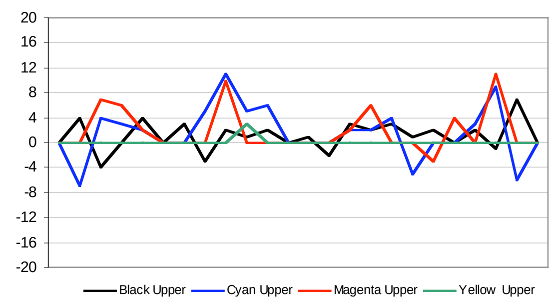
The solid ink densities during this portion of the study were maintained with the Web Printing Controls (WPC) closed-loop colour system which resides on the press. This system measures in real time the densities across the sheet after the printed images pass through the dryer and chill rollers. Measurements from the WPC system are displayed at the press console, which allows the operator to monitor and react to changes in density. The operator was asked not to adjust the ink fountain roller speed as a density control, but to only use the ink keys as the ink key change are recorded by the PECOM control system.

Fountain solution adjustments required to keep the image free of ink in the non-image area were recorded on a log by the press operator. These adjustments were noted for the upper and lower sections of each unit. Ink and fountain solution changes are typically required during a run as temperature increases due to friction. For this reason, temperature measurements of the upper unit blankets were also performed.

The combination of density, fountain solution, and press temperature all play a role in the press's ability to maintain colour stability throughout an extended pressrun. A slight variation of one of these may result in a pressrun were the first good sheet does not match the last.

The ability of the press to maintain a stable density during this study was evaluated on each of the printing units for all forty-two press trials. Results of this section will be discussed based on the ink key and fountain solution changes required for the press to remain stable from the start of the run to the end of the run.

The ink key changes required to maintain the desired solid ink film thickness throughout the forty-two trials were considered insignificant for the fact that the same changes were required for all trials. The changes that were expected to have been made would have been an increase in the volume of ink supplied to the press. This was not the case as in certain areas of the test image less ink was required to maintain the targeted values. The figure below shows a typical pressrun ink key adjustments for the top units. The ink key changes showed both an increase and decrease in the volume of ink being supplied to the unit. It should also be noted that the changes to each key are minor, moving less than 4 units on average.



Typical ink key adjustments, top of the web

On the bottom of the web, the same minor changes as either an increase or decrease were required. The stability of the upper and lower units have been contributed to the roller cooling system which attempts to maintain the ink oscillation rollers at 80ºF and the ink fountain roller at 85ºF.

Blanket temperature changes throughout each of the trials were also considered insignificant as the same changes in temperate was observed during each of the press trials. The change throughout an individual trial in temperature measured on the upper blankets was 4ºF or less. The table below shows the typical increase in temperature from the start of the run up to impression 31,000. These temperature increases are typical for this press as the same observations have been made during other studies performed at PIA/GATF on this press.

	Trial 4	Trial 23	Trial 29	Trial 36
K	3.0	3.2	2.2	0.8
C	3.2	4.0	2.6	2
M	3.5	3.9	2.9	2.7
Y	3.6	3.7	3.5	2.8

Average blanket temperature change over 32,000 impressions

Changes to the fountain solution settings were required during each of the press trials as temperature increased within each unit. The fountain solution changes were also considered insignificant for the fact that the same changes were required for all of the forty-two press trials ran during this investigation

The average increase in fountain solution was reported as 10 units. This increase attributed to scumming that would occur at sometime throughout the trial.

Runnability of the various combinations of press materials on press was consistent as each of the trials required the same changes to produce and maintain what would be considered a clean and acceptable print. The changes required were attributed to the increase in unit temperature which is common with any extended pressrun.

Conclusions

The print quality and runnability of the forty-two press trials varied. The results show that various magnitudes of piling and dampening system feedback were produced based on the different combinations of press materials used. The results and findings were validated by several repeat pressruns that produced excellent agreement to the previous runs.

Initial setup of each combination of materials, defined as the pre-trial, allowed for the definition of minimum ink and water balance. During this procedure piling and feedback volumes varied, indicating that ink and water balance could be a driving factor in controlling these unwanted results.

The majority of the piling produced during this investigation occurred in the title block area (image area piling) and at the outer most edges of the printable area. The volume of piling on unit one was far less than what was observed on unit four. When piling was produced on unit four, downstream piling generally occurred. Though piling was reported at measurable levels, at no time was the piling so great that print quality or runnability of the press became an issue.

Dampening system feedback was produced during certain pressruns accumulating on the water pan roller. This build-up generally appeared in line with areas of the print containing little or no coverage. With those conditions were feedback was produced it was not uncommon to see a build-up at the outer most edge of the dampening roller beyond the width of the paper.

The evaluation of the water window began at the ink and water settings defined during the pre-trial. From this start point water was increased while ink remained unchanged. In certain cases the water setting start points were at a high level so that the total range of fountain solution adjustments expected was unattainable.

During the transient start-up the number of impressions required to meet the targeted solid ink density values was recorded. The different combinations of press materials not only had an impact, but the screening methods as well were considered to have a significant impact. Important to note was that even though the various parameters did have an impact on achieving the targeted values, all forty-two pressruns were able to meet this requirement well before other make-ready procedures such as register were met.

Runnability with minimal intervention to maintain the targeted density values was considered not to be an issue. During each of the forty-two trials similar adjustments to the ink and water settings were required. The majority of the adjustments were driven by an increase in the temperature of the press that would generally be expected due to friction amongst the various parts.

Overall, the performance of the various press materials did indicate differences in performance. The differences did not however affect the press in such an adverse manner that would lead to the press having to be shut down. It can be said that to optimize the productivity of the press and quality of the print, based on these findings, specific combinations of materials should be selected.

Print quality of the forty-two press trials was considered satisfactory as all of the prints produced were of a quality that would meet or exceed sellable quality requirements.

With the objective of this investigation being fountain solution performance it was clear that each of the four fountain solutions used in this investigation were run successfully in combination with various other press consumables.