A PROJECT REPORT ON

STUDY OF INTERACTION BETWEEN FOUNTAIN SOLUTION & PAPER AND ITS EFFECTS ON PRINT

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TO STUDY THE INTERACTION BETWEEN FOUNTAIN SOLUTION & PAPER AND ITS EFFECTS ON PRINT

I Introduction

Introduction

Non-uniform print is one of the most frequent faults occurring in offset printed products. One can basically distinguish between three kinds of non-uniform printing result:

1. The faulty appearance of the print image caused by uneven ink absorption into the surface of the paper which results in uneven back splitting onto the blanket of the next printing unit (Backtrap Mottling).

2. An uneven printing result caused by a wrong trapping of ink, and also influenced by an uneven absorption of the ink by the paper.(Ink Trap Mottling)

3. If the rate of flow of fountain solution is high and/or the paper has poor water-absorbing characteristics, the film of water on the surface of the paper results in repulsion of the ink in the subsequent printing unit **(Water Interference Mottling)** causing unevenness in the print

Water Interference Mottling, one of the major causes of a common print defect could be analyzed and reduced only by first understanding the interaction between fountain solution & paper, & its effects on print.

The paper is wetted not only by the emulsified ink, but by the fountain solution as well, and the film of fountain solution that remains on the paper may cause problems with ink repellence in multicolor printing. It is important that the fountain solution rapidly penetrates the paper before it comes into contact with the ink in the subsequent printing unit. This penetration is not forced but spontaneous and is therefore controlled by paper properties such as surface free energy, pore structure, surface roughness and surface tension of the fountain solution.

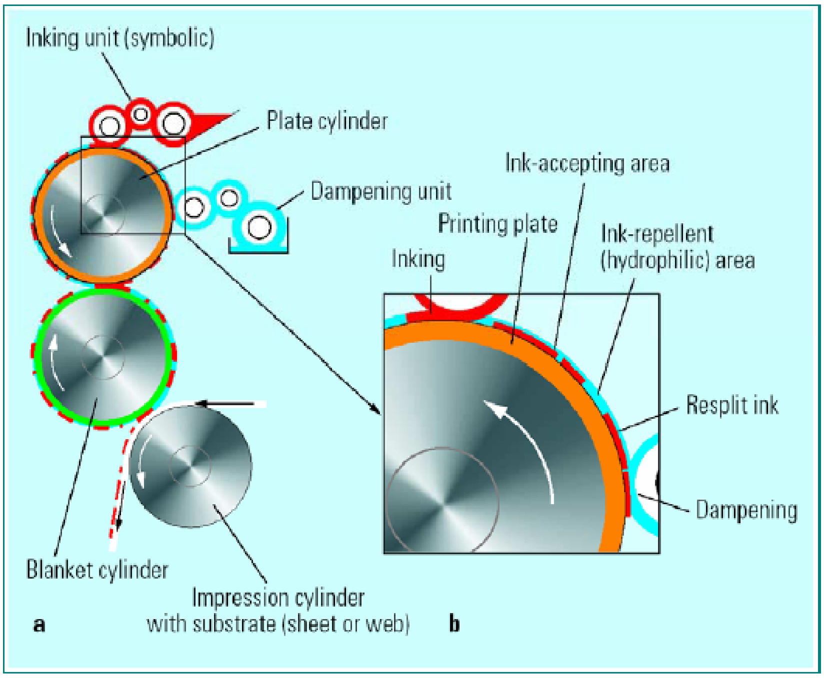
In order to understand this interaction better and to assess the influence of fountain solution on paper & print, various laboratory tests were performed and a series of press trials were taken under this project.

II Literature

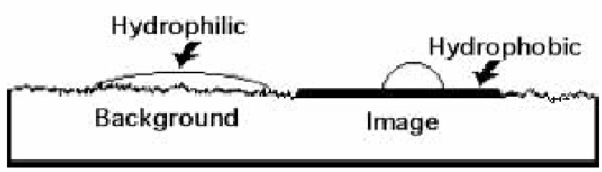
1. FOUNTAIN SOLUTION

1.1 Offset Printing & Fountain Solution

A distinctive feature of Offset Printing is the fact that the printing & non-printing areas on the printing plate are on the same level. To separate these areas, a very thin film (approximately 2 um) of fountain solution is applied to the entire plate by the Dampening unit.



The desensitized non-image areas of the plate, which are made that way by absorbing a thin film of gum arabic to them during plate making, are hydrophilic, or water loving, while the image areas are hydrophobic, or water repellent.



The fountain solution keeps the non-image areas of the plate moistened so that they do not accept ink. It is based on the principle that ink (oil) & water do not mix.

1.2 Composition of Fountain Solution

Most of the fountain solutions are acidic with a pH of 4 to 5.5 being typical.
In general, its ingredients are as follows.

- **Water**, with minimal impurities.
- **Acid or base**, depending to a large extent on the ink being used. Acids used include phosphoric acid and phosphate compounds, citric acid or lactic acid.
- **Gum**, either natural (gum Arabic) or synthetic, to desensitize non-image areas, i.e. to make them prefer water instead of ink.
- **Corrosion inhibitors**, to prevent the fountain solution from reacting with the plate.
- **Buffer**, a substance capable of neutralizing acids & bases in solutions and thereby maintaining the acidity or alkalinity level of the solution.
- **Wetting agents**, such as isopropanaol or an alcohol substitute, which decrease the surface tension of water and water-based solutions.
- **Drying stimulator**, a substance e.g. cobalt chloride that compliments the drier in the ink. It is used only if the ink is not drying fast enough.
- **Fungicide**, to prevent the formation of mildew and the growth of fungus and bacteria in the dampening system.
- **Antifoaming agent**, to prevent the build up of foam. Foam can interfere with the even distribution of fountain solution on the dampening rollers.

The composition of fountain solution may be influenced by the dampening system itself. For example, some dampening systems require use of a percentage of alcohol or alcohol substitute due to the method of applying the solution to the plate. Sometimes, in a conventional dampening system, the use of such an additive improves print quality although its presence in the fountain solution may not be essential.

1.3 The Basis: Water

Water is often overlooked but is critical to fine printing. Approximately 95-98% of a working fountain solution is water. Water found in nature is not clean; rather it contains numerous gasses and minerals. Water quality can vary seasonally, monthly, weekly and even daily. It is important that we be aware of the water conditions at all times to ensure quality, trouble free printing. Ideally, printers should treat their water to ensure consistency.

Water Hardness

The water's hardness is measured in appraising the quality of the water, which largely depends on the quantities of calcium and magnesium present. Water Hardness is thus the measure of amount of calcium, magnesium & iron salts dissolved in water. Depending on the concentration of these salts, water is classified from hard to soft. Hardness is generally expressed in degrees. One degree German hardness (1°dH) is equal to 10 mg of calcium oxide per litre water.

Determining the Hardness of Water

Range of Hardness	soft	medium	hard	very hard
Overall Hardness measured in °mMol Earth Alkali-Ions	0–1,3	1,4–2,5	2,6–3,7	>3,7
German Hardness Grade °d	0–7	8–14	15–21	>21
English Hardness Grade °e	0–9	10–18	19–26	>26
French Hardness Grade °f	0–13	14–25	26–37	>37

The overall hardness of the water may be measured simply by using test strips. Dip the hardness-strip briefly (1 second) into the water, and then read the results after two minutes. Ideally, the dampening solution should possess a water hardness of 8° dH to 12° dH.

Hard water is harmful in the pressroom because, hard water interacts with inks, particularly rubine types, to form insoluble calcium and magnesium soaps. These soaps are greasy and may deposit on either the plate non-image area (causing tinting and toning) or on the roller train (causing stripping or glazing).

The proportion of lime in the water can cause problems during printing,
for example:

- The inking rollers run blank (calcification)
- Deposits on the rubber blanket
- Impact on the pH-Balance
- Fluctuation in the pH-Balance

If the proportion of chloride, sulphate, or nitrate is too high, then it leads to corrosion.

Ideal Water Conditions

Water intended for the production of dampening agents for offset printing has to meet the following conditions. Whenever these conditions are not met, a water mineral processing unit is required.

hardness according to dH	8–10	= 1.428 – 1.785 mmol C_aO/l
carbonate hardness	3–4	= 0.071 – 1.428 mmol HCO_3/l = 65.33 – 87.1 mg HCO_3/l
pH-value	7.2 +/– 0.4	
conductivity	max. 320 +/- 30 µS at 20°C	
chloride upper limit	= 25 mg/l	
nitrate upper limit	= 20 mg/l	
sulphate upper limit	= 50 mg/l	

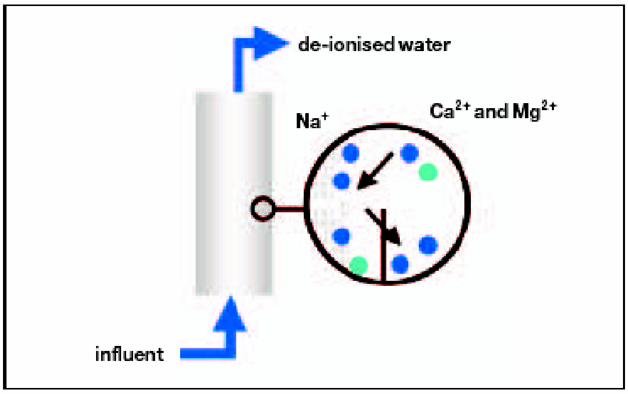
Water conditions

1.4 Water Treatment

Certain ions that are typically present in water can react with paper coatings or ink pigments. Understanding the composition of the water source feeding the plant can explain some press problems or point to an appropriate treatment method.

Interactions between ink, fountain solution and paper can be influenced by the presence of calcium ions. The presence of calcium in magenta ink is well known, and can cause deposits on magenta ink rollers and blankets. Accumulation of calcium from paper coatings or from fountain solution can lead to scaling problems.

De-ionization



To avoid serious scaling on ink rollers and blankets, calcium and magnesium are often reduced to a minimum by a process of ion exchange. Simply removing one of the salt forming components will prevent scaling from taking place. De-ionised water contains sodium ions instead of calcium and magnesium, and therefore, de-ionisation is usually the first step in the water treatment process. Once calcium and magnesium have been exchanged for sodium ions, the water is filtrated to remove the other salt forming components.

Reverse osmosis

It is common knowledge that a raisin swells when put into water. The principle behind this is the equalisation of the salt concentration. The process can be reversed by pressing a salt containing solution through a semi-permeable layer. This process is called reverse osmosis. The water which passes through the layer (the exchanger), loses up to 95 % of all dissolved salts, simply because dissolved ions are too big to pass. The layer consists of a mineral compound with holes of a specific width. Small molecules pass through the holes, whereas bigger compound molecules or even cellular material are stopped. Subsequently, the osmosis water is conditioned for the required process.

1.5 Parameters of Fountain Solution

1.5.1 pH

pH is derived from the Latin (Potentia Hydrogenii) and represents a logarithmic description of the concentrations of hydrogen ions. In other words, the ph-Balance is a measure used to determine the acid or alkaline content of aqueous solutions. What type of acid or base is involved cannot be determined.

The pH scale runs from 0 to 14.Water with a pH of 7.0 is neutral; a pH value of less than 7 means the water is slightly acidic, and above 7 means slightly alkaline.

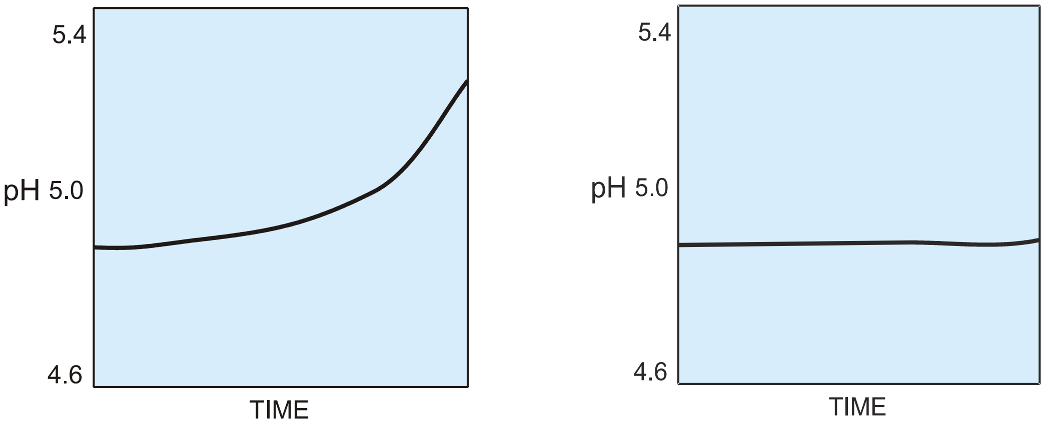
Generally, the pH of water is not an important consideration since the chemical buffering employed in fountain solutions serves to minimize any water pH problems. However, when it comes to fountain solutions it's a different story. For fountain solutions, the control of pH is very important to press performance and printing quality. Because the pH scale is logarithmic, each whole number is 10 times different than the one next to it. For instance, an acid-type fountain solution with a pH of 4.0 is 10 times as acidic as one with a pH of 5.0. To get the best results, fountain solution pH must be maintained within the operating range.

In general acid-type fountain solutions are designed to run in a narrow range somewhere between pH 4 and 5.5. As the press runs, the fountain solution absorbs contaminants from the paper and ink; many of these are alkaline and will to raise its pH. All modern acid-type fountain solutions however, contain a buffer system that is designed specifically to resist the effect of these contaminants and maintain a constant pH. Because the pH of buffered solutions changes very little with concentration, the correct dosage (ounces/gallon) must be measured and maintained using conductivity as a guide.

Depending on the pH value, calcium carbonate contained in the paper will react or not react with the fountain solution. At high pH values, calcium carbonate will be stable, but at low values, there can be an interaction between paper and water.

pH-Balance and Buffer

In modern dampening solution mixtures, the correct pH-balance is automatically predetermined, if dosages are mixed in according to instructions. Buffering prevents paper and ink from altering the pH-Balance.



Un-buffered Buffered

Possible printing problems when the pH value of fountain solution is low:

- Prolonged ink drying time
- Poor solidification of the ink film (which influences rub resistance)
- Increased wear of printing plates
- Roller stripping (ink does not spread evenly across roller surface due to surface not accepting ink)

Possible printing problems when the pH value of fountain solution is high:

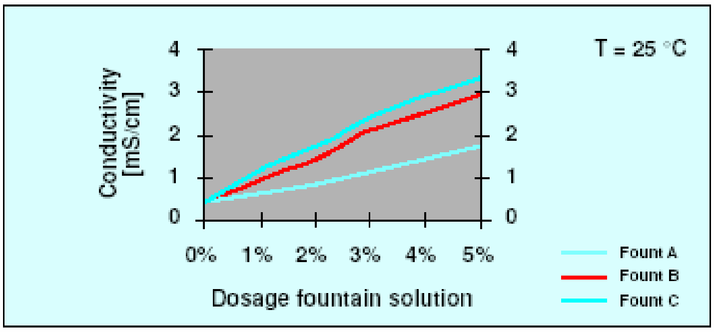
- Emulsification of ink and build-up on ink rollers
- Saponification of the ink (the ink goes into the water)
- Plates will not clean up on starts

1.5.2 Conductivity

Conductivity measures the ability of water or fountain solution to conduct electricity. Generally speaking, as the amount of dissolved materials (ions) increases, so does the conductivity. The units we use to measure conductivity are "micromhos". When dealing with a fountain solution, conductivity is important because it allows us to measure the amount of fountain concentrate in ounces/gallon that is mixed with water. Regardless of the type of fountain concentrate (acid, neutral or alkaline), each ounce added raises the conductivity by a specific amount.

Water in its purest form, such as good quality distilled water or water from a reverse osmosis type water management system has a conductivity of near zero. In contrast, tap water can range from near zero to over 1,000 micromhos. Regardless of what type of water is being used we need to know its conductivity because the correct conductivity for the mixed fountain solution is the sum of contributions from the water and the fountain concentrate.

Measuring conductivity is recommended before and after installing a fountain solution on press and then as an aid in diagnosing any problems that arise during the process of printing.

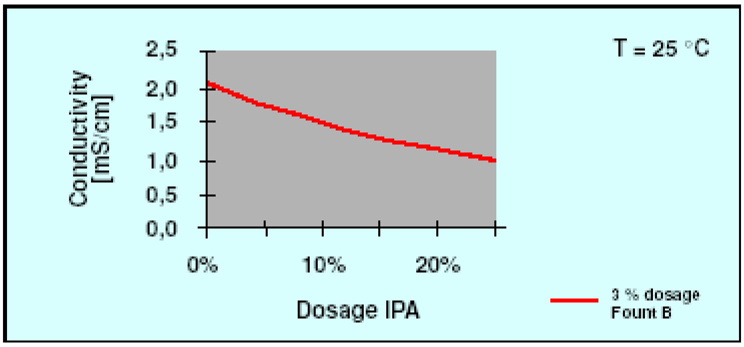


Conductivity versus dosage

The diagram shows that conductivity versus dosage normally is a linear correlation and starts with the value of the pure solvent (tap water, reverse osmosis water). The curve depends on the type of fountain solution. An absolute conductivity value is not very significant for its quality. What is decisive is the slope of the curve. The influence of paper on conductivity, depending on paper type, is often expressed as an increase of conductivity (5–10%) of the fountain solution caused by paper components extracted out of the top layer. However, in practice such values are always influenced by natural processes of production and consumption of the fountain solution, which means that the interaction cannot be easily expressed by way of a simple graphic.

A high conductivity does not necessarily cause problems. Fountain additives with IPA replacement often have a high conductivity to start with. Increasing conductivity on press points to contaminated fountain solution, which can lead to problems due to a disturbed ink / water balance:

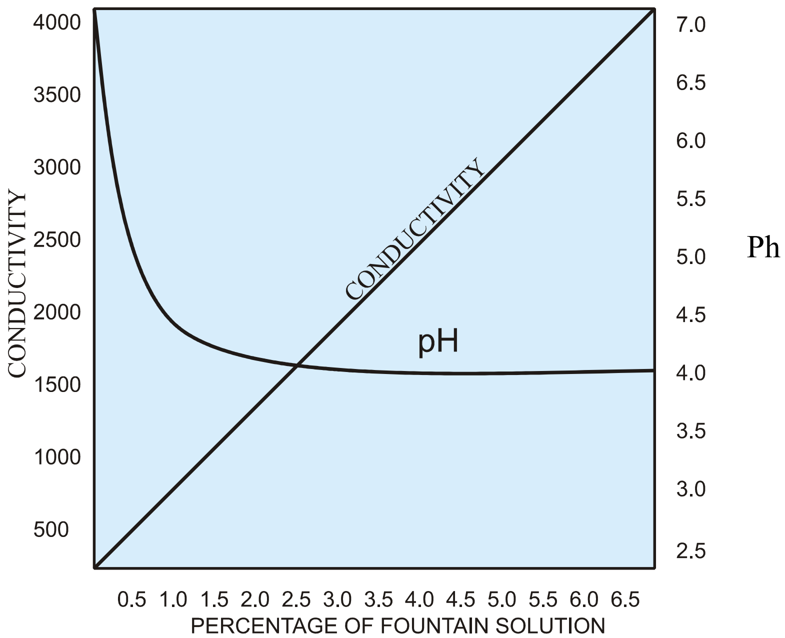
- Ink piling
- Poor ink drying
- Too high dot gain
- Poor print quality



Conductivity versus IPA

All of this means that different types of additives can result in different conductivity values at the same dosage level, without any relation to quality. The diagram below shows a decrease of conductivity when the IPA percentage is raised.

Following is the pH/Conductivity graph:



1.5.3 The Use of Alcohol

IPA (Isopropyl alcohol) in varying doses has been used in sheet-fed & web offset printing for almost 25 years.

Alcohol is a very good wetting agent.

Isopropanol, also referred to as IPA, lowers the surface tension, raises the viscosity of the dampening solution and in the process fosters film formation in the dampening unit. This produces a uniform wetness. Since IPA evaporates quickly, the ink dries more quickly. At the same time, the printing units are cooled by the evaporation cold. By adding IPA, production volume is raised, and the take up of the dampening solution is supported. IPA helps to inhibit lathering.

Arguments for and effects of the use of IPA

- Reduction of the surface tension in order to achieve thorough wetting of the printing plate (thin and homogeneous dampening film)
- Increase of fountain solution viscosity in order to achieve uniform fountain solution transport from the water pan to the printing plate
- Rapid evaporation of IPA generates a cooling effect
- Improvement of emulsification and stable ink /water emulsion
- Antibacterial effect
- Reduction of foaming

Arguments against the use of IPA

- Environmental damage due to the presence of VOC (Volatile Organic Compound)
- International legislation aimed at a reduction or total elimination of VOC emission
- Additional taxation in many countries
- IPA in the air is limited to max. 150 mg/m3 MAC (= the Maximum Allowed Concentration) in many countries
- IPA in the air may cause increased physical strain (e.g. respiration difficulties)
- The ignition temperature of fountain solution with IPA is lower than 50 °C. This implies a danger of fire and explosion, especially in case of incorrect handling and technical errors
- IPA is expensive

1.5.4 Viscosity

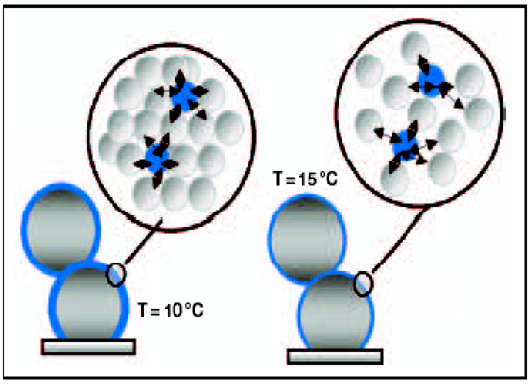
Viscosity of fountain solution and its relation to fount transfer

Viscosity is the degree of internal bonding of a liquid as a result of the attraction of molecules. In the same way, transfer of a liquid over a pair of rollers will be influenced strongly by internal molecular bonding. When viscosity increases, mass transfer increases as well (up to a given maximum). Therefore, in fountain solutions, there are two important parameters which influence the amount of transferred liquid:

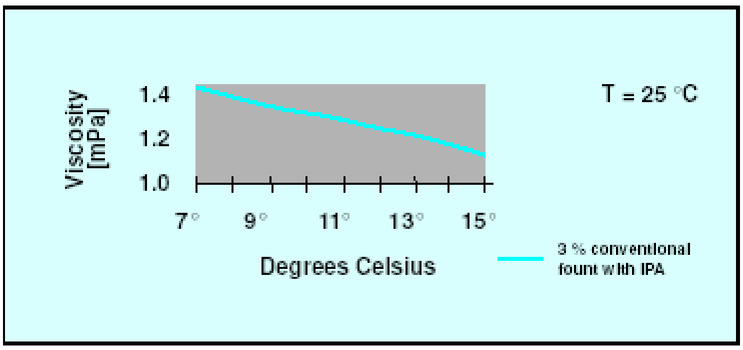
- Temperature
- IPA dosage

Viscosity and temperature

Temperature is a measure for the amount of molecule motion. Higher temperatures are the result of more intensive internal motion of the material and increasing intermolecular space. This in turn implies decreasing attraction of the molecules, and thus a lower viscosity. As shown in the diagram below, higher viscosity at lower temperatures produces a thicker fluid film on rollers, which leads to better transfer over a wide range of roller speeds.



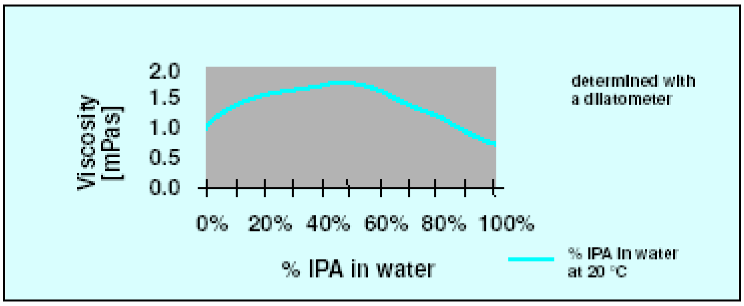
Influence of temperature on viscosity and temperature



Viscosity versus temperature

Influence of IPA dosage on viscosity

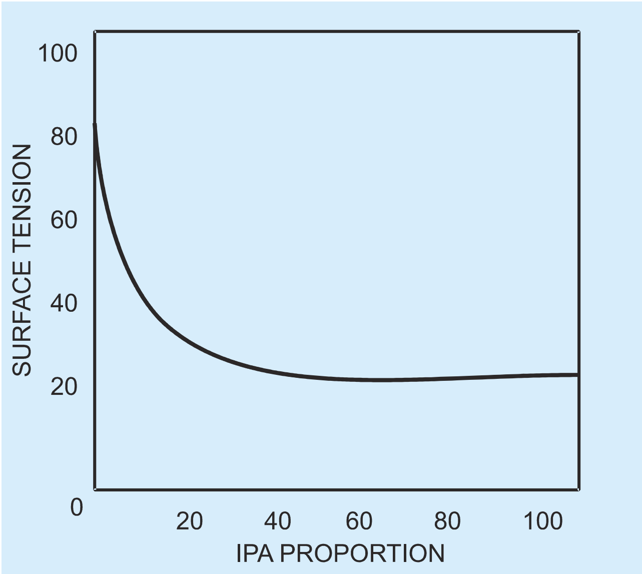
One of the most remarkable effects of the use of IPA is a change in viscosity. This is caused by the formation of three dimensional network structures in the liquid, which results in an increase of viscosity at certain dosage ranges. This means that IPA dosage also has a significant influence on the transfer behaviour of fountain solutions. Printer's notice that transfer is reduced when the IPA-percentage is lowered.Depending on the quality of the fountain solution, this has to be compensated for by increasing pan roller speed. Some fount specialists recommend the use of special rollers, sometimes combined with temperature reduction to imitate the viscosity effects of IPA.



Viscosity versus IPA dosage in water

1.5.5 Surface Tension

Surface tension is the "contractional" force between the molecules inside the fountain solution droplet, which makes the water molecules remain attached to each other.
Lower the surface tension better is the wettability.
Conventional fountain solutions based on a fountain concentrate plus IPA have a surface tension of about 40 mN/m, when the percentage of IPA is 8% or higher. The surface tension is nearly identical under static and dynamic circumstances, and adding more IPA does not lower the surface tension significantly.
When fountain solutions based on a fountain concentrate without IPA are used, the surfactants in the concentrate have to take over the role of IPA.



Graph of surface tension vs. alcohol content

2. PAPER

Paper, in terms of technical production, is an interwoven mat of vegetable fibres formed by deposition of these fibres from suspension in water. It is a tabular structure generated by natural agglutination and felting of fibres.
Graphic papers can be divided into two main categories: wood free and mechanical papers, either coated or uncoated. These papers are available in different grammages and surfaces, such as glossy, silk and matt.

Wood free papers are produced from cellulose (chemically treated wood free fibres), whereas mechanical papers are produced from a combination of cellulose and mechanically treated fibres. The main wood types used in the paper industry are deciduous wood (beech, eucalyptus) and coniferous wood (spruce, fir, pine). Hardwood from rain forests can not be used in the paper industry. In the paper mill the pulp is beaten to a specific length and thickness depending on the required paper quality. Fillers, binders and process materials are added to form the base paper. This uncoated base paper can be calendered, at which point it is basically fit for printing. To improve the paper surface and enhance printability, further finishing techniques are applied.

Currently, the most important finishing process for paper is coating. In the process of (machine) coating, the base paper is covered – coated – on each side with one or two, sometimes as many as three layers of a white pigment coating that consists of:

- Pigments (e.g. calcium carbonate, kaolin)
- Binders (e.g. latices, starches)
- Additives (e.g. dyes, optical brightening agents)

The function of binders is to finely distribute pigments in the coating and to bind them to the paper. Binder / coating recipes vary according to the printing process for which the end product is intended.
Coating application improves the paper surface (smoothness, shade), resulting in improved print quality. Glossy, matt and silk papers all have their own, specific coating formulations. Depending on the required paper surface, calendering may take place.

2.1 Paper properties

Optical properties:

- Brightness: whiteness of paper
- Opacity: degree of non-translucency of paper, expressed as the percentage of reflected light
- Gloss: specular reflection of light on paper's surface

Physical properties:

- Grammage: a paper's weight per square meter (g/m2)
- Thickness: a paper's thickness (µm)
- Bulk: volumic mass (g/cm3)

Mechanical properties:

- Tensile strength: Force of rupture of a strip of paper of standard width submitted to parallel extension.
- Stiffness: rigidity or resistance to bending.

Printability:

- Print gloss: specular reflection of light on a printed paper.
- Ink rub resistance: ability of the printed part of a paper to resist abrasion.
- Pick resistance: ability of coating/fibers to resist being pulled out of the surface during printing.
- Ink setting: selective penetration of ink components into the paper, leading to the immobilization of ink the paper.
- Ink drying: hardening of the ink film deposited on paper.

Some of the most important quality characteristics of the paper are explained bellow.

Basis weight

The basis weight of a paper means the weight in grams per square meter (g/m2) under conditioned circumstances. The entire mass is the sum of fibrous materials, fillers, process materials and water.

Brightness

The brightness (ISO) is a measure for the brightness degree of the paper expressed in percent compared with the brightness standard (magnesium oxide = 100%). The higher the brightness value, the brighter the paper is.

Gloss

The gloss figure in the data sheets indicates the percentage of reflected light with a defined angle of incidence. A higher gloss leads to stronger light reflections and higher gloss values.

PPS roughness

The geometric form of a paper surface is defined as deviation from the ideal flat level. The more the surface approaches the ideal level, the smoother the paper is. The measuring method (PPS) is based on the measurement of air leakage between the paper surface and the even measuring head. In the case of PPS roughness, the average pore depth over a defined circular area is measured. The higher the measured value is, the "rougher" the paper surface is.

Opacity

The opacity is a measure for the opacity degree of the paper, expressed in percent in relation to the reflected light. Paper which lets a lot of light through, is transparent; paper that lets little light through, is opaque. The higher the value, the more opaque the paper is.

Relative humidity

At a given temperature, there is a maximum to the amount of water vapour that the air can absorb. Relative humidity indicates the percentage of this maximum which is actually in the air (i.e. between the sheets of a stack or the windings of a reel).

pH value

The value in the data sheets defines the pH value of the surface. The pH values are indicated on a scale from 0 to 14. The value 7 marks the neutral point which corresponds to distilled water. Values below 7 refer to “increasingly acid ”, values above 7 stand for “increasingly alkaline”. Papers should have a pH close to the neutral point in order to meet ideal requirements for printing and further treatment.

Specific volume

Paper thickness is expressed in micrometer (µm). To compare the thickness of papers with different basis weights, specific volume is used.

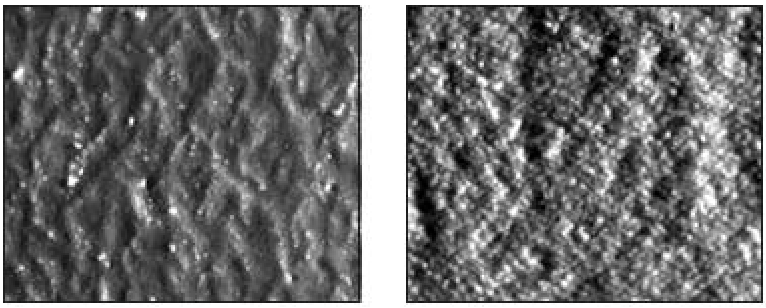
$$\text{Volume} = \frac{\text{thickness } (\mu m)}{\text{basis weight } (g/m2)}$$

2.2 Coated Papers

Various types of coated papers are available, from lightly coated papers where the coating does not completely cover the paper surface to papers where the surface is completely covered with an optimally regular coating, sometimes up to three coating layers per side. Some measure of order has been established by a distinction based on the weight of the coating layer applied per square meter, the method of application and the quality characteristics. In spite of this, there are still significant differences in papers that fall within the same category.

One of the most significant advantages of coated papers over uncoated papers is that the layer of mineral coating which covers them provides a smoother, more even surface. Papers that have a 100% mineral surface are generally considered to be the most ideal for printing purposes. The even, smooth surface of coated paper requires less printing pressure to be applied and, partially as a result of its micro porosity, less ink to be used. Also, because of the more uniform and more closed surface, higher printing gloss and more contrast can be achieved.

In order to apply thin and at the same time even layers of coating to the paper surface, various application methods have been developed. Practical tests have shown that blade coaters produce the best results in terms of surface smoothness.

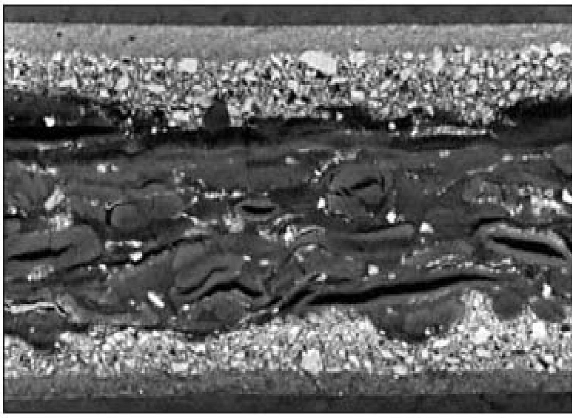


Paper surface detail: Gloss (left) and matt (right)

2.3 Coating Mass

The composition of the coating material itself can vary greatly, depending on the requirements for the job at hand and the method used for application. Coatings are primarily made up out of pigments, binders and additives. The most important pigments are aluminum silicate (commonly known as China Clay), natural or synthetic calcium carbonate and magnesium silicate (talc). The major binding agents are starch, CMC and polyvinyl alcohol, but above all synthetic dispersions, also known as latex binders. Rheological properties, water retention and an even distribution of the applied coating layer are largely dependent on the properties of the (combination of) binders.

Apart from these, many auxiliary materials are necessary for the production of suspensions with high dry solids content, control of flow behavior and pH, as well as colouring agents, preservatives, etc.



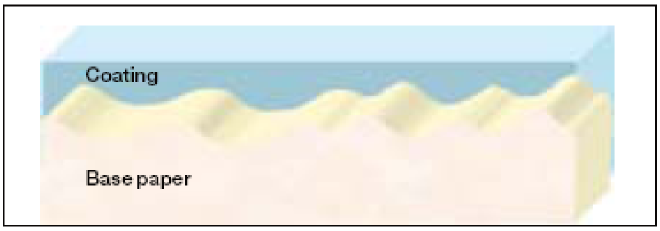
SEM-picture of a cross section coated paper. The lighter area on top and bottom are the coating layer (double coated) and the dark area is the base paper

2.4 The Benefits of Coated Paper

In recent decades, print media have had to meet increasingly high demands, in terms of visual aspects and in terms of printability. To meet these demands, coated papers were introduced many years ago.

Coating a paper enhances its optical and tactile characteristics – whiteness an d shade, gloss and smoothness – but it also improves its printing behaviour, allowing the use of very fine screens, yielding more colour in thinner ink layers and producing more contrast in printed images.

Film coating



Blade coating

When paper is coated, a covering layer of pigments, binding agents and process materials is applied to the surface. To achieve optimal results, all elements involved in the process must be perfectly tuned for mutual support, and this includes the coating colour, the coating method, the coating machine and its specific settings and the paper itself. One coating machine can apply multiple layers of coating, all depending on the intended use of the paper and all applications of coating requiring their own drying times. There are single coated papers, double coated papers and triple coated papers. In many cases, several methods of application are combined for an end result that benefits from each of the individual advantages.

2.5 Glossy Paper

Gloss is a perception based on the physical, optical property of a surface to specularly reflect projected light to a more or less pronounced degree. All three phenomena mentioned above, adherence, picking and rub resistance, have a major influence on gloss.

The better the lay of an ink on a paper, the higher the gloss. But the ink itself and the paper itself obviously have effects on gloss as well. On a matt paper it is less easy to achieve proper gloss by way of the ink and vice versa.

Gloss coated papers have a highly glossy appearance and a closed, even surface. Glossability is the overriding consideration in the very composition of the coating mass, which in many cases consists of extremely fine pigments, which leads to a smooth surface of low abrasivity. On top of that, the paper is passed through a supercalender.

A high-gloss paper surface, however, has two disadvantages. In the first place, the high gloss can be a source of irritation. Papers with a less smooth surface reflect light in a diffuse manner, which is clearly an advantage inasmuch as it is less tiring and more comfortable to read text and view images printed on a matt surface. Obvious examples are textbooks and annual reports. Secondly, the high gloss of the paper itself makes it hard to realize a printing gloss that significantly exceeds the gloss of the paper itself. As a result the difference in gloss of printed parts of the paper and the unprinted surface of the paper itself is usually much lower than that of matt papers and can occasionally even turn out negative. In general, high printing gloss emphasizes form and colour and adds to the quality of the printed job, as is illustrated by most art and photography books. Paper gloss and printing gloss are not correlated, by the way, since printing gloss is a result of many other factors. **Gloss is the degree to which a paper reflects a beam of light shining on its surface.**

To measure gloss, a beam of light of specific brightness is shone upon the paper surface under a certain angle and the percentage of light reflected is measured by means of a photoelectric cell. Gloss is often used as a synonym for smoothness, but there is a distinction. A surface can possess a high gloss even if it is not smooth and smooth surfaces can be very low in gloss.

Roughness is the degree to which irregularities appear in the surface. There are a number of methods to measure roughness, some of which do differentiate successfully between smooth and rough surfaces, but give no indication as to the size of the irregularities themselves. The overall test result of a large number of small irregularities, in these methods, is the same as that of a small number of large irregularities.

Matt papers were developed in order to improve readability, since gloss calendared papers reflect light at certain angles of incidence. Thus the early period of matt papers was peaceful, with good readability being provided for the literature sector. Over the years, however, publishers, creative people and printers became steadily more adventurous and printed works became more colorful.

During the same period the consumption of matt coated paper increased by over 50% as is the case everywhere; rationalization has become essential in everyday printing activities. This involves, for example, using “fresh inks” and related systems in order to reduce washing times and reduce non-productive time. There is no drying out of ink in the ink fountain or on the rollers, even after a machine shut-down of many hours (overnight). All these measures have had nothing but positive effects on gloss coated papers. For matt coated papers, however, printing inks of a duct-fresh nature or type are not the ideal starting situation. As in the case of successful printing on matt papers, the materials ink and paper, and the processing conditions at the printers and bindery, have a significant influence on the result.

Lack of knowledge about the different paper surfaces and the resulting technical limits in printing and processing have led to significant problems in the use of this demanding grade of paper.

2.6 Matt Coated Papers

As the term itself indicates, matt coated papers are papers with a matt surface, in other words, a low degree of gloss. To achieve a matt appearance, coarse pigments are used in the coating layer, preferably multi-edged particles that help disperse light diffusely in all directions. Surfaces that reflect less direct light appear more matt. This is why calendaring is not used in the production of matt paper (with the possible exception of a matt or soft calender), which has the additional effect of a usually higher paper thickness and stiffness than can be achieved with glossy papers.

The problem is that there is no exact definition of the concept “matt” and this makes it impossible to draw fine lines. Around the world, all sorts of coated papers are being produced with a specification of “matt“, regardless of rather large differences in gloss and smoothness. Some of these papers are distinctly matt, of around 10%, while others are slightly glossy, with gloss values of up to 50%. It only goes to show that “matt“ does not always mean “matt” in the proper sense of the word, but is used to include “Demi-matt“ as well. Demi-matt paper, also known as “satin“ or “silk”, is a compromise between high-gloss paper and truly matt paper. It is a paper with a silky surface, which favours readability. It is less coarse than matt papers, which makes it perform somewhat better in terms of ink rub resistance, and it lends itself fairly well to surface finishing. To produce a classic matt quality paper with good printability characteristics, the surface of the paper should combine a high macro-smoothness and evenness with a low micro-smoothness in order to obtain the diffuse reflection which is essential to the overall matt appearance of the paper. The advantage of the higher specific volume should be maintained.

The properties mentioned above will basically result in a lower degree of rub resistance – the high macro-smoothness and low micro-smoothness causing increased static and dynamic friction resistance because of the larger contact surface, coupled with a stronger coherence of micro irregularities. High micro-roughness of a paper leads to a higher surface porosity, which in turn results in faster ink absorption. If the ink strikes into the paper too quickly, the diluting agents may take some of the resin with them. This can leave the pigments on the surface of the ink film with very little resin to protect and hold them. In other words, the decreased presence of binders will make the ink film less rub resistant. This adds up to two possible causes for reduced ink rub resistance.

The terms matt coated paper and rub resistance seem to be inherently linked. Although paper makers, ink makers and printers are moving closer together in tackling problems connected with printing matt coated papers, the same old problems still continue to show up occasionally. Even though these days such problems are far more exceptional than they were in the past, problems with rub resistance are usually the most troublesome and costly in printing. This is not just because these problems usually occur in the finishing stage, when a lot of time and money has already been invested in the process up to that point, but also because at this final stage, the delivery deadlines are tight and the opportunities for recovery are limited. Generally speaking, rub resistance is a factor of three complex process ingredients: the ink, i.e. the resistance of the printed ink film, the paper, i.e. the toughness and roughness of the sheet when submitted to rubbing motions, and the mechanical motion which causes the actual rubbing. Each of these ingredients in turn, is made up of a complex structure of properties and dependencies. In most cases, the imperfections of each of these ingredients can be compensated for by one or both of the other two. However, sometimes the unfortunate choice of one or an unfortunate combination of two or all three of them can be the cause of such serious problems that no remedy is possible.

Blade coating involves the application of an abundant amount of coating on the paper by way of a roll or a nozzle (jet coating) filled with coating. Immediately after application, the excess coating is scraped off by a blade (comparable to the procedures used in gravure printing) which evens out the applied layer.

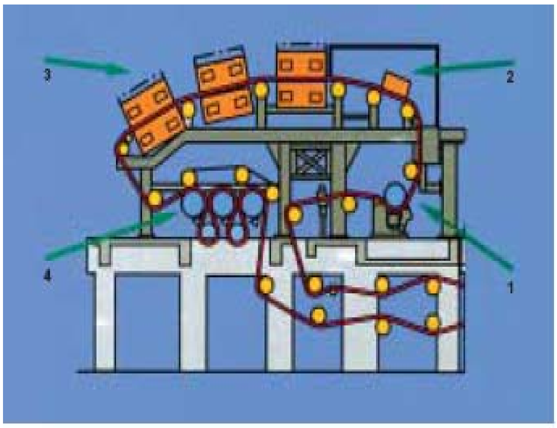


Fig. A1 *Coating machine:*
1 Coating unit — *3 Hot-air drying*
2 IR drying — *4 Cooling*

Fig. A2 *Coating machine PM 11 in Gratkorn*

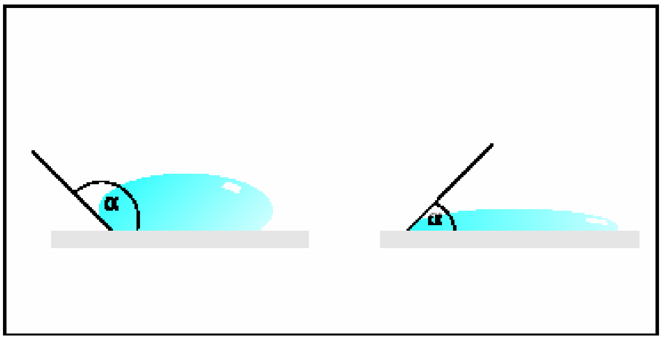
The amount of coating to be applied is determined by the viscosity and dry solids content of the coating, by the speed of the machine, the distance between blade and paper and the pressure and angle of the blade. Modern blade coaters are running at operating speeds of up to 2000 m/min (Fig. A1 & A2)

Of course the evenness of the base paper itself also determines the smoothness and evenness of the coating layer. Irregularities in the fiber distribution can cause inconsistencies in the density and thickness of the coating layer with the possible result of variations in ink acceptance and absorption, leading to a mottled printed image.

3. INTERACTION BETWEEN FOUNTAIN SOLUTION & PAPER

3.1 Introduction to contact angles

In most cases where a liquid droplet is applied to a solid material, an angle is formed at the point of contact between droplet and solid, the so-called wettability angle or contact angle. This contact angle is an indication of the wetting performance of liquids applied to solids. The contact angle is measured as the angle between the base and the tangent at the point of contact between liquid and surface. This value corresponds to the surface energy level in the equilibrium system between liquid and solid on condition that the surface is smooth, non-porous, non-absorptive and homogenous. Furthermore the liquid must not react chemically with the substrate. Wetting is defined as a contact angle of 90 ° or less.



High (left) and low (right) surface tension

Contact measurements and wetting studies can be performed using a Dynamic Absorption Tester (DAT 1100, Fibro System AB).

3.2 Surface tension and surface free energy

Surface tension is the "contractional" force between the molecules inside the fountain solution droplet, which makes the water molecules remain attached to each other. With the Fibro DAT instrument, the surface tension can be directly measured from the shape of the fountain solution droplet. This measurement is expressed in mN/m. The surface tension is usually characterised by two components: polar (water attracting) and dispersive (water repellent).

Surface free energy, similarly, is "attractional" force, which is available on the surface of a solid substrate to attract the liquid molecules. Surface free energy has two components as well: polar and dispersive. In contrast to surface tension, surface free energy cannot be directly measured, so it has to be calculated from contact angle measurements with two or more selected liquids.

3.3 Wetting and penetration

It must be emphasised that wetting performance depends on the interaction between fountain solution and paper. Quality inks or quality papers by themselves are not enough, since fountain solution and paper have to be tailored to one another to obtain the desired performance. Even with a good match, it may be necessary to reduce the contact angle. To reduce the contact angle, the surface tension of the fountain solution can be reduced (by adding isopropyl alcohol or tensides), the surface free energy can be increased (corona treatment), or a combination of both can be used. The wetting process starts when the lowest part of the liquid drop first makes contact with the paper. The liquid starts to spread over the surface and penetrate into the porous paper. In offset printing, fountain solution is transferred to the paper from a blanket. This fountain solution must disappear from the surface before the paper enters the next printing nip. Hence, initial penetration is very important in this printing process.

Penetration is controlled by properties such as:

- surface energy
- paper roughness
- surface tension of fountain solution

Contact angles of fountain solution droplets on paper are not only dependent on the surface free energy, but are also influenced by the porosity of the paper and the size of the pores.

3.4 Paper Structural Properties

The above factors indicate the importance of paper properties, such as surface topography, porous structure, and formation on the uniformity of printing.

The surface of paper is the primary bearer of the print. An ideal paper surface for printing should be a surface that is able to accept, retain and present the ink to the observer in an optimum manner. This means that paper should be smooth enough to provide good contact, and the pore size should have a suitable mean size and uniformity to absorb ink or fountain solution evenly.

The smoothness and porosity of a paper are significantly dependent upon the uniformity of its formation. A paper with poor formation may have "hills" and "valleys" on the surface of paper.

The porous structure of paper depends on the components of paper and their spatial arrangement. These components include fibres, fines, fillers and coatings, and the spatial arrangement is influenced by the formation of paper and the degree of pressing and calendenng.

A more completed description of the porous structure of paper is given by the pore size distribution of paper. The porous structure of paper is complicated due to the irregular shapes of pores and the interconnection between pores.

3.5 Interaction between Fountain Solution and Paper

The paper is wetted not only by the emulsified ink, but by the fountain solution as well, and the film of fountain solution that remains on the paper may cause problems with ink repellence and water interference mottling in multicolor printing. As the fountain solution gets transferred on the paper, it is forced into the voids in the surface of paper. Some of it then penetrates into the porous structure of the paper while rest remains on the paper. Once the printing pressure is released, the fountain solution will be drawn into the paper structure by capillary penetration and spreading. This penetration is not forced but spontaneous and is therefore controlled by paper properties such as surface free energy, pore structure, surface roughness and surface tension of the fountain solution

There are three factors controlling the interaction between fountain and paper.

1) Contact between the fountain solution film and the paper i.e. wettability, which mainly depends on the surface tension of the fountain solution and surface free energy of the paper.

2) Penetration of fountain solution into the paper, which mainly depends on the surface roughness and porous structure of paper i.e. porosity of the paper & the pore distribution and also printing pressure.

3) Rate of penetration which is affected mainly by the printing speed and printing pressure.

It is important that the fountain solution rapidly penetrates the paper before it comes into contact with the ink in the subsequent printing unit.

4. PRACTICAL EXAMPLES & SOLUTIONS

4.1 Ink / water balance

When too little fountain solution is fed, the non-printing area of the plate will accept ink, and the print will start scumming. At too high levels of fountain solution, the ink is washed away from the printing area. It is up to the printer to find the correct amount of ink and fountain solution fed to the printing plate. This is called the ink / water balance.

An ink that can easily absorb an overdosed amount of fountain solution is said to have a wider "water window".

Parameters that are of influence are:

- Paper / ink combination
- **Water absorptivity of the ink**
- Plate type
- **Fountain solution chemistry**
- Press ink- and dampening roller settings
- Temperatures

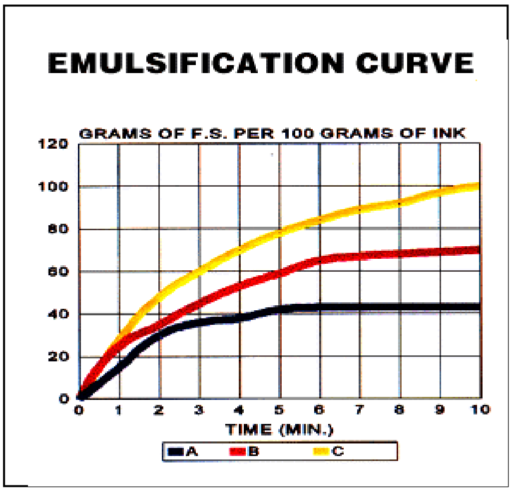


Figure shows the effect of different types of fountain solutions with a typical ink formulation. As you can see from the chart, the selection of fountain solution can be critical in determining your ink and water balance. The same can be true for different inks and a single fountain solution.

When an ink over-emulsifies, or takes up too much water, it changes its flow properties, with the effect that transference is adversely affected. This leads to the need to run with an excessive ink film (just to achieve somewhere near the correct density) and all the problems, which are associated with that.

4.2 Ink Repellence

This phenomenon is usually characterized by a cloudy printed image. The problem occurs when, during printing, the thin film of fountain solution on the paper has not disappeared
before the subsequent colour is printed. Because ink is repelled from this film, the subsequent colour will show a cloudy print.

A quick way to establish whether the problem really is ink repellence is switching off the colour(s) prior to the poorly printing colour. If the print result improves, ink repellence is
the cause. Decreasing the dampening feed on units prior to the poorly printing colour will solve the problem or at least improve the result.

Possible causes for ink repellence are:

- Poor water absorption characteristics of the substrate
- High flow rate of fountain solution
- Too high dampening feed
- Fountain solution containing components which are absorbed (too) slowly into the substrate.

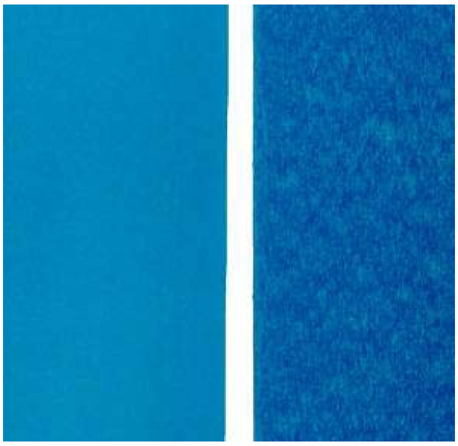
4.3 Wet Pick

The fact that water as well as ink is transferred to paper may lead to one more phenomenon called Wet Pick. When the paper is wetted several times, water may affect ink transfer because it changes the surface structure of the paper. For example, it is possible the water is weakening the paper surface to such an extent that paper particles are pulled off from the surface by the tack of the ink. This is nothing but wet pick.

A higher penetration of the fountain solution into the paper can lead to a higher sensitivity for wet pick (weakening of the coating layer).

The solubility degree of coating of offset papers when brought into contact with fountain solution can be determined by the Adam's Wet Rub tester.

4.4 Print Mottle



Mottling is the uneven appearance of the print. The printed image visually appears undesirably blotchy, streaky or non-uniform. Print mottle is usually the result of uneven ink lay or non-uniform ink absorption across the paper surface, especially visible in mid-tone imagery or areas of uniform color such as solids and continuous-tone screen builds. This visible non-uniformity may be the result of differential ink gloss, density, or color of the printed ink film.

Mottle is influenced by many parameters: type of ink, colour sequence, construction of printing press, speed, rubber blanket, damping water and the most important one: the type of paper. Variations in the surface characteristics as absorption and smoothness play an important role in the mottle and are caused by the production process and the components in the paper.

There can be three main kinds of mottle:

- Back trap mottle: an uneven printing result, caused by uneven ink absorption of the paper.
- Ink trap mottle: an uneven printing result caused by a wrong trapping of the ink in tack and/or viscosity and is also influenced by an uneven absorption of the ink by the paper.
- **Water interference mottle:** an uneven printing result, caused by insufficient and uneven water absorption of the paper, followed by uneven ink absorption.

  If the rate of flow of fountain solution is high and/or the paper has poor water-absorbing characteristics, the film of water on the surface of the paper results in repulsion of the ink in the subsequent printing unit. This is associated with a reduction in the depth and saturation of the colour. If these repulsion effects partially occur to different extents, solid areas show an uneven print-out, especially with reproduction of large areas of screen. The dots are not very sharp and coverage is reduced.

5. TECHNICAL TIPS ON MOTTLE

This section gives different types of mottle, their potential causes and guidelines for troubleshooting.

5.1 Printer's Mottle

The result of a misconfigured press that transfers an inconsistent ink film to the paper. This potential mottle cause should be the first focus for trouble-shooting.

Causes and Solutions

- Prepress – First determine that the mottle pattern is not inherent in the original art or the color separations. Check for conflicting screen angles, moiré patterns, or mid-tone inconsistencies. Avoid using flat screens in the 50% range.
- Ink Train – Roller condition, durometer, and settings are key elements. Insure that the chill system temperature preset is optimum. Most conventional ink formulations transfer best at 75-80° F. (24-27° C.). Consult ink supplier.
- Fountain Solution – Insure proper conductivity, pH and uniform, moderate delivery to the plate. Avoid excessive use of alcohol substitutes.
- Ink – Ink film thickness on the rolls should be optimum for proper ink transfer. Some ink formulations such as grey and brown can be problematic. Using varnish instead of tint base to formulate tints can often improve ink lay.
- Plate – Check plates for consistent caliper and packing requirements. Surface grain can affect water pick-up.
- Blanket – Check surface condition for proper smoothness and release characteristics. Harder blankets can often smooth print mottle on solid ink lay. Insure solvent and blanket compatibility to minimize potential for swelling and embossing. Maintain proper and consistent caliper, packing, and torque specs. Avoid mixing blanket types.
- Blanket Packing – Inspect packing for uniform basestock formation and caliper accuracy.
- Impression Squeeze – Check for weak or excessive impression squeeze. Back-off impression squeeze until image breaks, then increase minimally to optimize print.

Guidelines for Troubleshooting

- Check consecutive press sheets. If the mottle pattern is consistently the same sheet-to-sheet, focus on plate, blanket, impression, and packing integrity and insure proper packing height over bearer with a packing gauge. Compare mottle pattern to the plate image to insure prepress integrity.
- Isolate mottle to an individual unit of print by analyzing solid ink lay in the color-bars. If only one color in the ink rotation demonstrates visible mottle, focus on the components of that particular unit of print. Running dry solids in the suspect unit of print can offer an effective tool for analysis.
- Lift varnish or aqueous coating off impression and compare print quality.
- Determine if mottle manifests itself immediately on start-up or if it slowly develops on the run. If press starts up without mottle, blanket swelling from solvent wash may be masking other issues. Focus on plate, blanket, impression, and packing relationships.
- Flip sheet and compare, or try a competitive sheet of equal grade, surface, and basis weight. If condition persists, continue focusing on press related issues.

5.2 Ink Trap Mottle

Poor or inconsistent unit-to-unit ink trap which transfers non-uniformly to the paper and/or previous ink films. Trap requires one wet ink film to capture or "trap" subsequent ink films. Incorrect ink tack
grading, wrong ink sequence, screens over solids, and paper absorbency are most often the cause.

Causes and Solutions

- Ink does not build tack fast enough to effectively trap subsequent ink films. In multi-unit printing, the previous ink must be of greater tack than that of the ink being applied to maximize percentage of ink trap. Initial ink tack and ink tack build through the press should be graded accordingly.
- Improper ink sequence. Ink sequence should be determined by tack grading and ink coverage. Avoid trying to trap screens on solids or light coverage on heavy coverage.

- Paper or substrate set rate is incompatible with ink set rate. For example, a tighter, gloss surfaced sheet would require a quicker ink set than a more open, soft-surfaced sheet.

Guidelines for Troubleshooting

- Insure that Printer's Mottle is not the issue.
- Document and analyze ink sequence in relationship with ink tack ratings.
- Isolate suspect units of print and determine if mottle involves at least two overprinting colors.
- Analyze color-bars for individual unit print integrity and measure the percentage of trap between the suspect colors.
- Pull single prints and progressive combination prints and compare print integrity.
- Determine if the mottle may be the result of poor ink trap and subsequent back-trap due to light ink coverage printing over heavy ink coverage. Blue-sky images, where light coverage magenta prints over a heavier cyan is a common example of this type of mottle. In this case, transposing the cyan/magenta ink sequence and tack may be an opportunity to improve ink trap and dot fidelity.
- Flip sheet and compare, or try a competitive sheet of equal grade, surface, and basis weight. A faster setting sheet may improve progressive ink trap.
  (Note: A faster setting surface may also adversely diminish ink holdout and retained ink gloss).

5.3 Back-trap Mottle (BTM)

As the sheet travels from unit-to-unit, the ink film non-uniformly traps back onto subsequent blankets resulting in uneven ink transfer and absorption on the paper. Paper uniformity and setting characteristics, ink set rates, poor ink trap, and blanket type are the usual suspects.

Causes and Solutions

- Fast setting inks. An ink that is setting too fast through the press is releasing its vehicle too quickly and may then be pulled back off the printed sheet (back-trapping) non-uniformly onto subsequent blankets as it progresses from unit to unit.

- Dark solids or coarse ground, heavy-pigmented inks printing in first-down units with no fresh ink overprint in last-down units. Change sequence to run these colors further down in rotation. Ideally, these types of colors and solid images print and smooth out best when bumping off only one subsequent unit.
- Excessive plate/blanket or blanket/impression squeeze. Improper blanket surface or release characteristic causing non-uniform ink film split. Change to quicker-release blankets.
- Heat generated during long press runs can increase ink tack through rapid evaporative solvent loss.
- Extended make-ready or press downtime can also result in high ink tack through excessive evaporative solvent loss. Keep rollers well lubricated between press pulls or rinse rollers if necessary.
- Cyan/magenta ink traps, such as blue-sky image, are notorious for back-trap mottle potential as is any situation where poor ink trap transfers through subsequent units of print. Adjust ink tacks or transpose ink sequence as necessary. (Refer to Ink Trap Mottle).
- The more units of print, the greater the potential for back-trap mottle. Optimize sequence to minimize the number of units on impression. This may be of particular concern running web offset where open units subsequent to the first unit of print must run on “wet” impression.
- Non-uniform drainage of ink into the paper or non-uniform paper absorbency.

Guidelines for Troubleshooting

- Insure that Printer’s Mottle is not the issue.
- Document and analyze ink sequence in relationship with tack ratings.
- Determine that affected color is in an early-down unit and printing through subsequent units with minimal or no fresh ink overprint.
- Run singles and compare print integrity.
- Progressively lock off impressions of later-down units from the last unit back, one unit at a time, to determine if first-down colors print smoother without bumping off subsequent units. Maintain consistent press speed during this test.
- Vary press speed. Increased press speed may minimize back-trap mottle.

- Paper or substrate set rate is incompatible with ink set rate. Optimize ink set rate to substrate. If condition persists, flip sheet and compare, or try a different production run of paper, and/or a competitive sheet of equal grade, surface and basis weight.

5.4 Water Interference Mottle

The non-uniform acceptance or rejection of the fountain solution across the sheet surface. If the sheet does not absorb fountain solution uniformly, ink applied in subsequent units may not transfer and lay uniformly. Ink and water imbalance can affect the uniformity of ink transfer resulting in a non-sharp, hollow, or weak dot structure in respective units of print.

Causes and Solutions

- Any inconsistency in the metering of the fountain solution or irregularity in the solution mix, such as high conductivity or pH, that may necessitate running heavy water to the plate to keep the non-image clean. Excessive water can over-emulsify the ink and adversely affect the paper's ability to uniformly absorb the excess. Adjust to carry less water to the plate in all units.
- Incorrect ink water pick-up compromising proper ink emulsification and transfer.
- Excessively heavy ink film on the rolls also demands excessive water to the plate.
- Increase impression cylinder squeeze and compare print integrity.
- Non-porous paper or substrate surface can not absorb water quick enough from unit to unit or carry and transfer water effectively. Low or non-absorbent substrates demand less water to the plate.
- Paper surface does not absorb water uniformly from unit-to-unit. Excess water on the sheet surface negates uniform ink transfer.

Guidelines for Troubleshooting

- Insure that Printer's Mottle is not the issue.
- Inked solids and dots appear washed out under magnification.
- Over-emulsified ink will transfer dots that exhibit feathery edges or hollow centers.

- Progressively lock off impressions in first-down units preceding the mottle and compare prints.
- Pull progressive, single-unit prints and compare print integrity.
- This type of mottle has greater potential on light coverage forms with light ink take-off. Consider using take-off bars to increase fresh ink displacement. This will help maintain ink integrity and transfer capability.
- As with Back-trap Mottle, the more units of print, the greater the potential for water-interference mottle in later-down units. Avoid running "wet" in open or pre-dusting units.
- Flip sheet and compare, or try a different production run of the same paper. If condition persists, try a competitive sheet of equal grade, surface, and basis weight.

5.5 Plain Paper Mottle

Non-uniform ink lay that is the result of paper manufacturing process variables or the result of unique paper surface print characteristics.

Causes

- Paper manufacturing process variables such as uneven coat weight, binder migration, wire/felt patterns, poor basestock formation, or fiber clumps.
- Non-uniform surface absorption of the paper.
- Non-uniform basesheet contributing to gloss variation and surface galvanization.
- Optical incompatibility between basesheet and coating.
- Wrong paper surface choice for the job.

Options and Solutions

- Compare both sides of the sheet and run the more critical imagery on the smoother side.
- Replace the paper with a different production run of the same grade.
- Softer, more absorbent paper surfaces may demand double-hits or underlays to smooth and maximize solid ink holdout and depth. Avoid connected dots in the mid-tone range (45% - 60%) to minimize visual mottle when printing continuous flat screens and screen mixes on these types of surfaces.

- Determine the appropriate grade and surface most suitable for the imagery in question and consult with customer.

Guidelines for Troubleshooting

- Insure that Printer's Mottle is not the issue.
- Mottle is evident in all colors and usually worse in heavy coverage solids.
- Check sheet-to-sheet print consistency. A problem sequentially repeating mottle every third sheet suggests a paper issue.
- Flip sheet and compare, or try a different production run of the same paper.
- Some textured, soft-surfaces offer an aesthetic appeal that can result in nonuniform ink holdout by design. Depending upon imagery and desired affect, the end print result can be perceived as either mottle or texture. Consult with customer to align reasonable expectations.

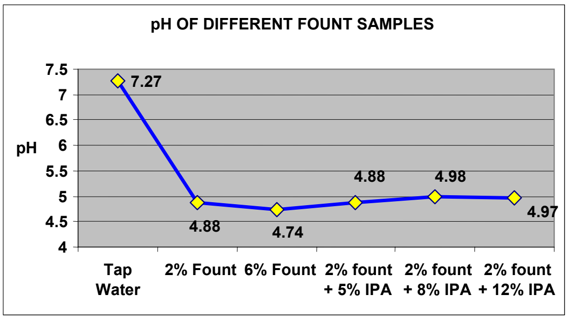
III Laboratory Testing

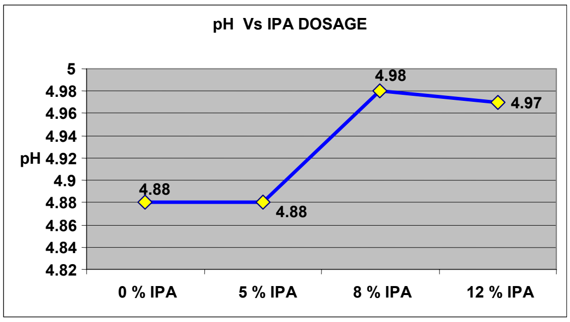
1. MEASUREMENT OF PH, CONDUCTIVITY AND SURFACE TENSION OF FOUNTAIN SOLUTION

1.1 pH

pH is a measure used to determine the acid or alkaline content of aqueous solutions. What type of acid or base is involved cannot be determined. A liquid with a pH-Balance of 5 has 10 times more acid than a liquid with a pH Balance of 6. Ideally, the dampening solution should possess a pH-Balance of 4.8 to 5.5. As a general rule, dampening solution additives are buffered, in order – for the most part – to neutralize external influences. A pH-Balance measure does not tell us very much about the quality of the dampening solution. The measure only shows, whether an additive is present or not. Naturally, in order to determine the quality of the dampening solution, its conductivity should also be determined.

pH of six different fountain solution samples was measured.
Fount used: Micro Fount 0009





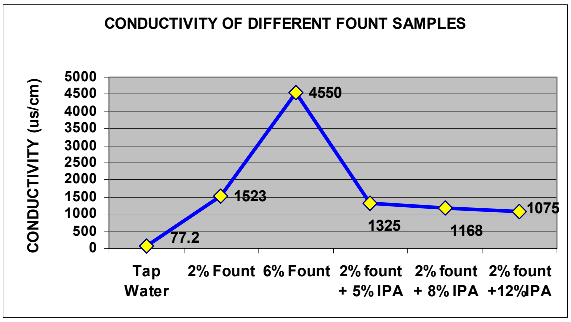
Since fountain solutions are buffered there is not much change in pH even after increasing the fount concentrate or the IPA proportion.

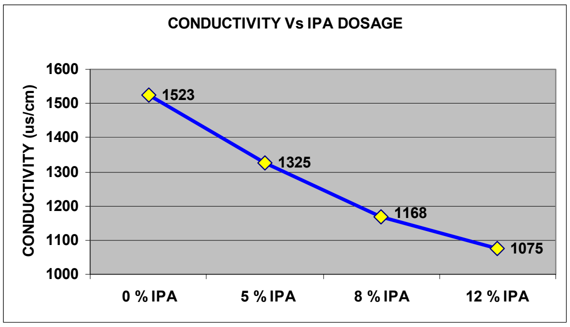
1.2 Conductivity

Conductivity(µS/cm) describes how electricity is conducted through a liquid; impurities in the dampening solution allow conductivity to increase. Conductivity varies depending on the water and additives. The temperature and the concentration of alcohol also influence conductivity. By increasing Isopropanol (IPA), conductivity declines.

Modern conductivity gauges also measure for temperature. It is important that the conductivity gauge in the central dampening solution be regularly cleaned and re-calibrated. Conductivity should be determined using a "freshly prepared dampening solution", so that this measure can then serve as a "measuring staff" for when the dampening solution is later exchanged. When the conductivity in the dampening solution has climbed by approx. 1000 µS/cm, this should be taken as a signal that it is time to change the dampening solution. In order to guard against printing problems, it is recommended that the dampening solution be renewed every 14 days. The pH-Balance, the temperature, as well as conductivity can be measured by means of a universal test control device. All electronic measuring instruments must be regularly re-calibrated.

Conductivity of six different fountain solution samples was measured.
Fount used: Micro Fount 0009





Thus, conductivity of tap water is low which increases with the increasing additive but declines with the increasing IPA. Note that after certain limit conductivity does not decline even with increasing IPA.

1.3 Surface Tension

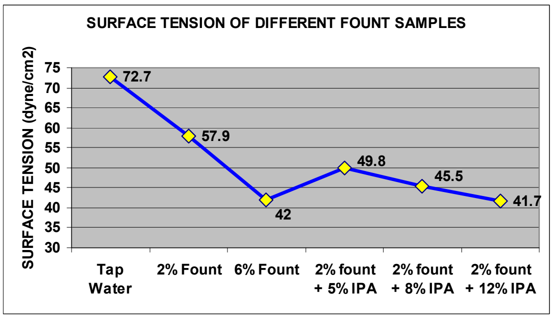
Surface tension is the "contractional" force between the molecules inside the fountain solution droplet, which makes the water molecules remain attached to each other. With the Fibro DAT instrument, the surface tension can be directly measured from the shape of the fountain solution droplet. This measurement is expressed in mN/m.

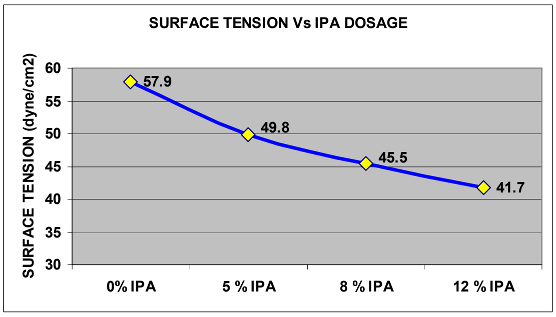
Conventional fountain solutions based on a fountain concentrate plus IPA have a surface tension of about 40 mN/m, when the percentage of IPA is 8% or higher. The surface tension is nearly identical under static and dynamic circumstances, and adding more IPA does not lower the surface tension significantly.

When fountain solutions based on a fountain concentrate without IPA are used, the surfactants in the concentrate have to take over the role of IPA.

Surface Tension of six different fountain solution samples was measured.

Fount used: Micro Fount 0009





Thus, surface tension falls as the fount concentrate increases; and but it can be lowered more by increasing IPA proportion. Note that after certain limit surface tension does not decline even with increasing IPA.

The following table gives the measured values of pH, conductivity and surface tension of various samples of fountain solutions.

	Sample	**pH**	**Conductivity (µS/cm)**	**Surface Tension (dyne/ cm2)**
1	Tap Water	7.27	77.2	72.7
2	Tap Water + 2 % Fount	4.88	1523	57.9
3	Tap Water + 6 % Fount	4.74	4550	42
4	Tap Water + 2 % fount + 5 % IPA	4.88	1325	49.8
5	Tap Water + 2 % fount + 8 % IPA	4.98	1168	45.5
6	Tap Water + 2 % fount + 12 % IPA	4.97	1075	41.7

1.4 Comparison Of pH, Conductivity & Surface Tension *Before And After Emulsification*

DUKE TESTER

This instrument is used to test the ink-fountain emulsification. 50 gm of ink + 50 gm of fountain solution (Tap water + 2% fount + 8% IPA) was stirred for 10mins in the duke-tester. The emulsified mass was then removed from the container and the remaining emulsified water was measured in a cylinder. The amount of water taken up by the ink was found out from this value.

Note the Water Pick-up on Duke Tester:

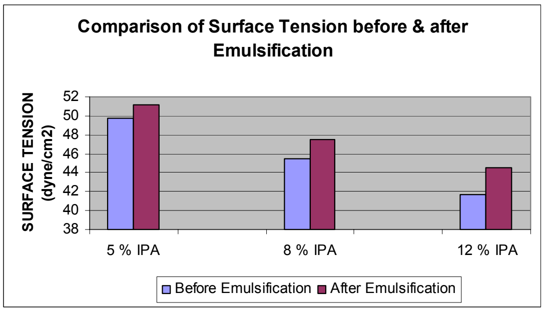
Sample	**Water Pick-Up (%)**
2 % fount + 5 % IPA	40 %
2 % fount + 8 % IPA	42 %
2 % fount + 12 % IPA	44 %

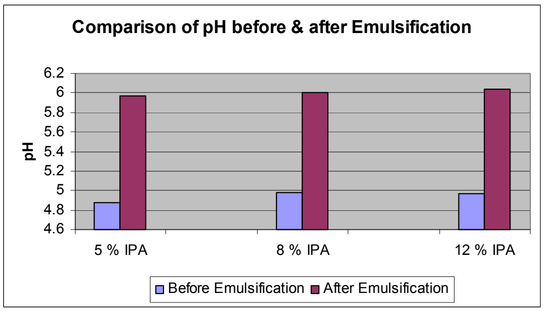
The above values are for Cyan ink.

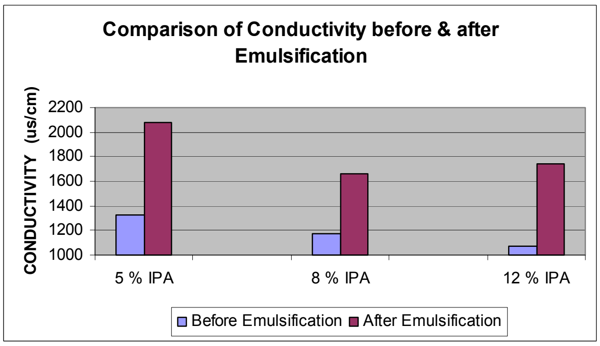
The table below gives the measured values of pH, conductivity and surface tension of various samples of emulsified fountain solutions.

	Sample	**pH**	**Conductivity (µS/cm)**	**Surface Tension (dyne/ cm2)**
1	Emulsified Water 2 % fount + 5 % IPA	5.97	2080	51.2
2	Emulsified Water 2 % fount + 8 % IPA	6.00	1658	47.5
3	Emulsified Water 2 % fount + 12 % IPA	6.04	1741	44.5

Before and After emulsification - pH, conductivity & surface tension







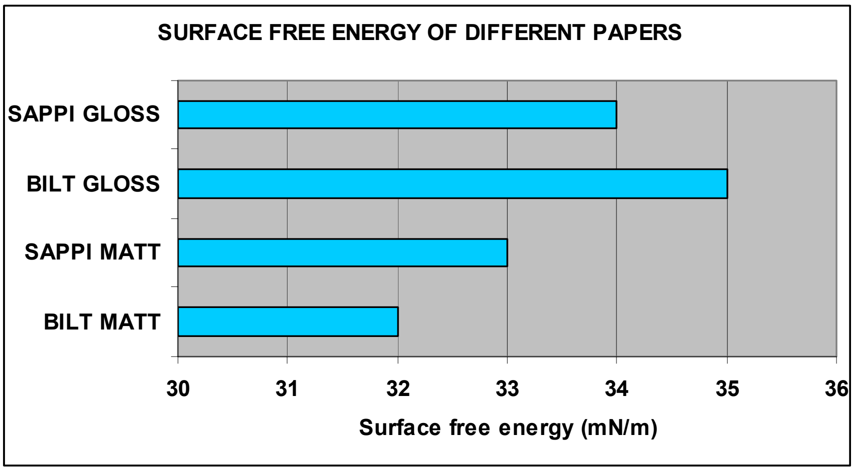
Normally we measure pH, conductivity, and surface tension of fountain solution, before it is used on press and we consider it as the final one. But in reality its chemistry changes on press when it comes in contact with INK. Due to shear action of rollers and plate cylinders some components of ink gets mixed with fountain solution. So the product which we get from this action can be called as emulsified fountain solution.

To consider the properties of this emulsified fountain solution is as important as an emulsified ink, reason is emulsified fountain solution is going to be transferred to blanket cylinder and then on to the paper. So the actual change is surface tension of fountain solution after emulsification will decide its transfer from plate to blanket and to paper. The test that we conducted shows that pH, conductivity, and surface tension all increases after coming in contact with ink, i.e. after emulsification.

2. SURFACE FREE ENERGY OF PAPERS

Surface free energy is an "attractional" force, which is available on the surface of a solid substrate to attract the liquid molecules. Surface free energy has two components: polar and dispersive. In contrast to surface tension, surface free energy cannot be directly measured, so it has to be calculated from contact angle measurements with two or more selected liquids.

These are made using a Drop Test Analyzer. Surface free energy is measured in units of energy per area (mJ/m2) or equivalently, force per length (dynes/cm).



3. WET PICK AND WET REPELLENCE

INTRODUCTION:

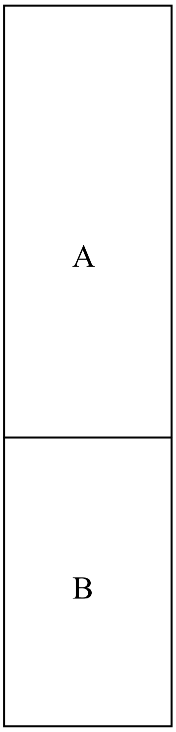
In offset printing, the fact that water as well as ink are transferred to paper may well lead to complications. Especially in process printing, where the paper is wetted several times, water may affect ink transfer because it changes the surface structure of the paper. For example, it is possible the water is weakening the paper surface to such an extent that paper particles are pulled off from the surface by the tack of the ink. This phenomenon is known as wet pick. Another possible effect of water is that the paper does not accept ink because the water did not completely penetrate into the paper. This is called wet repellence. Both phenomena may occur simultaneously and sometimes it is difficult to differentiate between them, because they both appear as white spots in the print. During offset printing a moisture film of about 0.2 to 0.3 µm (0.2 to 0.3 g/m2) per colour is applied to the paper. To investigate and check a paper for wet pick and wet repellence a water film of this thickness is needed and sometimes a thicker water film to imitate the multi colour process. The occurrence of wet pick and wet repellence is also influenced by the time interval between damping and printing. This is the case in multi colour printing presses. The time lapse between two colours depends on printing speed and the distance between printing units. In practice this time is dependent to the type of printing press and varies between about 0.03 and 1 s.

PRINCIPLE:

The damping unit consists of a screened damping disc with doctor blade and a printing disc. An excess of damping fluid is applied to the disc, which is then metered by a doctor blade. The amount of fluid remaining on the damping disc is transferred to the paper, which is printed on with a standard ink, if required after the set time interval. After this the printed sample is checked on wet pick or wet repellence. There are damping discs available for the application of moisture films of 0.25, 0.5 and 1.0 µm.

Specifications Used During The Test :

Hardness of rubber disc	**65 shore A**
Speed	**0.3 m/sec**
Fountain solution thickness	**0.3 g/m^2**
Printing force	**625 N/cm (constant speed)**
Inking unit type	**AE TYPE**
Ink film thickness	**3.2 microns**
Inking time	**60 sec**
Temperature of fountain solution	**13 degree Celsius**
Strips of paper to be tested	**55 x 340 mm,**



A = not damped, only printed

B = damped and printed

A Printed Strip on IGT

Damping unit

ASSESSMENT:

1. Visually (d = density)

* No wet pick / no wet repellence: dA = dB. There are no paper particles on the printing disc after the first print

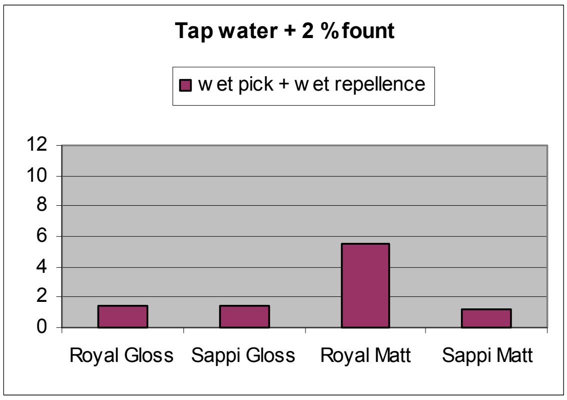
2. Densitometrically

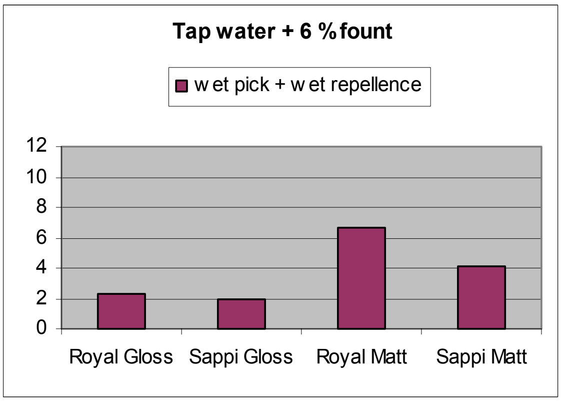
After the ink has dried measure the density of the areas A & B (dA & dB). The drying time of the Huber ink is about 30 minutes. Calculate the wet pick and wet repellence with the following formulas:

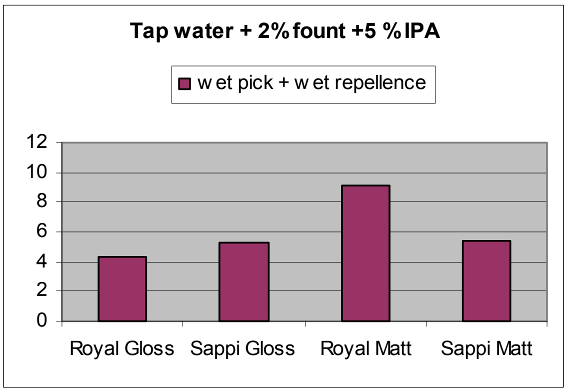
$$\text{Wet pick + wet repellence} = \frac{dA - dB}{dA} \times 100\%$$

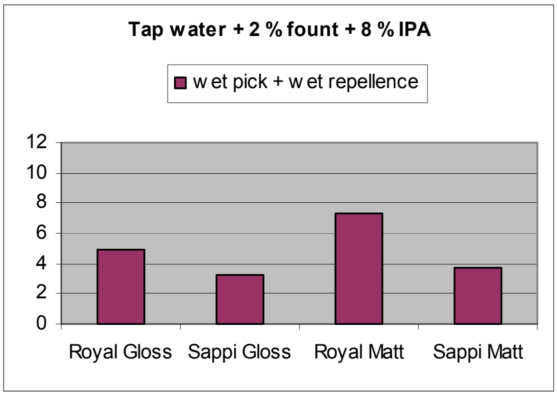
The results from the calculation have been presented graphically as follows:-

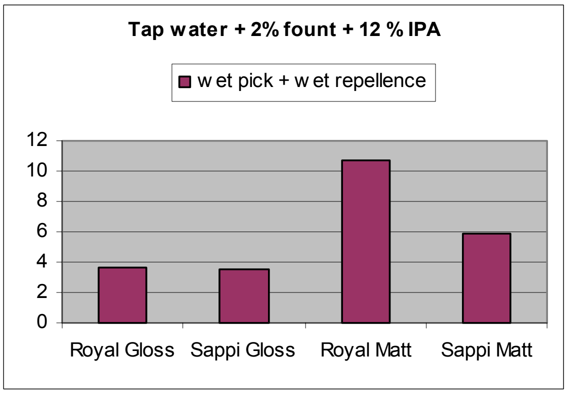
RESULTS OF DIFFERENT TESTS CARRIED OUT ON IGT, FOR DIFFERENT FOUNT AND IPA COMBINATIONS







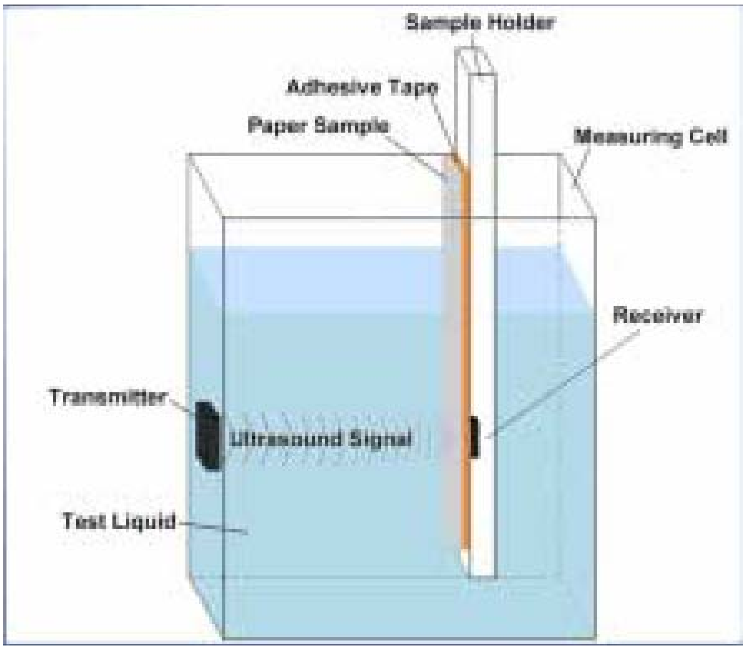




Note that:- **On x-axis '0' indicates No wet pick / no wet repellence.**

4. DYNAMIC PENETRATION TEST

PRINCIPLE :



A paper sample is fixed with double-sided tape at a sample holder and is brought in contact with testing liquid in a measuring cell. From the moment of liquid contact, it is radiated in the Z-direction with high-frequency low energy ultrasonic signals with a frequency of 2MHz or 1MHz optional. The attenuation of the ultrasound changes as the paper reacts with the liquid. Uneven liquid reaction/ penetration from point to point results in different signal intensities at the different sensors. These variations are gathered point-dependent by a novelly receiver with a resolution of approx. 25dpi. The Mottle Rating, the Variance, the Mottle Index M and the Structure Dimension S can be further calculated by a personal computer.

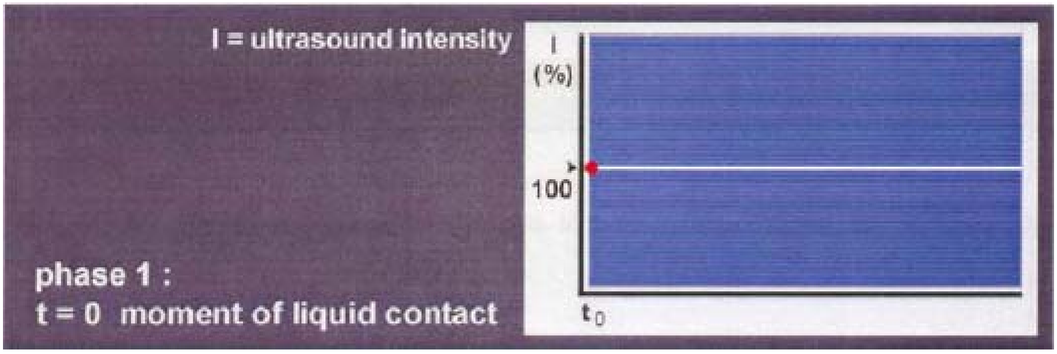
SPECIFICATIONS:

Dynamic penetration Tester	emtec PDA.C 02 Module Coating
Measuring frequency	2MHz (for paper)
First analytical value	approx. 40ms after liquid contact
Amount of liquid in insert	approx. 240ml

INTERACTION BETWEEN PAPER & WATER

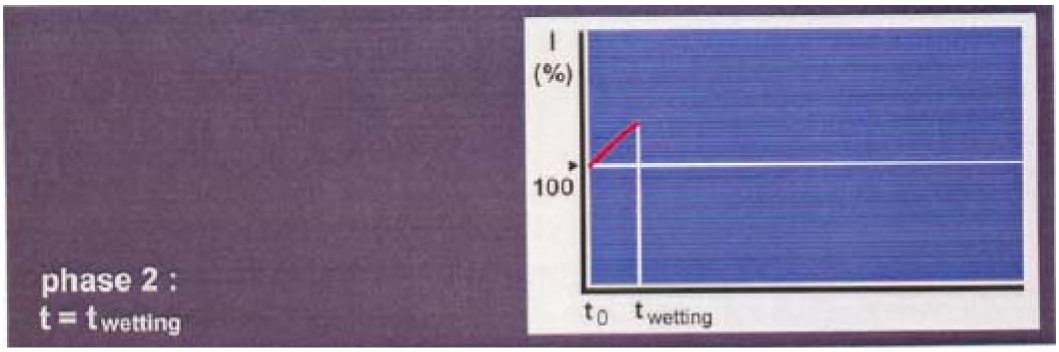
The fountain solution/water which penetrates into the paper changes the ultrasound transmission of the paper sample. Thus the intensity gathered by the receiver changes in a characteristic manner dependent on time and therewith represents important parameters of paper or fountain solution such as surface porosity of the paper.
The ultra sound signal alteration thus represents the paper-water interaction taking place which is described in the following four phases.

Phase I



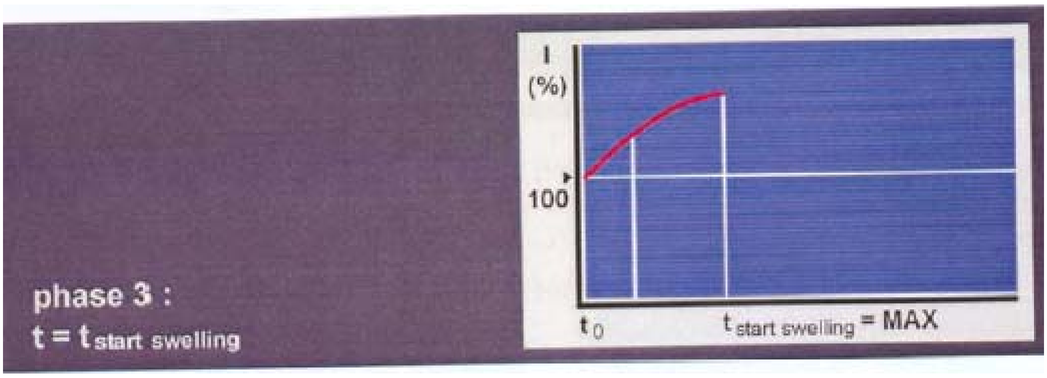
At the time point t=0 the paper is unwetted. Between the water and the paper surface there is a thin film of air. A small part of the signal will be reflected by the film. The dry paper sample attenuates the transmaitted signal.

Phase II



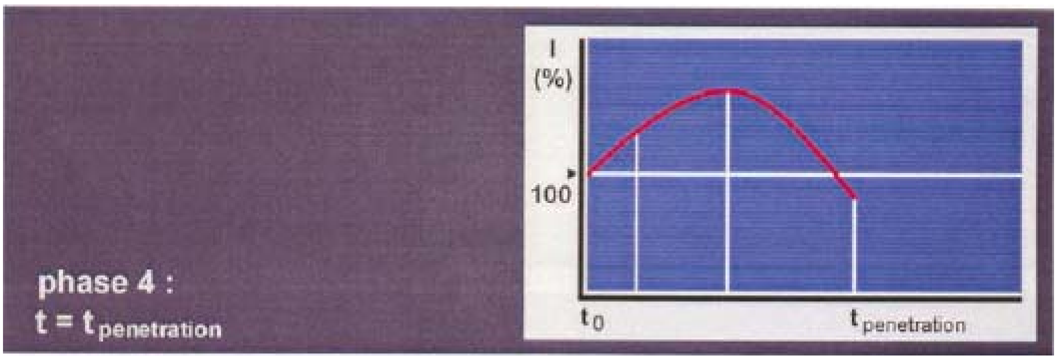
After the wetting period there is no more film of air and signal reflection on the surface. The signal intensity increases.

Phase III



Because of the sizing of paper the water penetrates slowly into the surface fiber structure. The air will be compressed because the sample backside is closed. The ultrasound transmission increases, because the transmission of the penetrated part of the sample increases.

Phase IV



After a defined time, dependent on the sizing degree, the water will be absorbed by the fibers and the fibre structure starts swelling (t=max). Also the strength of the fibre structure will be reduced because the opening hydrogen bridge bonds. Probably the compressed air can flow back into the swollen structure and can generate air traps in the bigger pores. This results in extremely strong scattering of ultrasound and so in a decreasing of the transmission.

PENETRATION CURVES

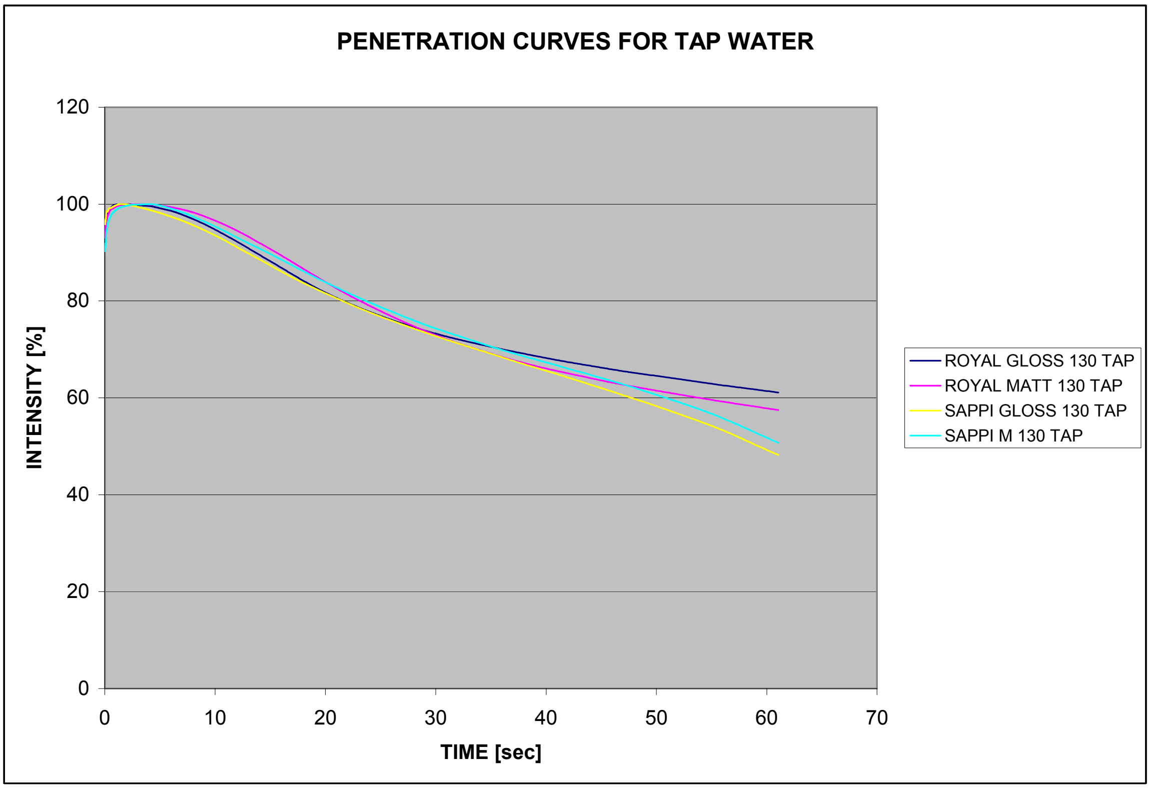
The alteration of the ultrasound intensity dependent on the time is shown in intensity vs. time diagram.

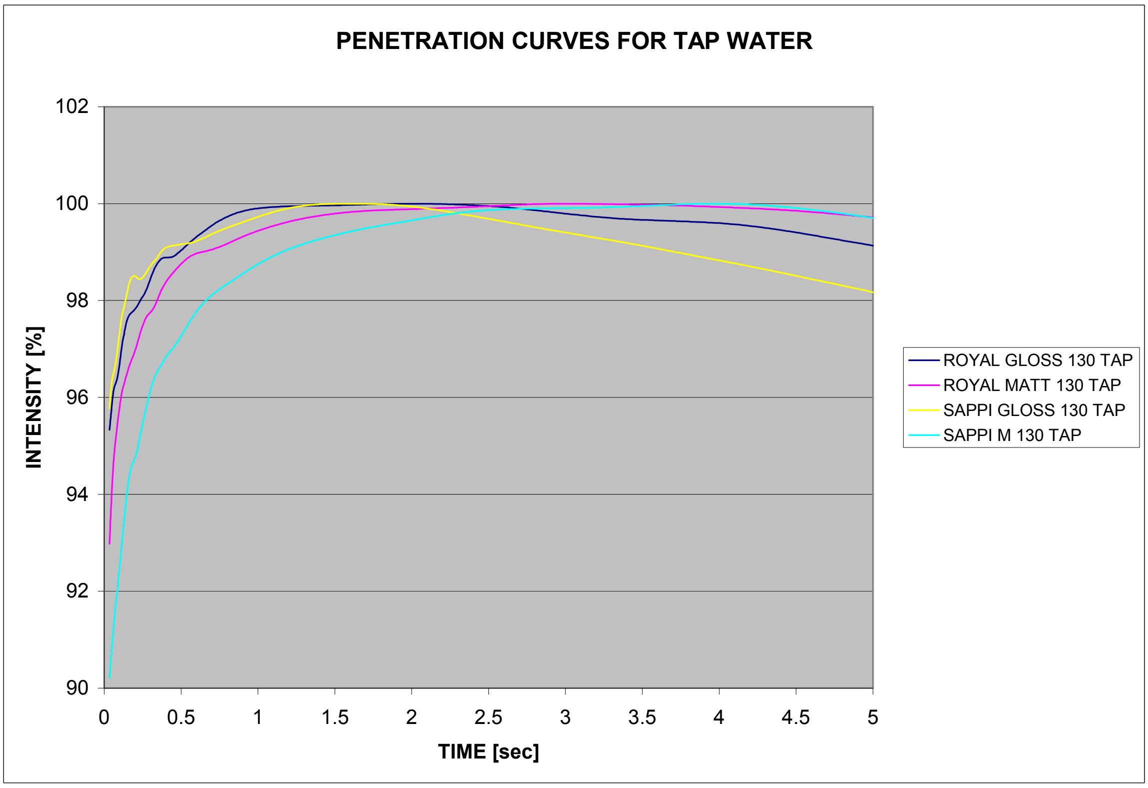
Note:

- a signal increasing at the receiver because of the decreasing reflection on the liquid-to-paper interface during wetting.
- a signal decreasing at the receiver because of the increasing in scattering as a result of air being trapped at isolated points in the paper structure during uneven penetration.
- a signal increasing at the receiver because of the decreasing in ultrasound absorption as the pores and capillaries are completely filled with water.

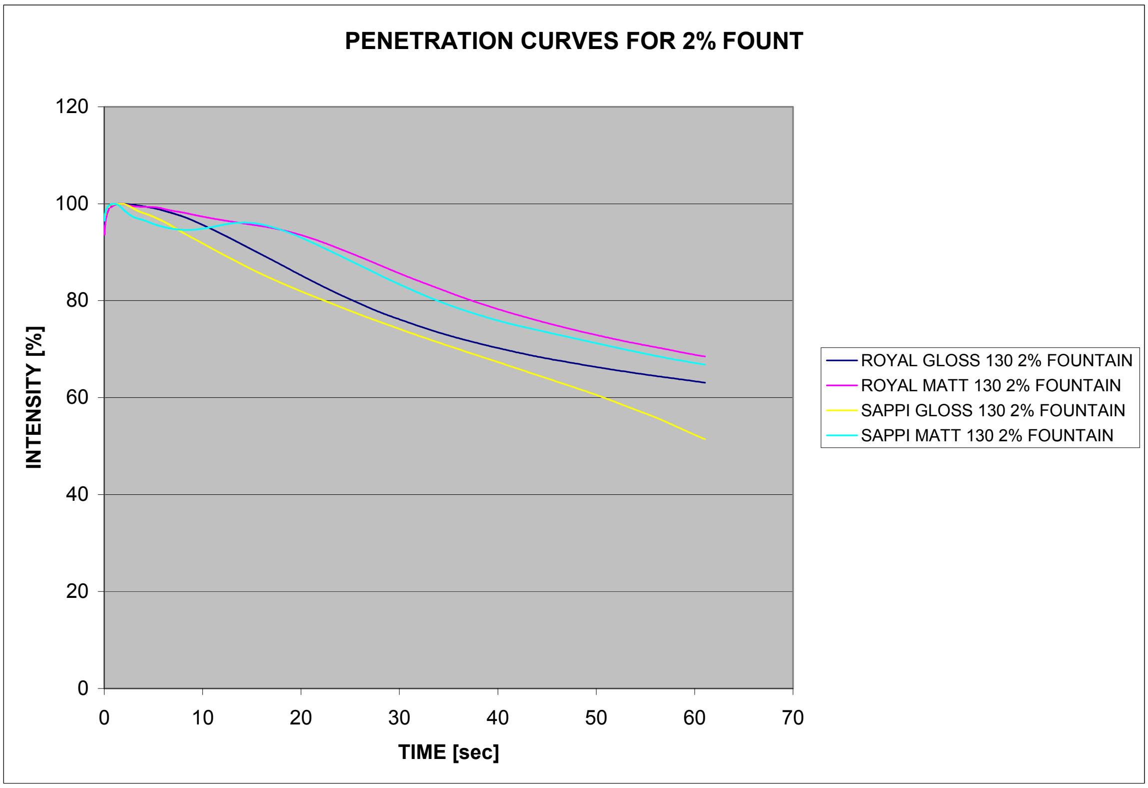
We obtained penetration curves for different fountain solution samples on different papers. The Y-axis gives the ultrasound intensity and the X-axis is the time axis. The graph showing time period of 70 sec helps to study the interaction of paper & fountain solution step by step. While the graph of 5 sec indicates only the initial penetration which is important in the printing process.

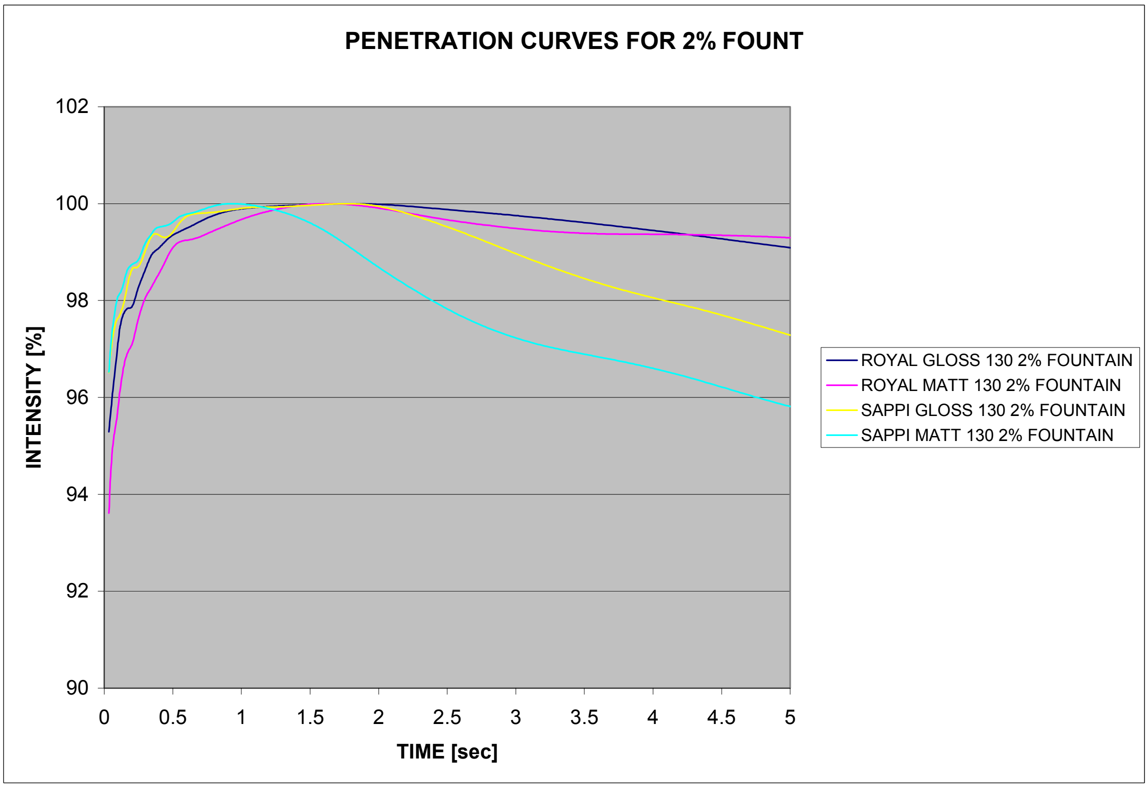
1. TAP WATER


PENETRATION CURVES FOR TAP WATER
INTENSITY [%]
TIME [sec]
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
ROYAL GLOSS 130 TAP
ROYAL MATT 130 TAP
SAPPI GLOSS 130 TAP
SAPPI M 130 TAP

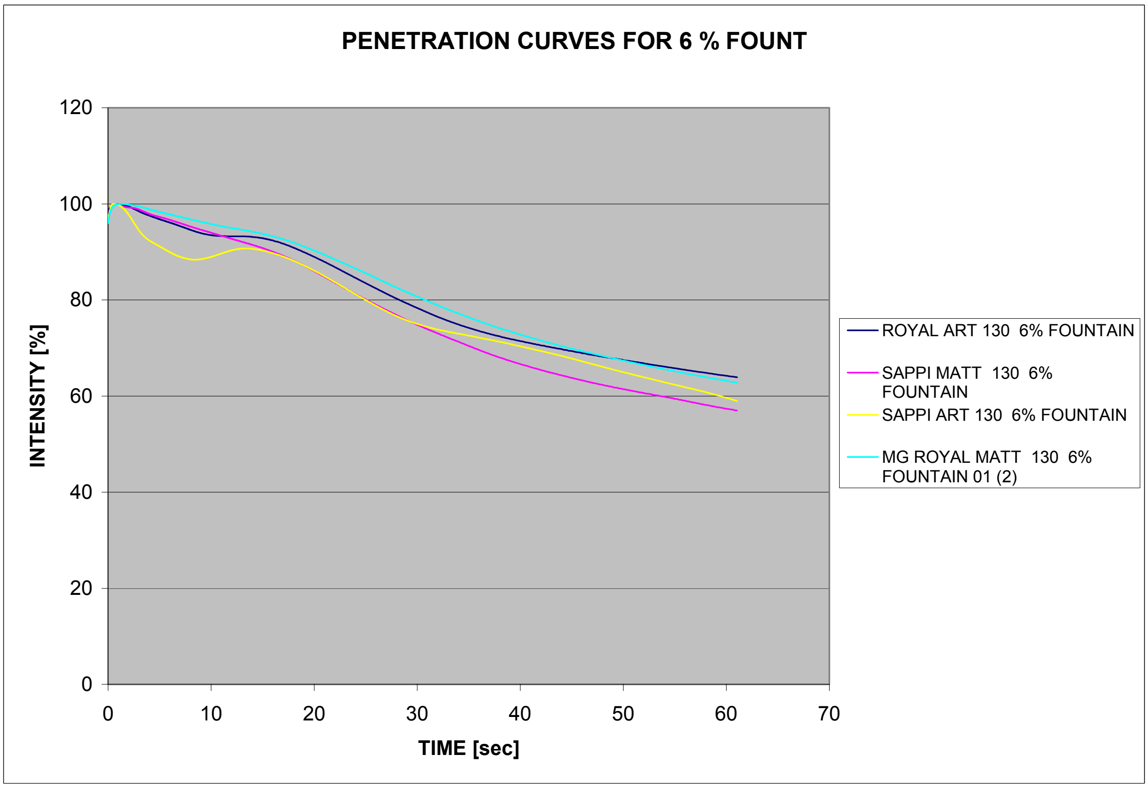

PENETRATION CURVES FOR TAP WATER
INTENSITY [%]
TIME [sec]
102
100
98
96
94
92
90
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
ROYAL GLOSS 130 TAP
ROYAL MATT 130 TAP
SAPPI GLOSS 130 TAP
SAPPI M 130 TAP

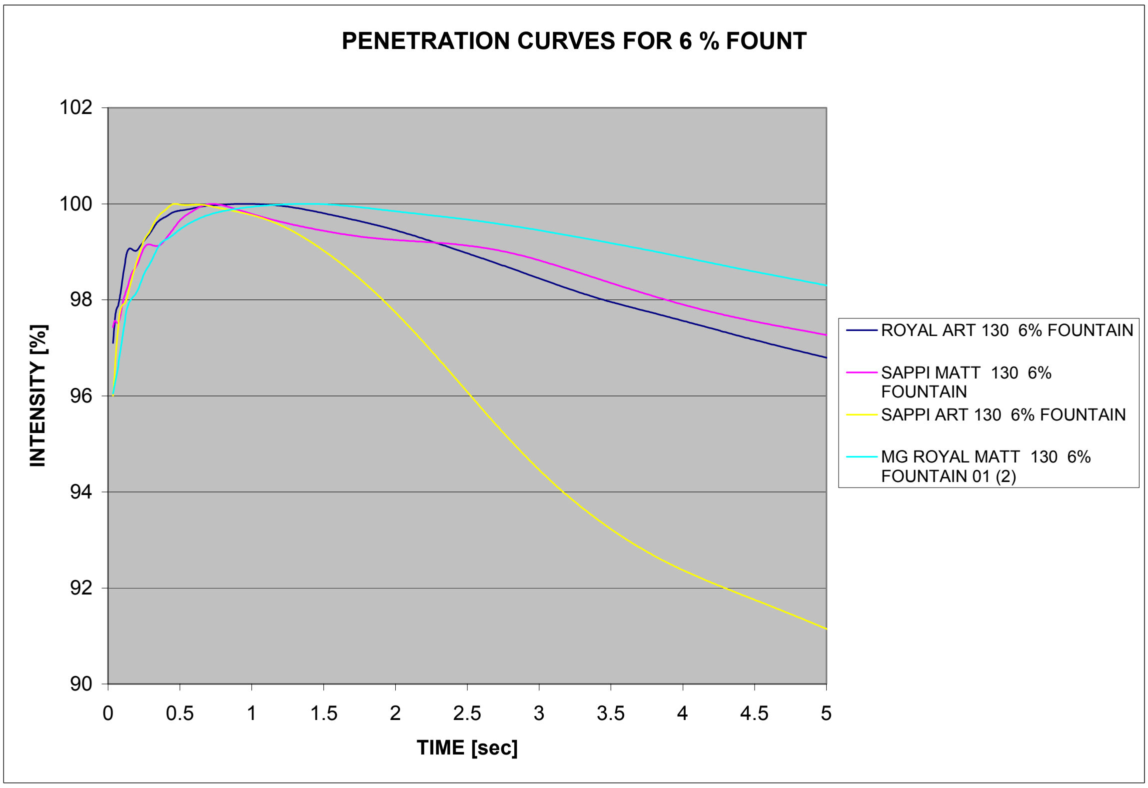
2. 2 % FOUNT


PENETRATION CURVES FOR 2% FOUNT
INTENSITY [%]
TIME [sec]
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
ROYAL GLOSS 130 2% FOUNTAIN
ROYAL MATT 130 2% FOUNTAIN
SAPPI GLOSS 130 2% FOUNTAIN
SAPPI MATT 130 2% FOUNTAIN

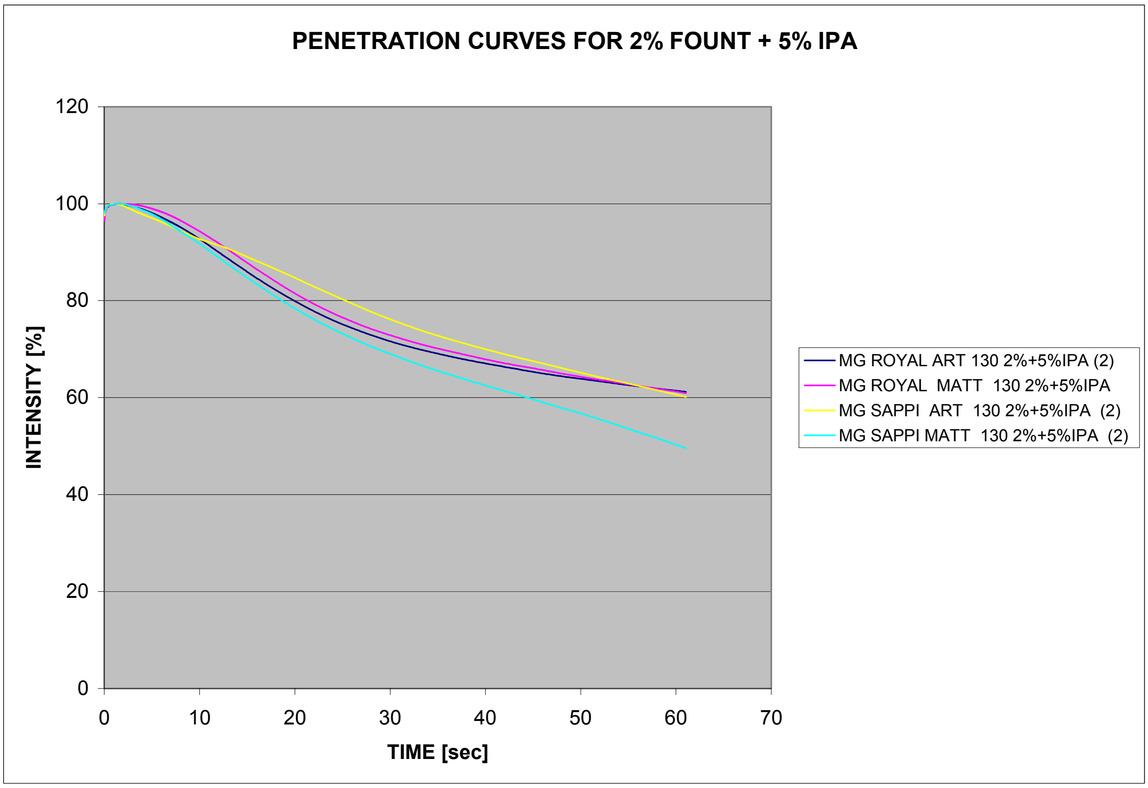

PENETRATION CURVES FOR 2% FOUNT
INTENSITY [%]
TIME [sec]
102
100
98
96
94
92
90
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
ROYAL GLOSS 130 2% FOUNTAIN
ROYAL MATT 130 2% FOUNTAIN
SAPPI GLOSS 130 2% FOUNTAIN
SAPPI MATT 130 2% FOUNTAIN

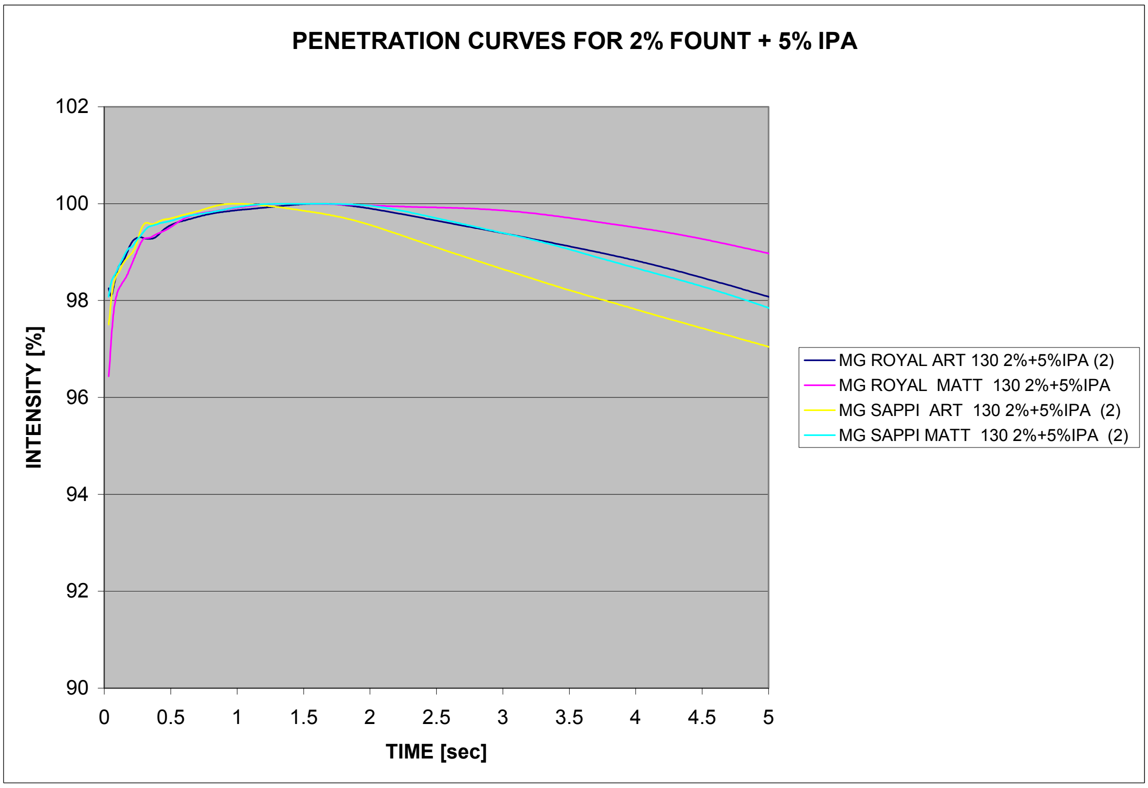
3. 6 % FOUNT


PENETRATION CURVES FOR 6 % FOUNT
INTENSITY [%]
TIME [sec]
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
ROYAL ART 130 6% FOUNTAIN
SAPPI MATT 130 6% FOUNTAIN
SAPPI ART 130 6% FOUNTAIN
MG ROYAL MATT 130 6% FOUNTAIN 01 (2)

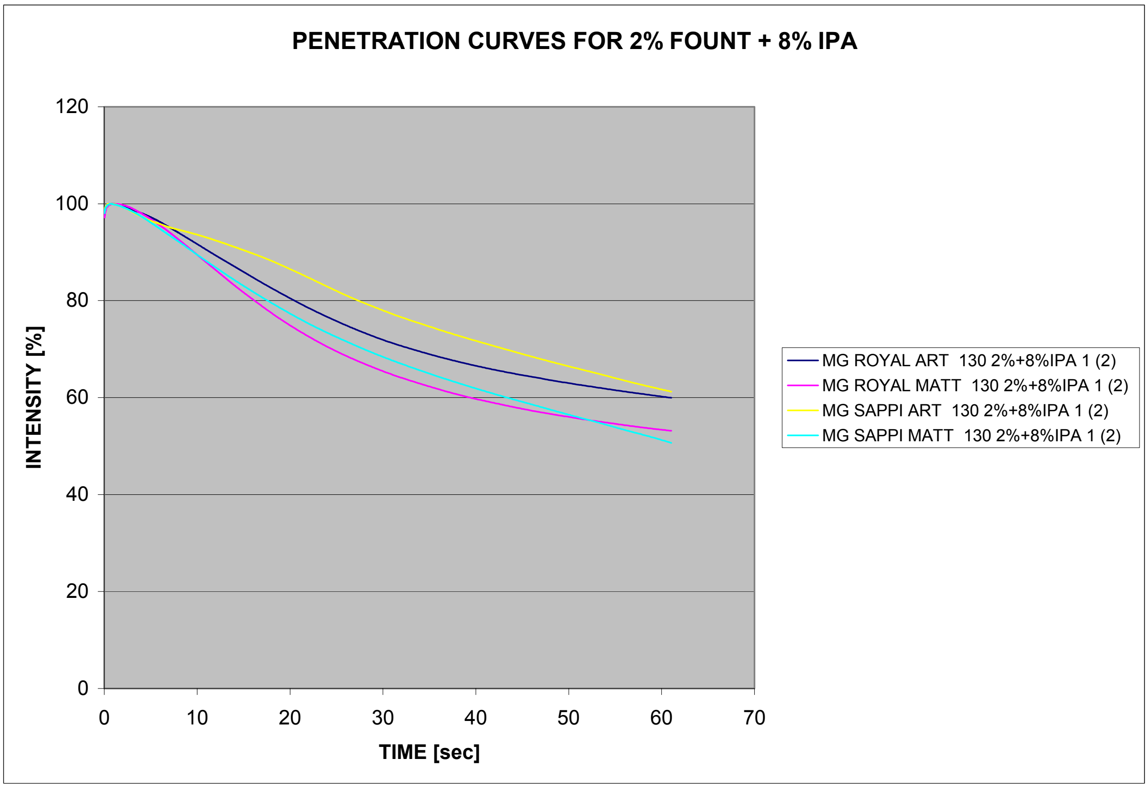

PENETRATION CURVES FOR 6 % FOUNT
INTENSITY [%]
TIME [sec]
102
100
98
96
94
92
90
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
ROYAL ART 130 6% FOUNTAIN
SAPPI MATT 130 6% FOUNTAIN
SAPPI ART 130 6% FOUNTAIN
MG ROYAL MATT 130 6% FOUNTAIN 01 (2)

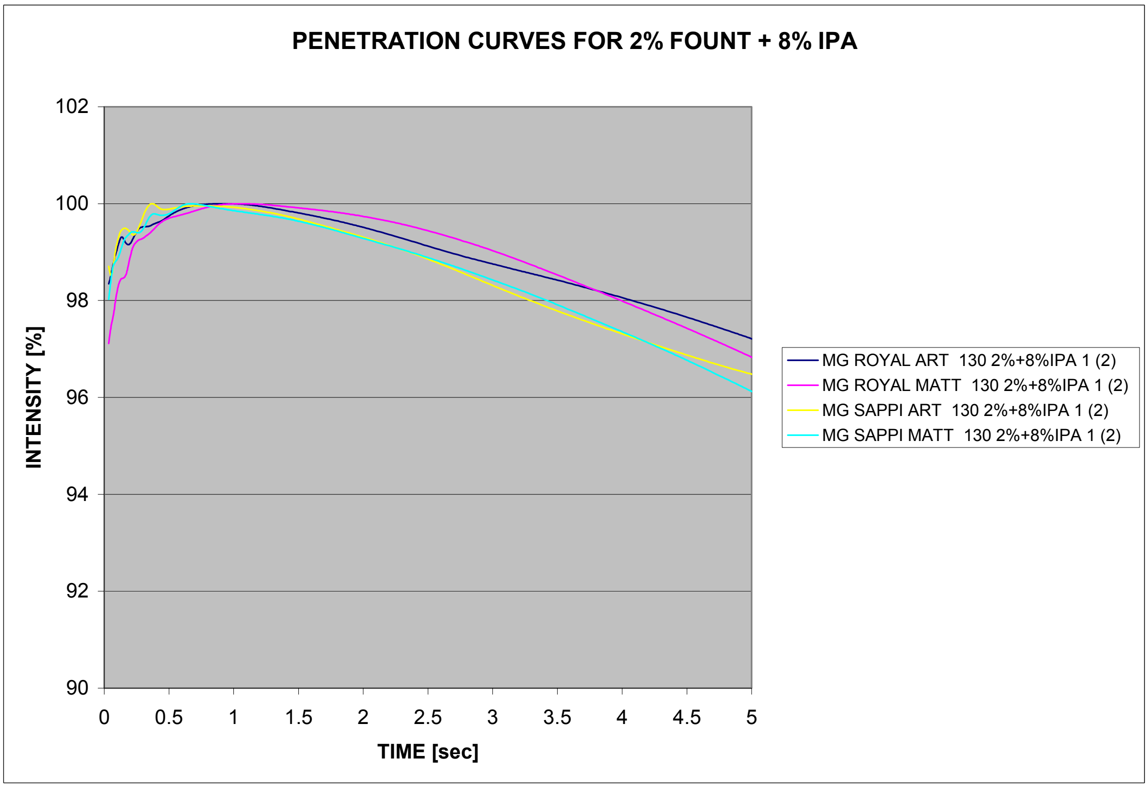
4. 2% FOUNT + 5% IPA



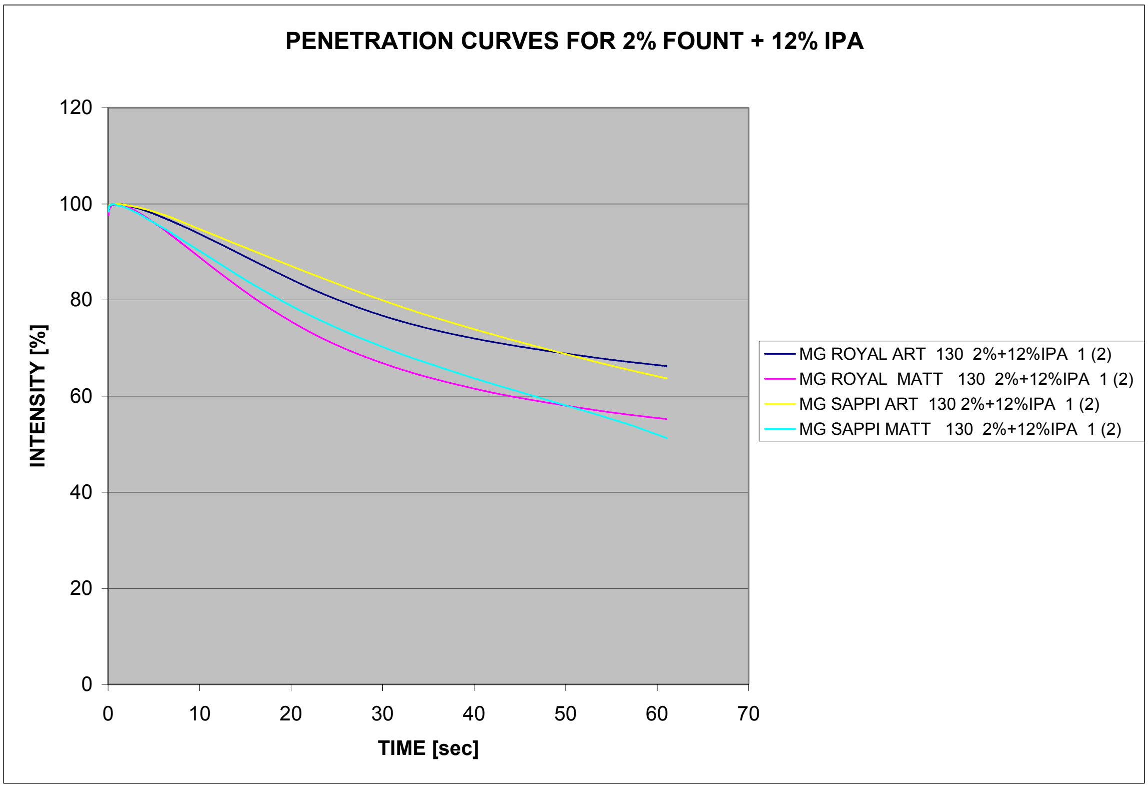


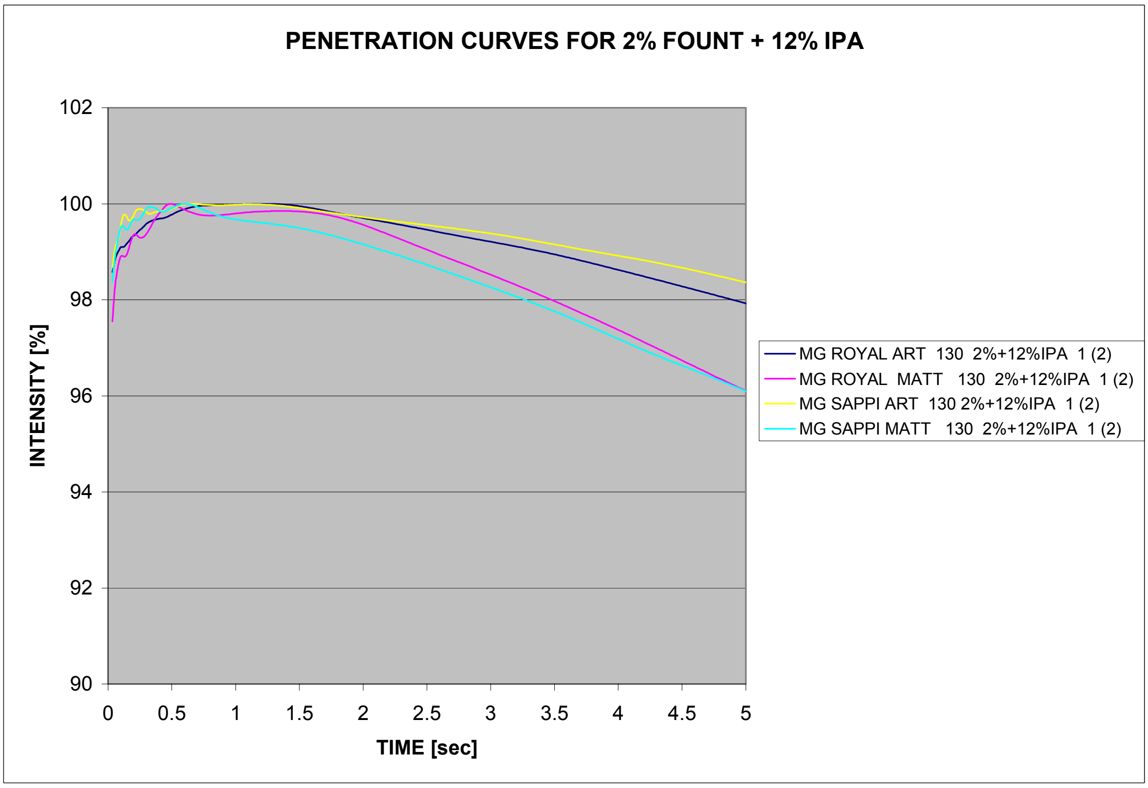
5. 2% FOUNT + 8% IPA





6. 2% FOUNT + 12% IPA



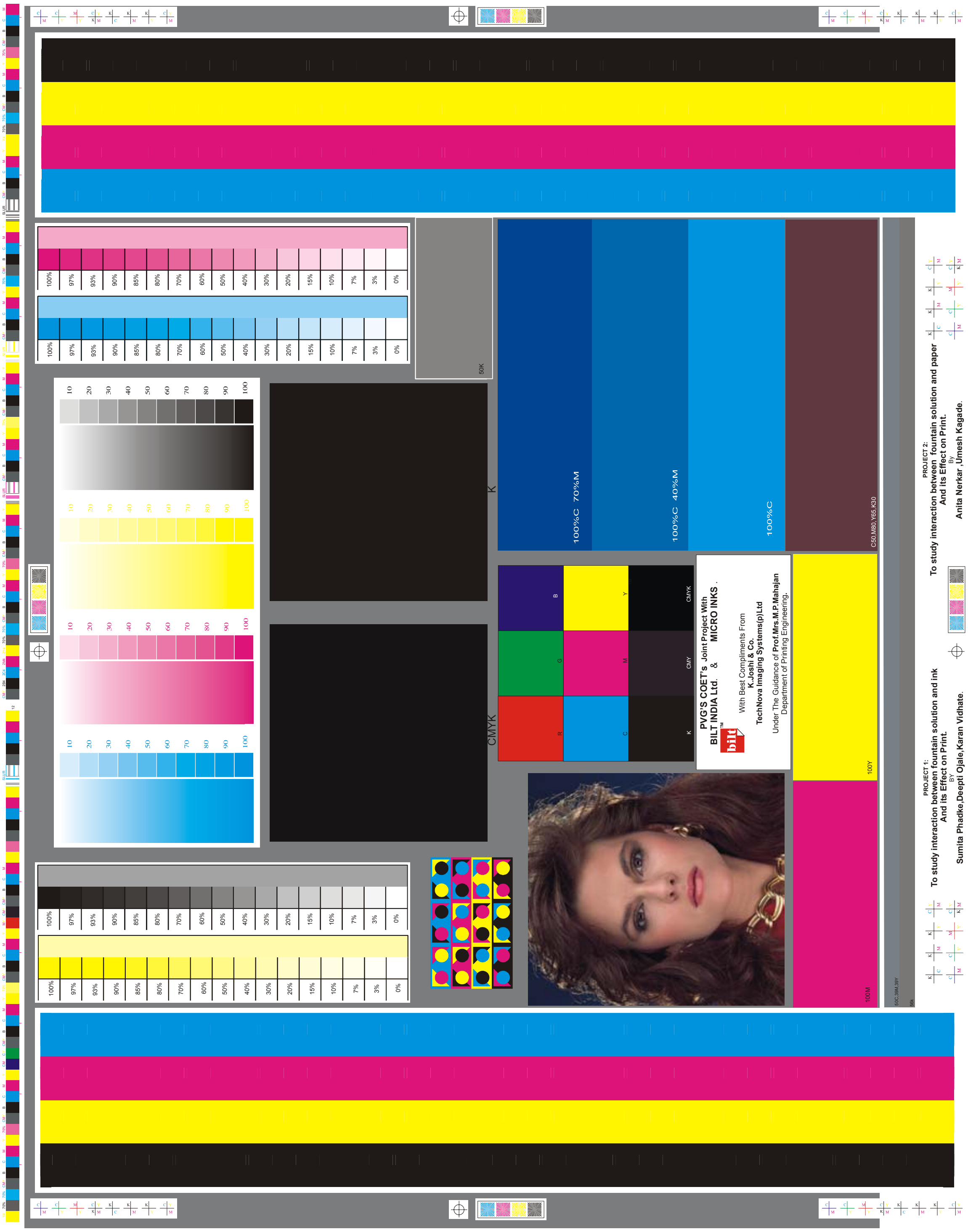


OBSERVATIONS AND INFERENCES

- As the penetration increases, ultrasound intensity decreases.
- As IPA % increases, penetration as a function of time increases.
  Thus **penetration increases as the surface tension decreases**.
- Sappi matt shows more penetration than Bilt matt and Sappi gloss shows more penetration than Bilt gloss.

IV Practical Test Form

1. TEST FORM



2. PURPOSE OF TEST FORM

The basic print parameters that we needed to check in our trail were density, dot gain, trapping, contrast. We also needed to check slur, vignettes, image and colour reproduction. We accordingly designed the test form using standard test targets. Our project requirement was also to check mottling and wet pick for which we included special elements such as the cyan and magenta patch for mottling and CMYK & K patch for wet pick.

PRINT ANALYSIS PROCEDURE

To analyze a single sample sheet, the user needs a hand magnifier, a reflection densitometer, a color viewing booth, The types of analyses performed on the sample can be divided into visual and instrumental categories.

The visual analyses include assessment of slur, doubling, toning, mottle, image fit, highlight and shadow reproduction, and, most important, the extent to which the color reproductions match the color standard

The instrument-assisted category of print analysis includes densitometric determination of ink density, dot gain, print contrast, ink trapping, hue error, and grayness

A possible sequence for the analysis of a single printed sample follows:

- Check the sample for wrinkles.
- Examine the gripper marks at the lead edge of the sheet for evenness and pressure.
- Scan the overall sheet for signs of toning, fill-in, or tinting.
- Examine register and fit of the printed images.
- Scan the sheet for defects such as picking, hickeys, or dissolved coating debris.
- Measure the solid densities across the test form.
- Measure the dot gain in several locations.
- Measure the print contrast.
- Measure the ink trapping for blue, green, and red.
- Evaluate the ladder targets. Examine the star targets to evaluate slur and doubling. After this initial look at the sample, a more thorough evaluation based on the quality control targets is undertaken

3. PRINT ELEMENTS/ TARGETS FOR EVALUATION

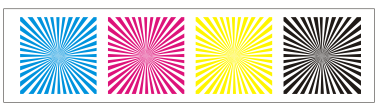
1. Color Strip:

This color strip consists of various elements like solid patches, slur gauge, three color and single color gray patches etc. These various elements are used for controlling the press parameters and maintaining the print quality. The Strip also consist patches of 70% for contrast measurement, over print patches for trapping.

2. Density And Dot Gain Strips (K C M Y):

These stripes contain 17 cells of dots ranging from 0 to 100, minimum dot size is of 3 and max is of 97. These strips are provided for all 4 color i.e. C M Y K. These are generally used for measuring density and dot gain.

3. Star Targets:



The star targets are also extremely sensitive to critical dot transfer problems that occur on press. They are placed in several locations because some print problems, such as doubling, can be highly localized. A star target is comprised of a circular pattern of alternating solid and clear wedges tapering to a very fine central point. The exact center of the star is a tiny clear area. When this area fills in during sheetfed printing on coated paper, excessive ink spreading from some source (dot gain, slur, or doubling) is occurring. Quick visual analysis of a star target, aided by a hand magnifier, easily reveals when too much dot gain is occurring or when a directional gain, such as slurring or doubling, If the enlarged central section of the star target is asymmetrical, the gain has a directional association. If the central section is an ellipse, ink slurring is occurring. The direction of the slur is perpendicular to the long axis of the ellipse

If, for example, a target had an elliptical center oriented across the test form, slurring around the cylinder would be the diagnosis. The cause might be paper slipping in the grippers or a loose blanket.

When the central filled-in area looks as if it has two centers, image doubling is the diagnosis, the causes might be that a given ink is not setting quickly enough and it is re-imaging from a following printing blanket or from the same printing blanket but slightly out of register

4. Digital Ladder Targets

The GATF digital ladder targets are very sensitive to a number of print problems including slur, doubling, wash marks, and paper fan-out. The targets are imaged for each color along the outside edges of the test form. The targets are large extending almost completely around the printing cylinders. The digital ladder target is divided into three vertical bands, with each band being comprised of 50%, 150-lpi (60-line/cm) straight-line screen tints. The tints are of equal value, but their orientations (90°, 0°, and 90°) differ, as seen in the above callout. The analysis of the digital ladder target is usually performed visually. However, at times, densitometry can be used to quantify visually-observed density differences. The ideally reproduced target is one where the three different screen orientations cannot be distinguished by the observer at a normal viewing distance. The uniformity of the digital ladder target

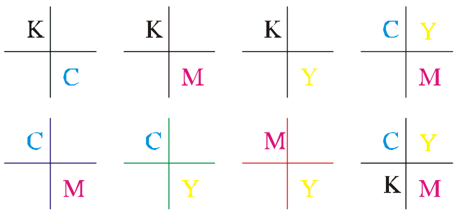
bands should be confirmed on the films or plates prior to printing. If the targets are not uniform in tone on the film, then a problem is indicated with the filmsetter. The targets should be even in density from gripper to trailing edge of the printed sheet. If any of the

three strips is noticeably different in density, a printing problem is indicated. The direction of line orientation is influencing the density that results on the printed sheet. This can be due to slurring or doubling of the lines. Closer examination with a magnifier of both the target and printed halftone dots will allow the user to distinguish a slur from a double. Slurred dots are round with a comet-like tail; while doubled dots appear as two partially superimposed dots where one is darker than the other. The direction of the slur is perpendicular to the screen orientation that had the
darkest printed density. If the darkened condition is uniform from gripper to tail, the directional gain is consistent around the entire cylinder for that color. For example, if the center section (90° orientation) of the digital ladder target is darker than the 0° orientation section, slur in the direction of travel is indicated.

This condition may be caused by a loose printing blanket. If the trailing section of the target shows cross-directional density gain that the leading edge does not show, the cause might be paper movement (fan-out) during printing. When the left-side digital ladder target and the right-side digital ladder target do not show the same conditions, uneven cylinder pressures or paper slippage may be the cause.

If the central section of the target is consistently lighter from gripper to tail than the two outside sections, cross-cylinder movement and excess water may each be at fault. If there is excess water, the lines perpendicular to printing (central, 90° orientation section) are lower in density than the lines parallel to travel. This is because the excess water will have the effect of washing across the cross-direction line elements. When a hand magnifier is used to examine the target, signs of small wash
marks may be seen.

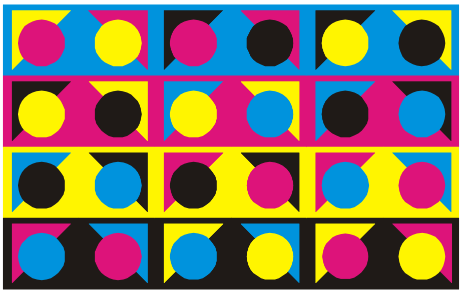
5. Transfer Grids



It is important to evaluate two types of registration during a pressrun: external register of the printed elements to the substrate and internal register, or fit, between color separation halftones. Maintaining tight registration between the four colors is essential for good color reproduction.

The transfer grid is a matrix of crosses, with each color cross printed by two units of the press. Each cross is accompanied by two numbers to identify the press units that imaged it. When the two crosses are indistinguishable from each other due to being superimposed, good register has been achieved between those two cylinders. By displaying all of the two-cylinder printing combinations in a single matrix, the transfer grid eases the task of determining which of the press cylinders to move in relation to the others to most efficiently achieve register during makeready. The amount of misregister across and around the cylinders an be measured on the transfer grids with a magnifier.

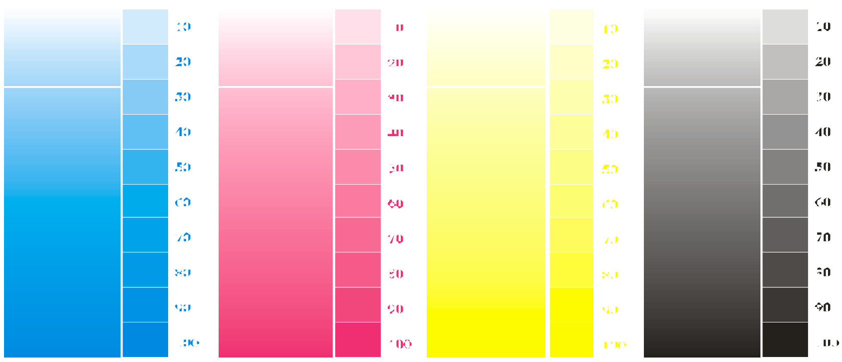
6. Image Fit Target



This target is made up of four horizontal bands (CMYK) that each have a series of colored triangles and circles positioned across them. The pattern of triangles and circles is arranged to give all combinations of the other three process colors against each process color background. Furthermore, the triangle and circle were chosen because these shapes presented horizontal, vertical, diagonal, and curved lines forming the boundaries between colors. The image fit target is used to evaluate the register accuracy of any output device (e.g., a digital press or proofing system).

The target are placed with no trapping between colors. The direction and magnitude of the misregister are determined from the location and thickness of the white lines.

7. Ten Step Tone Scales and Vignettes:

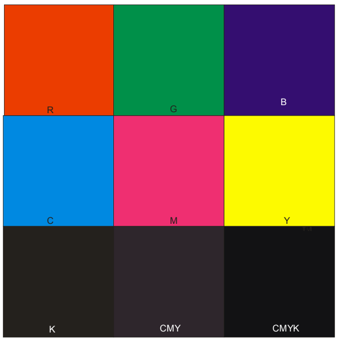


The tone scales are indexed in 10% steps from 10% to 100%. Each patch is 5*5 mm, which is sufficient to be conveniently measured with most hand-held densitometers. The screen ruling, dot shape, and screen angles of the tone squares are not predetermined; they will be applied by the user at the time of output.

The tone scales also contain highlight/shadow patches. The tone scales are used to measure the dot gain of the printing system. This data can be used to construct dot gain curves.

Each tone scale is accompanied by a vignette, where the tone is gradually changed from 0% to 100%. The printed vignettes are evaluated for any signs of banding, which is an objectionable, abrupt change in the tonal gradation.

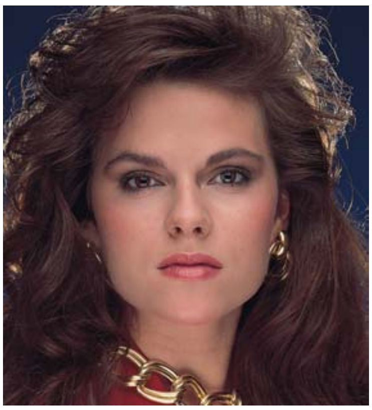
8. Trapping Patches/Mottle Patches:



These patches were used for 2 purposes, first for checking trapping & second for checking mottle.

As mottle is mostly prevalent in overprint R, G, B patches were also used for analyzing mottling.

9. Female Portrait:

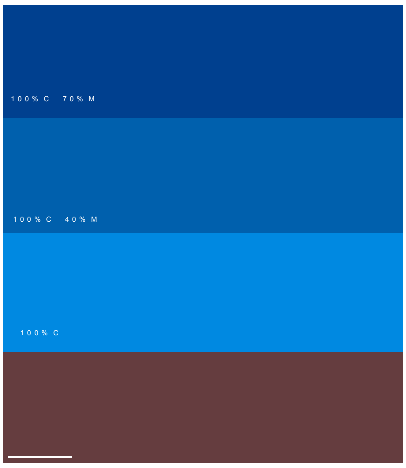


Because the most frequently reproduced flesh tones are those of female Caucasian models, the female portrait is a photograph that emphasizes this challenge to process color printing. In this image all tones i.e. highlight, middle tone, and shadows can be examined. The smooth gradations of flesh tone, details of the hair can be seen. Sudden change of tone is also seen in the region where light falls on the hair, this is useful in checking the contrast and sharpness. Sharpness may also be checked in the eyes.

10. Wet Pick Patches

A heavy coverage of black was observed to show high sensitivity to wet pick. We therefore included a 10 X 10 patch of a ***single colour black and a four colour black***. Both these patches were to help detect wet pick if any.

11. Mottle patches



Ink mottle ranks high among the print problems that plague sheetfed lithography. Ink mottle, a visual defect, is the non-uniformity of color or gloss in large areas of ink coverage. Smaller areas of coverage are sometimes insufficient to detect mottling when it occurs.

Mottling is more prevalent in Cyan-magenta ink traps and hence various cyan-magenta combination patches were used as mottle patches. It was also required to check mottling in a 100% cyan patch. A brown patch of CMYK was observed to show considerable mottling. Hence it was also included in the test form. Gray patch too can help in detecting mottling.

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4. ANALYSIS OF PRINT ATTRIBUTES

1. Solid Ink Density

Examine the density variation across the test form, around the printing cylinders, and between the various samples selected for analysis.

First, measure the solid ink densities across the test form to test conformance to the target ink densities. Use the solid color control bar across the trailing edge of the test form and the color patches following the ladder targets for this purpose.

The densitometer used for this analysis will affect the readings. If the densitometer used during the pressrun is also used for this analysis, differences in density can be attributed to dryback of the inks. If two different densitometers are used, their spectral responses should match; otherwise, the readings will show significant differences.

Enter the density readings in a tabular form. Also enter the density aim point, upper tolerance limit, and lower tolerance limit for each color into the table. A graphic representation of density profiles can be useful to communicate this information at a glance. These density profile graphs show how much variation there is in ink density across the test form and the readings are to the aimpoints. Record the average densities, high density readings, and low density readings. This data should be carefully examined to see if there are any identifiable trends such as consistent falloff of densities from the leading to the trailing edge of the form.

2. Dot Gain

Dot gain refers to the difference between dot sizes on color separation films and the apparent printed dot area of those same dots on paper. Dot gain is known to have a more pronounced effect on the visual appearance of a print than ink density. A slight shift in dot size of a few percent will produce a visually noticeable shift in hue for many colors. All printing systems have some amount of dot gain resulting from a number of factors. First, it varies for different original film values, meaning that highlight dots are subject to a different magnitude of dot gain than midtone or shadow dots. Second, the screen ruling influences dot gain. Finer screen rulings will experience more dot gain than coarse screens. Third, dot gain is comprised of both physical and optical components. The light scattering properties of the substrate have an influence on dot gain. Fourth, true dot gain is easily confused by a host of other printing problems including slur, doubling, or toning.

Several targets are included on the Sheetfed Test Form for measurement of dot gain. To characterize the dot gain of a printing system, it is referenced to the midtone. Read the fifty percent tint patches on the printed sheet with a densitometer then calculate apparent dot area using the Murray-Davies equation:

$$\%ADA = \frac{1 - 10^{-D_T}}{1 - 10^{-D_S}} \times 100$$

ADA = apparent dot value
D_T = density of tint
D_S = density of solid

Many densitometers are equipped with microprocessors to make this calculation automatically. It is important to calibrate the densitometer to an adjacent solid ink patch and to the substrate when making these readings. Some confusion may arise from the use of the Yule-Nielson equation. The Yule-Nielson equation is a special form of the Murray-Davies equation that is used to isolate mechanical or physical dot gain from optical dot gain. This is performed by an “N factor” that relates to the light scattering/absorbing properties of the substrate. If the N-factor is set at one, the Yule- Nielson equation becomes the Murray-Davies equation. It is most convenient to measure total dot gain (physical plus optical) using the Murray-Davies equation.

As a starting point, it may be useful to consider some industry-wide averages. Following is are average midtone dot gains :

Yellow	18%
Magenta	20%
Cyan	20%
Black	23%

3. Print Contrast

A print attribute that is closely related to dot gain is print contrast. It is a numerical index based on the relationship of the printed density of a 75% film dot patch vs. the solid density.

The formula is:

$$PC = \frac{D_s - D_{75}}{D_s} \times 100$$

PC = print contrast
D_s = density of solid
D_{75} = density of 75% tint

The print contrast values for the four ink colors can be conveniently measured using the control bar. Enter the print contrast values into a tabular form. The average of print contrast values is calculated for each sample.

Higher print contrast values are better than low ones. The higher the print contrast, the greater the number of tones that can be distinguished between the three-quarter tones and solid ink density.

The aimpoints for print contrast, like dot gain aimpoints, are best based on shop standards. The average print contrasts are as follows:

Yellow	37
Magenta	41
Cyan	39
Black	43

Calculate the correlations between print contrast, ink density, and dot gain. A negative correlation will exist between dot gain and print contrast. As dot gain increases, print contrast will decrease. The relationship between density and print contrast should be a curvilinear one; that is, as ink density increases, print contrast increases until a point is reached where further increases in density cause lower print contrast values. This is due to the excessive ink film thickness needed to raise densities beyond this point which cause dot gain to rise at an accelerated rate, thereby decreasing print contrast.

4. Ink Trapping

Ink trapping is a print attribute that relates to the two-color overprints of green, blue, and red. It estimates the amount of ink that is transferred to a previously printed ink film, compared to the transfer of ink to an unprinted substrate. The printing sequence must be known to make trapping measurements. The Preucil equation for calculating ink trapping is Microprocessor-assisted densitometers can automatically perform trapping calculations.

It is important that the density measurements be made with the filter appropriate to the second-down ink color.

The ink trapping values should not be interpreted as identifying the percentage of the second-down ink that transfers to the first ink film. The failure of the law of additivity of ink densities prevents this relationship from holding true. The highest achievable values are sought.

There are substantial differences in trap values based on the printing sequence. There are differences in trapping due to the spectral response of the densitometer. Several different equations can be used to calculate trapping values; e.g., the Childress equation, the Hamilton equation, and the Brunner equation. Therefore, process control aimpoints should be based on the highest achievable values that can be attained with a given printing system.

Control bar or the trapping patches facilitate measurement of ink trapping at five locations. The calculations of trapping for each color are averaged together to arrive at a trapping value for a sample sheet.

Ink trapping is dependent on the rheological properties of the inks, which are dynamically variable during a pressrun. Ink trapping can be monitored as a run control attribute. As ink trapping shifts, so do important hues in the shadow section of the color gamut. Many originals have important greens, blues, and reds as well as dark near-neutrals and tertiary colors making the transfer of ink to previously printed ink films an attribute worth monitoring during a pressrun.

For example, the green trapping might be decreasing continuously during the run, perhaps due to excessive levels of water take-up in the yellow ink. Under these conditions, the dark green vegetation in a color reproduction would be gaining a bluish cast as the green trapping of yellow ink decreased. The press operator might reduce the cyan ink density to alleviate the problem, but the blues in the reproduction would shift towards magenta as a consequence. When analyzing the ink trapping variability data, it is desirable to test correlations between ink trapping and density levels of first-down inks, or between trapping and the other print attributes. Also, off-line test results, such as ink/water emulsification levels or ink tack ratings, can be examined in relation to ink trapping.

V Press Trials

1. TEST PROCEDURE

The same Test Form of 4-colour sheetfed offset was used.

The printings were carried out in three series of tests in order on 4 color Mitsubishi to experiment on all of the variables given in the table below.

2. VARIABLES IN THE PRINTING TRIALS

The table below shows different papers & fountain solution additives used under different conditions in the test.

1st item	Sort of Paper	
	A = Bilt Matt 130 gsm B = Sappi Matt 130 gsm C = Bilt Gloss 130 gsm D = Sappi Gloss 130 gsm	
2nd item	Fountain Solution additive	
1]	Micro Fount 0009 IPA	2 % 5 %
2]	Micro Fount 0009 IPA	2 % 8 %
3]	Micro Fount 0009 IPA	2 % 12 %
3rd item	Amount of fountain solution and ink	
	Optimum Increased Reduced	 20 % 0f Optimum 10 % of Optimum

3. EXPERIMENT CONDITIONS

1st Series of test

The first Series of Test was performed with Fountain Solution additive1 i.e. with 5% IPA. The Fountain Reservoir was filled with a fountain solution - Tap water + Fount + IPA in the proportion 100: 2: 5.

Bilt Matt (paper type A) was arbitrarily selected to be the first paper for printing followed by Sappi Matt (B), Bilt Gloss (C) and Sappi Gloss (D) and the first printing was carried out under normal printing conditions i.e. Optimum Ink & water. This condition was marked by achieving the target ink densities. This laid down the reference position for the experiment on the increased ink & water condition and reduced ink & water condition.

The second printing was carried out under Increased ink & water conditions for all types of papers. The increase was by 20% of the optimum condition.

While the third printing was carried out under Reduced ink & water conditions, again for all the types of papers. This decrease was by 10% of the optimum condition.

Table 1 gives quantification of the amount of ink & water for all the three conditions through Ink duct rotation and Dampening duct rotation.

Table 1: 1st Series of test with Fountain Solution additive 1 (5% IPA)

Paper	Amount of Fountain Solution & Ink	Ink Duct Rotation				Dampening Duct Rotation			
		K	C	M	Y	K	C	M	Y
A B C D	Optimum	13	14	16	14	35	38	34	34
A B C D	Increased	16	17	20	18	41	44.5	40	40
A B C D	Reduced	10	11	12	11	31	34	30	30

2nd Series of test

The Second Series of Test was performed with Fountain Solution additive 2 i.e. with 8% IPA.

3 liters of IPA was now added to the Fountain Reservoir to contain the fountain solution - Tap water + Fount + IPA in the proportion 100 : 2 : 8.

The first printing was carried out under Optimum Ink & water conditions again by achieving target ink densities. It should be noted that with an increase in IPA % the amount of ink & water required to achieve the optimum condition had gone down. Table 2 shows these Ink duct rotation and Dampening duct rotation values.

The second printing with 20% Increased ink & water and third printing with 10% Reduced ink & water conditions were carried out again using the same sequence of paper types.

Optimum condition again served as the reference condition for the rest two conditions.

Table 1 gives quantification of the amount of ink & water for all the three conditions for this series of test.

Table 2: 2nd Series of test with Fountain Solution additive 2 (8% IPA)

Paper	Amount of Fountain Solution & Ink	Ink Duct Rotation				Dampening Duct Rotation			
		K	C	M	Y	K	C	M	Y
A B C D	Optimum	11	13	13	12	33	34	30	30
A B C D	Increased	13	16	16	14.5	39.5	41	36	36
A B C D	Reduced	9	11	11	10	27.5	29	25	25

3rd Series of test

The Third Series of Test was performed with Fountain Solution additive 3 i.e. with 12% IPA.

4liters of IPA was added further to the Fountain Reservoir to contain the fountain solution - Tap water + Fount + IPA in the proportion 100 : 2 : 12.

The first printing was carried out under Optimum Ink & water conditions again by achieving target ink densities. It should be noted that with further increase in IPA %, the amount of ink & water required to achieve the optimum condition had also gone down further. Table 2 shows these Ink duct rotation and Dampening duct rotation values.

The second printing with 20% Increased ink & water and third printing with 10% Reduced ink & water conditions were carried out again using the same sequence of paper types.

Optimum condition again served as the reference condition for the rest two conditions.

Table 1 gives quantification of the amount of ink & water for all the three conditions for this series of test.

Table3: 3rd Series of test with Fountain Solution additive 3 (12% IPA)

Paper	Amount of Fountain Solution & Ink	Ink Duct Rotation				Dampening Duct Rotation			
		K	C	M	Y	K	C	M	Y
A B C D	Optimum	10	12	10	9	30	31	27	27
A B C D	Increased	12	14.5	12	11	36	37	32.9	33
A B C D	Reduced	8	10.5	8.5	7.5	25	26	23	23

4. PRESS RELATED SPECIFICATIONS

Target Ink Densities :

Cyan	1.45
Magenta	1.45
Yellow	1.2
Black	1.8

Press Details:

Machine Used	4 color Mitsubishi
Speed	7000 IPH
Dampening System	Plate feed alcohol
Machine Size	600 mm × 730 mm

Inventory Details

Inventory	Details
CTP Plates	175 lpi
Substrate Used	Sappi Gloss & Sappi Matt (130 GSM) Bilt Gloss & Bilt Matt (130 GSM)
Ink Used	High Performance Micro Inks
Fountain Solution Used	Micro Fount 0009
Mitsubishi Diamond 1000 LS	Machine Size: 600mm × 730mm Plate Size: 600 mm × 730 mm Gripper: 48mm
Press Room Temperature	23 degree Celsius
Temperature of Fountain Solution	12 degree Celsius.
Densitometer	Gretag Macbeth.

VI Analysis of Print Samples

VI ANALYSIS OF PRINT SAMPLES

a) Densitometrical Analysis
b) Visual Analysis

a) Densitometrical Analysis:

This includes analysis and evaluation of print attributes measured from the Test Form using a Densitometer.

The attributes include:

- Solid ink density
- Dot gain
- Print contrast
- Ink trapping

The analysis presented here is limited to measurable print attributes.

b) Visual Analysis:

Some important print attributes which cannot be readily quantified are analyzed visually.

We have simply ranked mottle and the visual status of the samples by subjective ranking on a rating scale of 1-5.

1 – Very Poor

2 – Poor

3 – Satisfactory

4 – Good

5 – Very Good

The attributes include:

- Slur
- Mottling
- Gray patch
- Vignettes
- Image:
    - Shadows
    - Flesh tone
    - Metal

Analysis is divided in the following parts.

Part I: To study the effect of change in IPA proportion

Part II: To study the effect of change in the amount of fountain solution

Part III: Paper Comparison

1. PART I
To Study The Effect Of Change In Ipa Proportion

To study the above effect on print and visual parameters, we plotted their graphs showing direct comparison of 5%, 8% and 12% IPA for each of the conditions of Optimum water & ink, increased water & ink & reduced water & ink.This was done for all the four types of papers individually.

The following section holds graphs for the conditions given below.

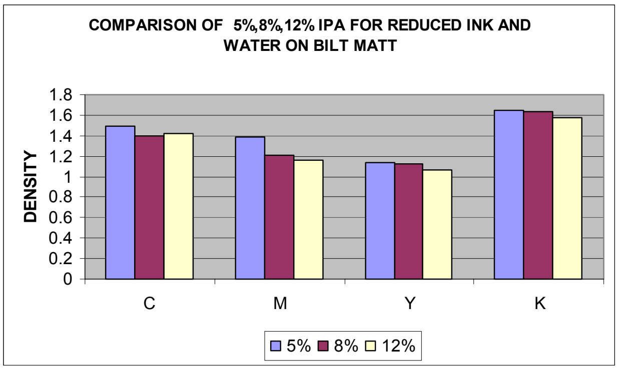
Optimum ink & water – 5% IPA
8% IPA
12% IPA

Increased ink & water – 5 % IPA
8% IPA
12% IPA

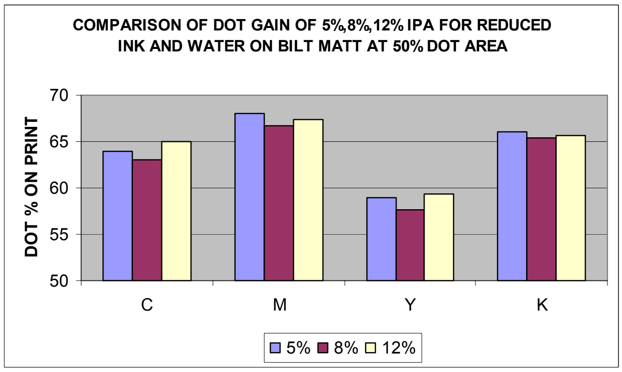
Reduced ink & water – 5 % IPA
8% IPA
12% IPA

Below set of graphs has been plotted for each of the papers Bilt Matt, Bilt Gloss, Sappi Matt & Sappi Gloss.

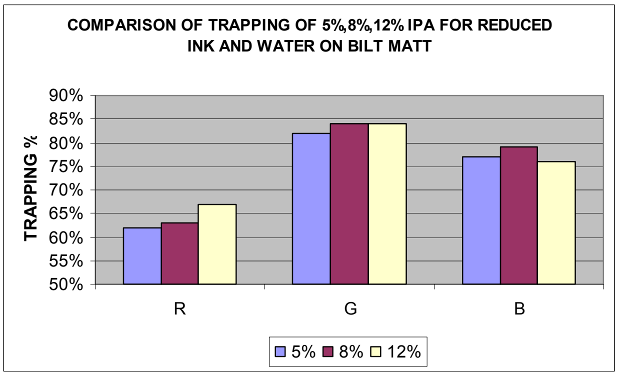
5%, 8%, 12% IPA FOR REDUCED INK & WATER - BILT MATT



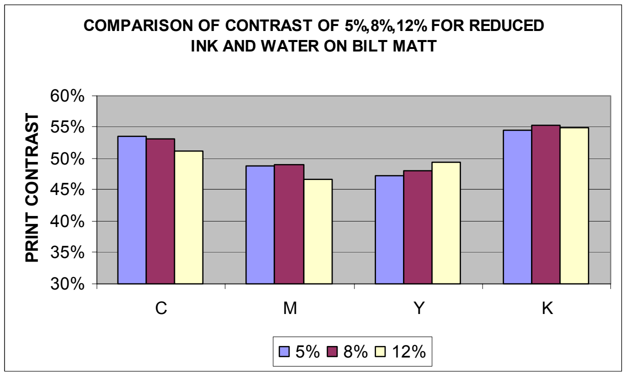
DENSITY



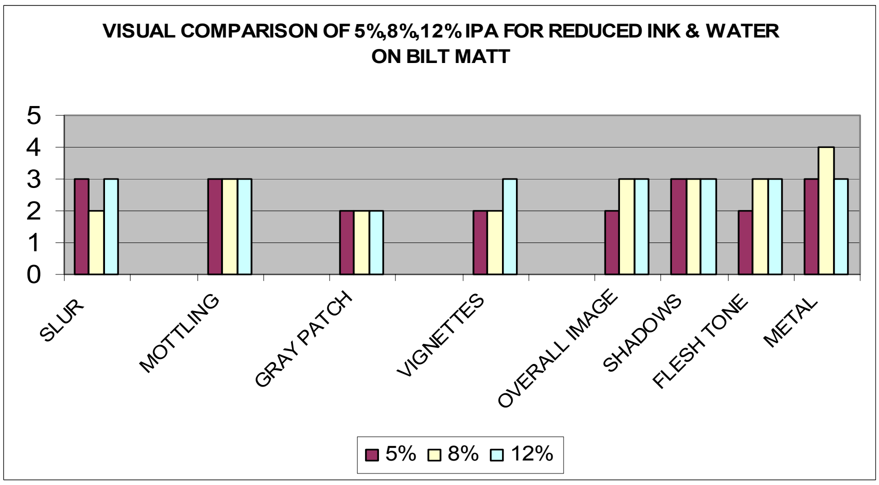
DOT GAIN



TRAPPING



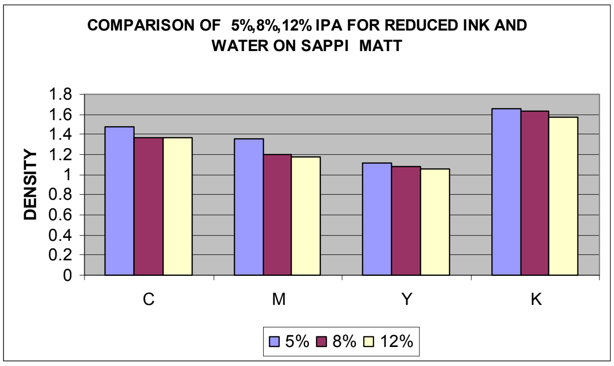
CONTRAST



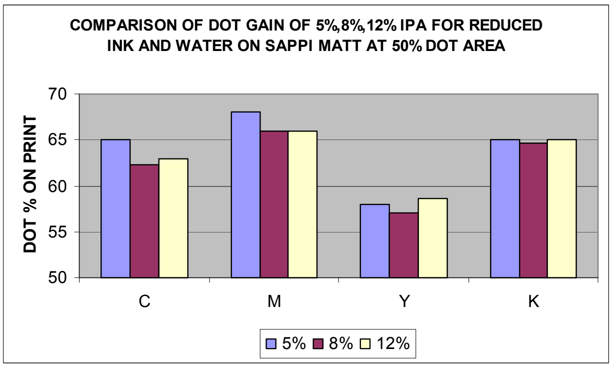
VISUAL

With the increasing IPA proportion, overall Density was seen to be deceasing; while dot gain showed a rise from 5% to 12% with an exception of 8% showing lesser dot gain. Trapping showed better results again with increasing IPA %. However, Print Contrast value fell as the IPA % rose. Bilt Matt showed same average mottling result for all IPA % with reduced ink & water; but overall visual analysis points towards 8% & 12% IPA for giving better results on Bilt Matt.

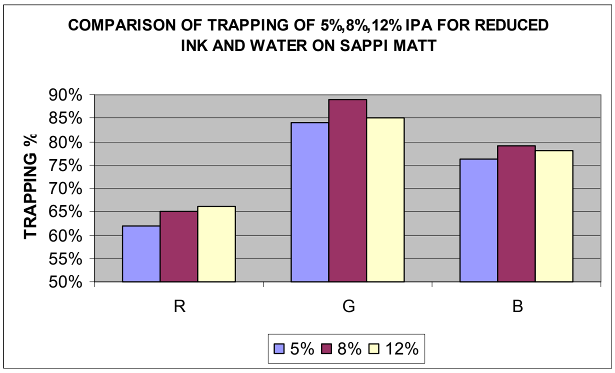
5%, 8%, 12% IPA FOR REDUCED INK & WATER – SAPPI MATT



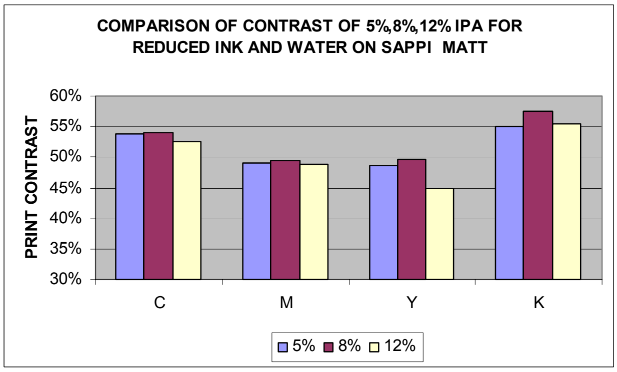
DENSITY



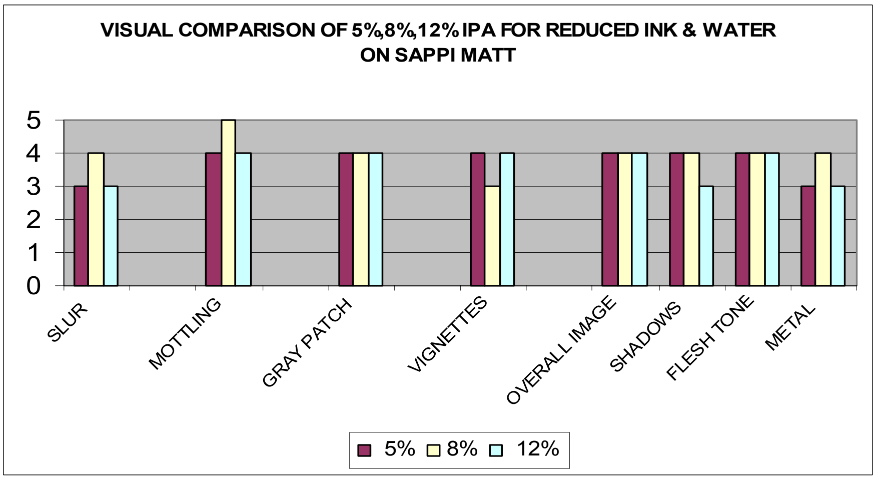
DOT GAIN



TRAPPING



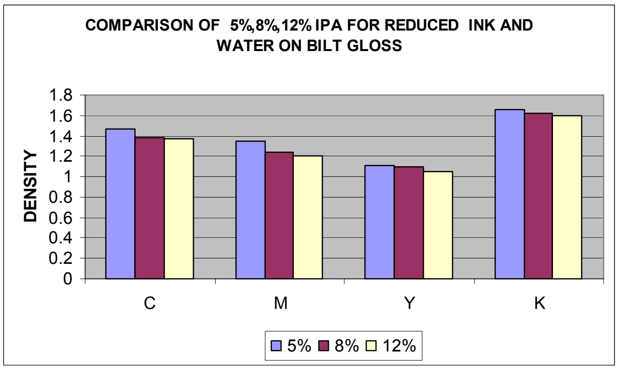
CONTRAST



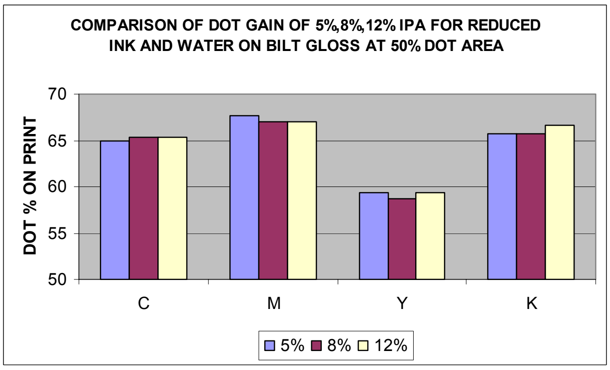
VISUAL

As the IPA % increased, but density decreased; while Dot Gain decreased. Here, trapping gave better results from 5% to 12% with 8% having the best results. Print Contrast did decrease with increasing IPA %, but again 8% IPA showed the best contrast. Sappi Matt showed very little mottle for all IPA % with 8% as the best condition again. All three variations of IPA performed well on Sappi Matt with 8% IPA condition as the outstanding one.

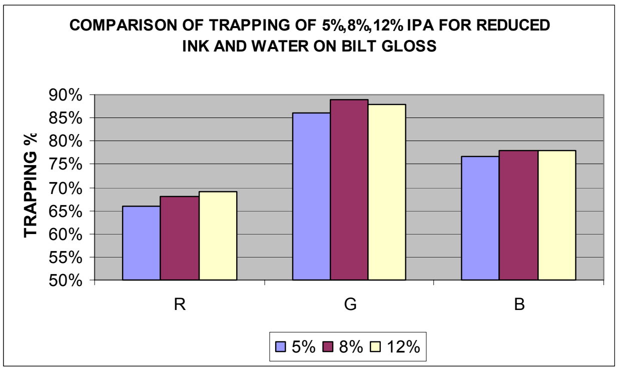
5%, 8%, 12% IPA FOR REDUCED INK & WATER – BILT GLOSS



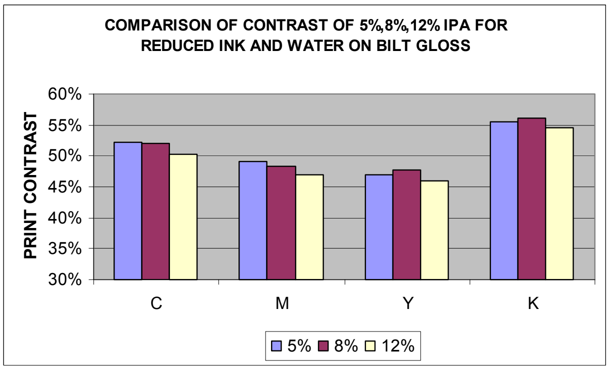
DENSITY



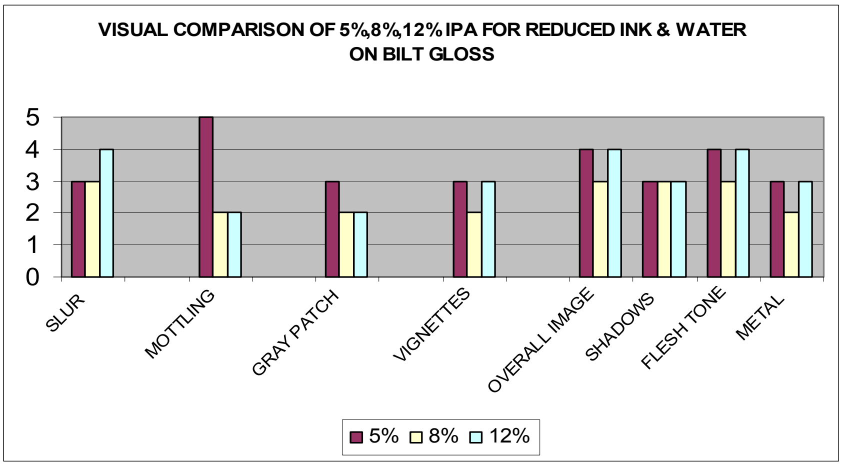
DOT GAIN



TRAPPING



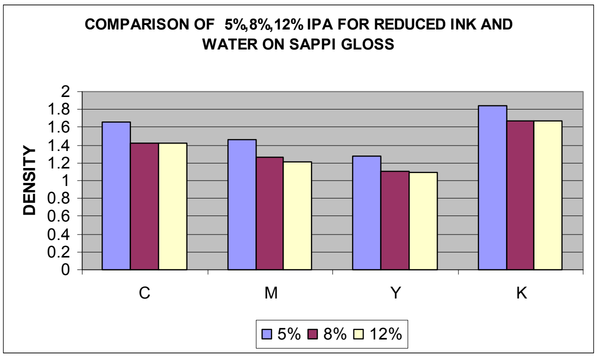
CONTRAST



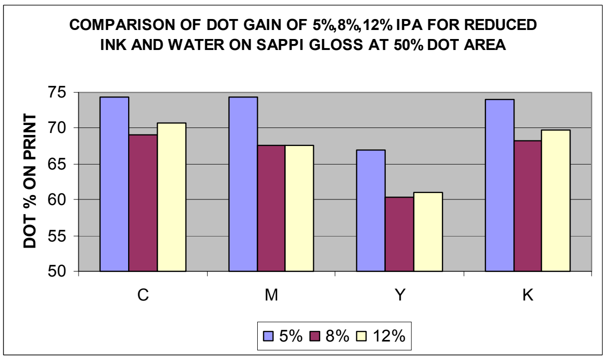
VISUAL

With the increasing IPA proportion, Density decreased; while dot gain increased only for cyan & black and remained almost same for magenta & yellow. Trapping showed better results with increasing IPA %. But Print Contrast decreased as the IPA % increased. Bilt Gloss showed excellent mottling result for 5% IPA with reduced ink & water; while overall visual analysis showed that 5% & 12% IPA gave better results on Bilt Gloss.

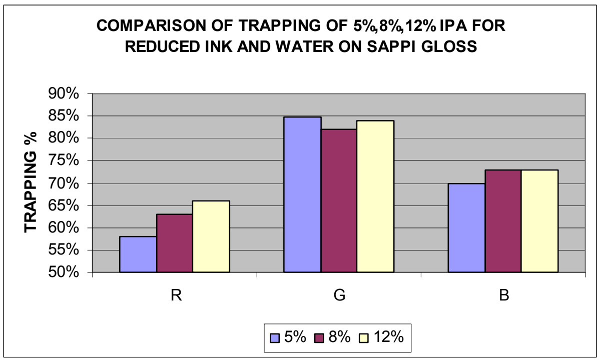
5%, 8%, 12% IPA FOR REDUCED INK & WATER – SAPPI GLOSS



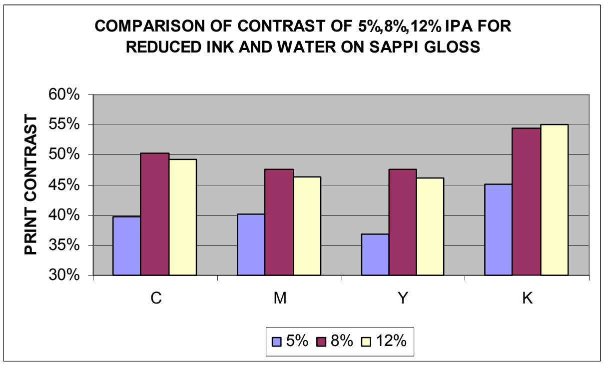
DENSITY



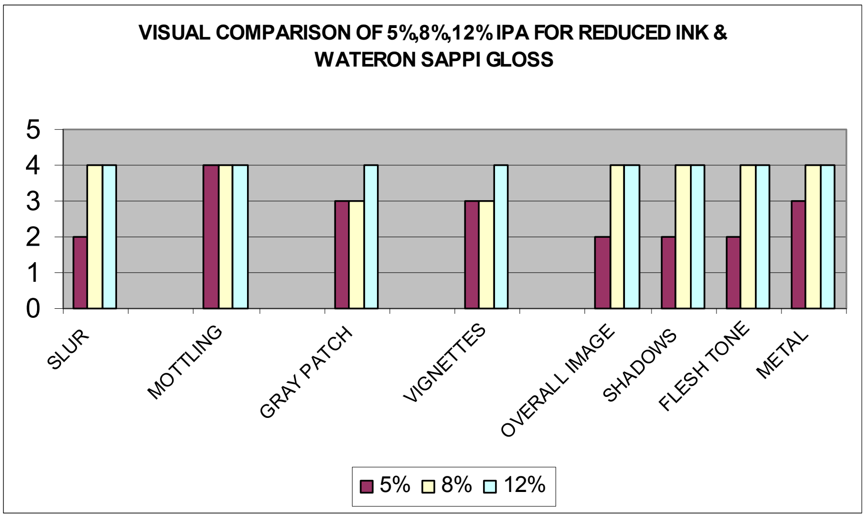
DOT GAIN



TRAPPING



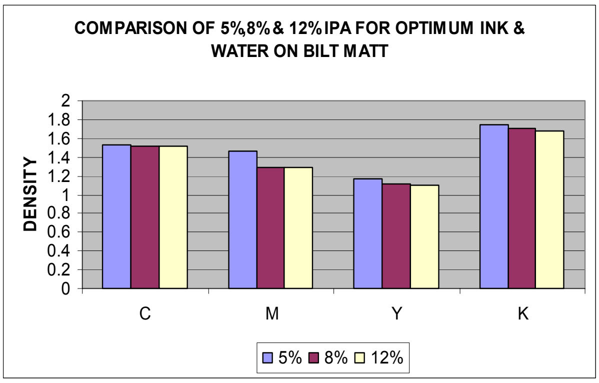
CONTRAST



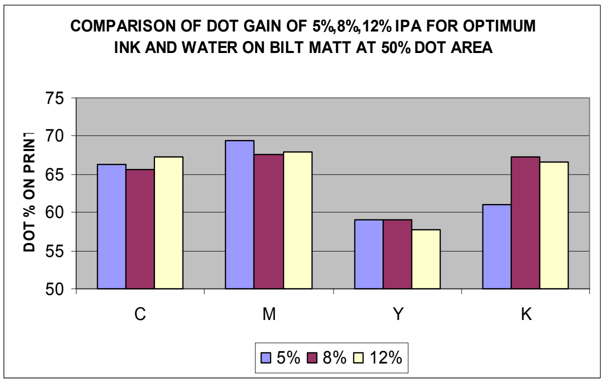
VISUAL

Sappi Gloss showed the same trend of falling Density with increasing IPA %. However, it showed exactly opposite trend of decreasing Dot Gain as against other papers. Trapping was better with increasing IPA proportion. But again Print Contrast showed opposite result of increase in contrast with increase in IPA %. Sappi Gloss showed little mottle with all three IPA %. But better visual results were for 8% & 12% IPA.

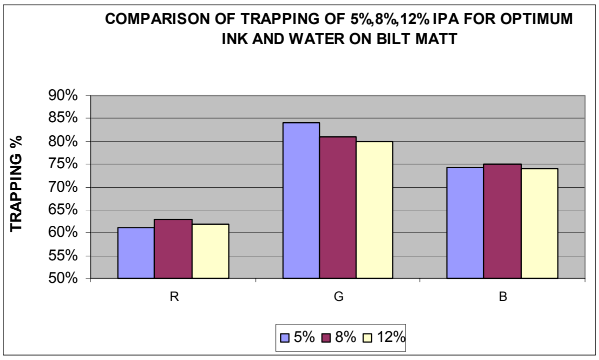
5%, 8%, 12% IPA FOR OPTIMUM INK & WATER – BILT MATT



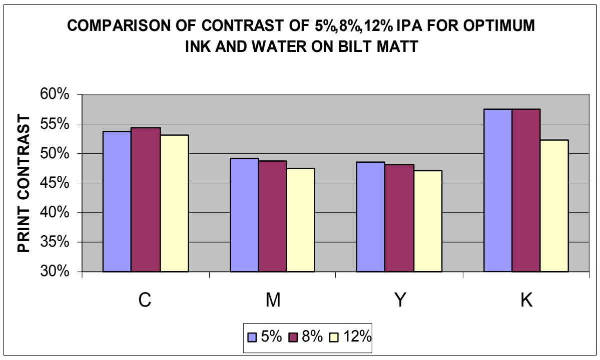
DENSITY



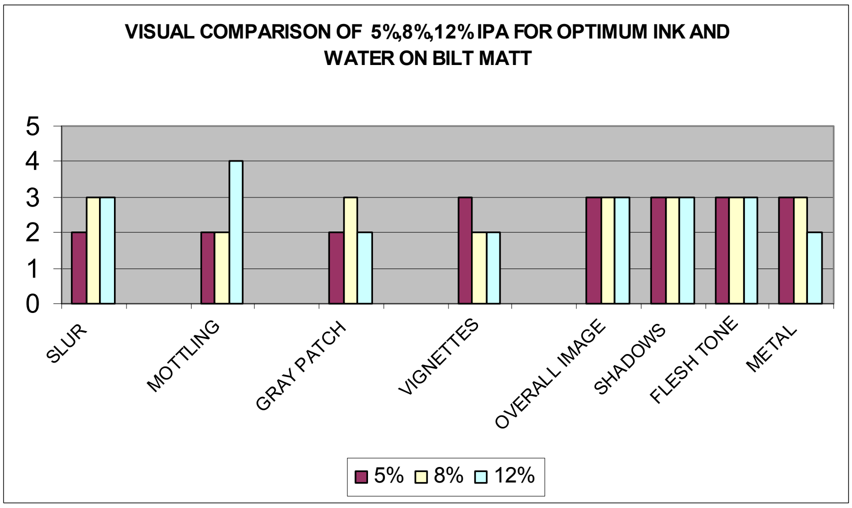
DOT GAIN



TRAPPING



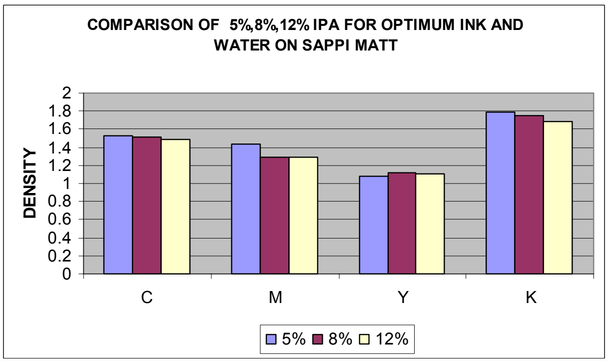
CONTRAST



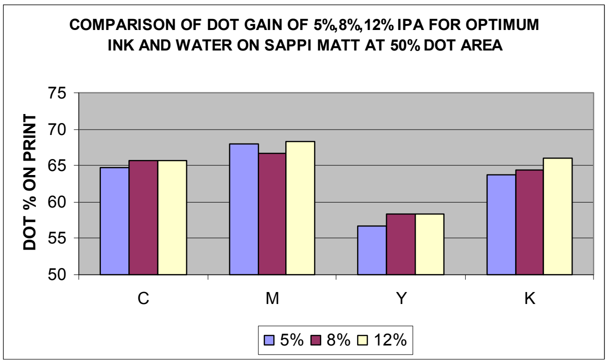
VISUAL

As IPA % is increased, density decreased. However Bilt Matt under optimum condition showed inconsistent dot gain, neither an increasing nor a decreasing trend but 8% showed a lower dot gain. As such, trapping showed better values for 8% IPA but again, 8% performed better. Print Contrast showed a falling trend with increasing IPA%. Bilt matt gave good results for mottling for 12% IPA. However, visual comparison of all three variations gave similar results on Bilt matt under this condition. Overall performance of 8% was better.

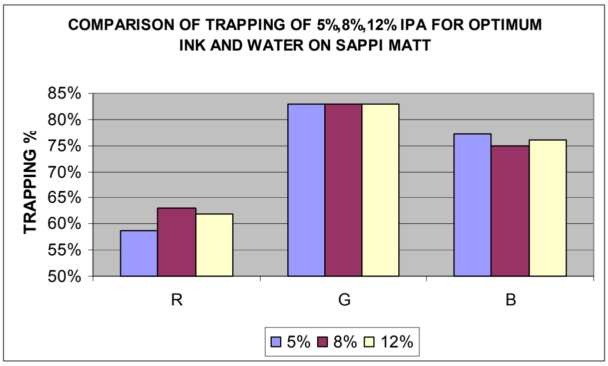
5%, 8%, 12% IPA FOR OPTIMUM INK & WATER – SAPPI MATT



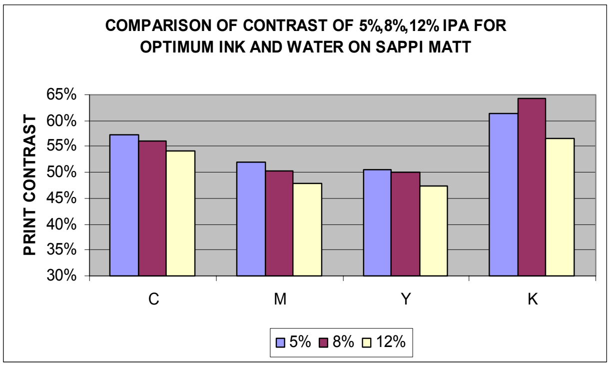
DENSITY



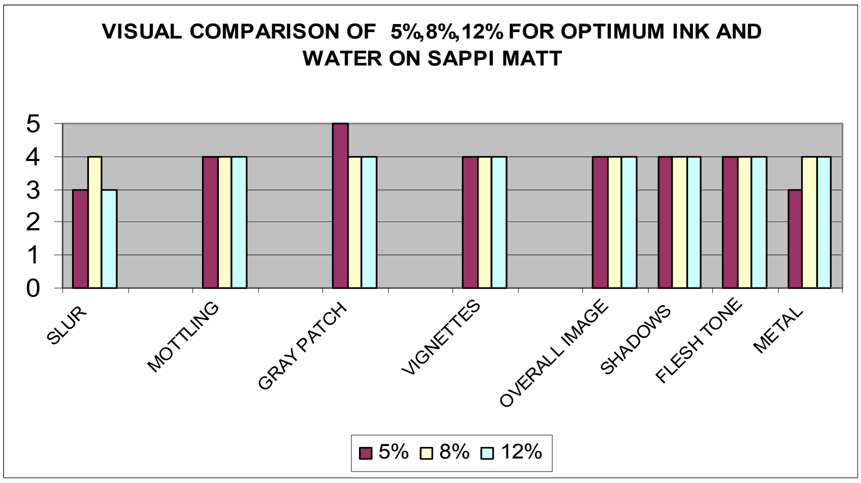
DOT GAIN



TRAPPING



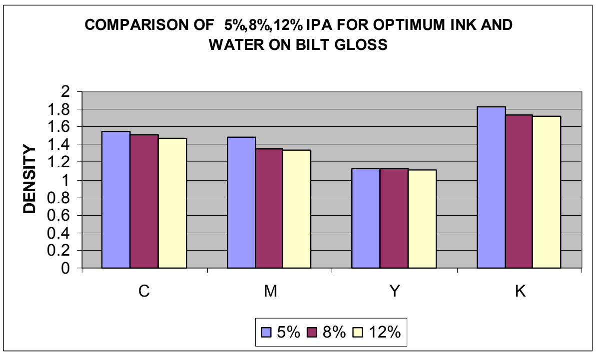
CONTRAST



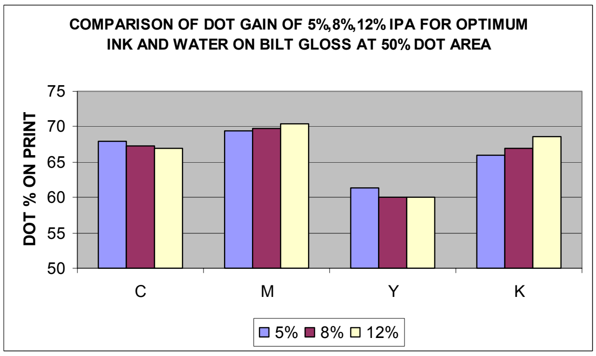
VISUAL

Density decreased while the dot gain increased with the increasing IPA %. Trapping showed very inconsistent values. Whereas Print contrast showed a steady fall with IPA% increasing from 5 to 12%.Sappi matt showed little mottle and good visual results for all three IPA %. 8% IPA gave consistently good results for this condition.

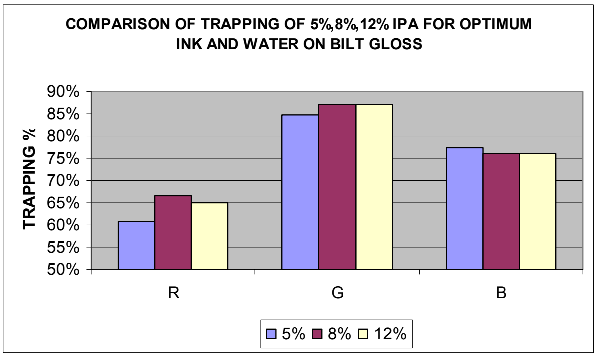
5%, 8%, 12% IPA FOR OPTIMUM INK & WATER – BILT GLOSS



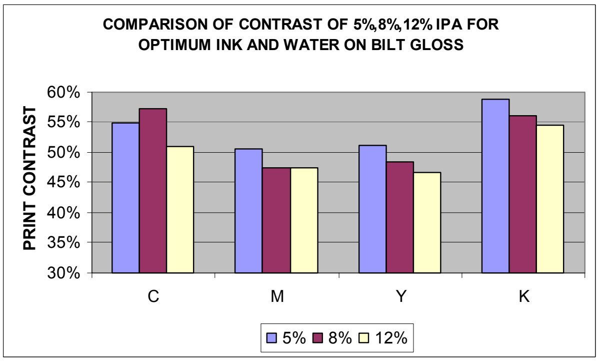
DENSITY



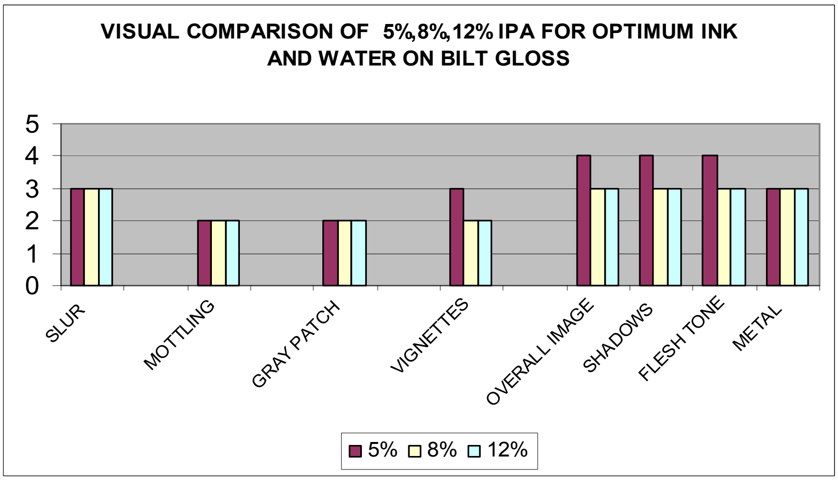
DOT GAIN



TRAPPING



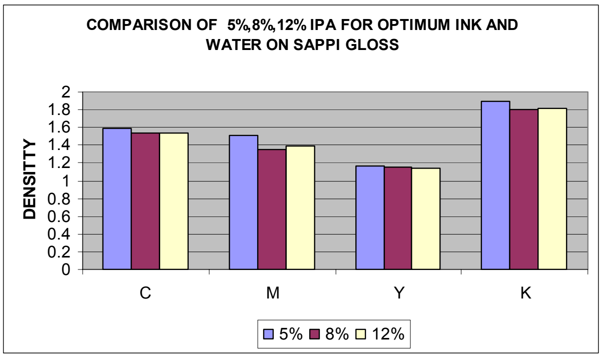
CONTRAST



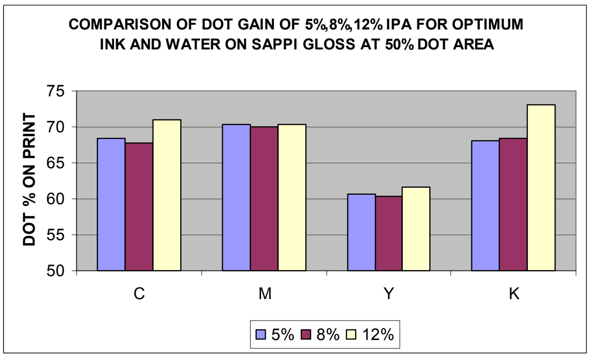
VISUAL

With the increasing IPA proportion, Density decreased; while dot gain showed an increasing trend only for magenta & black while a falling trend for cyan & black. Trapping showed inconsistent results but 8% IPA can be said to be performing better. Print Contrast decreased as the IPA % increased again. Bilt Gloss showed poor mottling result for all IPA% with optimum ink & water; while overall visual analysis showed that 5% IPA gave better results.

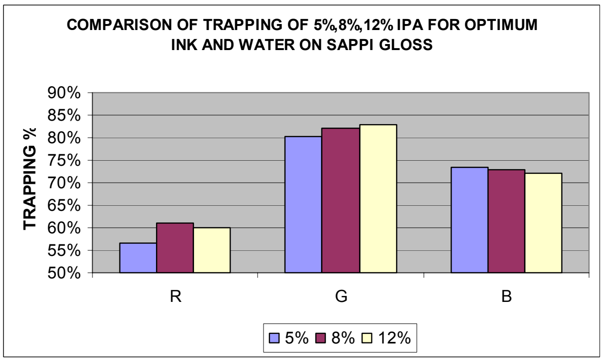
5%, 8%, 12% IPA FOR OPTIMUM INK & WATER – SAPPI GLOSS



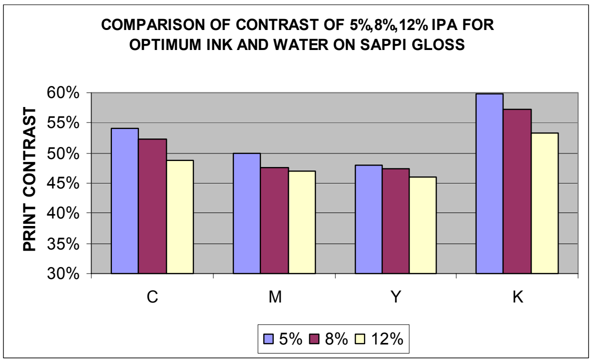
DENSITY



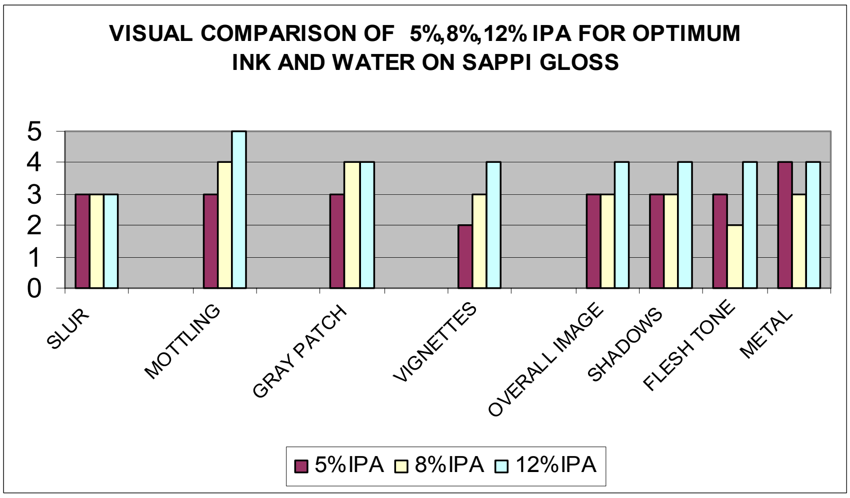
DOT GAIN



TRAPPING



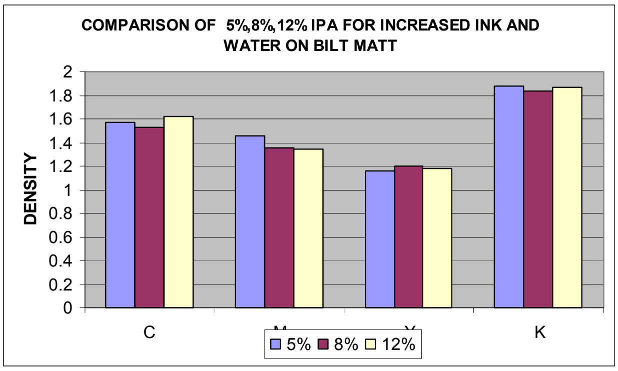
CONTRAST



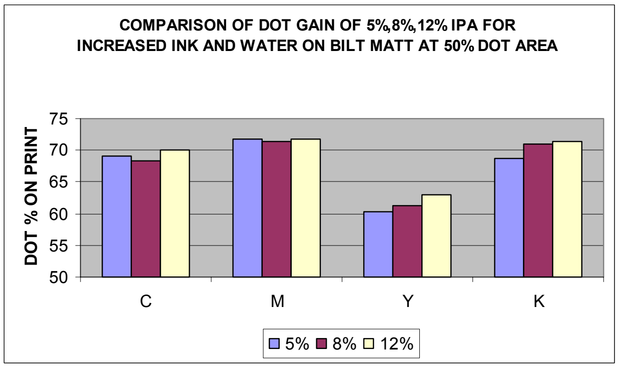
VISUAL

Density decreased while the dot gain increased with the increasing IPA %. 8% IPA showed lesser dot gain. Trapping showed very inconsistent values but again 8% gave better trapping values. Whereas Print contrast showed a steady decrease with increasing IPA%. Sappi gloss showed very little mottle for 8% & 12% IPA. 12% IPA showed good visual results on Sappi gloss.

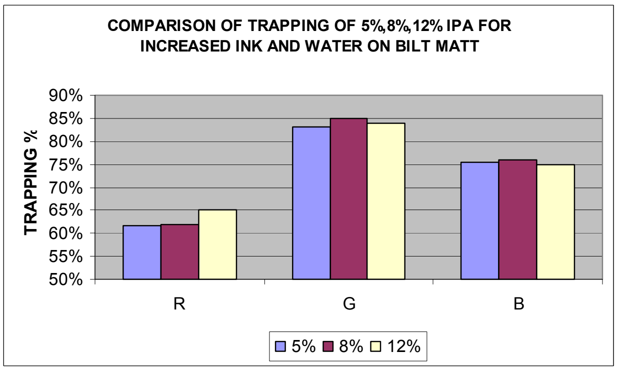
5%, 8%, 12% IPA FOR INCREASED INK & WATER – BILT MATT



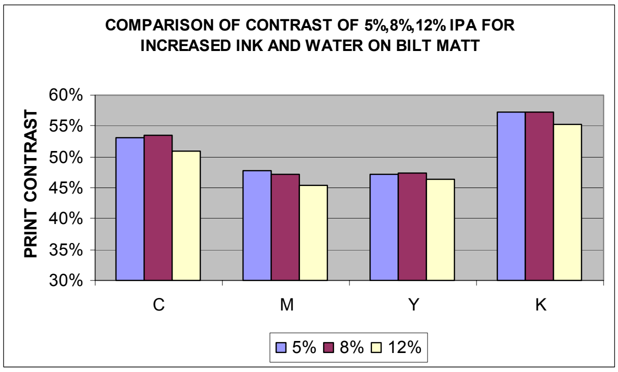
DENSITY



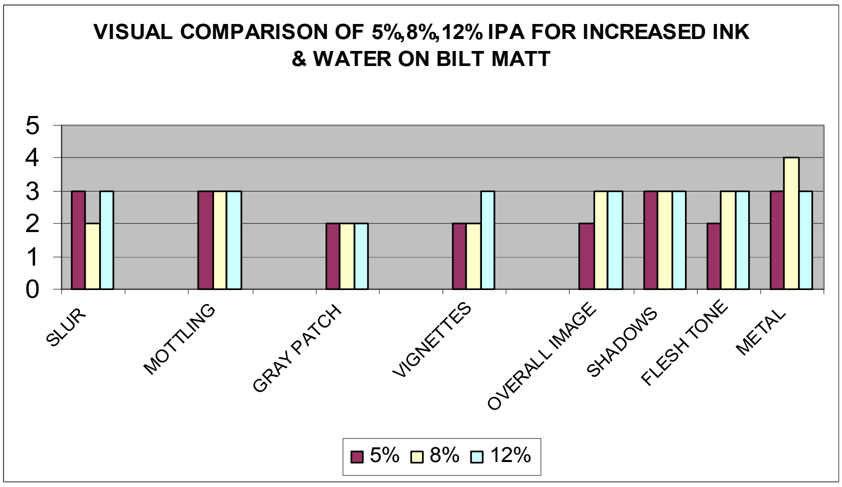
DOT GAIN



TRAPPING



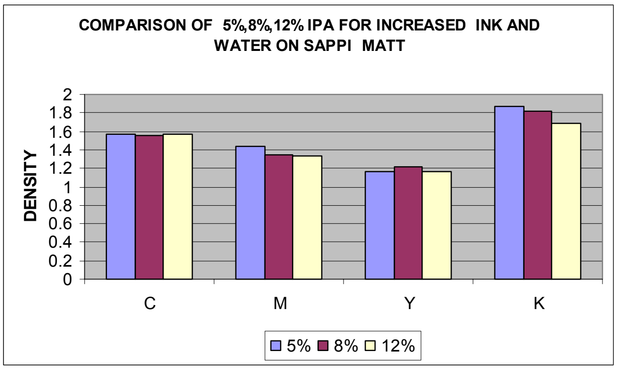
CONTRAST



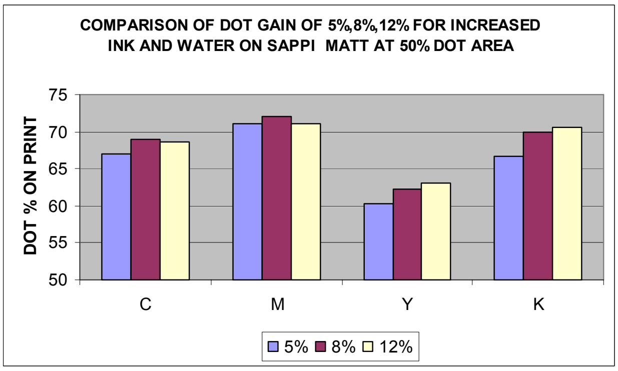
VISUAL

With increasing IPA %, density decreased on an average but with 12% giving more density. Dot gain showed an increasing trend. Trapping again showed inconsistent values. Print contrast showed a decrease with increasing IPA. Bilt matt gave average mottling on all three variations. Visual analysis showed 5% & 12% IPA giving better results.

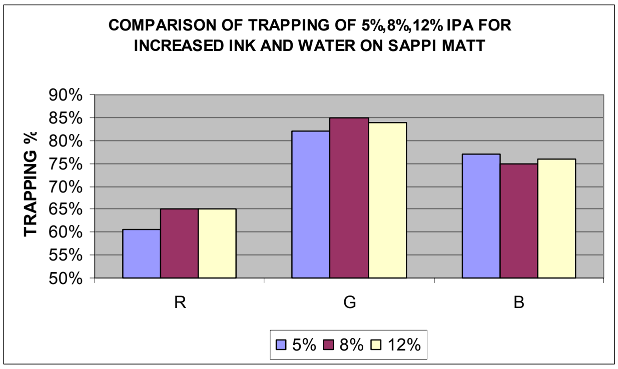
5%, 8%, 12% IPA FOR INCREASED INK & WATER – SAPPI MATT



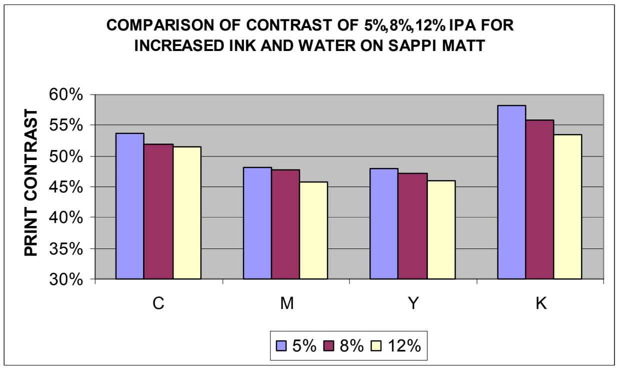
DENSITY



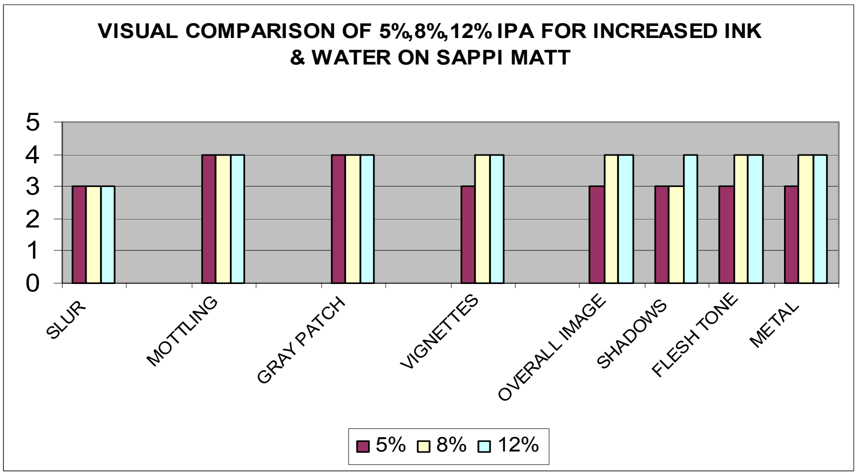
DOT GAIN



TRAPPING



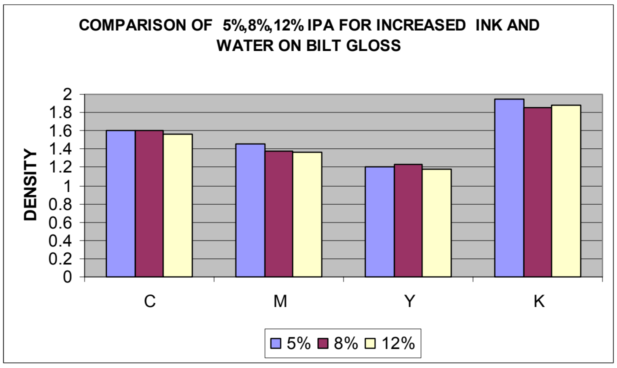
CONTRAST



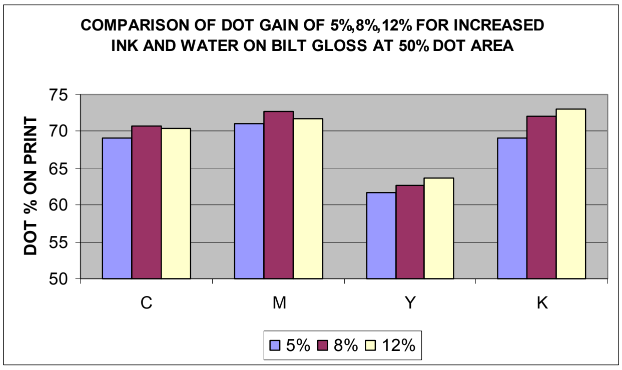
VISUAL

With the increasing IPA proportion, overall Density was seen to be deceasing; while dot gain showed a rise from 5% to 12%. Trapping showed inconsistent results. However, Print Contrast value fell as the IPA % rose. Sappi Matt showed good mottling result for all IPA %; but overall visual analysis points towards 8% & 12% IPA for giving better results.

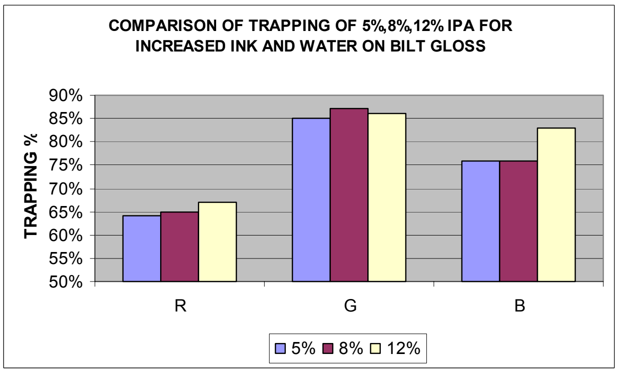
5%, 8%, 12% IPA FOR INCREASED INK & WATER – BILT GLOSS



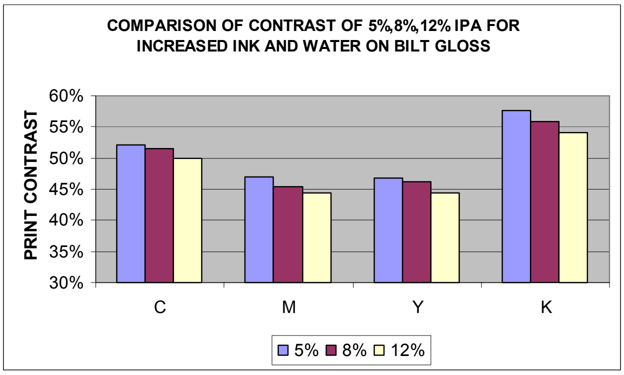
DENSITY



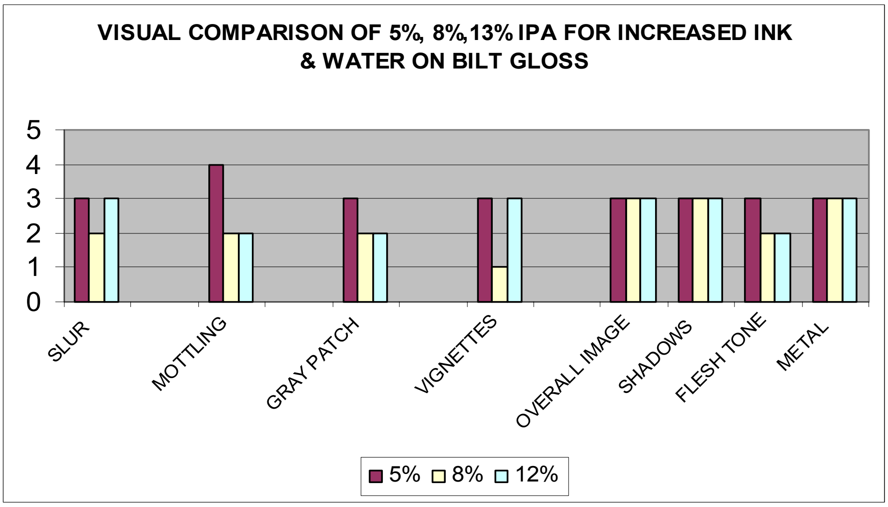
DOT GAIN



TRAPPING



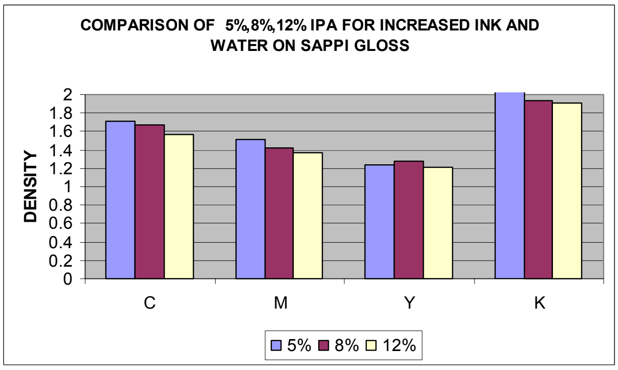
CONTRAST



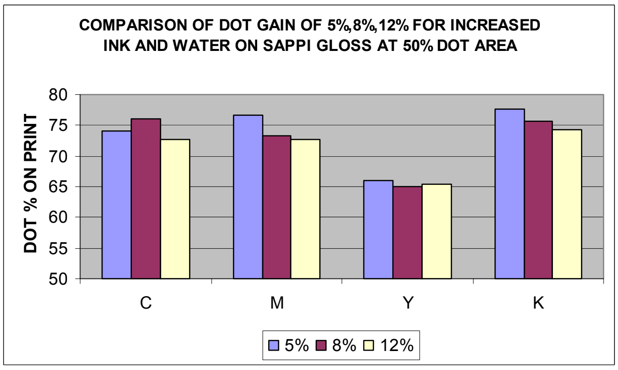
VISUAL

As IPA proportion increased, density decreased but inconsistently. Also dot gain showed an increased trend without consistency.12% IPA gave better trapping values. Print contrast was seen to be falling with increasing IPA. Bilt gloss showed little mottling and good visual results with 5% IPA.

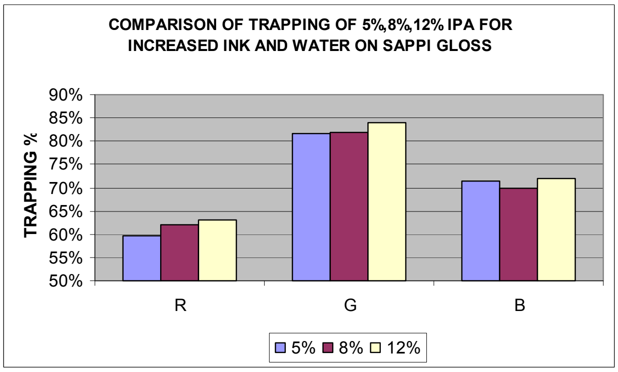
5%, 8%, 12% IPA FOR INCREASED INK & WATER – SAPPI GLOSS



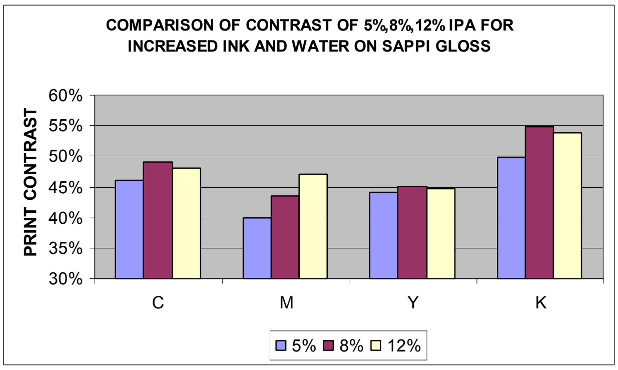
DENSITY



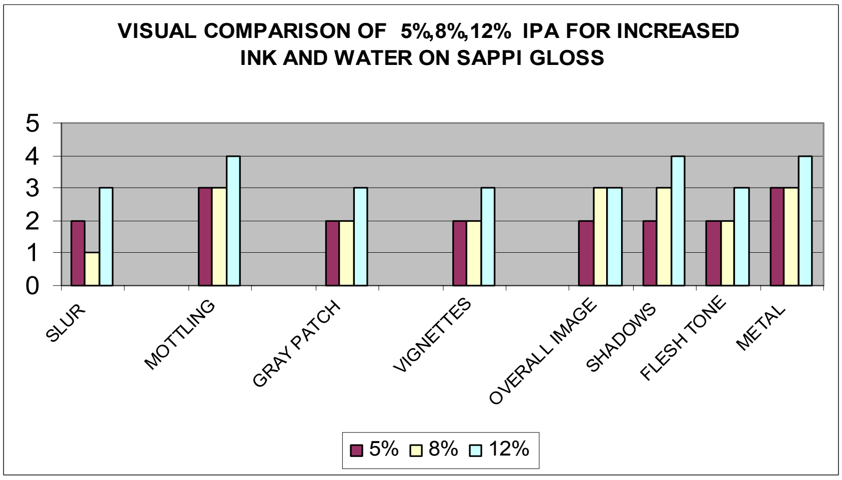
DOT GAIN



TRAPPING



CONTRAST



VISUAL

With the increasing IPA proportion, Density decreased; while dot gain also decreased. Trapping showed an increasing trend. Print Contrast can also said to be increasing with IPA %. Sappi Gloss showed good mottling for 12% IPA; overall visual analysis also showed that 12% IPA gave better results for increased ink & water.

Analysis of PART I : Change in IPA proportion

Results obtained from the Print trial:

As IPA % increases,

- Density decreases
- Dot gain increases
- Contrast decreases

Trapping showed inconsistent results, hence effect of change in IPA % on trapping could not be established.

Co-relation of Print results with Lab Tests:

As IPA % increases,

Contact angle	Decreases
Surface Tension	Decreases
Wettability	Increases
Ink Repellence	Increases
Mottling	Increases
Water-pick up	Increases
Emulsification	Increases
Tack	Decreases
Density	Decreases
Dot gain	Increases
Contrast	Decreases

As IPA % increases, surface tension reduces which means contact angle decreases. Smaller the contact angle better is the wettability. However, the problem of ink repellence improves at a higher contact angle. Higher the contact angle, lower is the sensitivity for ink repellence.
Thus as the IPA % increases, ink repellence increases.

It is now known from the test printings that a higher flow of water is necessary when printing with little alcohol. Thus, as IPA % goes on increasing, flow of water is reduced. However, water on plate remains the same under all these conditions; what varies is the water uptake by the ink.
Apparently the printing plate always requires the same quantity of water. Water uptake of ink demonstrates different behaviour each time. Inspite of increased flow of water with 5% IPA, quantity of water transported with the ink is much smaller than with 12 % IPA. Therefore it gives a better printing result with regard to water related mottling.
Also the lab tests show that water pick-up of the ink increases with the increasing IPA %.This increases emulsification i.e. the water emulsified in the ink and this explains increased mottling with increase in IPA %.
Thus the water emulsified in the ink plays a decisive role with regard to the differences in water interference mottling observed with one and the same paper.
The samples showed that both a low water supply and use of less Isopropanol could largely prevent water interference mottling.

As the water pickup of the ink increases with increase in IPA %, emulsification or the water emulsified in ink increases and the density decreases. Also tack reduces and hence, dot gain increases while contrast decreases.

2. PART II
To Study The Effect Of Change In The Amount Of Fountain Solution

To study the above effect on print and visual parameters, we plotted their graphs showing direct comparison of optimum, increased & reduced ink & water for each of the conditions of 5%, 8% & 12% IPA.This was done for all the four types of papers individually.

The following section holds graphs for the conditions given below.

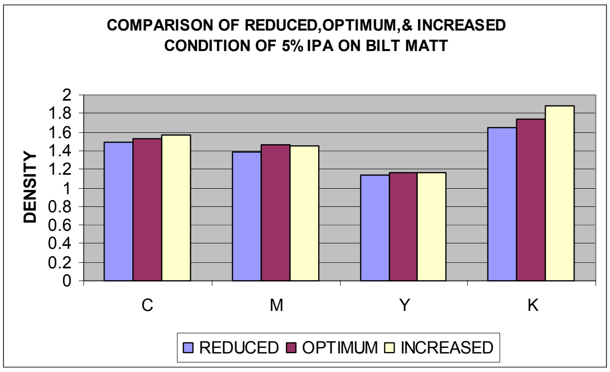
5% IPA – Optimum ink & water
Increased ink & water
Reduced ink & water

8% IPA – Optimum ink & water
Increased ink & water
Reduced ink & water

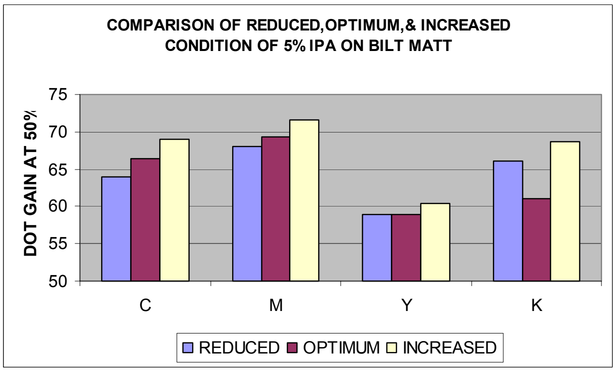
12% IPA – Optimum ink & water
Increased ink & water
Reduced ink & water

Below, set of graphs has been plotted for each of the papers Bilt Matt, Bilt Gloss, Sappi Matt & Sappi Gloss.

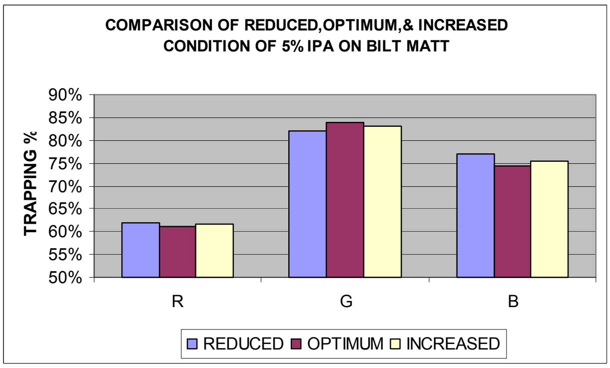
REDUCED, OPTIMUM, INCREASED CONDITION FOR 5% IPA - BILT MATT



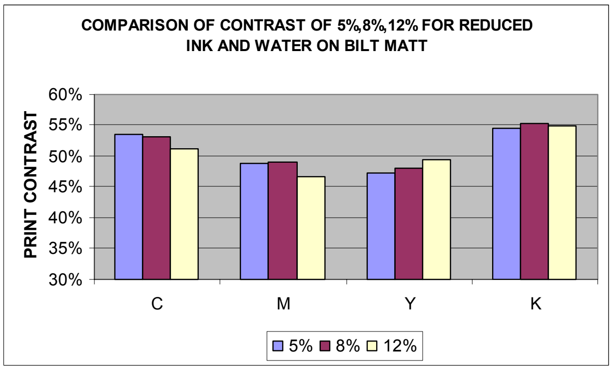
DENSITY



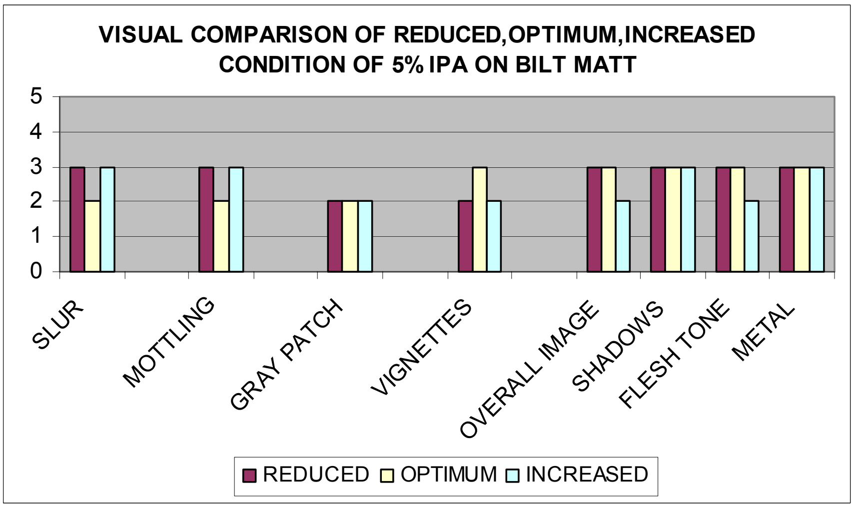
DOT GAIN



TRAPPING



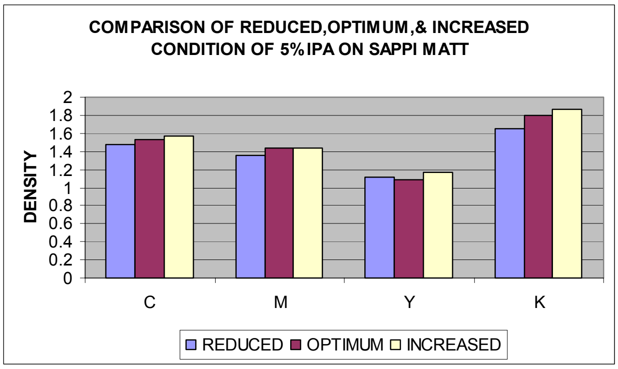
CONTRAST



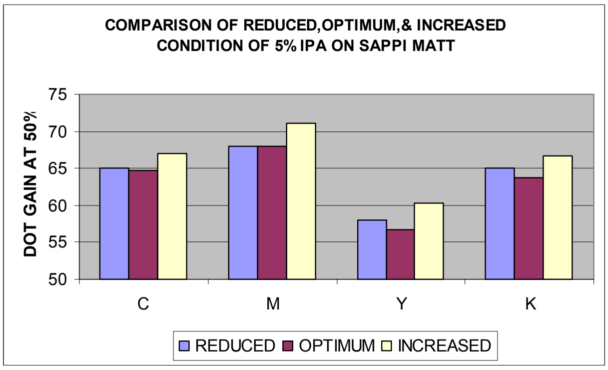
VISUAL

As the amount of ink & water increased, density and dot gain both increased. Trapping showed inconsistent values. While print contrast decreased with the increase in the ink & water amount. Mottling was satisfactory on Bilt matt for 5% IPA for reduced as well as increased condition. Overall visual analysis says that reduced & optimum condition performed better for 5% IPA on Bilt matt.

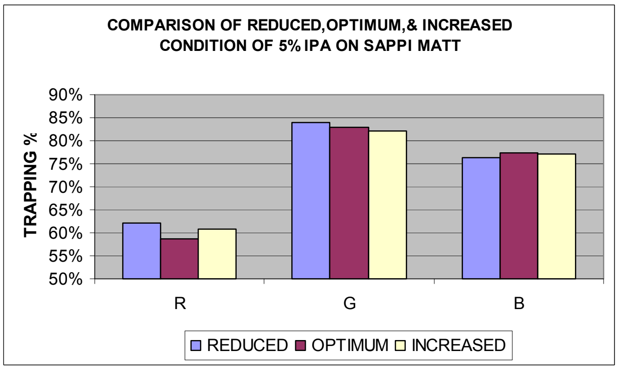
REDUCED, OPTIMUM, INCREASED CONDITION FOR 5% IPA – SAPPI MATT



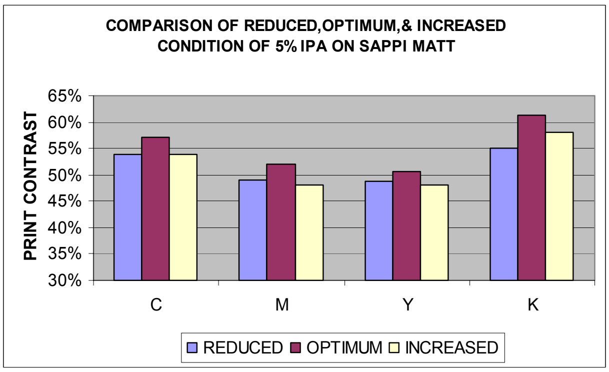
DENSITY



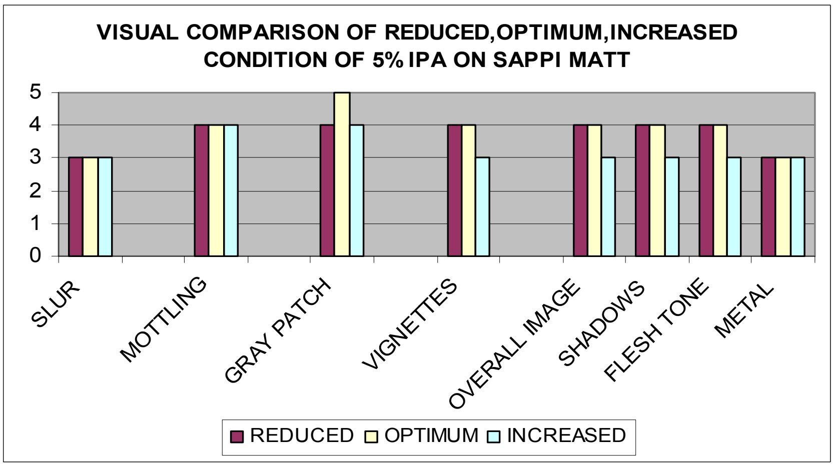
DOT GAIN



TRAPPING



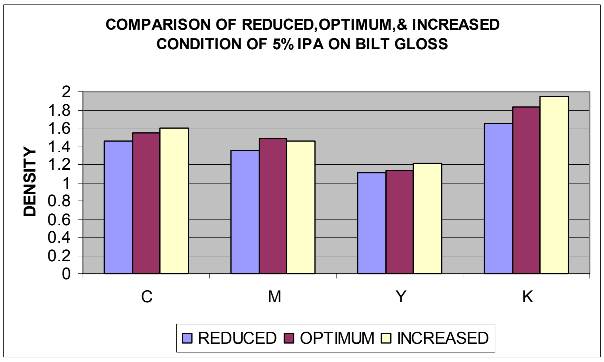
CONTRAST



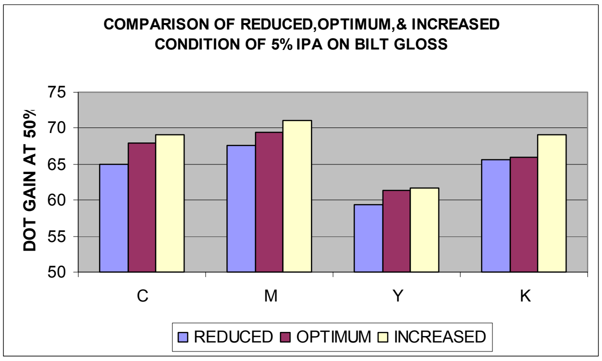
VISUAL

With the increasing amount of ink & water, density increased and with it increased the dot gain but with optimum condition showing lesser dot gain. Trapping showed inconsistent results print contrast showed best results for optimum ink & water. Sappi matt gave good mottling results for 5% IPA for all conditions. But again overall visual analysis gave more points to reduced & optimum condition.

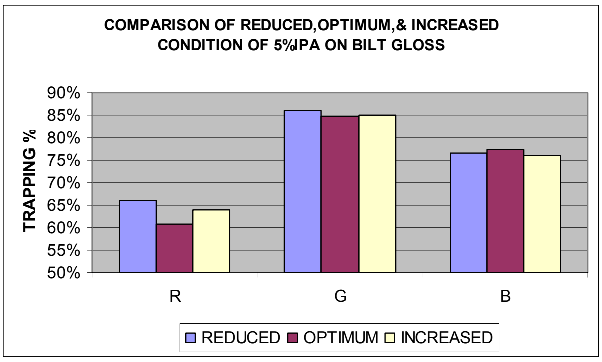
REDUCED, OPTIMUM, INCREASED CONDITION FOR 5% IPA – BILT GLOSS



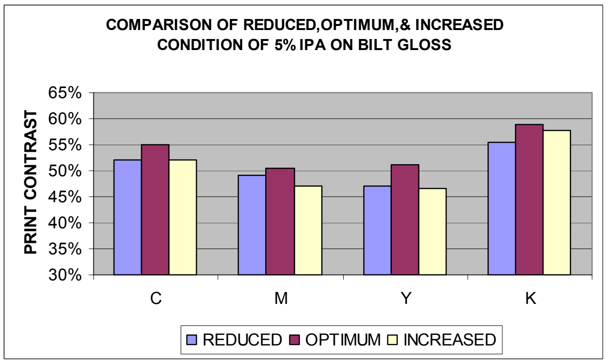
DENSITY



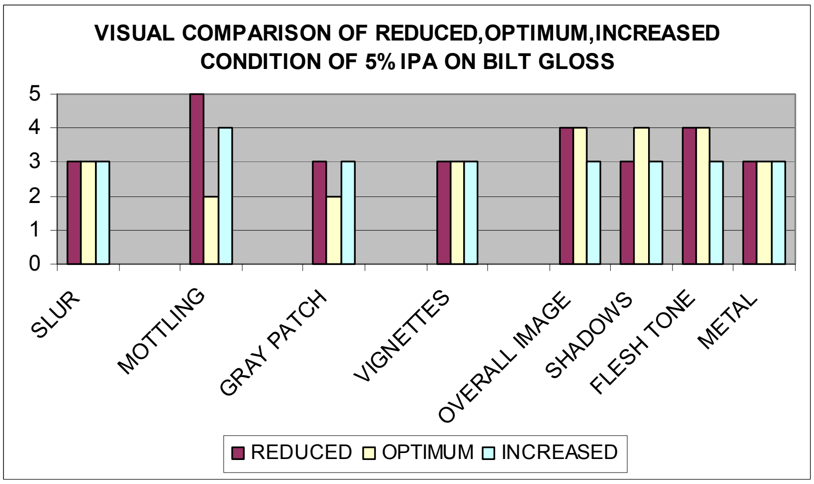
DOT GAIN



TRAPPING



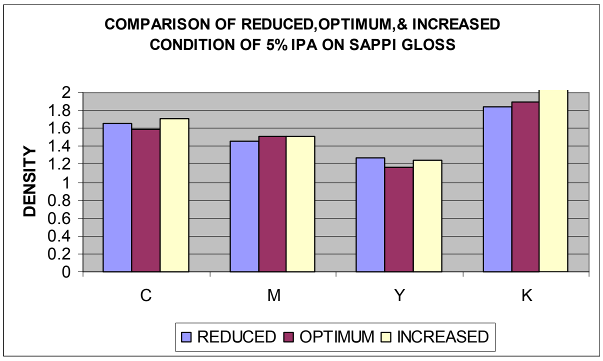
CONTRAST



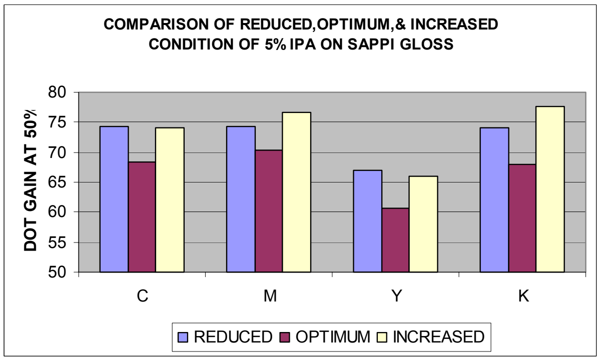
VISUAL

As the amount of ink & water increased, density increased and with it increased the dot gain. Trapping values decreased to a small extent as the amount of ink & water increased. Optimum condition showed best contrast. Bilt gloss gave excellent mottling results for 5% IPA reduced ink & water condition. Visually also, reduced & optimum conditions showed better results.

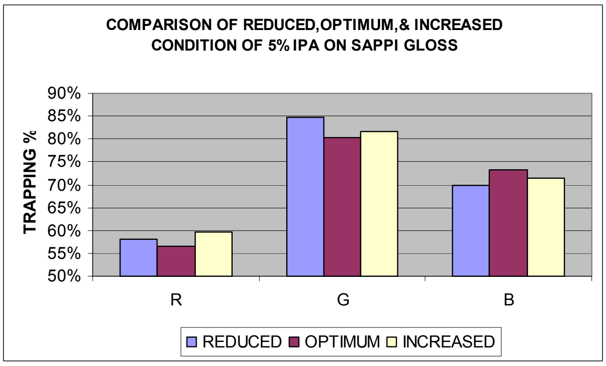
REDUCED, OPTIMUM, INCREASED CONDITION FOR 5% IPA – SAPPI GLOSS



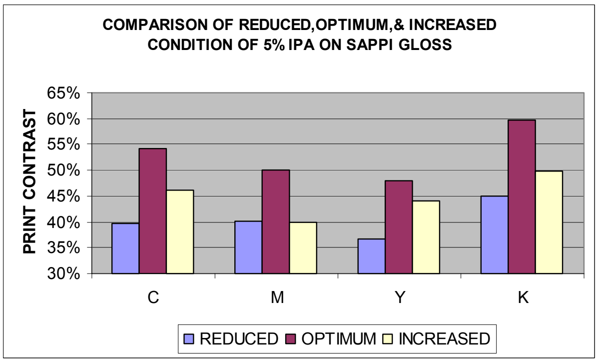
DENSITY



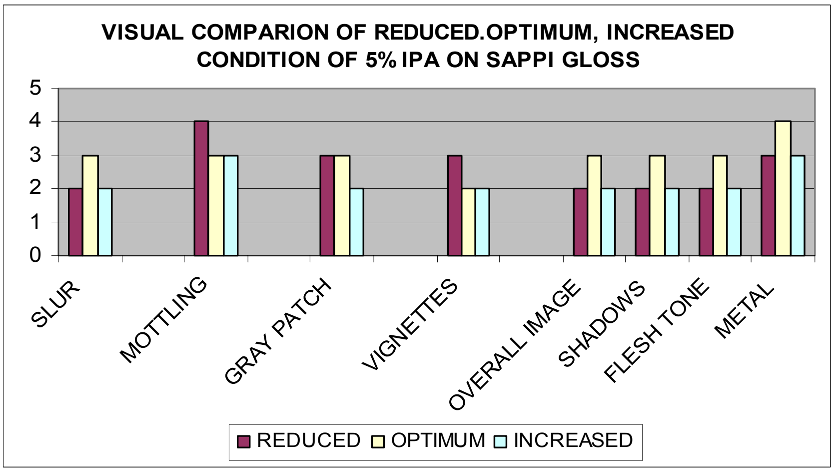
DOT GAIN



TRAPPING



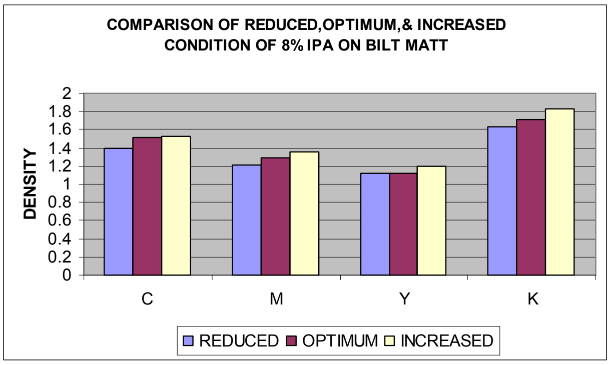
CONTRAST



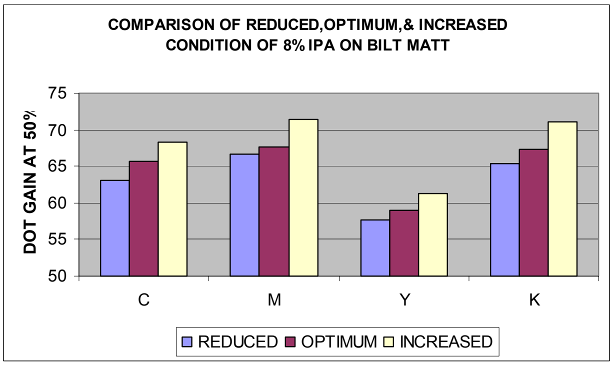
VISUAL

Sappi gloss showed inconsistent increase in the density with the increase in ink & water amount. Dot gain also increased from reduced to increased condition, but optimum condition showed much lesser dot gain. Trapping gave very inconsistent results. Print contrast increased from reduced to increased condition and showed drastically high values for optimum condition. Very little mottling was seen for this condition- 5% IPA with reduced ink & water.

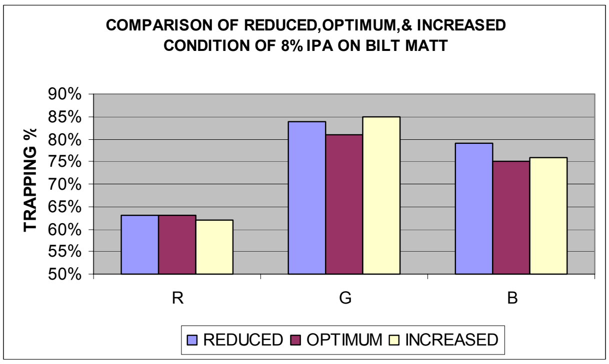
REDUCED, OPTIMUM, INCREASED CONDITION FOR 8% IPA – BILT MATT



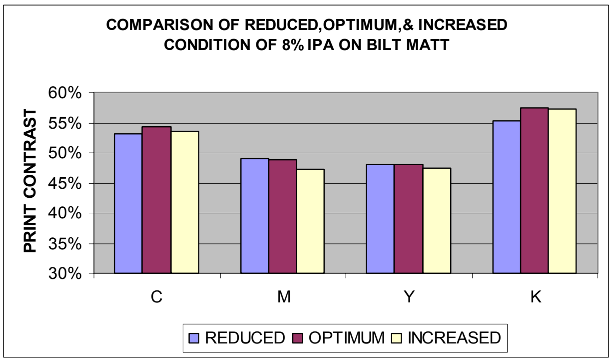
DENSITY



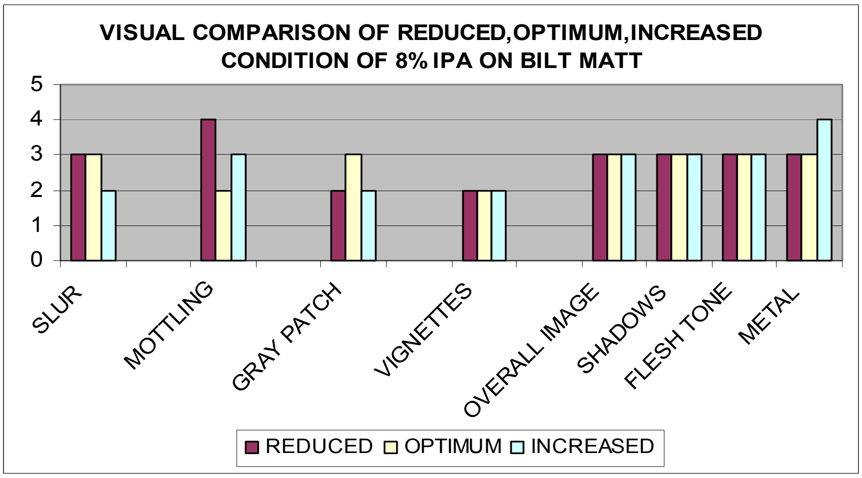
DOT GAIN



TRAPPING



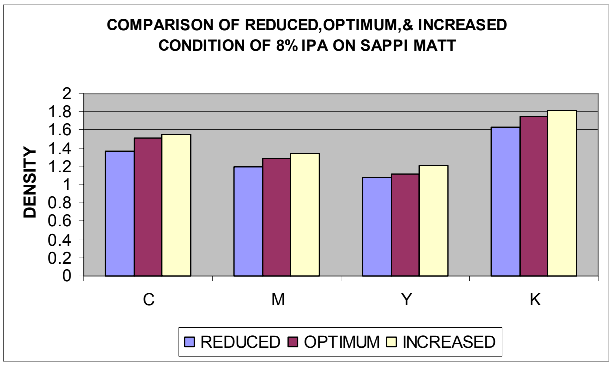
CONTRAST



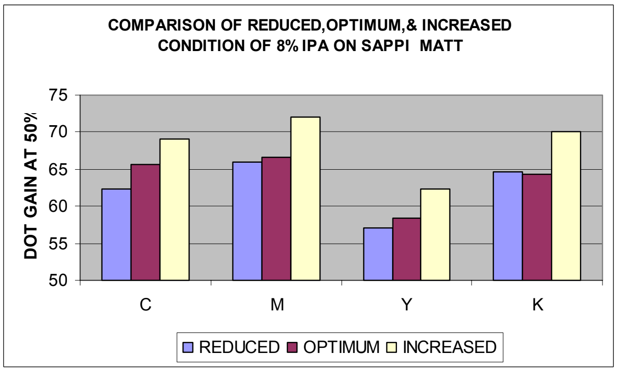
VISUAL

With the increasing amount of ink & water, density increased and with it increased the dot gain. Trapping showed inconsistent results. Print contrast showed best results for optimum ink & water. Bilt matt gave good mottling results for reduced conditions. But again reduced & optimum conditions performed better under visual analysis.

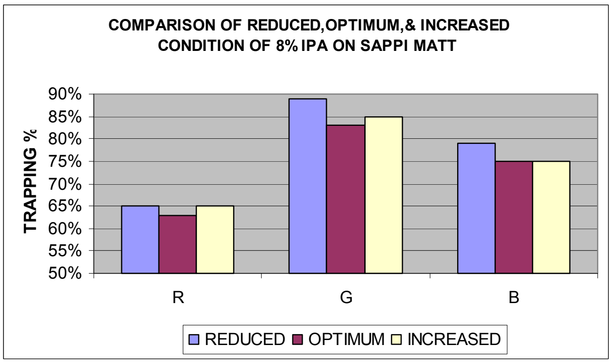
REDUCED, OPTIMUM, INCREASED CONDITION FOR 8% IPA – SAPPI MATT



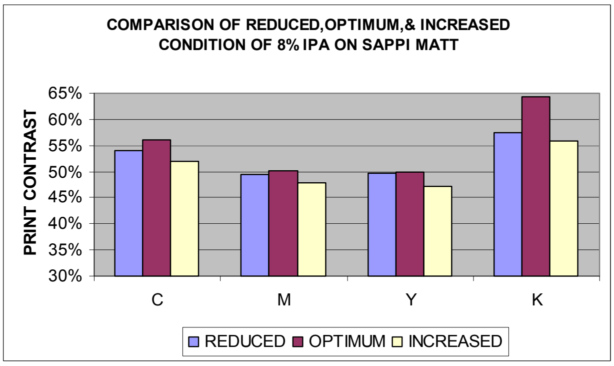
DENSITY



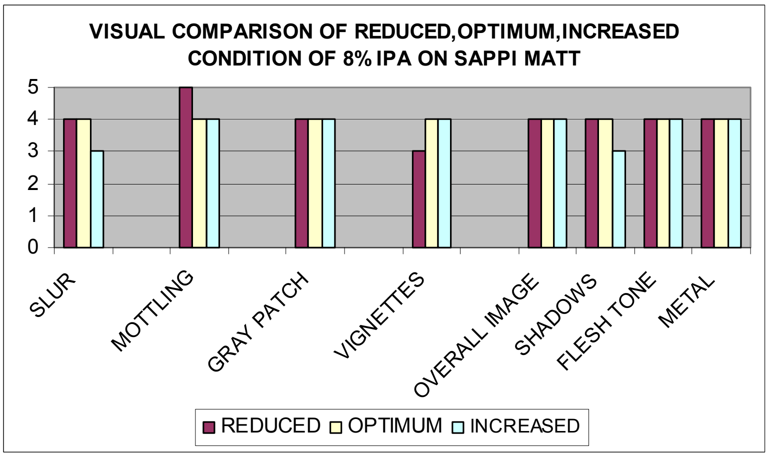
DOT GAIN



TRAPPING



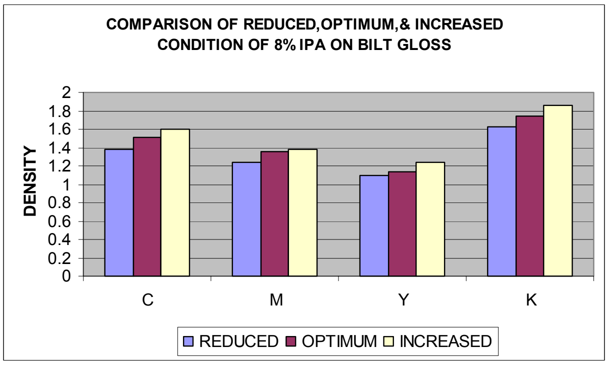
CONTRAST



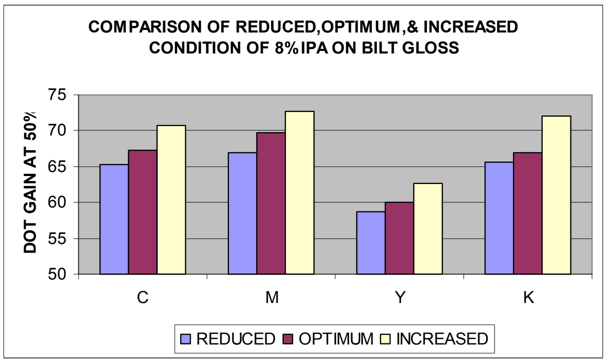
VISUAL

As the amount of ink & water increased, density and dot gain both increased. Trapping values decreased from the reduced condition to increased condition. Print contrast decreased with the increasing amount if ink & water but optimum condition showed highest contrast. Sappi matt gave excellent mottling results for all conditions but the best for reduced ink & water condition. Visually also, 8% IPA gave good results for all conditions on sappi matt.

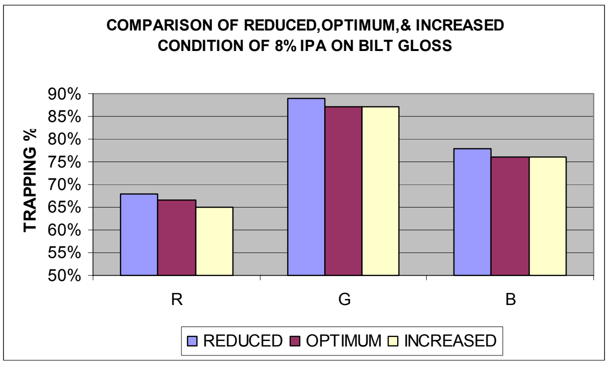
REDUCED, OPTIMUM, INCREASED CONDITION FOR 8% IPA – BILT GLOSS



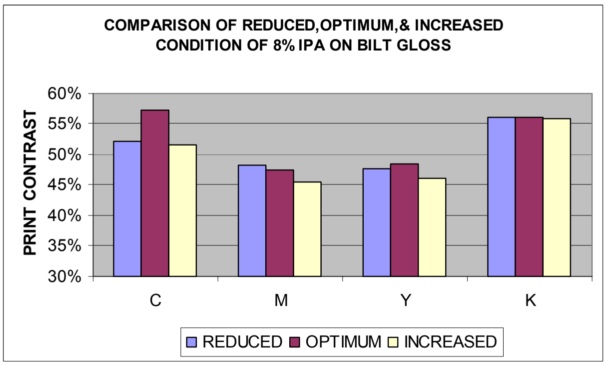
DENSITY



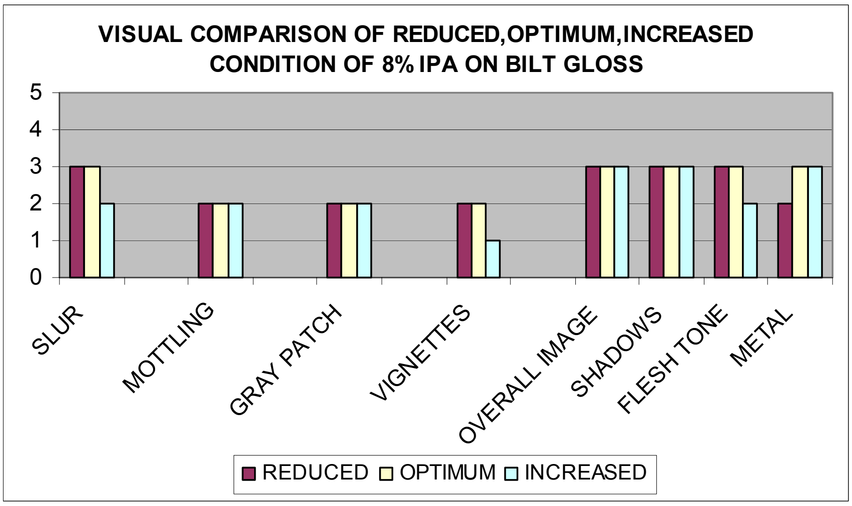
DOT GAIN



TRAPPING



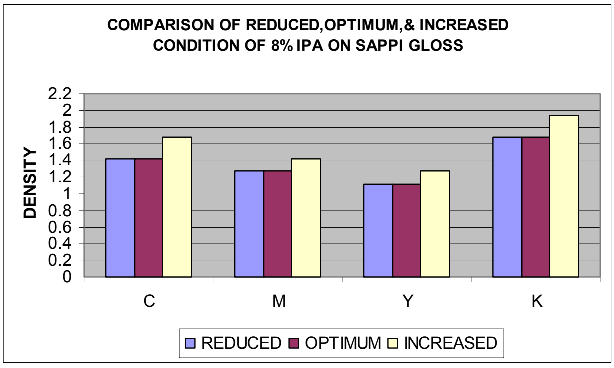
CONTRAST



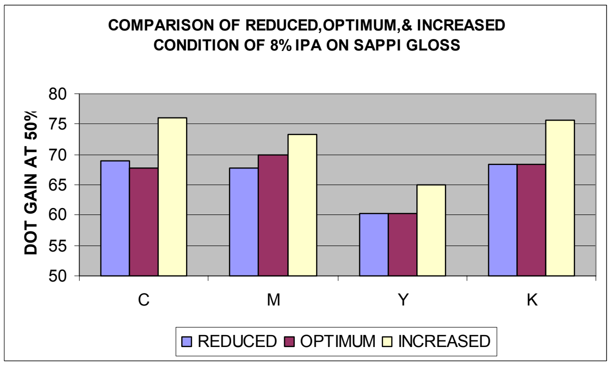
VISUAL

As the amount of ink & water increased, density and dot gain both increased consistently. While trapping and print contrast decreased, although decreasing trend in contrast is inconsistent. Mottling was poor on Bilt gloss for 8% IPA for all conditions. Under visual analysis all conditions performed sastisfactory. To point out, the favorable conditions would be reduced & optimum condition for 8% IPA on Bilt gloss.

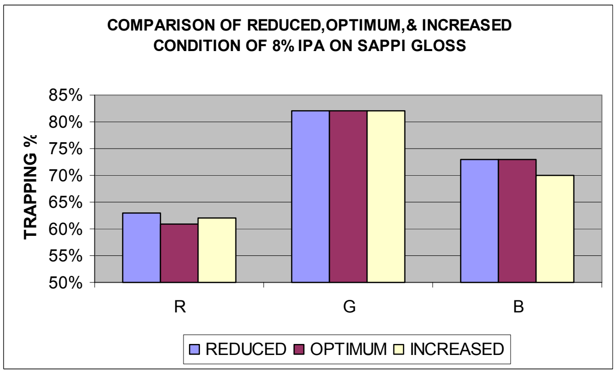
REDUCED, OPTIMUM, INCREASED CONDITION FOR 8% IPA – SAPPI GLOSS



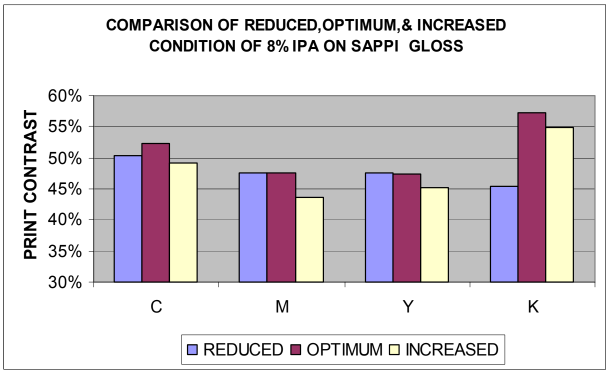
DENSITY



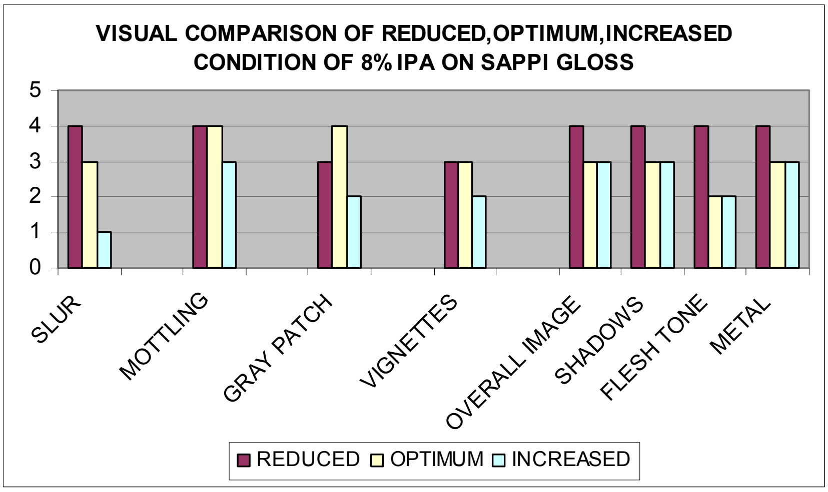
DOT GAIN



TRAPPING



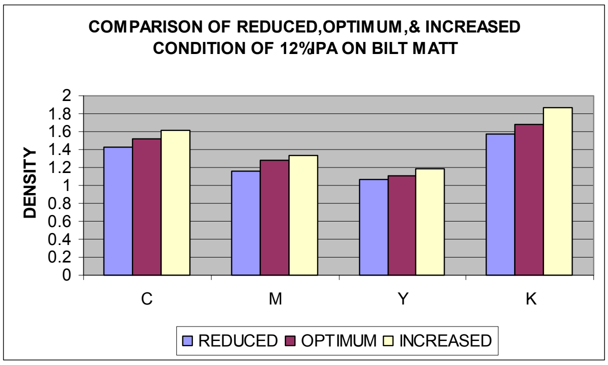
CONTRAST



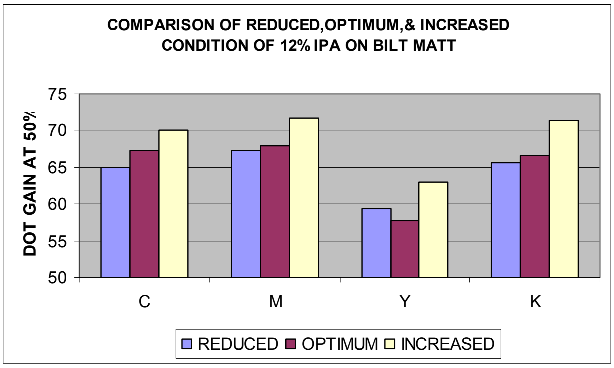
VISUAL

With the increasing amount of ink & water, density increased and with it increased the dot gain. Trapping decreased by a very small extent with increase in the amount of ink & water but optimum still showed better trapping. Overall contrast decreased but with optimum condition again showing better contrast. Sappi gloss gave good mottling results for 8% IPA for reduced & optimum conditions. But again overall visual analysis gave more points to reduced condition & then to the optimum condition.

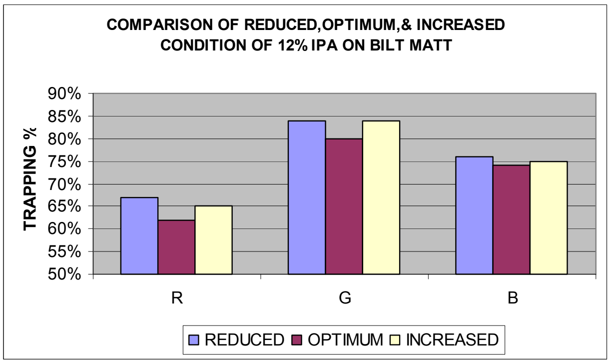
REDUCED, OPTIMUM, INCREASED CONDITION FOR 12% IPA – BILT MATT



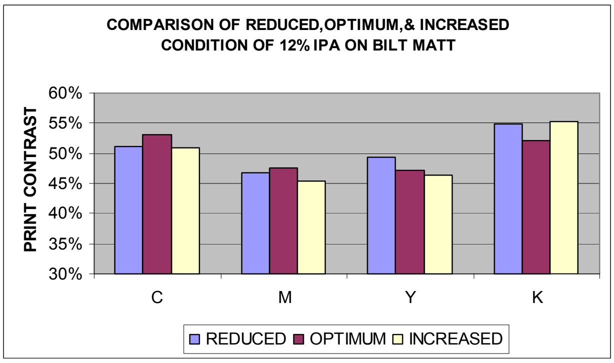
DENSITY



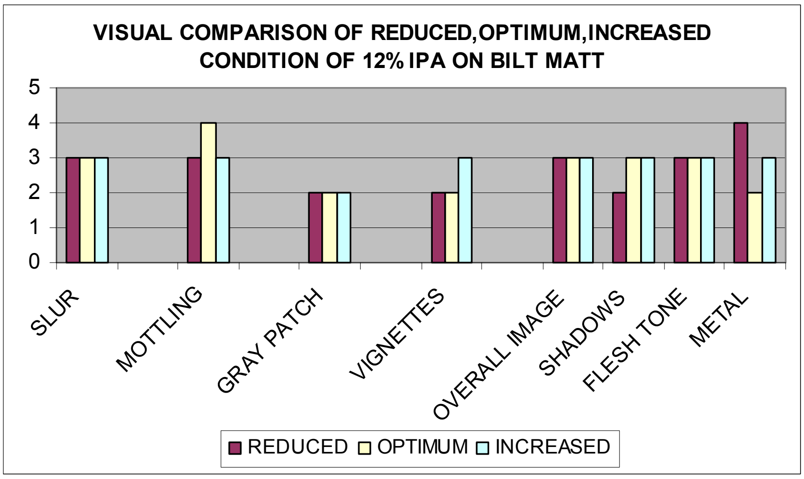
DOT GAIN



TRAPPING



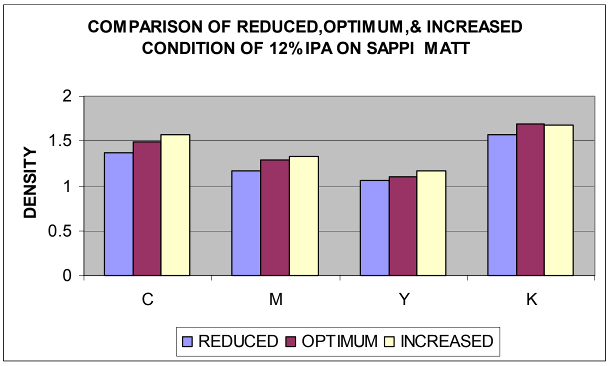
CONTRAST



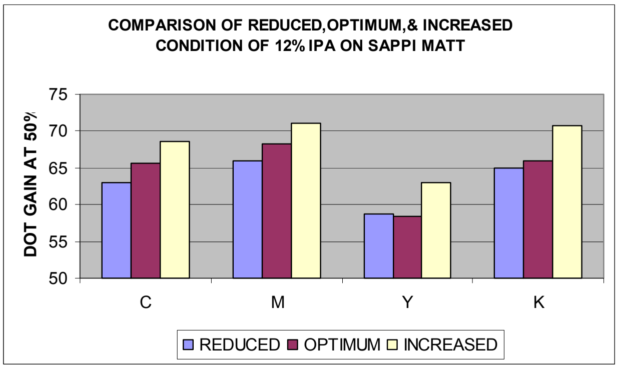
VISUAL

Density as well as dot again increased with the increase in ink & water amount. Trapping decreased from the condition of reduced to the increased condition but optimum condition showed lesser trapping. Print contrast also reduced from first to last condition but without consistency. Bilt matt showed better mottling for optimum condition. All conditions more or less performed the same.

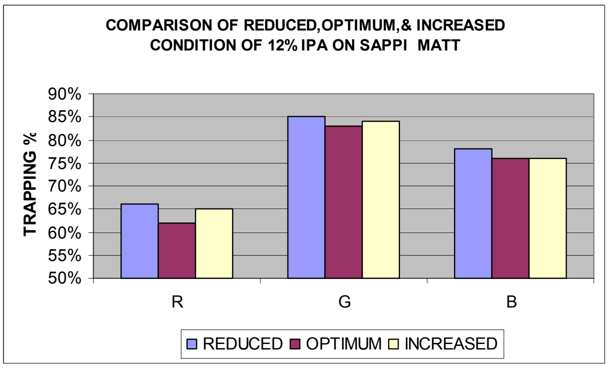
REDUCED, OPTIMUM, INCREASED CONDITION FOR 12% IPA – SAPPI MATT



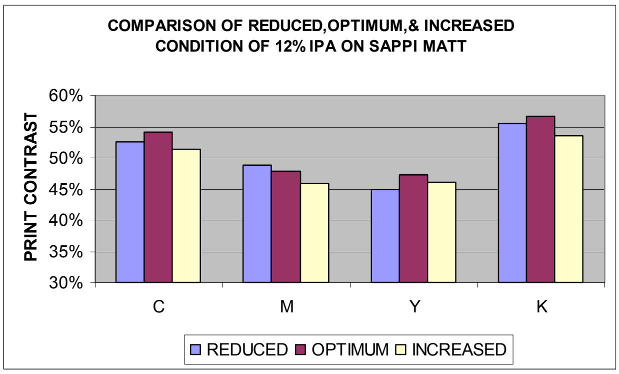
DENSITY



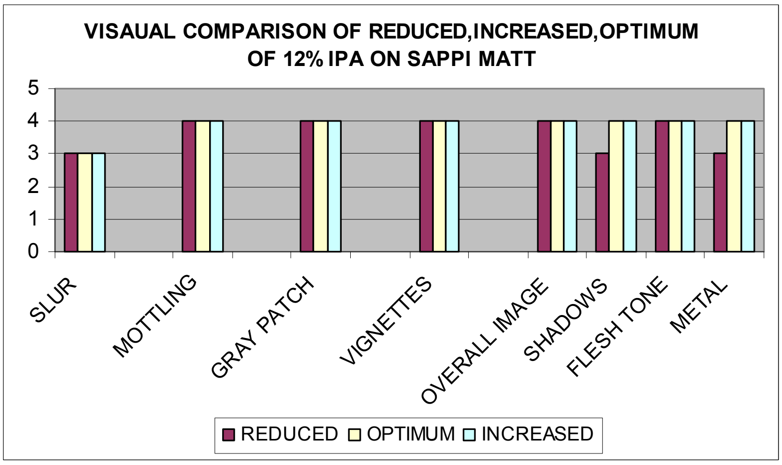
DOT GAIN



TRAPPING



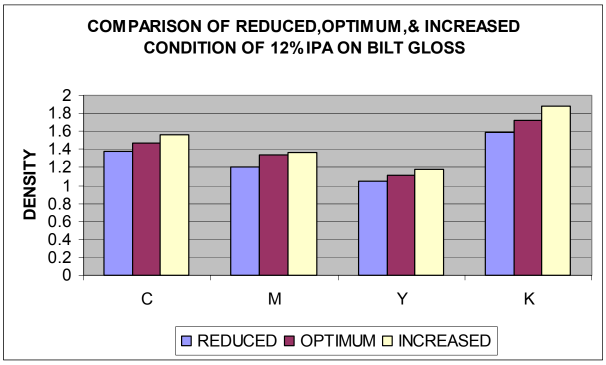
CONTRAST



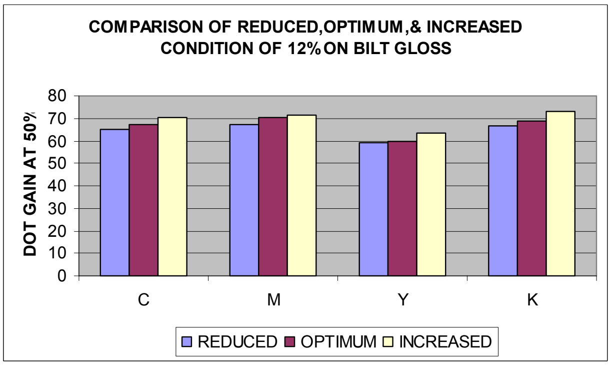
VISUAL

With the increasing amount of ink & water, density increased and with it increased the dot gain. Trapping decreased from the reduced condition to the increased condition but optimum condition showed much lesser trapping value. Overall contrast decreased but with optimum condition again showing better contrast. Sappi matt gave very good mottling results for 12% IPA for all conditions. Overall visual analysis was almost same for all conditions. To point out favorable condition it would be reduced & then the optimum condition.

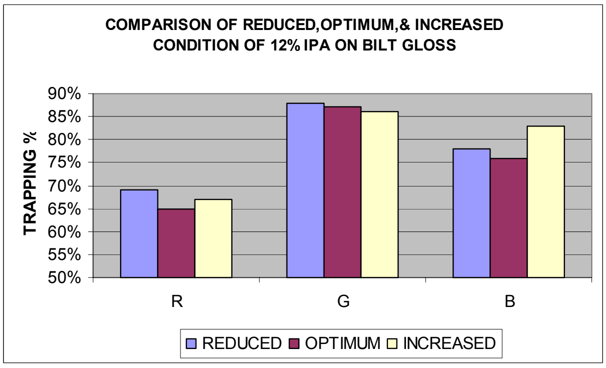
REDUCED, OPTIMUM, INCREASED CONDITION FOR 12% IPA – BILT GLOSS



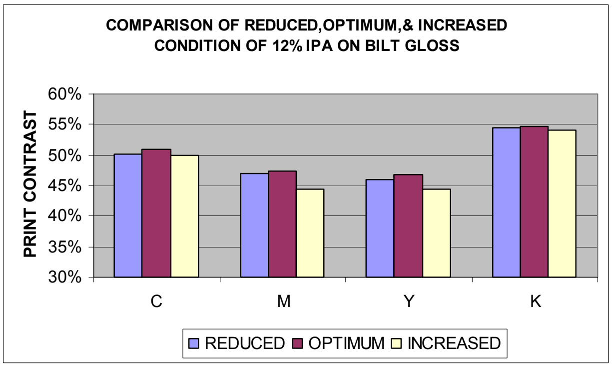
DENSITY



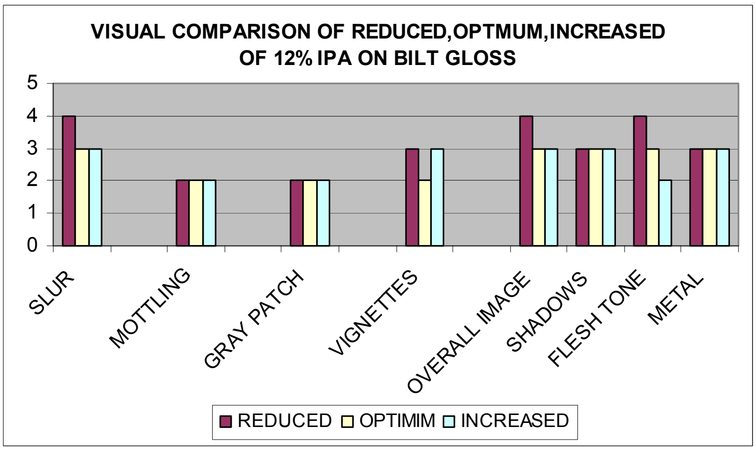
DOT GAIN



TRAPPING



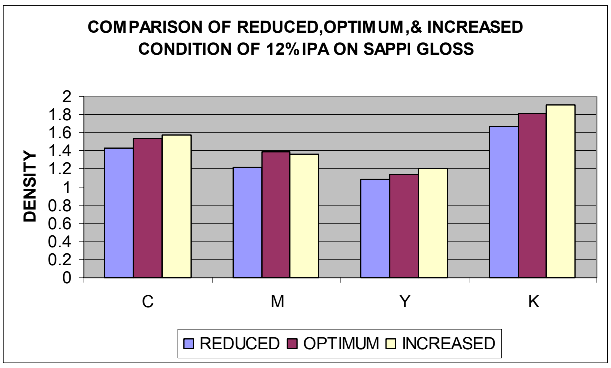
CONTRAST



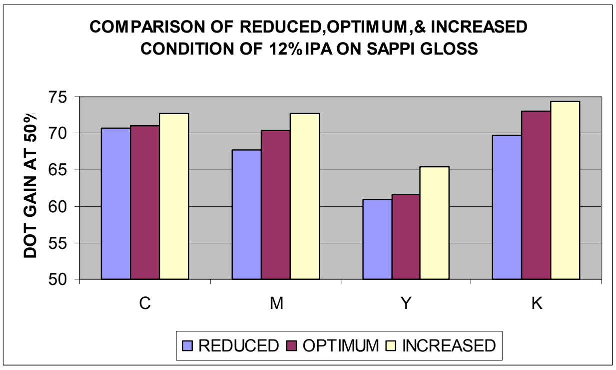
VISUAL

As the amount of ink & water increased, density and dot gain both increased consistently. Trapping showed inconsistent results. Print contrast decreased but optimum condition showed higher contrast. Mottling was poor on Bilt gloss for 12% IPA for all conditions. Under visual analysis reduced ink & water condition performed better.

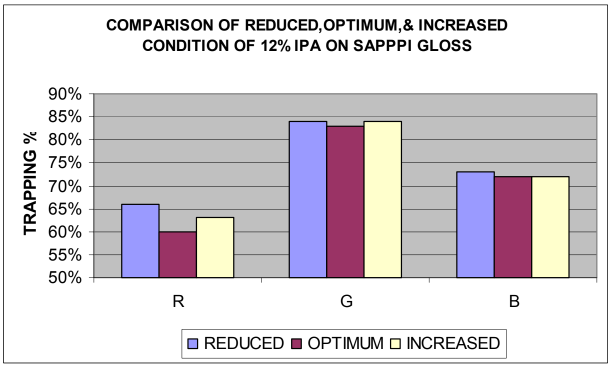
REDUCED, OPTIMUM, INCREASED CONDITION FOR 12% IPA – SAPPI GLOSS



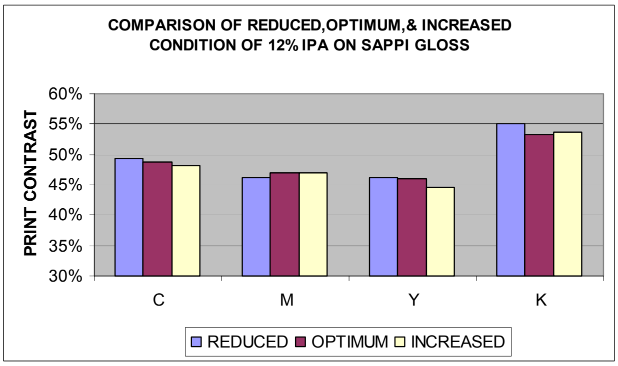
DENSITY



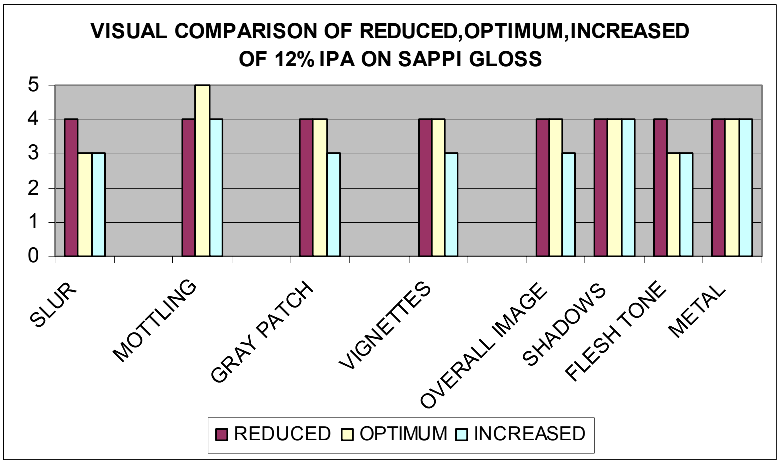
DOT GAIN



TRAPPING



CONTRAST



VISUAL

With the increasing amount of ink & water, density and dot gain both increased. Trapping showed inconsistent results but reduced condition showed highest trapping. Overall contrast decreased from reduced condition to increased condition but again reduced condition showed better contrast. Sappi gloss gave very good mottling results. Reduced and optimum ink & water conditions performed better with 12% IPA on Sappi gloss.

Analysis of PART II : Change in amount of fountain solution & ink

Results obtained from the Print trial:

As amount of fountain solution & ink increases,

- Density increases
- Dot gain increases
- Contrast showed better results with Optimum ink & water
- Trapping showed better results with Reduced ink & water

Thus, as the amount of fountain solution & ink increases,

Density	Increases
Dot gain	Increases
Ink Repellence	Increases
Mottling	Increases

Reduced ink & water showed better results in terms of mottling. Microphotography of the print samples also showed sharper screen dots in case of reduced ink & water than in the other conditions

3. PART III

Paper Comparison

To compare Bilt Matt with Sappi Matt and Bilt Gloss with Sappi Gloss, we plotted graphs of print & visual parameters for all the conditions of IPA % & fountain solution amount.

The following section holds graphs for the conditions given below.

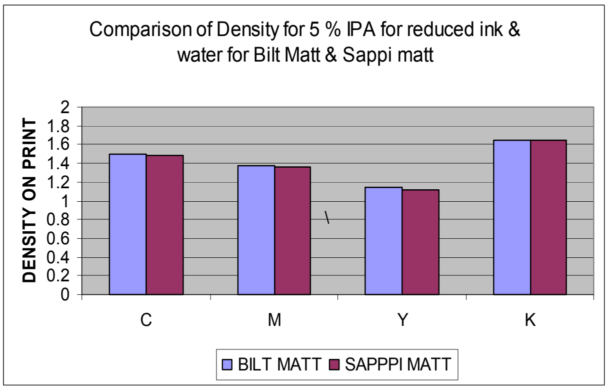
5% IPA - Optimum ink & water
5% IPA - Increased ink & water
5% IPA - Reduced ink & water

8% IPA -Optimum ink & water
8% IPA - Increased ink & water
8% IPA -Reduced ink & water

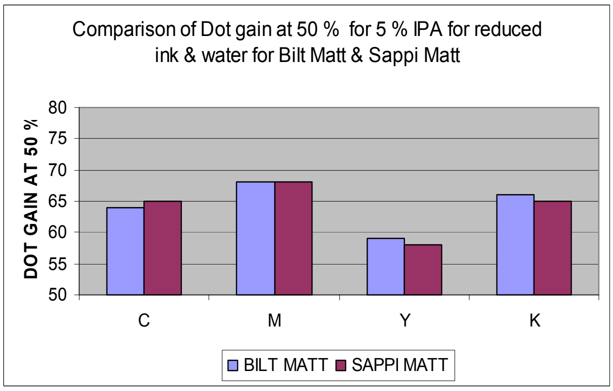
12% IPA - Optimum ink & water
12% IPA - Increased ink & water
12% IPA -Reduced ink & water

Below, set of graphs has been plotted for each of the paper comparisons of Bilt Matt & Sappi Matt and Bilt Gloss & Sappi Gloss.

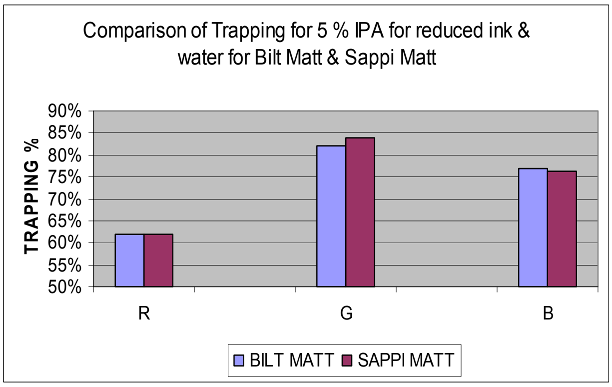
5 % REDUCED INK & WATER – BILT MATT & SAPPI MATT



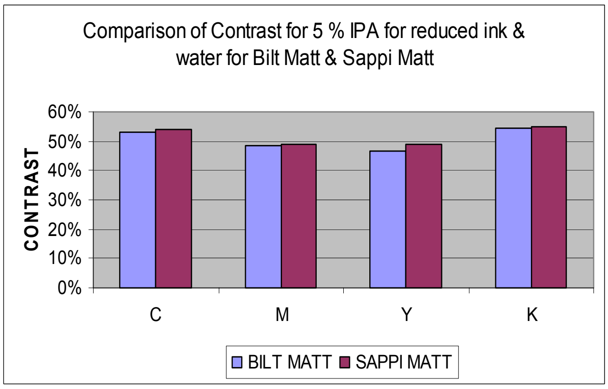
DENSITY



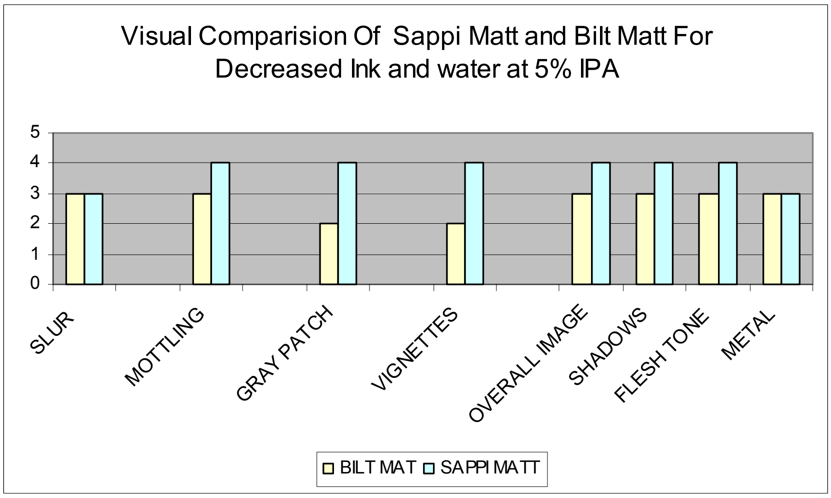
DOT GAIN



TRAPPING



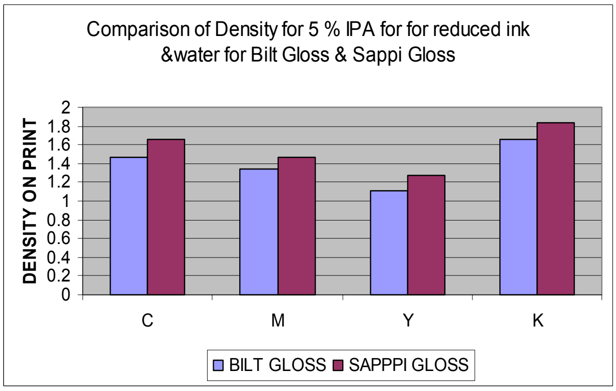
CONTRAST



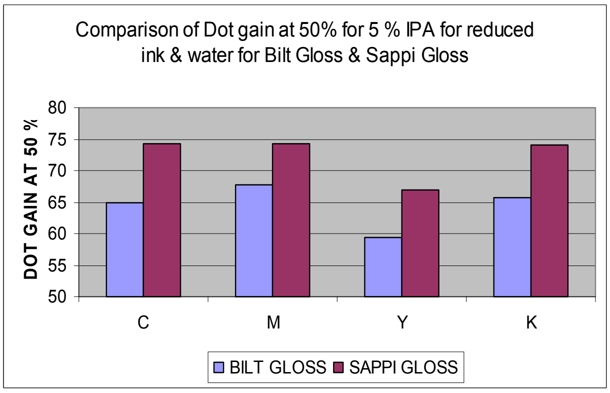
VISUAL

Both Bilt Matt & Sappi Matt performed almost the same under reduced ink & water condition for 5% IPA. But visually Sappi Matt performed much better than Bilt Matt.

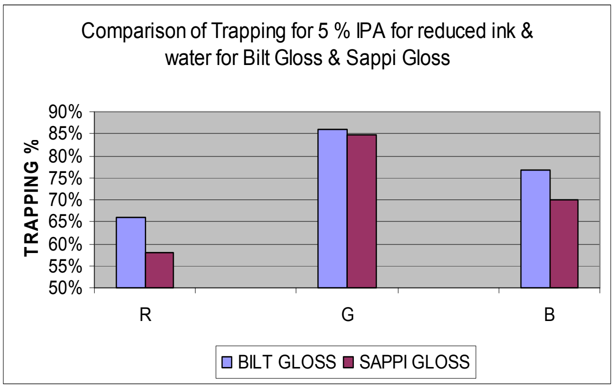
5 % REDUCED INK & WATER – BILT GLOSS & SAPPI GLOSS



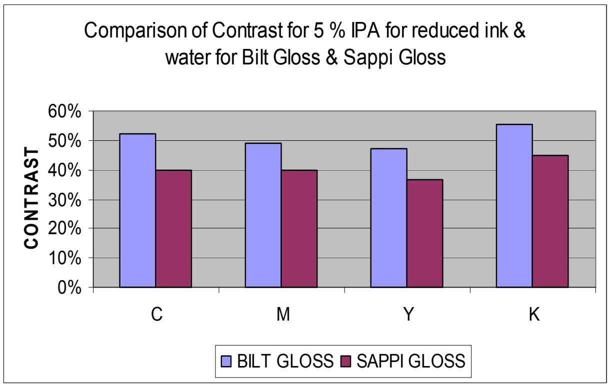
DENSITY



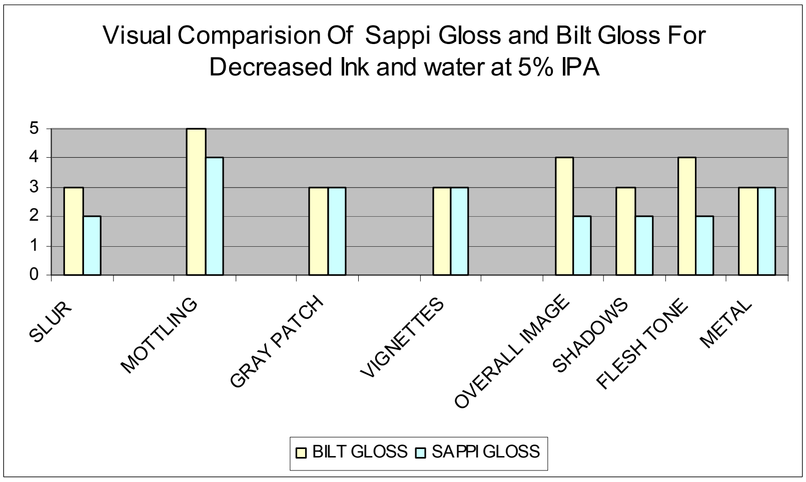
DOT GAIN



TRAPPING



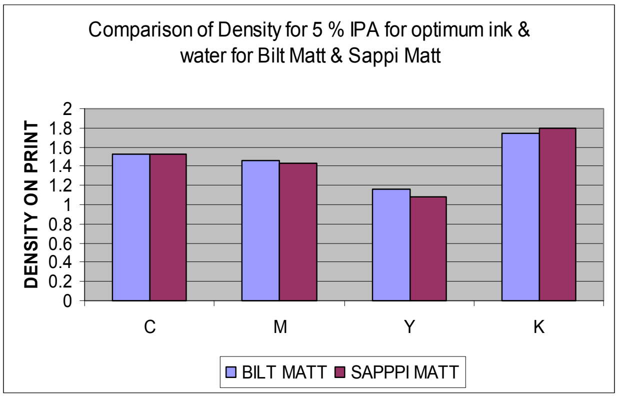
CONTRAST



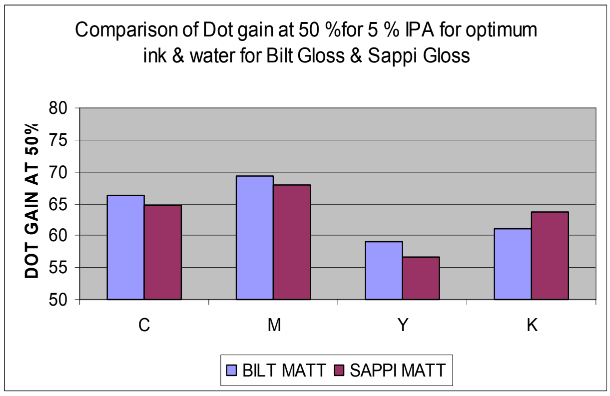
VISUAL

Sappi gloss showed higher densities and higher dot gain values than Bilt gloss. Whereas it showed lower trapping and contrast values than Bilt gloss. Visual analysis indicates that Bilt gloss performed better than Sappi gloss. Mottling gave excellent results with this condition especially on Bilt gloss.

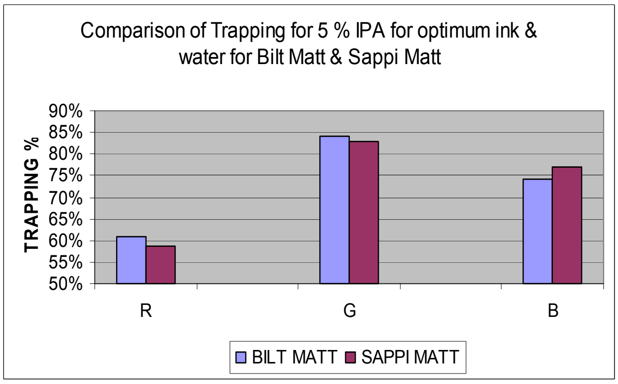
5 % OPTIMUM INK & WATER – BILT MATT & SAPPI MATT



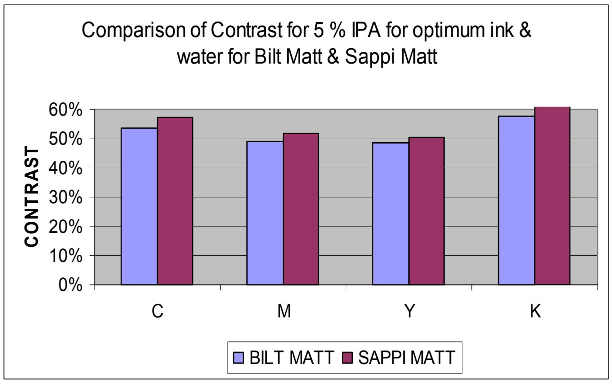
DENSITY



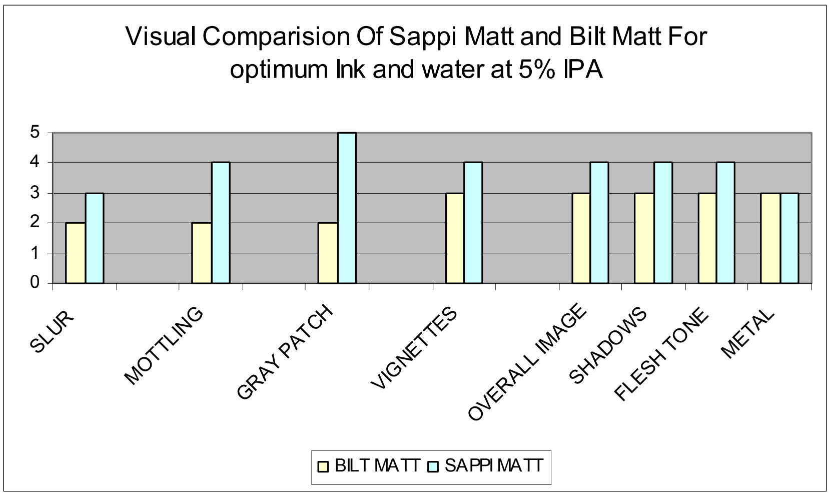
DOT GAIN



TRAPPING



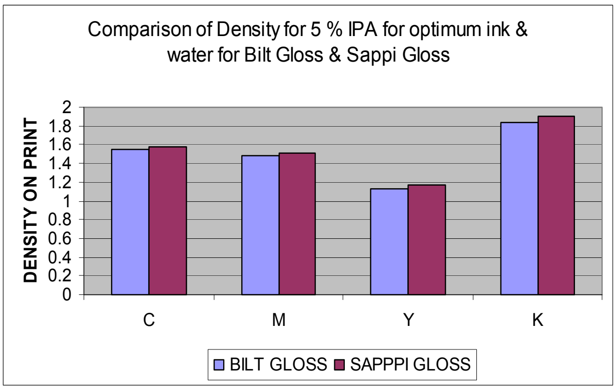
CONTRAST



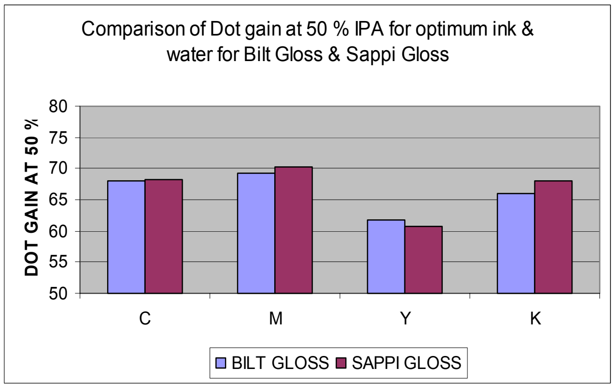
VISUAL

Densities are almost the same for both the papers. However Sappi matt showed lesser dot gain than Bilt matt. There is no much difference in the trapping values. Whereas Sappi matt showed better contrast to some extent. Sappi matt appeared better than Bilt matt visually also. Mottling results are also good on Sappi matt than on Bilt matt.

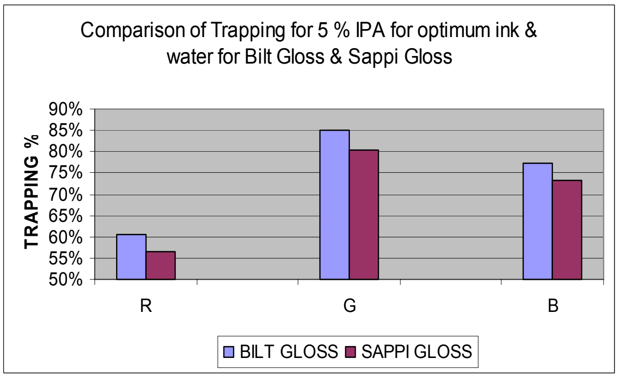
5 % OPTIMUM INK & WATER – BILT GLOSS & SAPPI GLOSS



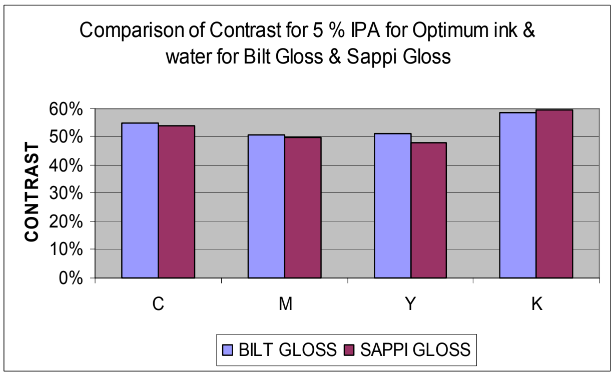
DENSITY



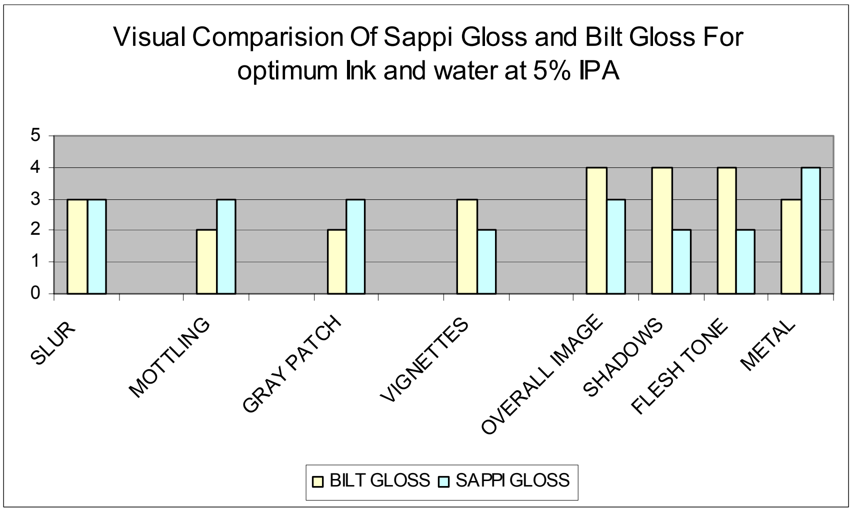
DOT GAIN



TRAPPING



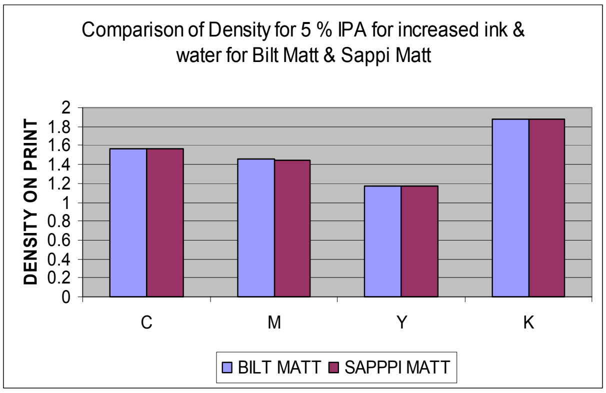
CONTRAST



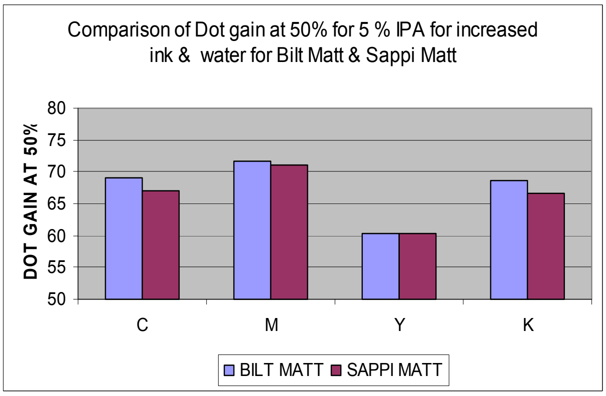
VISUAL

Densities and dot gain values are almost the same for both the papers. Sappi gloss showed little lesser values of trapping while print contrast remained almost same for both papers. Sappi gloss showed better mottling but overall visual analysis gave more points to Bilt gloss.

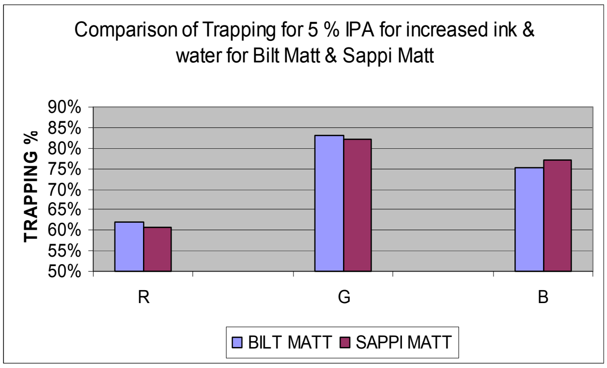
5 % INCREASED INK & WATER – BILT MATT & SAPPI MATT



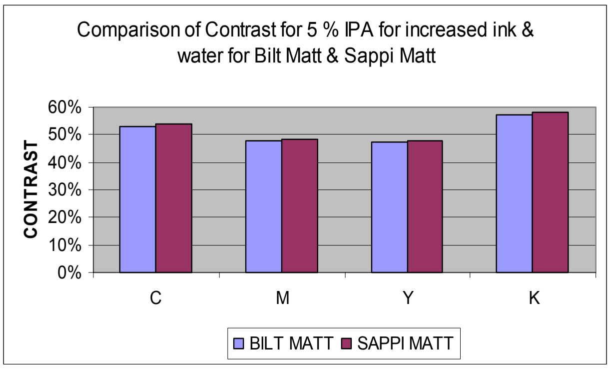
DENSITY



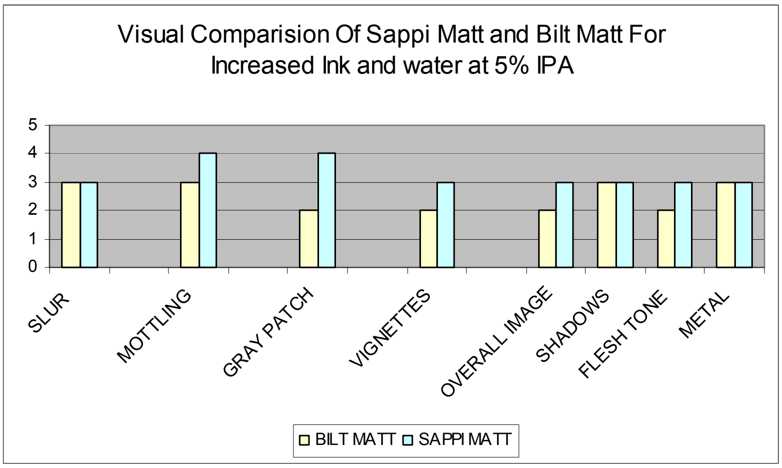
DOT GAIN



TRAPPING



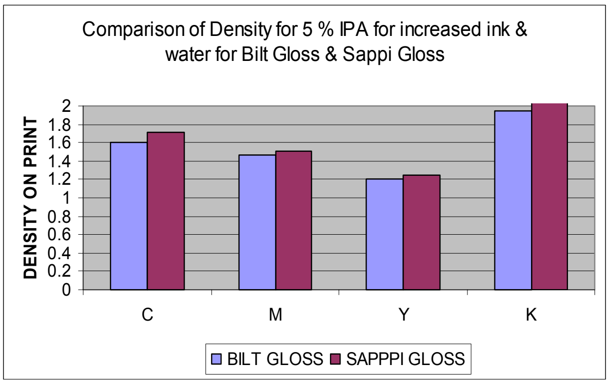
CONTRAST



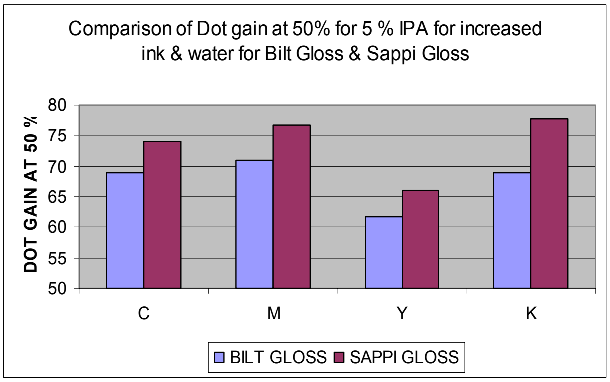
VISUAL

Both Bilt Matt & Sappi Matt performed almost the same under increased ink & water condition for 5% IPA. But visually Sappi matt showed better results than Bilt matt.

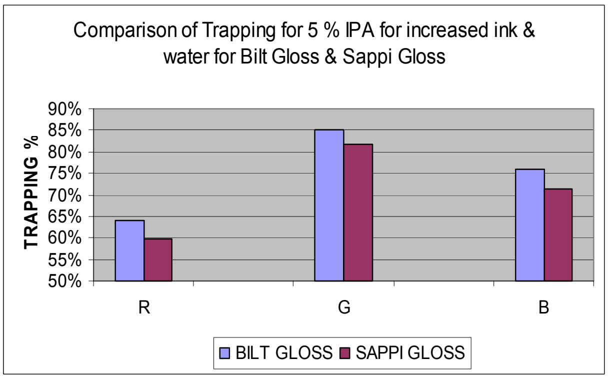
5 % INCREASED INK & WATER – BILT GLOSS & SAPPI GLOSS



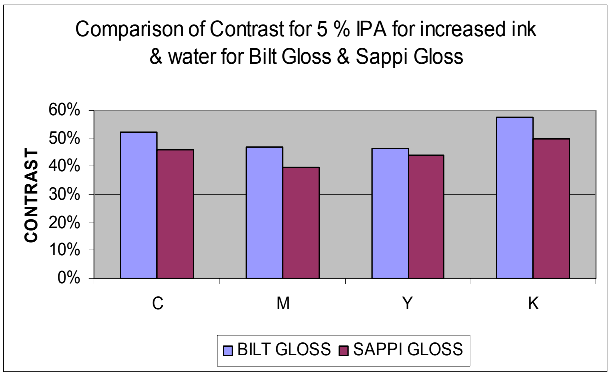
DENSITY



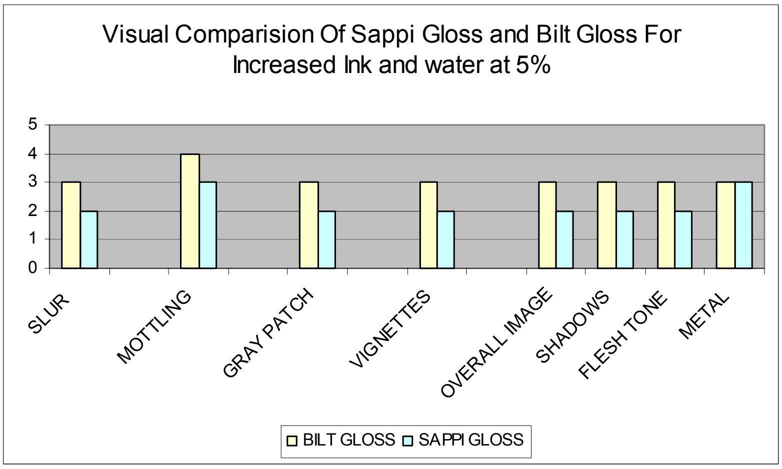
DOT GAIN



TRAPPING



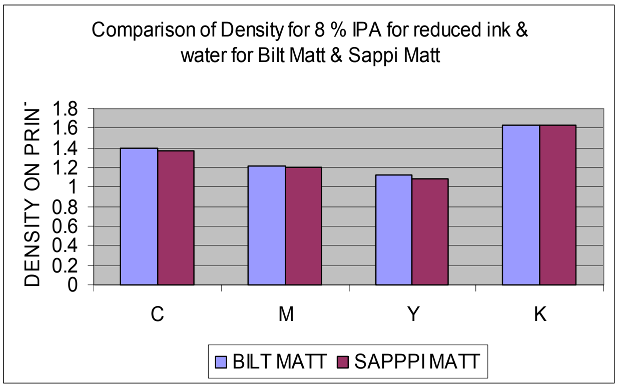
CONTRAST



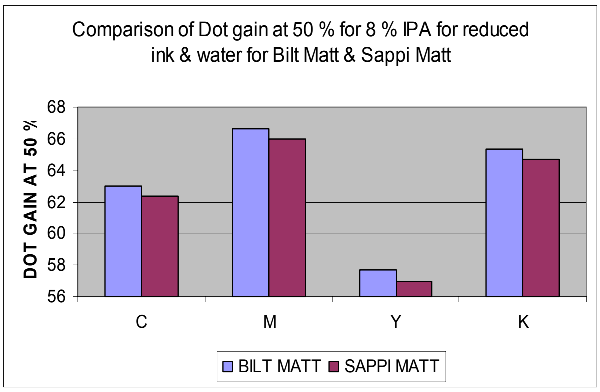
VISUAL

Sappi gloss showed higher densities and higher dot gain values than Bilt gloss. Whereas it showed lower trapping and contrast values than Bit gloss. Visual analysis indicates that Bilt gloss performed better than Sappi gloss.

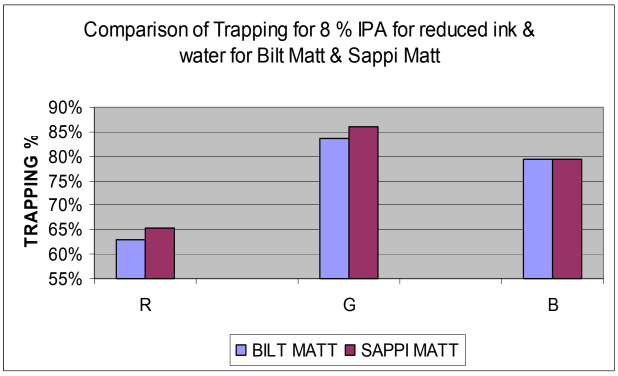
8% REDUCED INK & WATER – BILT MATT & SAPPI MATT



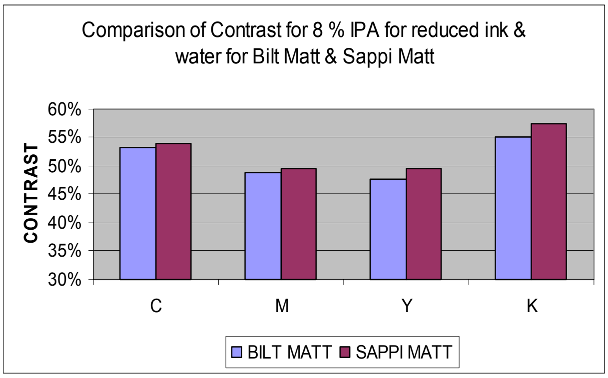
DENSITY



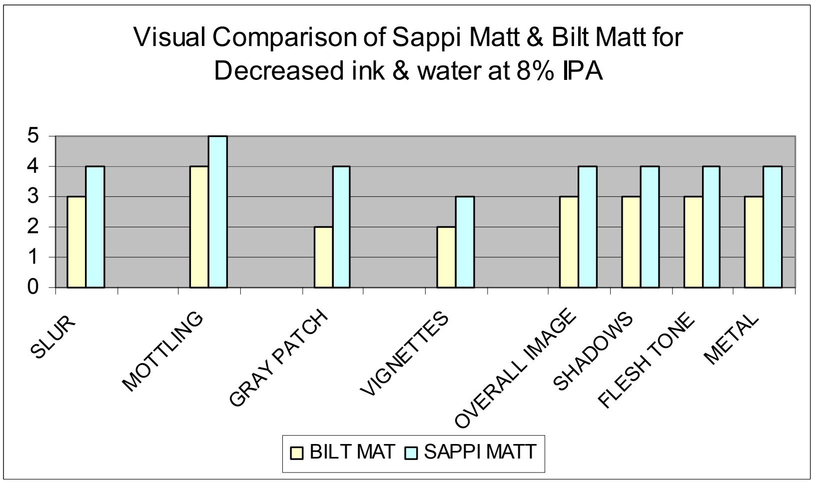
DOT GAIN



TRAPPING



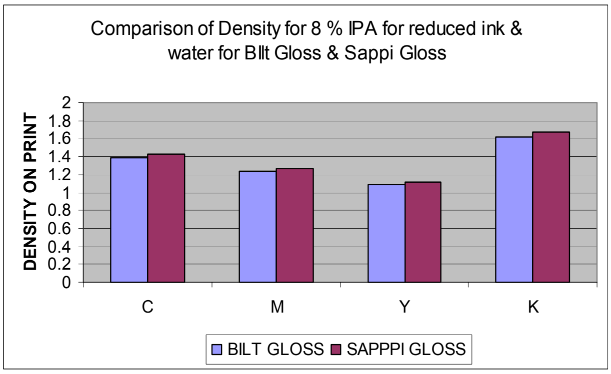
CONTRAST



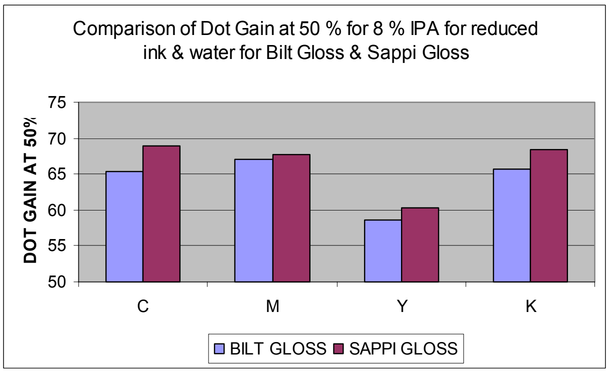
VISUAL

Both the papers showed almost same densities. But Sappi matt showed lesser dot gain, better trapping and contrast, although the difference in the values is not much.Visually also Sappi matt appears better than Bilt matt under this condition.

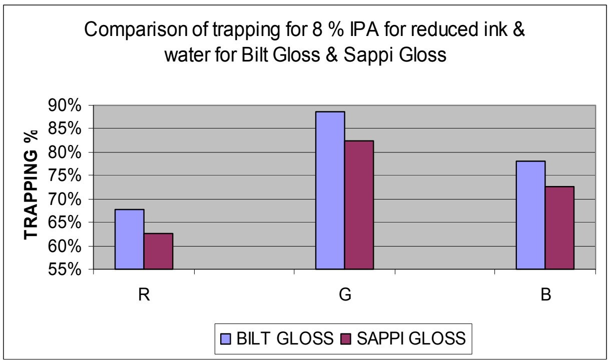
8% REDUCED INK & WATER – BILT GLOSS & SAPPI GLOSS



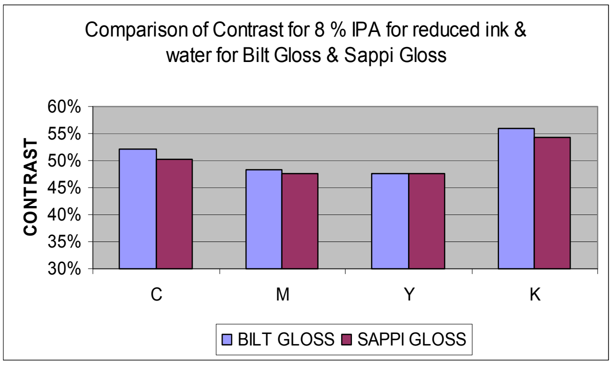
DENSITY



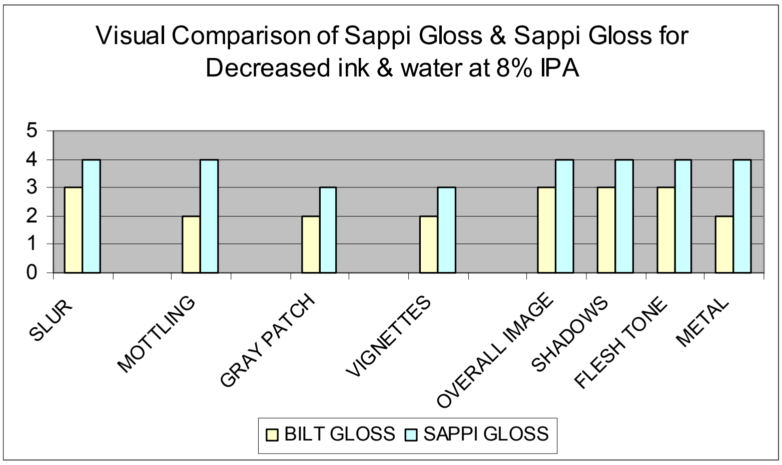
DOT GAIN



TRAPPING



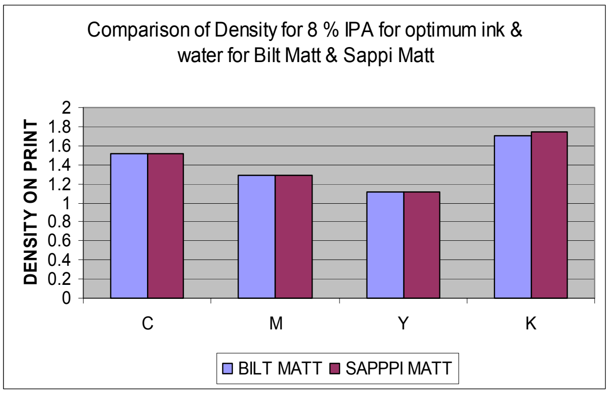
CONTRAST



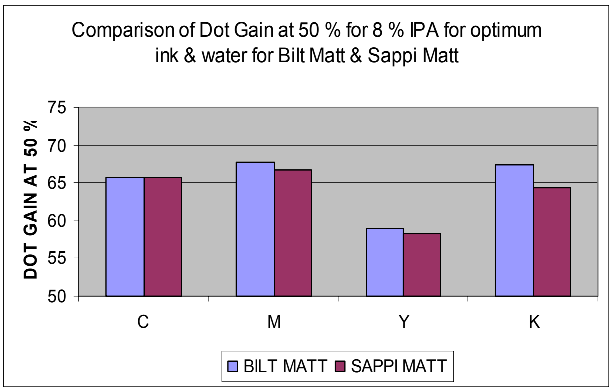
VISUAL

Although the densities were same for both the papers, Bilt gloss showed lesser dot gain, better trapping and contrast, although the difference in the values is not much. But Visually Sappi gloss appears better than Bilt gloss under this condition.

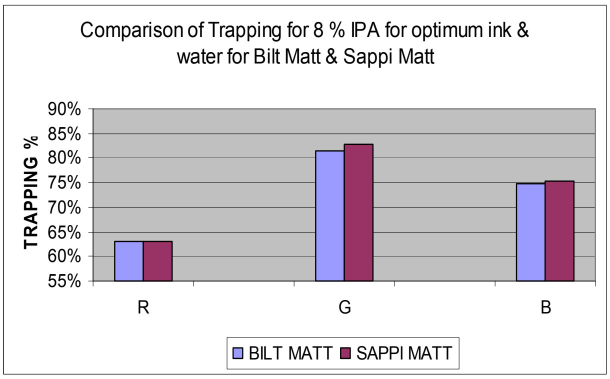
8% OPTIMUM INK & WATER – BILT MATT & SAPPI MATT



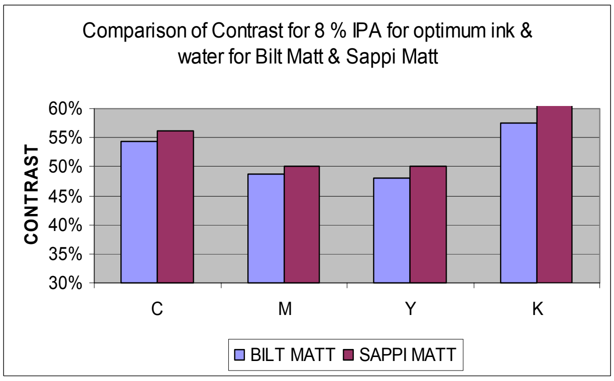
DENSITY



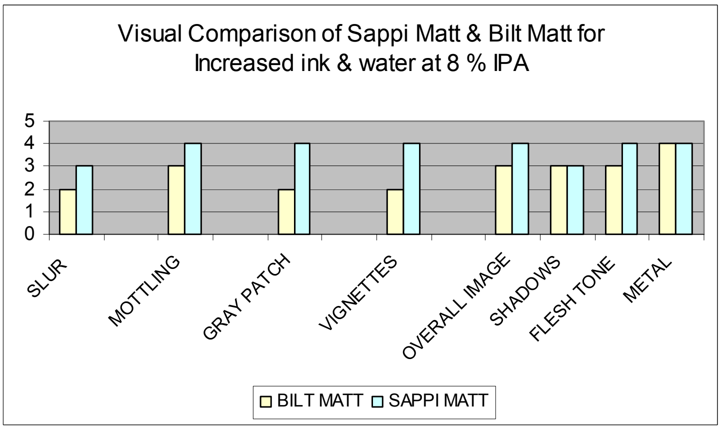
DOT GAIN



TRAPPING



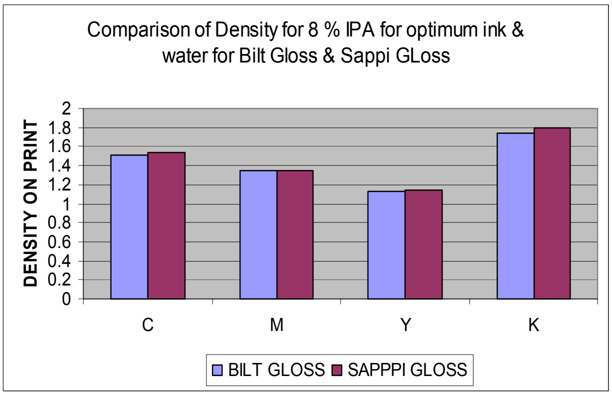
CONTRAST



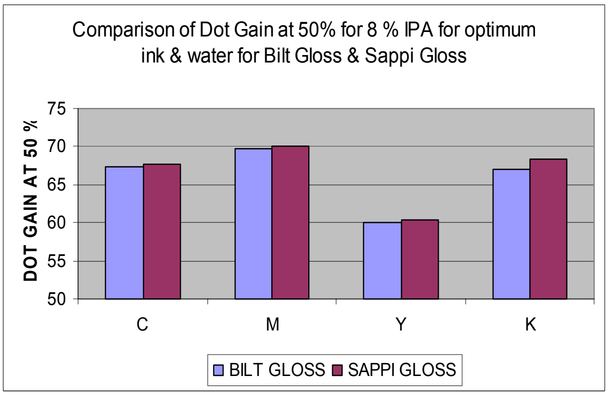
VISUAL

Both Bilt Matt & Sappi Matt performed almost the same under 8% increased ink & water condition. Sappi matt showed lesser dot gain, better trapping and contrast, but with very little difference in the values. Visually Sappi matt clearly showed better results than Bilt matt.

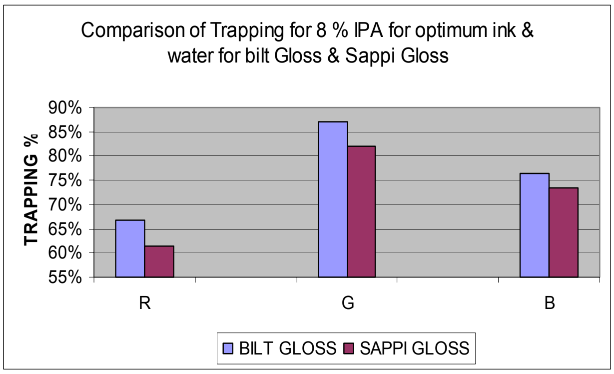
8% OPTIMUM INK & WATER – BILT GLOSS & SAPPI GLOSS



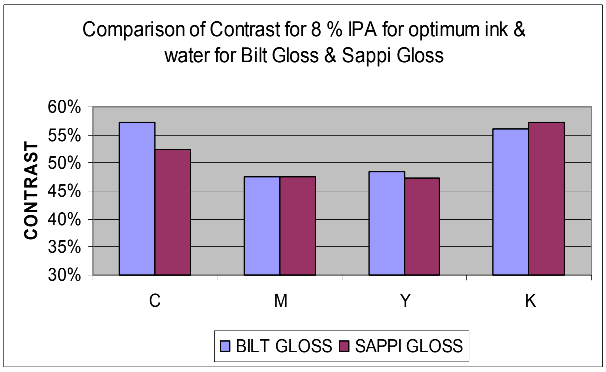
DENSITY



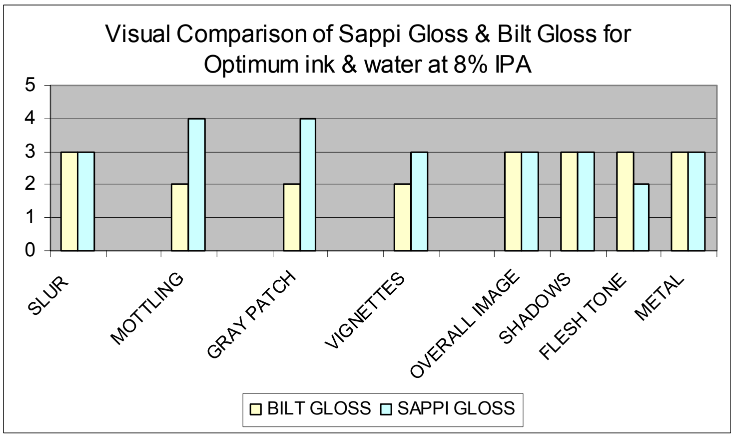
DOT GAIN



TRAPPING



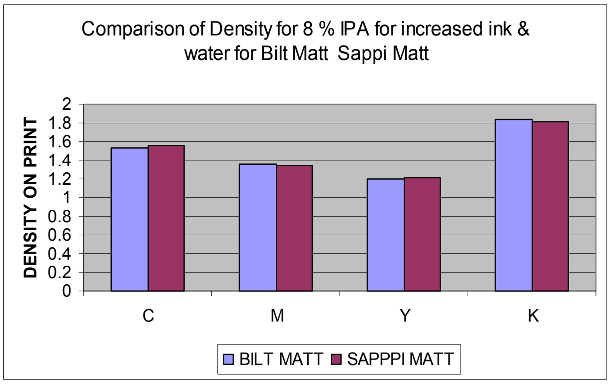
CONTRAST



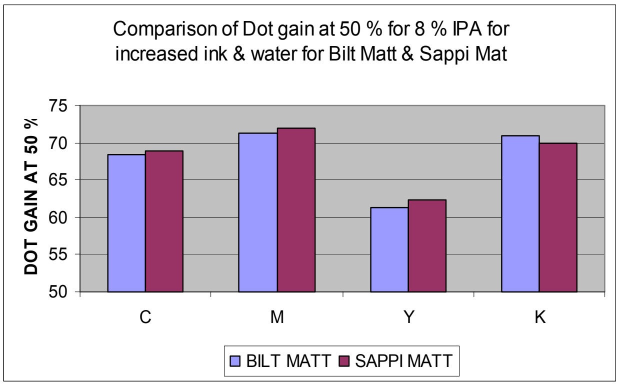
VISUAL

Densities and dot gain values were almost the same for both the papers. Sappi gloss showed better trapping and contrast, although the difference in the values was minimal. But Visually Sappi gloss performed better Bilt gloss under this condition.

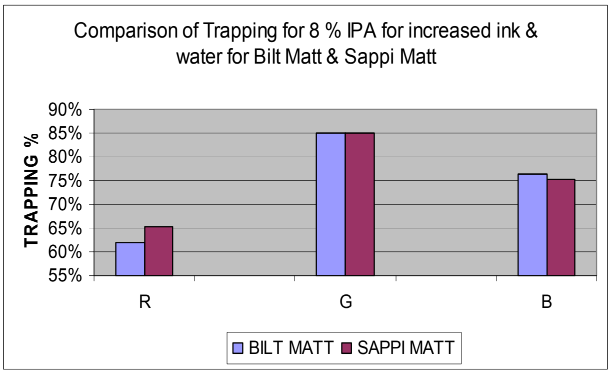
8% INCREASED INK & WATER – BILT MATT & SAPPI MATT



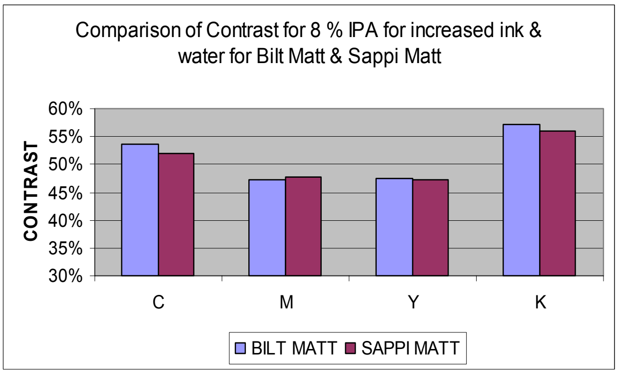
DENSITY



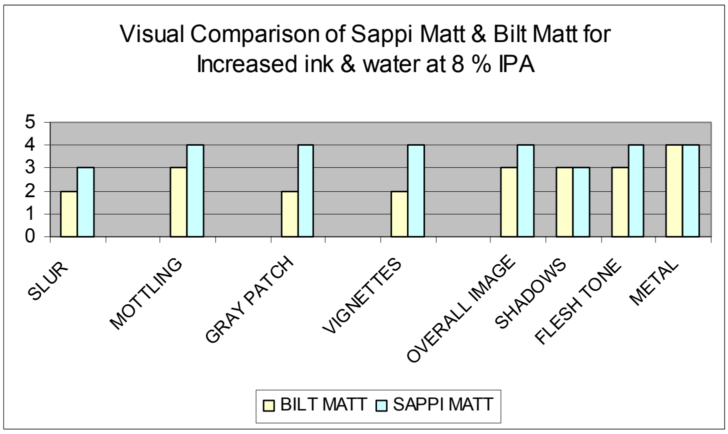
DOT GAIN



TRAPPING



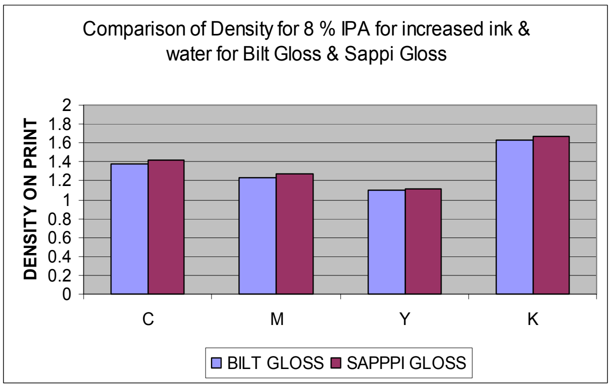
CONTRAST



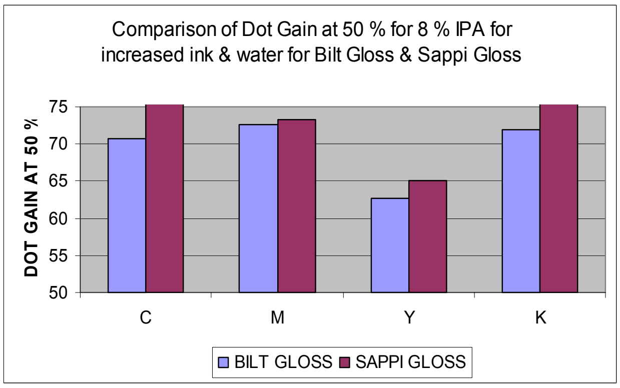
VISUAL

Both the papers showed more or less the same values. But Visual analysis clearly showed Sappi matt to have better performance than Bilt matt under this condition.

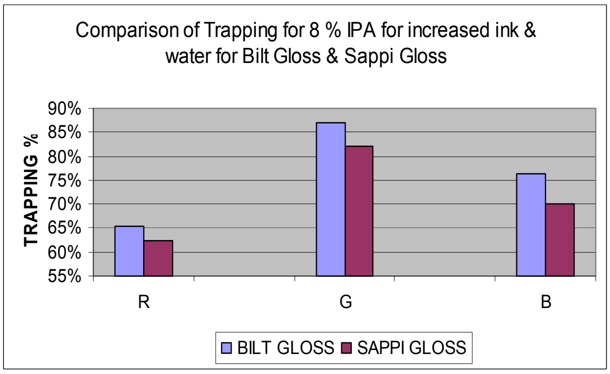
8% INCREASED INK & WATER – BILT GLOSS & SAPPI GLOSS



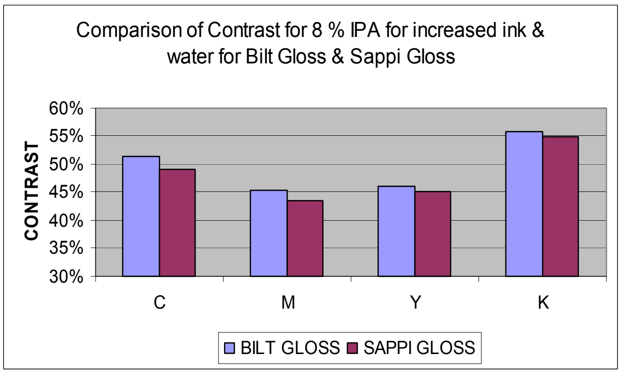
DENSITY



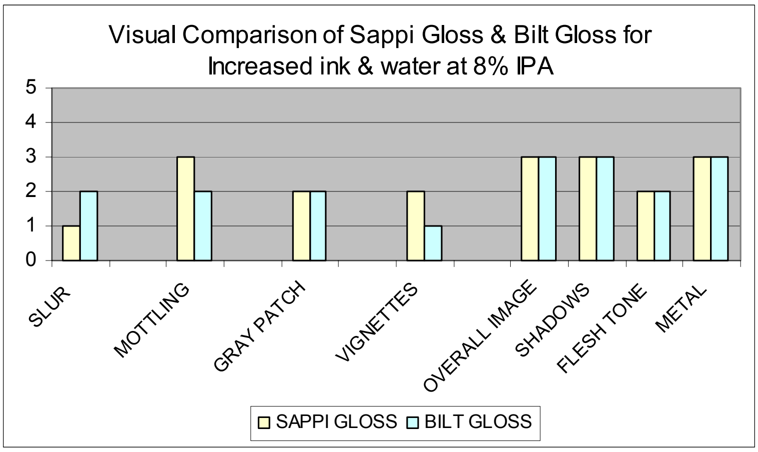
DOT GAIN



TRAPPING



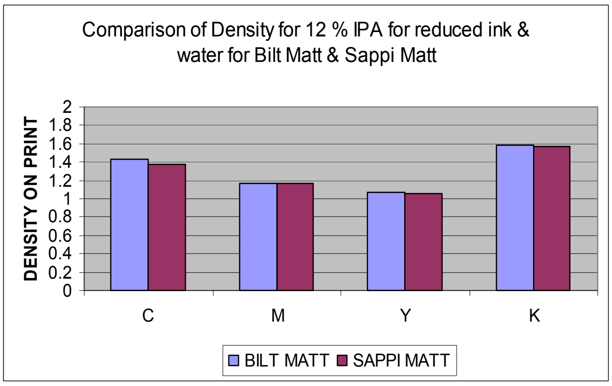
CONTRAST



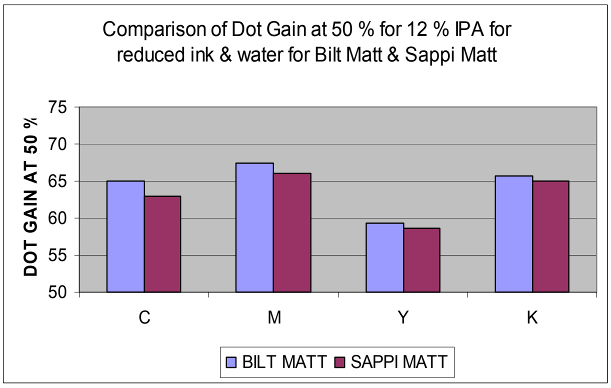
VISUAL

Although the densities were almost same for both the papers, Bilt gloss showed lesser dot gain, better trapping and contrast. But Visually Sappi gloss appears better than Bilt gloss under this condition.

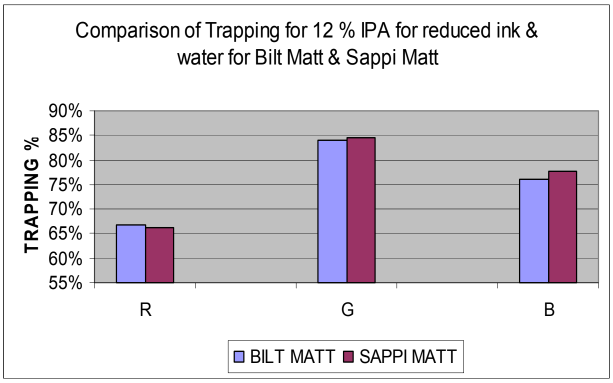
12% REDUCED INK & WATER – BILT MATT & SAPPI MATT



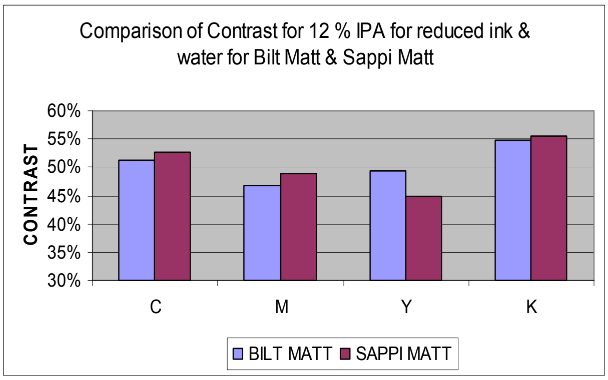
DENSITY



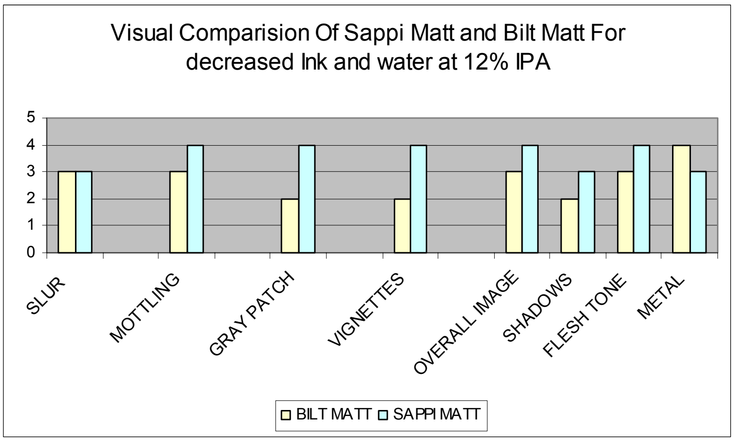
DOT GAIN



TRAPPING



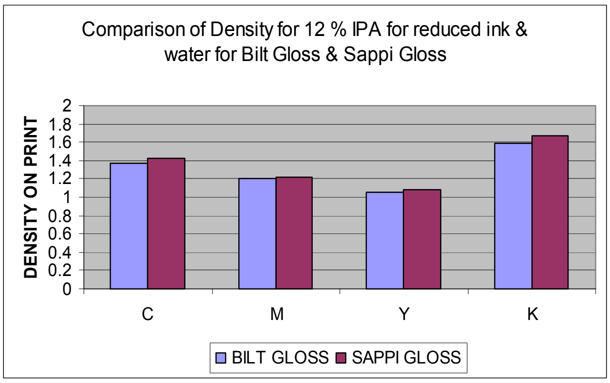
CONTRAST



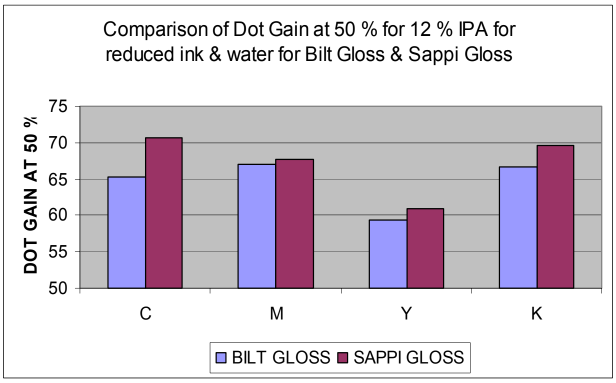
VISUAL

Both Bilt Matt & Sappi Matt performed almost the same under this condition. Sappi matt showed lesser dot gain, better trapping and contrast, but with very little difference in the values. Visually Sappi matt clearly showed better results than Bilt matt.

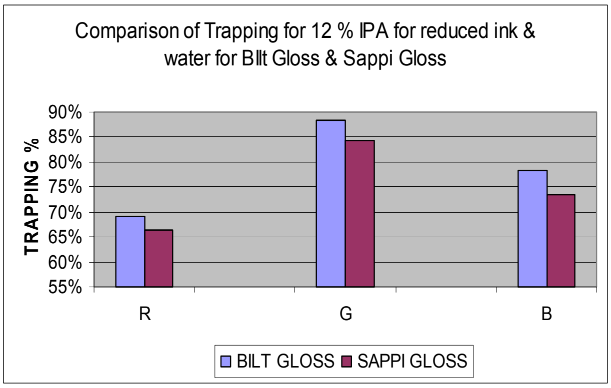
12% REDUCED INK & WATER – BILT GLOSS & SAPPI GLOSS



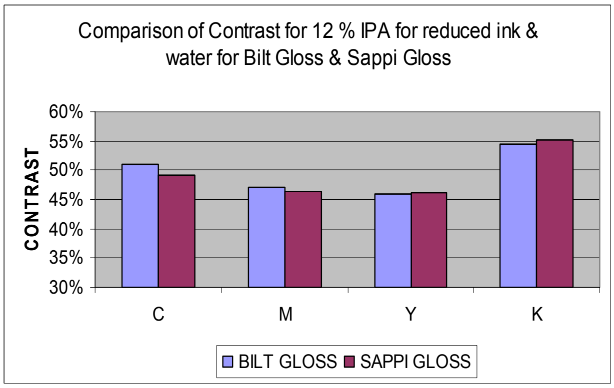
DENSITY



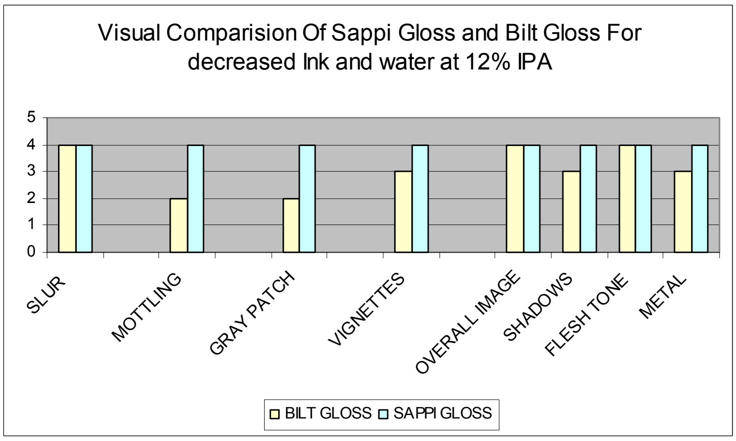
DOT GAIN



TRAPPING



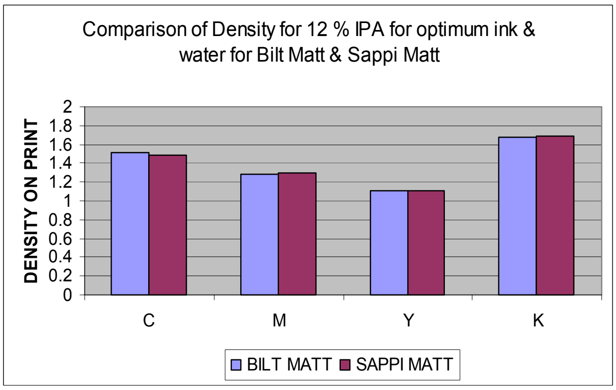
CONTRAST



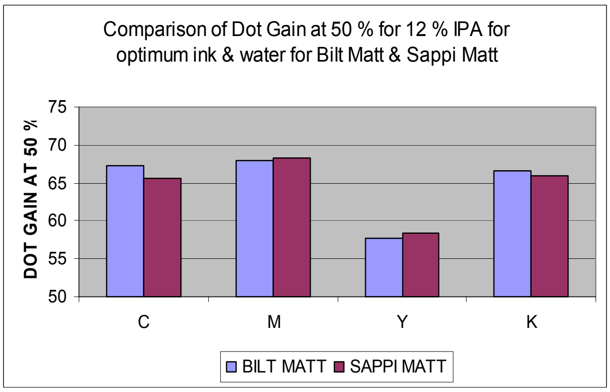
VISUAL

Although the densities were almost same for both the papers, Bilt gloss showed lesser dot gain, better trapping and contrast but with little difference in their values. But visually Sappi gloss appears better than Bilt gloss under this condition.

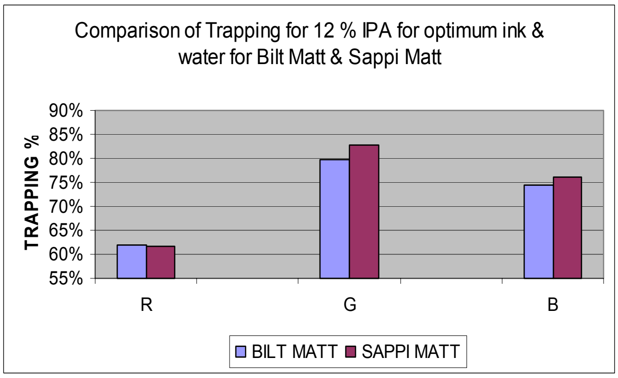
12% OPTIMUM INK & WATER – BILT MATT & SAPPI MATT



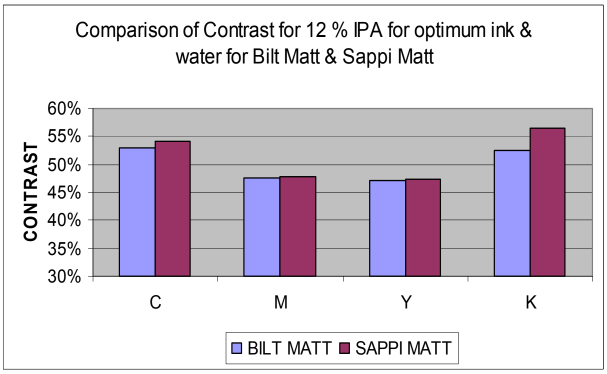
DENSITY



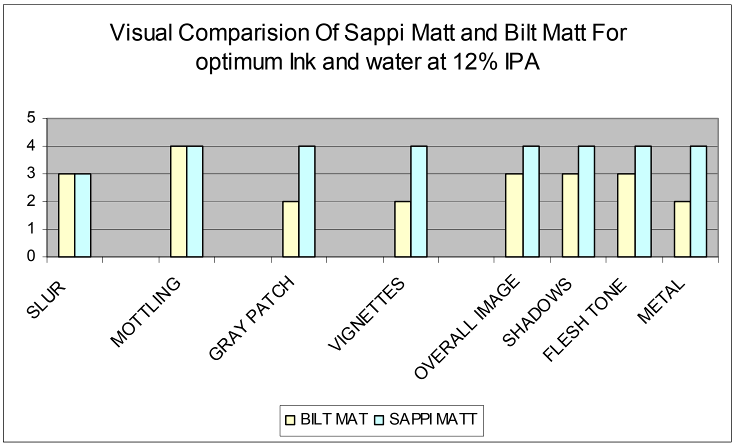
DOT GAIN



TRAPPING



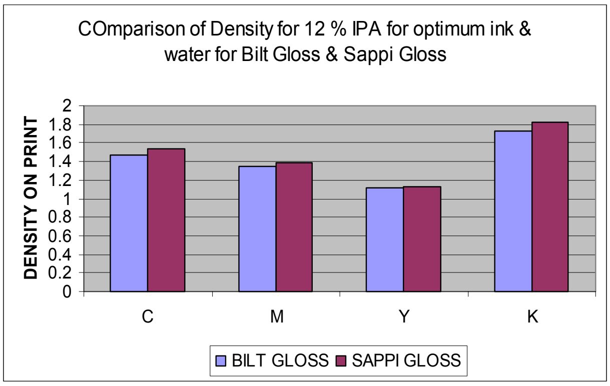
CONTRAST



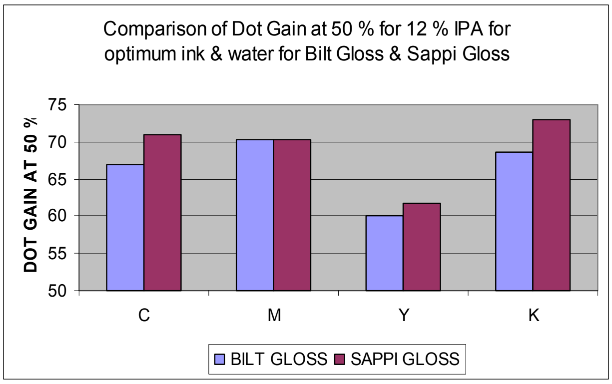
VISUAL

Both Bilt Matt & Sappi Matt performed almost the same under this condition. Sappi matt showed better trapping and contrast with very little difference in the values. Visually Sappi matt clearly showed better results than Bilt matt.

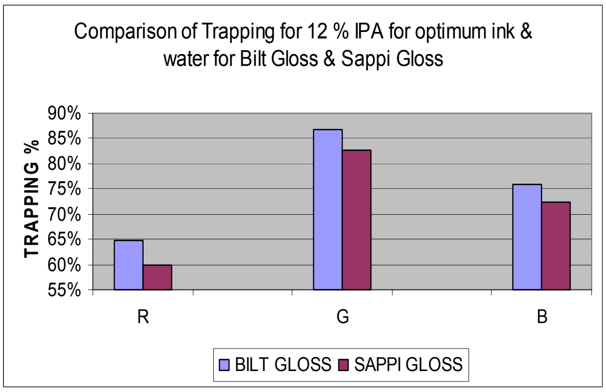
12% OPTIMUM INK & WATER – BILT GLOSS & SAPPI GLOSS



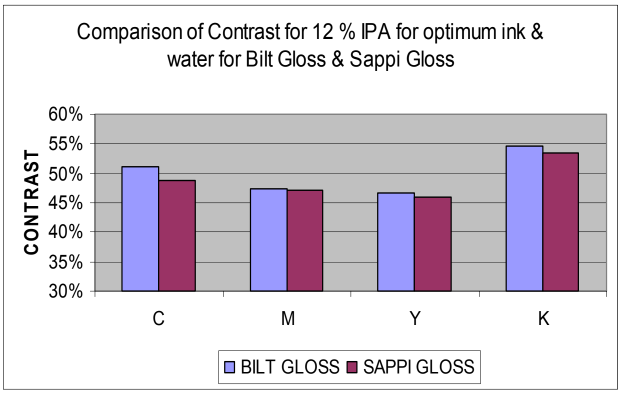
DENSITY



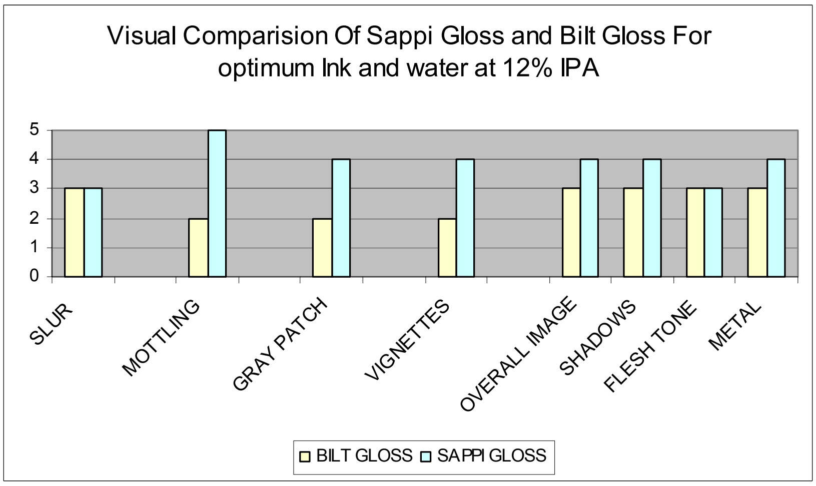
DOT GAIN



TRAPPING



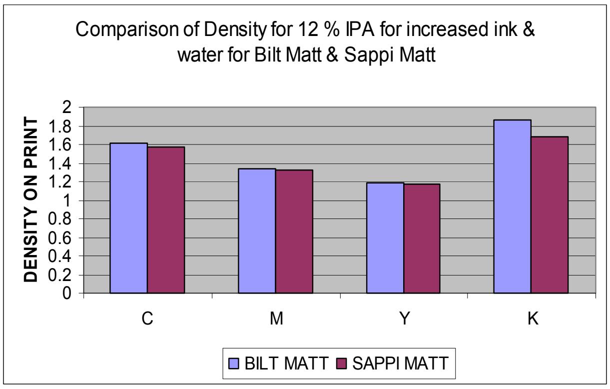
CONTRAST



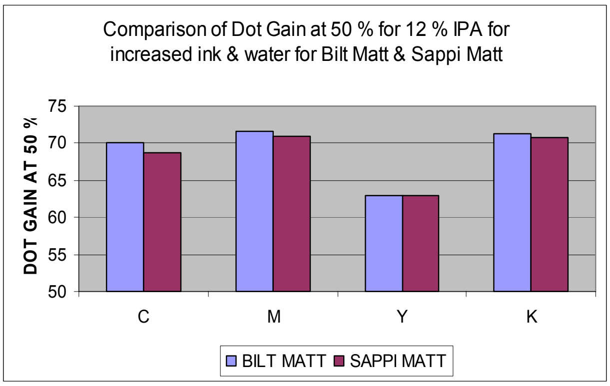
VISUAL

Although the densities were almost same for both the papers, Bilt gloss showed lesser dot gain, better trapping and contrast but with not with much of difference in their values. But visually Sappi gloss clearly appears better than Bilt gloss under this condition.

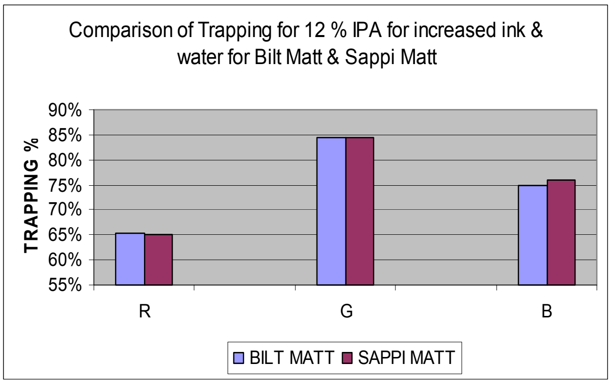
12% INCREASED INK & WATER – BILT MATT & SAPPI MATT



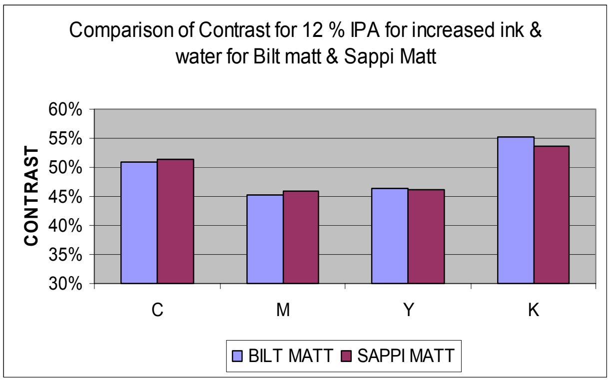
DENSITY



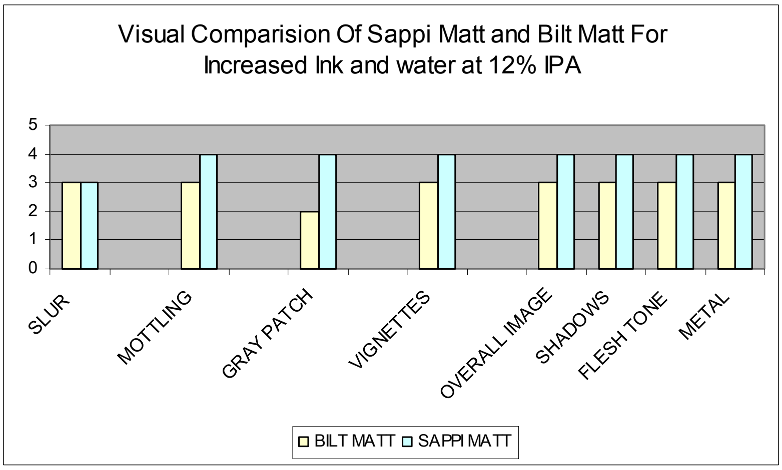
DOT GAIN



TRAPPING



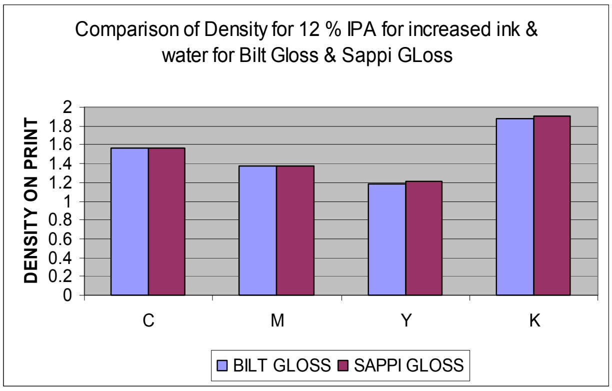
CONTRAST



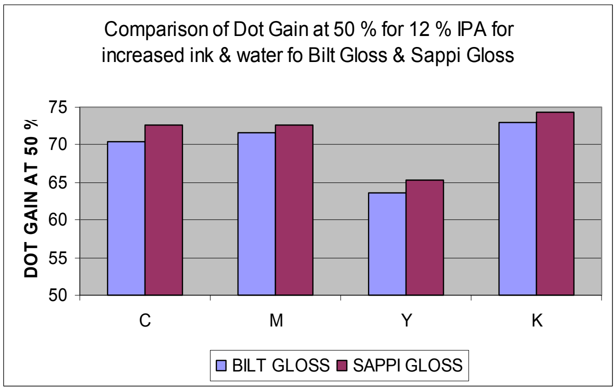
VISUAL

Both the papers showed more or less the same values. But Visual analysis clearly showed Sappi matt to have better performance than Bilt matt under this condition.

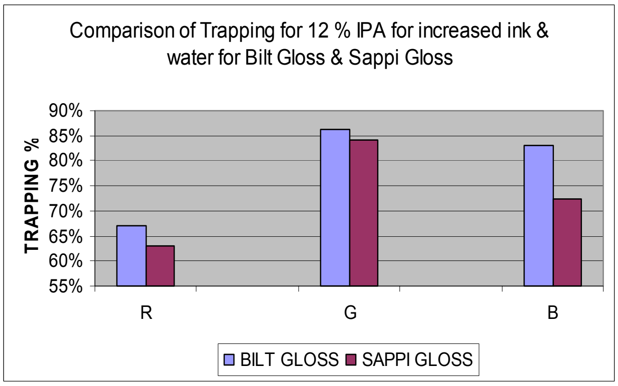
12% INCREASED INK & WATER – BILT GLOSS & SAPPI GLOSS



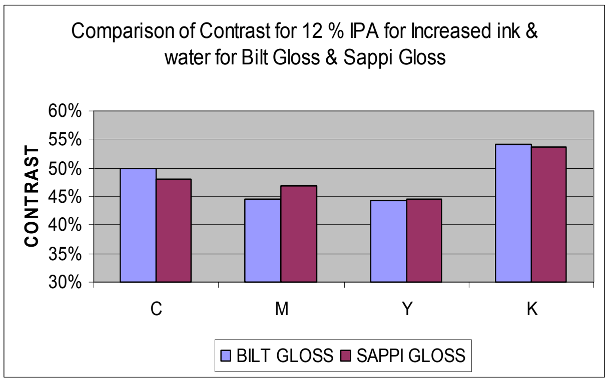
DENSITY



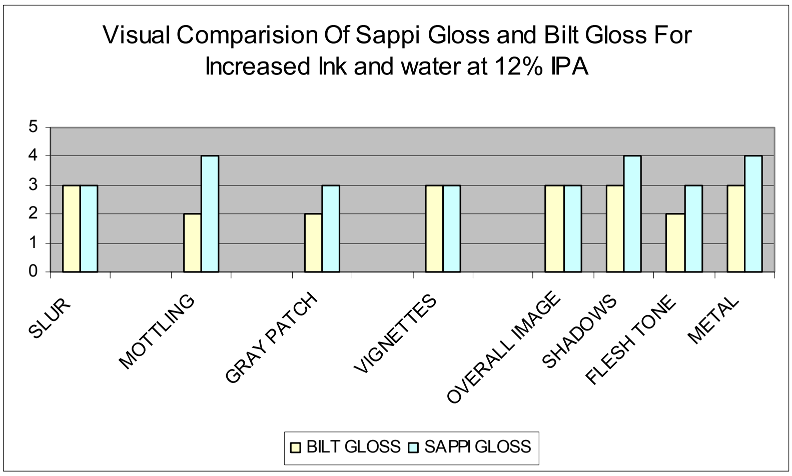
DOT GAIN



TRAPPING



CONTRAST



VISUAL

Although the densities were almost same for both the papers, Bilt gloss showed lesser dot gain, better trapping and contrast but with not with much of difference in their values. But visually Sappi gloss clearly appears better than Bilt gloss under this condition.

Analysis of PART III : Paper Comparison

5% IPA: Bilt Gloss is performing better than Sappi Gloss in terms of both Print & Visual parameters.

Bilt Matt and Sappi Matt performed almost same.

8% IPA: Bilt Gloss showed better performance than Sappi Gloss in terms of print parameters.

However Sappi Gloss appears visually better.

Bilt Matt and Sappi Matt showed same performance. But Sappi Matt appears visually better.

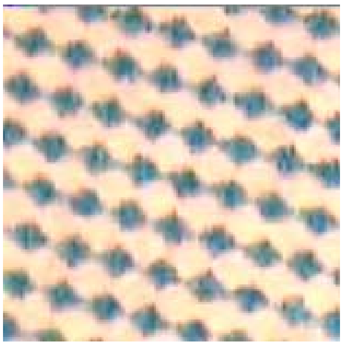
12% IPA: Bilt Gloss is better in terms of print parameters. Sappi gloss is however visually better.

Bilt Matt and Sappi Matt are showing same results, however Sappi matt is again appearing visually better.

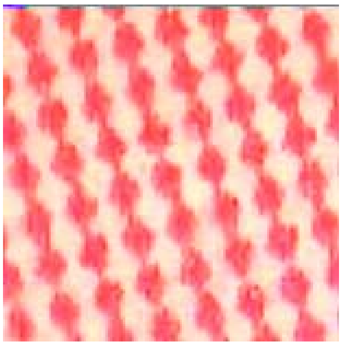
4. MICROPHOTOGRAPHY (of 40% dot):

5% IPA Reduced Ink & Water

BILT MATT

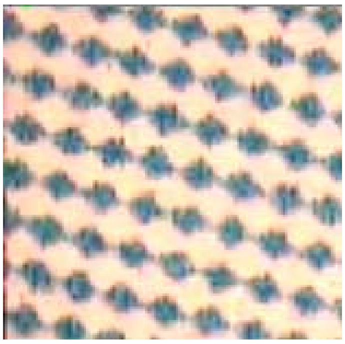


CYAN

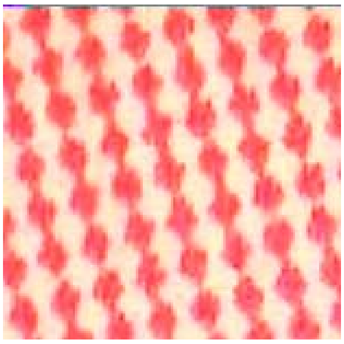


MAGENTA

SAPPI MATT

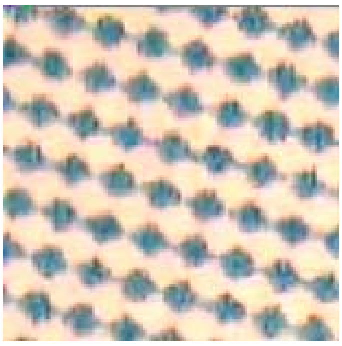


CYAN

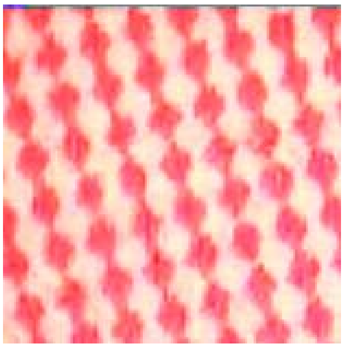


MAGENTA

BILT GLOSS

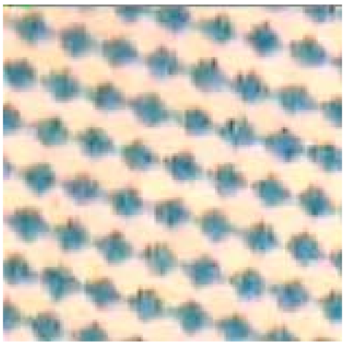


CYAN

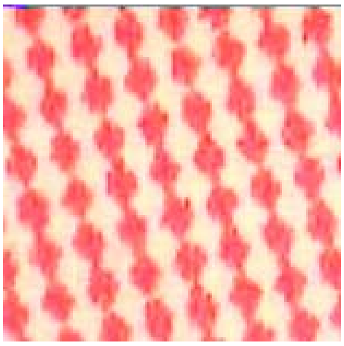


MAGENTA

SAPPI GLOSS



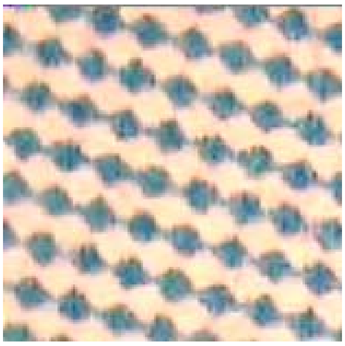
CYAN

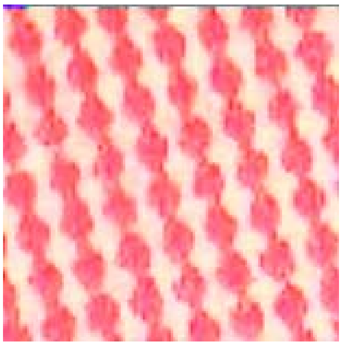


MAGENTA

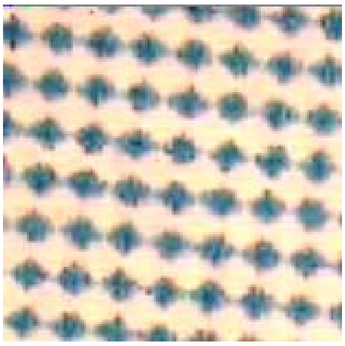
5% IPA Optimum Ink & Water

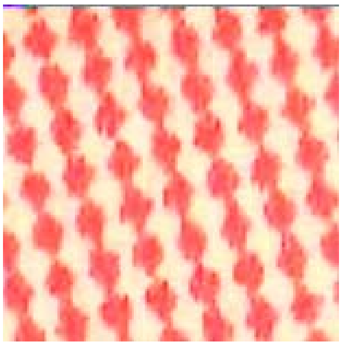
BILT MATT


CYAN

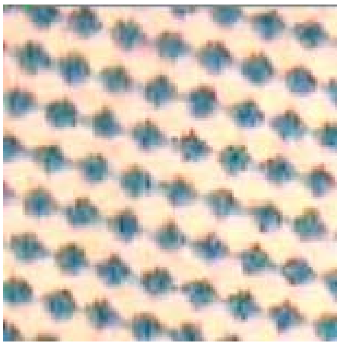

MAGENTA

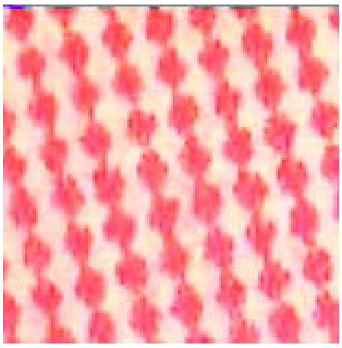
SAPPI MATT


CYAN

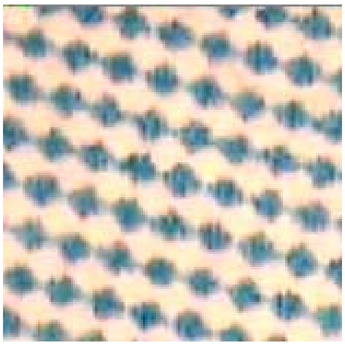

MAGENTA

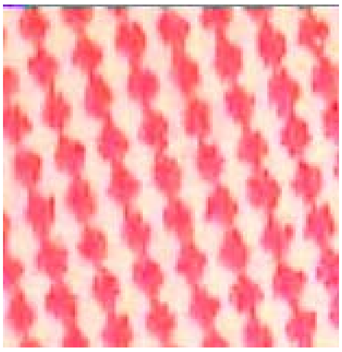
BILT GLOSS


CYAN


MAGENTA

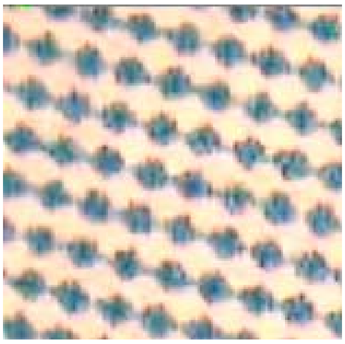
SAPPI GLOSS


CYAN

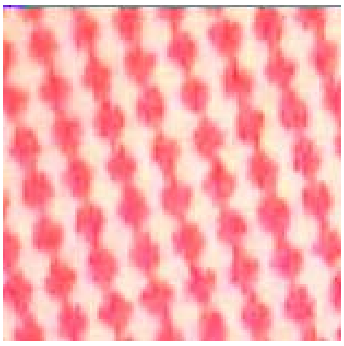

MAGENTA

5 % IPA Increased Ink & Water

BILT MATT

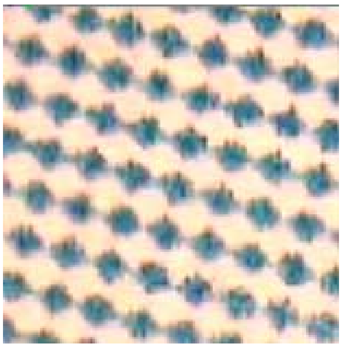


CYAN

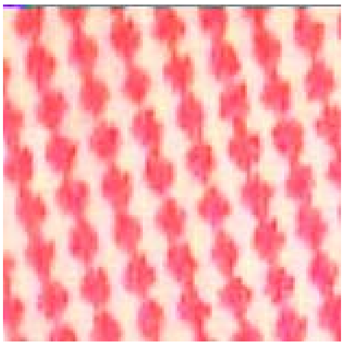


MAGENTA

SAPPI MATT

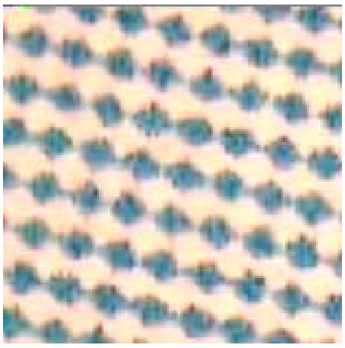


CYAN



MAGENTA

BILT GLOSS



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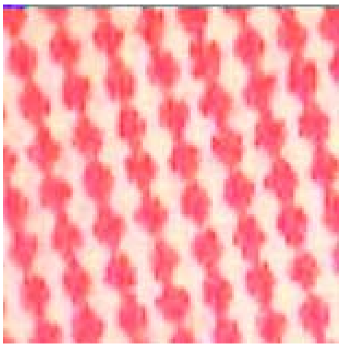
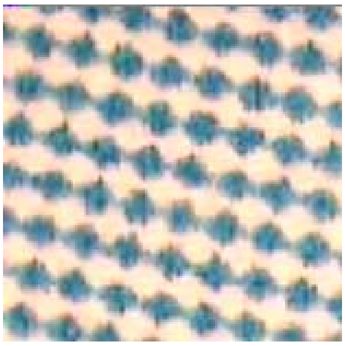
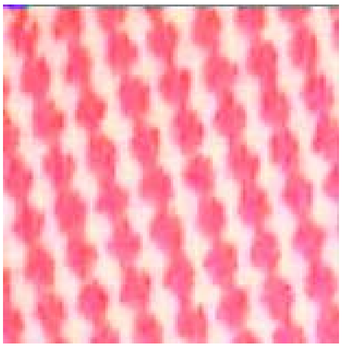


MAGENTA

SAPPI GLOSS



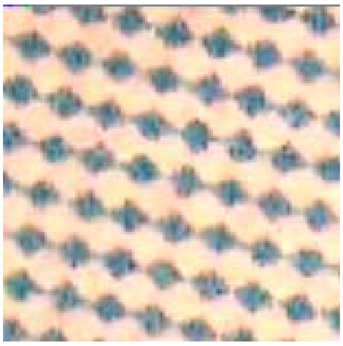
CYAN

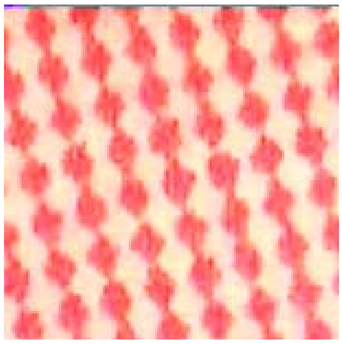


MAGENTA

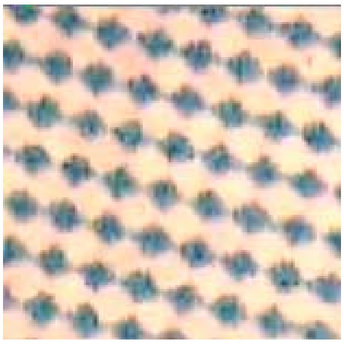
8 % IPA Reduced Ink & Water

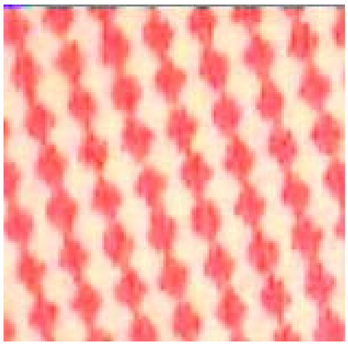
BILT MATT


CYAN

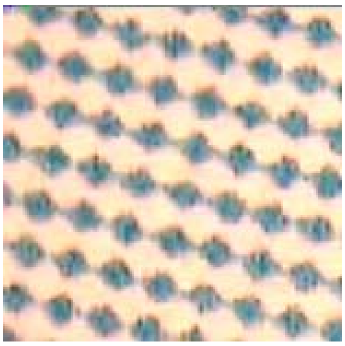

MAGENTA

SAPPI MATT


CYAN


MAGENTA

BILT GLOSS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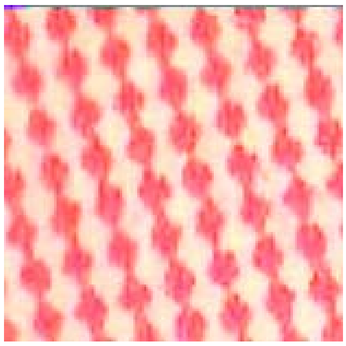
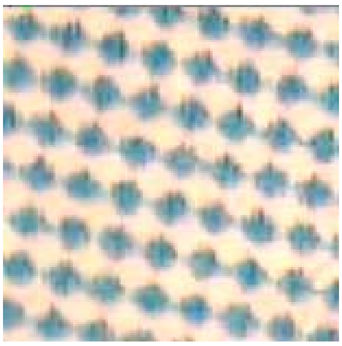
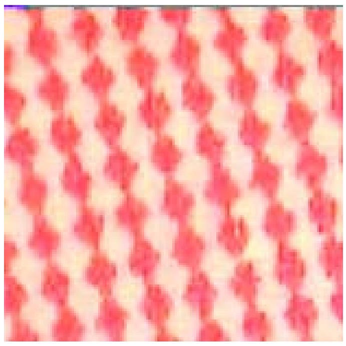

MAGENTA

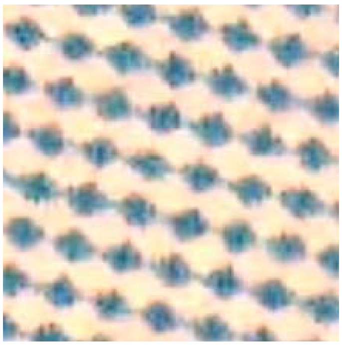
SAPPI GLOSS


CYAN

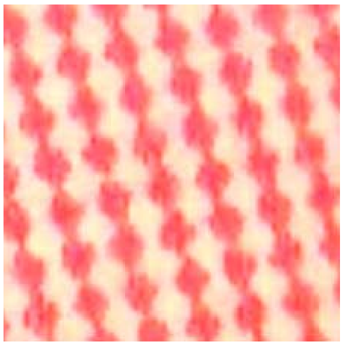

MAGENTA

8% IPA Optimum Ink & Water

BILT MATT

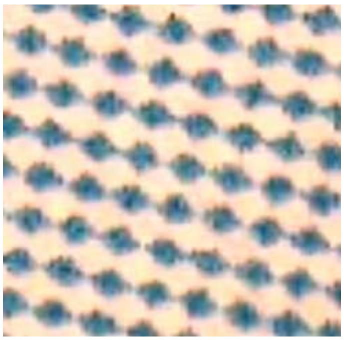


CYAN

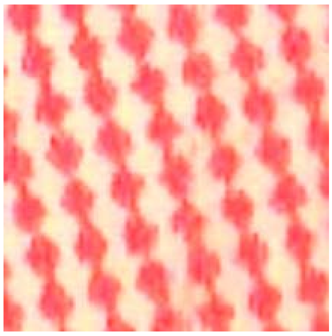


MAGENTA

SAPPI MATT

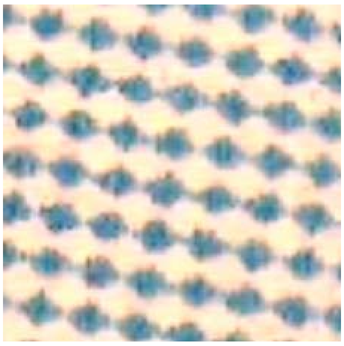


CYAN

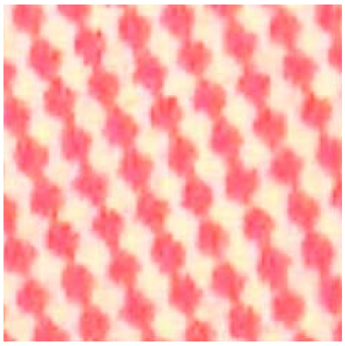


MAGENTA

BILT GLOSS

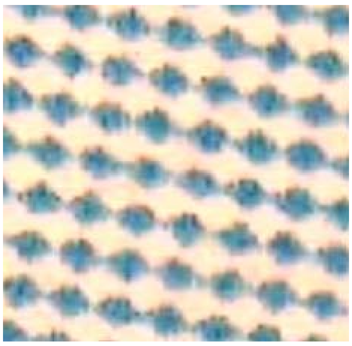


CYAN

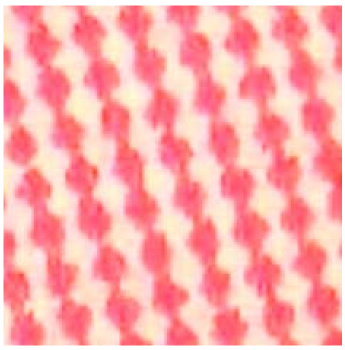


MAGENTA

SAPPI GLOSS



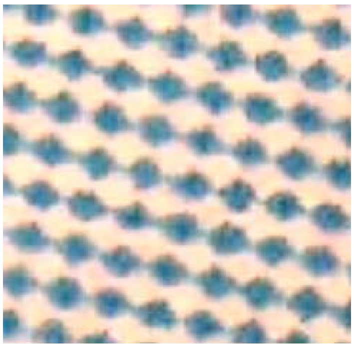
CYAN



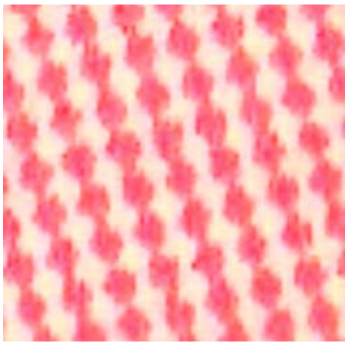
MAGENTA

8 % IPA Increased Ink & Water

BILT MATT

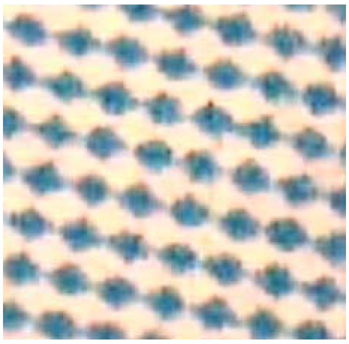


CYAN

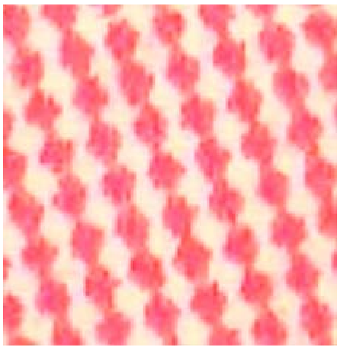


MAGENTA

SAPPI MATT

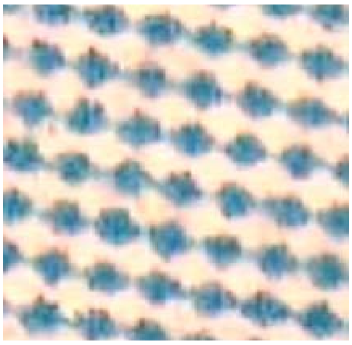


CYAN

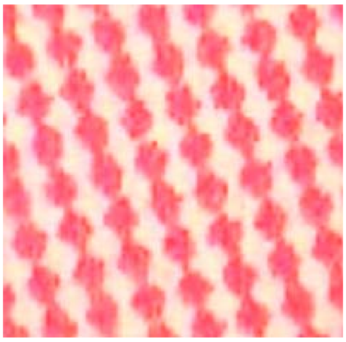


MAGENTA

BILT GLOSS

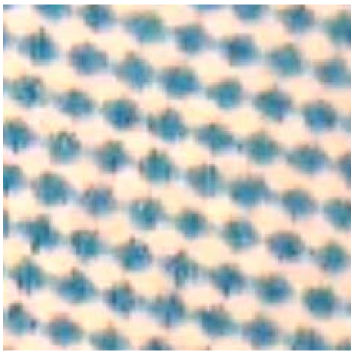


CYAN

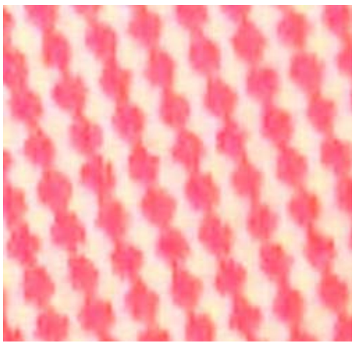


MAGENTA

SAPPI GLOSS



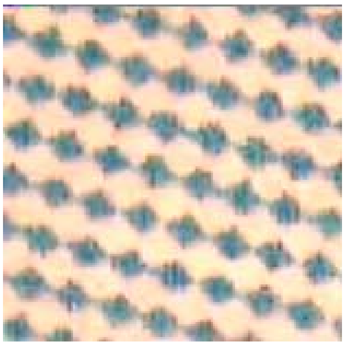
CYAN



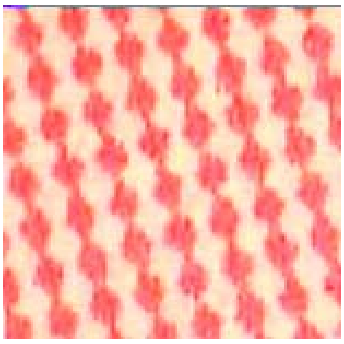
MAGENTA

12 % IPA Reduced Ink & Water

BILT MATT

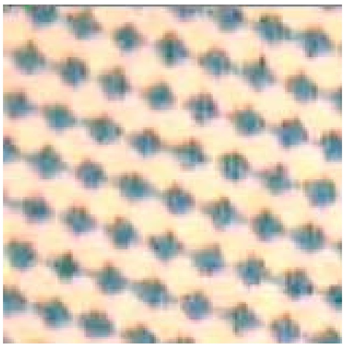


CYAN

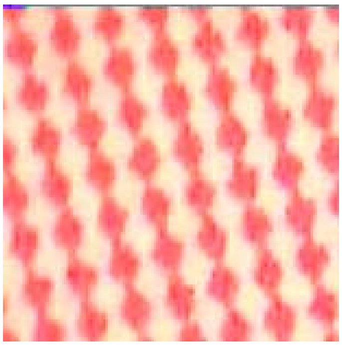


MAGENTA

SAPPI MATT

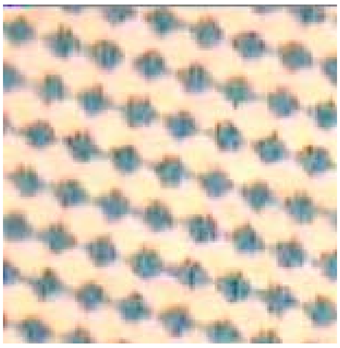


CYAN

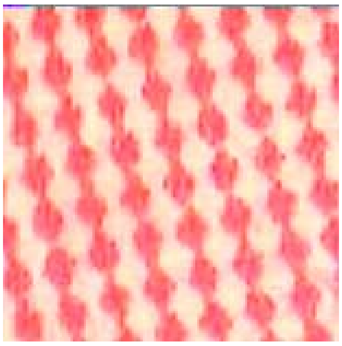


MAGENTA

BILT GLOSS

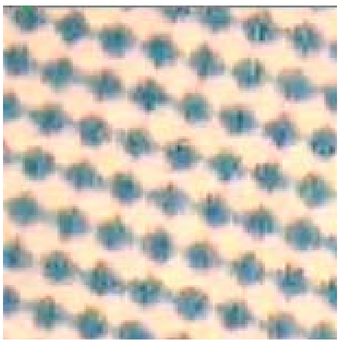


CYAN

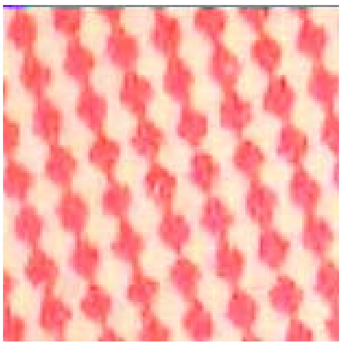


MAGENTA

SAPPI GLOSS



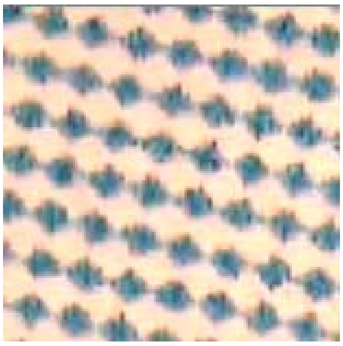
CYAN



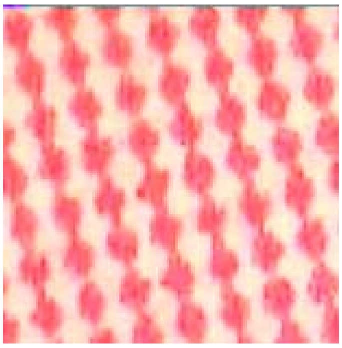
MAGENTA

12 % IPA optimum ink & water

BILT MATT

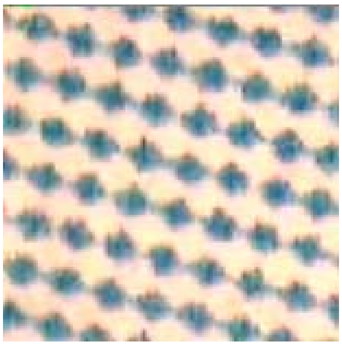


CYAN

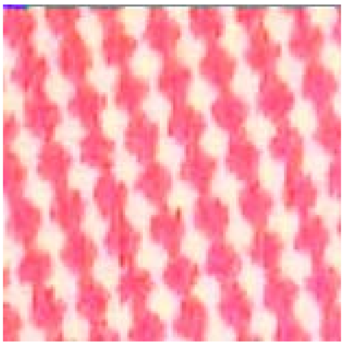


MAGENTA

SAPPI MATT

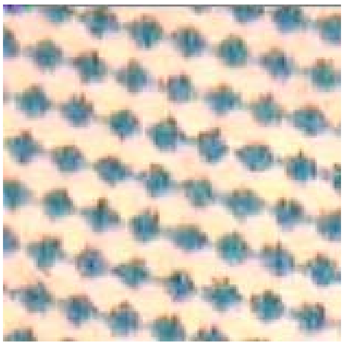


CYAN



MAGENTA

BILT GLOSS



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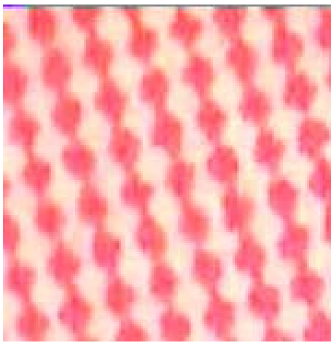
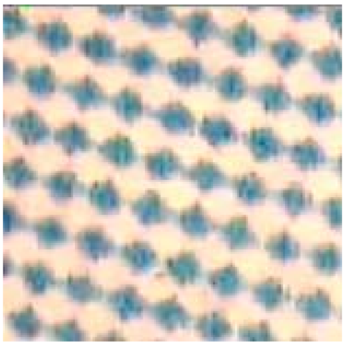


MAGENTA

SAPPI GLOSS



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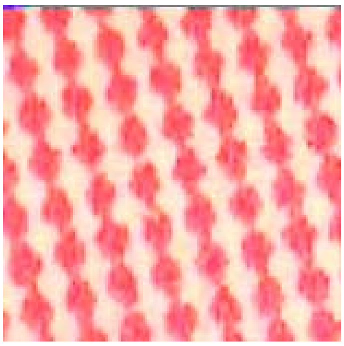
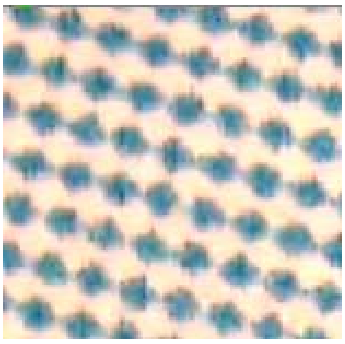


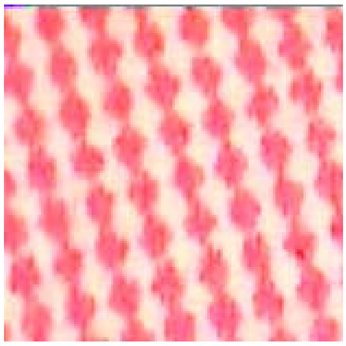
MAGENTA

12 % IPA Increased Ink & Water

BILT MATT

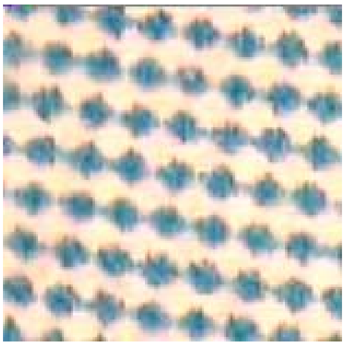


CYAN

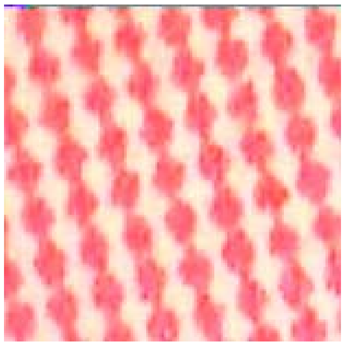


MAGENTA

SAPPI MATT

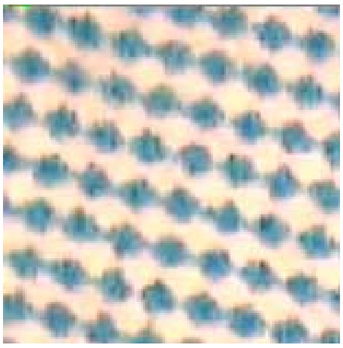


CYAN

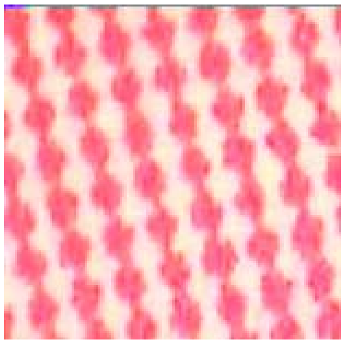


MAGENTA

BILT GLOSS



CYAN



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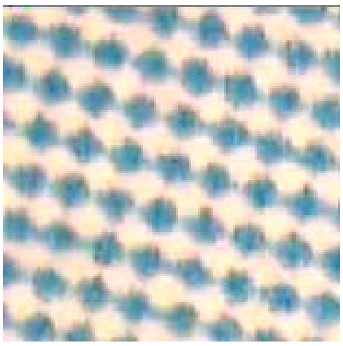
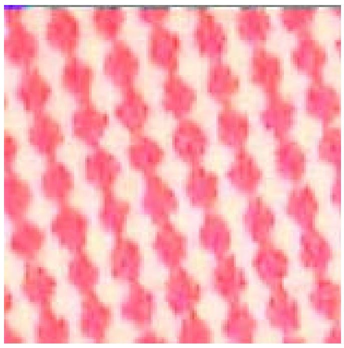
SAPPI GLOSS

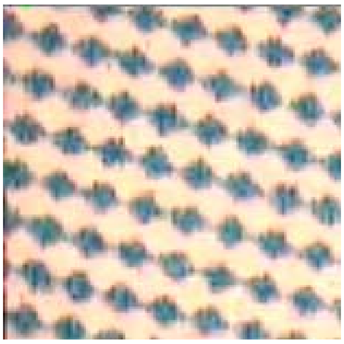


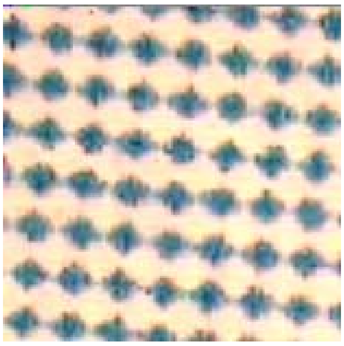
CYAN

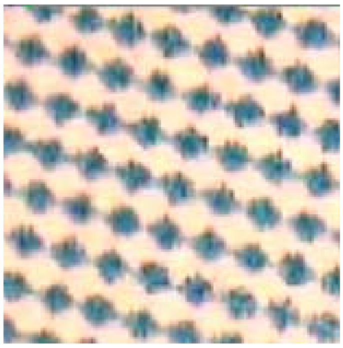


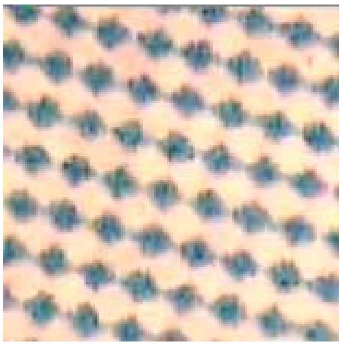
MAGENTA

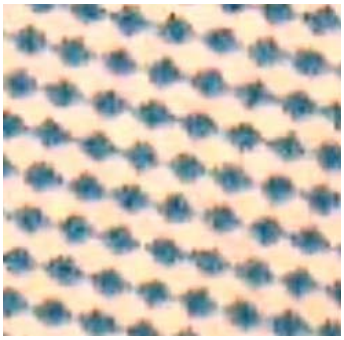
Comparison of Dot Structure to Study the Effect of Change in IPA % and in the amount Of Fountain Solution & Ink

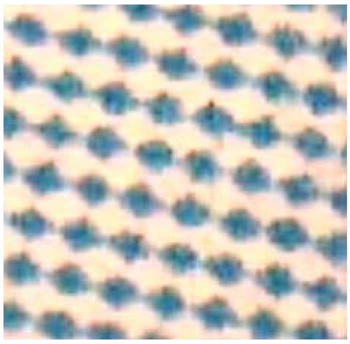

5% REDUCED – SM

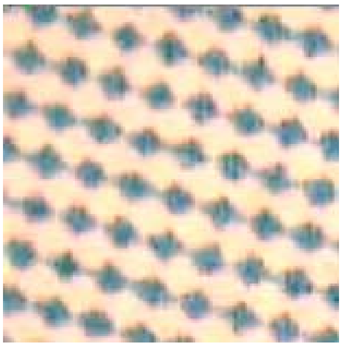

5% OPTIMUM – SM

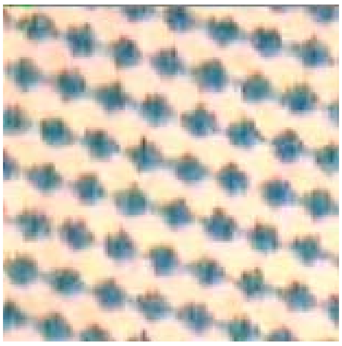

5% INCREASED – SM

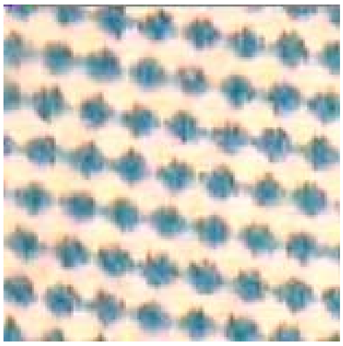

8% REDUCED – SM


8% OPTIMUM – SM


8% INCREASED – SM


12% REDUCED – SM


12% OPTIMUM – SM


12% INCREASED – SM

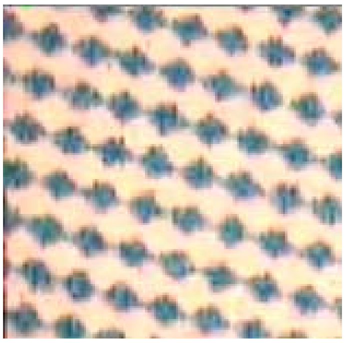
These photographs show a detailed view of all the conditions on one of the papers for 40% dot (Sappi matt) for one of the color (Cyan).

They clearly demonstrate the influence of either too much ink & water or reduced ink & water. Increased ink & water shows imperfect screen dots, less sharpness and higher dot gain. Whereas Reduced ink & water shows sharper dots with lower dot gain.

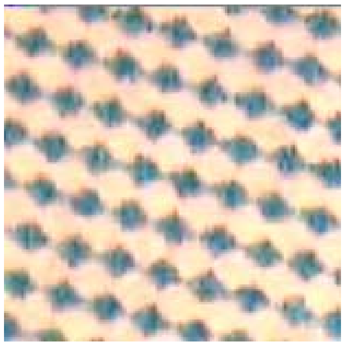
Also, these pictures clearly show the effect of increased emulsification (more water in ink) with increase in IPA %. For example, compare 5% reduced, 8% reduced and 12% reduced. 5% IPA shows better results than 12%.

These pictures suggest that 5% reduced is the best condition leading to good printing results while 12% increased is the worst condition giving undesirable printing results.

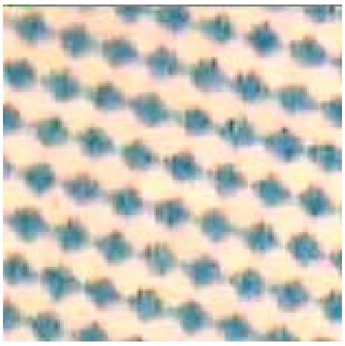
Paper Comparison:



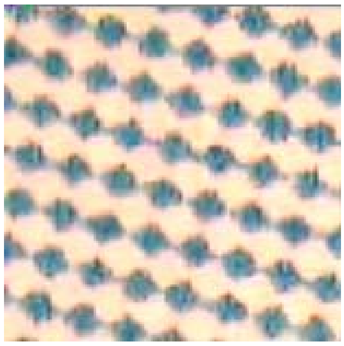
5% REDUCED – SAPPI MATT



5% REDUCED – BILT MATT



5% REDUCED – SAPPI GLOSS



5% REDUCED – BILT GLOSS

5. GLOSS MEASUREMENT

GLOSS AT 75 degree ANGLE

5 % IPA

SAMPLE SHEET	5% IPA REDUCED INK & WATER			5 % IPA OPTIMUM INK & WATER			5 % IPA INCREASED INK & WATER		
	SHEET GLOSS	PRINT GLOSS		SHEET GLOSS	PRINT GLOSS		SHEET GLOSS	PRINT GLOSS	
		C	CMYK		C	CMYK		C	CMYK
BILT GLOSS	73	90	93	73	90	94	73	92	94
SAPPI GLOSS	74	92	94	72	92	96	74	94	96
BILT MATT	33	66	71	35	68	73	33	68	74
SAPPI MATT	40	76	82	39	81	87	41	78	84

8 % IPA

SAMPLE SHEET	8% IPA REDUCED INK & WATER			8% IPA OPTIMUM INK & WATER			8% IPA INCREASED INK & WATER		
	SHEET GLOSS	PRINT GLOSS		SHEET GLOSS	PRINT GLOSS		SHEET GLOSS	PRINT GLOSS	
		C	CMYK		C	CMYK		C	CMYK
BILT GLOSS	73	90	93	72	91	94	73	90	95
SAPPI GLOSS	72	93	96	74	92	95	72	93	96
BILT MATT	34	67	73	34	67	72	34	69	76
SAPPI MATT	42	74	81	41	76	84	41	79	84

12 % IPA

SAMPLE SHEET	12% IPA REDUCED INK & WATER			12% IPA OPTIMUM INK & WATER			12% IPA INCREASED INK & WATER		
	SHEET GLOSS	PRINT GLOSS		SHEET GLOSS	PRINT GLOSS		SHEET GLOSS	PRINT GLOSS	
		C	CMYK		C	CMYK		C	CMYK
BILT GLOSS	71	89	91	74	88	91	74	93	95
SAPPI GLOSS	76	93	93	74	94	95	74	94	96
BILT MATT	32	66	72	35	77	81	36	71	77
SAPPI MATT	42	74	80	41	68	74	41	76	84

6. CONCLUSION

The printing tests that we conducted and the laboratory tests both confirmed the influence of fountain silution on paper and on the tendency towards an uneven printing result. This shortcoming can be caused by excessive emulsification of water in the printing ink and through uneven formation of the water film on the surface of the paper.
Coated papers always have a certain tendency towards mottling. Optimal adjustment of the constitution and supply of the fountain solution enables the printer to minimise the unevenness of the printing result in order to fulfill the increasing quality requirements of the customer.

Most favorable printing condition for **reduced mottle** was found to be 5 % IPA with reduced ink & water.

We arrived at the **three best conditions** of printing out of all the variation.

1. 5 % IPA – Reduced ink & water
2. 5 % IPA – Optimum ink & water
3. 8 % IPA – Optimum ink & water

Note that 12% IPA and Increased ink & water showed the worst results.

Paper Comparison:
Bilt and Sappi papers showed almost same performance with little difference in the print parameters. But Sappi papers appear visually better.

VII Project Summary

PROJECT SUMMARY

Interaction between Fountain Solution and Paper

The paper is wetted not only by the emulsified ink, but by the fountain solution as well, and the film of fountain solution that remains on the paper may cause problems of ink repellence and water interference mottling in multicolor printing. As the fountain solution gets transferred on the paper, it is forced into the voids in the surface of paper. Some of it then penetrates into the porous structure of the paper while rest remains on the paper. Once the printing pressure is released, the fountain solution will be drawn into the paper structure by capillary penetration and spreading. This penetration is not forced but spontaneous and is therefore controlled by paper properties such as surface free energy, pore structure, surface roughness and surface tension of the fountain solution

There are three factors controlling the interaction between fountain and paper.

1) Contact between the fountain solution film and the paper i.e. wettability, which mainly depends on the surface tension of the fountain solution and surface free energy of the paper.

2) Penetration of fountain solution into the paper, which mainly depends on the surface roughness and porous structure of paper i.e. porosity of the paper & the pore distribution and also printing pressure.

3) Rate of penetration which is affected mainly by the printing speed and printing pressure.

It is important that the fountain solution rapidly penetrates the paper before it comes into contact with the ink in the subsequent printing unit.

Laboratory Study

As the IPA proportion increases, surface tension reduces. With the reducing Surface tension, contact angle decreases & wettability increases.

The lower the contact angle , the higher is the sensitivity for ink repellence. This was confirmed with the ink repellence test on the IGT AIC II/5.

Another test is the Dynamic Penetration Test – A higher penetration and/or slower penetration of the fountain solution can lead to a higher sensitivity for wet pick.

Press trials

The following table shows different types of papers, fountain solution additives & other variables used in the experiment.

1st item	**Sort of Paper**	
	A = Bilt Matt 130 gsm B = Bilt Gloss 130 gsm	
	C = Sappi Matt 130 gsm D = Sappi Gloss 130 gsm	
2nd item	**Fountain Solution additive**	
1]	Microinks Fount 0009 IPA	2 % **5 %**
2]	Microinks Fount 0009 IPA	2 % **8 %**
3]	Microinks Fount 0009 IPA	2 % **12 %**
3rd item	**Amount of fountain solution and ink**	
	Optimum	
	Increased	20 % 0f Optimum
	Reduced	10 % of Optimum

Test Printings on 4-Colour Mitsubishi machine:

Using the variables mentioned earlier, we took three trials with 5%, 8% & 12% IPA ; each variation further having three conditions: *optimum ink & water, increased ink & water and reduced ink & water*.

Analysis of the print samples & Co-relation with Lab Tests:

1. To study the effect of change of IPA proportion in the fountain solution

As IPA % increases,

Contact angle	Decreases
Surface Tension	Decreases
Wettability	Increases
Ink Repellence	Increases
Mottling	Increases
Water-pick up	Increases
Emulsification	Increases
Tack	Decreases

Density	Decreases
Dot gain	Increases
Contrast	Decreases

With less Isopropanol in the fountain solution additive, less water is transported onto the paper over the printing ink in spite of increased water supply.The quantity of water on the non-printing areas of the plate remains the same.Thus the water emulsified in the ink plays a decisive role with regard to the differences in water interference mottling observed with one and the same paper.

The samples showed that both a low water supply and use of less Isopropanol could largely prevent water interference mottling.

2. To study the effect of change of amount of fountain solution & ink

Reduced ink & water showed better results in terms of mottling. Microphotography of the print samples also showed sharper screen dots in case of reduced ink & water than in the other conditions.

As the amount of ink & water increases,

Density	Increases
Dot gain	Increases
Contrast	Decreases
Ink Repellence	Increases
Mottling	Increases

3. Paper Comparison

5% IPA: Bilt Gloss is performing better than Sappi Gloss in terms of both Print & Visual parameters.

Bilt Matt and Sappi Matt performed almost same.

8% IPA: Bilt Gloss showed better performance than Sappi Gloss in terms of print parameters. However Sappi Gloss appears visually better.

Bilt Matt and Sappi Matt showed same performance. But Sappi Matt appears visually better.

12% IPA: Bilt Gloss is better in terms of print parameters. Sappi gloss is however visually better.

Bilt Matt and Sappi Matt are showing same results, however Sappi matt is again appearing visually better.

Conclusions:

We arrived at the **three best conditions** of printing out of all the variation.

1. 5 % IPA – Reduced ink & water
2. 5 % IPA – Optimum ink & water
3. 8 % IPA – Optimum ink & water

Most favorable printing condition for **reduced mottle** was found to be 5 % IPA with reduced ink & water.

Paper Comparison:

Bilt and Sappi papers showed almost same performance with little difference in the print parameters. But Sappi papers appear visually better.

VIII Closing Remarks

CLOSING REMARKS

A final printed piece has three components: paper, ink and fountain solution emulsified in the ink. These key components are complex in composition and the process of bringing them together to satisfy a broad range of customers is extremely challenging.

Offset printing is still a very complex process. If one of the links in the chain is not performing optimally, it can seriously compromise the end result.

Good co-operation between manufacturers of presses, ink, paper and fountain solution remains all-important.

We carried out the laboratory tests at BILT & Micro Inks and conducted test printings at K. Joshi & Co., Pune.

We thank these companies for their contribution to this project.

Ballarpur Industries Ltd.

Micro Inks Ltd.

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- Print Mottle
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  IGT Information Leaflet W32

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  Emtec Measuring Systems

X Annexure

ANNEXURE

5% REDUCED INK & WATER

BILT MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.52	1.40	1.14	1.64	65	68	59	66	62	81	76	54	49	48	54
SHEET 2	1.47	1.37	1.14	1.66	64	68	59	67	62	83	77	53	49	46	55
SHEET 3	1.49	1.38	1.14	1.66	64	68	59	66	62	83	78	53	48	47	54
AVG.	**1.49**	**1.38**	**1.14**	**1.65**	**64**	**68**	**59**	**66**	**62**	**82**	**77**	**54**	**49**	**47**	**54**

SAPPI MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.57	1.37	1.12	1.64	64	68	59	65	62	83	75	54	49	48	55
SHEET 2	1.46	1.35	1.11	1.65	65	68	58	65	62	84	76	54	49	48	55
SHEET 3	1.40	1.35	1.13	1.67	65	67	58	65	63	84	78	54	50	50	56
AVG.	**1.48**	**1.36**	**1.12**	**1.65**	**65**	**68**	**58**	**65**	**62**	**84**	**76**	**54**	**49**	**49**	**55**

BILT GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.46	1.33	1.12	1.67	65	68	60	66	66	88	76	52	48	47	55
SHEET 2	1.46	1.36	1.10	1.65	65	67	60	65	65	83	77	52	49	47	56
SHEET 3	1.47	1.36	1.11	1.66	65	68	58	66	67	87	77	52	51	47	55
AVG.	**1.46**	**1.35**	**1.11**	**1.66**	**65**	**68**	**59**	**66**	**66**	**86**	**77**	**52**	**49**	**47**	**55**

SAPPI GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.65	1.49	1.37	1.75	73	73	67	74	56	86	61	39	40	37	42
SHEET 2	1.61	1.44	1.19	1.77	74	75	66	73	57	82	74	37	39	37	44
SHEET 3	1.72	1.46	1.26	2.00	76	75	68	75	61	86	75	44	41	36	49
AVG.	**1.66**	**1.46**	**1.27**	**1.84**	**74**	**74**	**67**	**74**	**58**	**85**	**70**	**40**	**40**	**37**	**45**

5 % OPTIMUM INK & WATER

BILT MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.52	1.42	1.12	1.78	66	68	57	54	61	83	76	56	52	51	56
SHEET 2	1.51	1.43	1.12	1.77	66	67	58	63	59	8Z	76	56	52	50	60
SHEET 3	1.55	1.54	1.26	1.68	67	73	62	66	63	88	71	50	44	45	56
AVG.	**1.53**	**1.46**	**1.17**	**1.74**	**66**	**69**	**59**	**61**	**61**	**84**	**74**	**54**	**49**	**49**	**58**

SAPPI MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.53	1.44	1.12	1.79	65	68	57	64	59	83	76	57	52	50	61
SHEET 2	1.54	1.46	1.11	1.79	64	68	56	64	59	84	78	57	53	51	61
SHEET 3	1.52	1.41	1.02	1.80	65	68	57	63	58	82	78	57	51	50	62
AVG.	**1.53**	**1.44**	**1.08**	**1.79**	**65**	**68**	**57**	**64**	**59**	**83**	**77**	**57**	**52**	**51**	**61**

BILT GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.55	1.51	1.12	1.84	66	69	57	65	60	85	78	56	52	54	60
SHEET 2	1.57	1.49	1.13	1.85	70	71	58	67	61	84	76	54	49	50	57
SHEET 3	1.54	1.45	1.14	1.81	68	68	69	66	61	85	78	55	51	49	59
AVG.	**1.55**	**1.48**	**1.13**	**1.83**	**68**	**69**	**61**	**66**	**61**	**85**	**77**	**55**	**51**	**51**	**59**

SAPPI GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.59	1.51	1.18	1.90	68	69	60	67	57	80	74	54	51	48	61
SHEET 2	1.57	1.50	1.17	1.87	68	71	61	69	56	81	72	55	50	48	59
SHEET 3	1.59	1.51	1.17	1.92	69	71	61	68	56	80	74	53	50	48	59
AVG.	**1.58**	**1.51**	**1.17**	**1.90**	**68**	**70**	**61**	**68**	**57**	**80**	**73**	**54**	**50**	**48**	**60**

5 % INCREASED INK & WATER

BILT MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.58	1.46	1.17	1.91	70	72	59	70	62	83	77	52	46	47	58
SHEET 2	1.55	1.44	1.17	1.86	68	71	61	68	61	83	75	54	48	48	57
SHEET 3	1.56	1.45	1.16	1.86	69	72	61	68	62	83	74	53	49	47	57
AVG.	**1.56**	**1.45**	**1.16**	**1.88**	**69**	**72**	**60**	**69**	**62**	**83**	**75**	**53**	**48**	**47**	**57**

SAPPI MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.57	1.47	1.17	1.86	68	72	61	68	60	79	76	54	49	47	57
SHEET 2	1.57	1.42	1.17	1.88	66	70	60	67	61	84	78	53	47	49	58
SHEET 3	1.57	1.42	1.17	1.87	67	71	60	65	61	83	77	54	48	48	59
AVG.	**1.57**	**1.44**	**1.17**	**1.87**	**67**	**71**	**60**	**67**	**61**	**82**	**77**	**54**	**48**	**48**	**58**

BILT GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.62	1.50	1.21	1.97	70	72	62	70	63	85	76	52	46	47	57
SHEET 2	1.59	1.47	1.21	1.93	68	71	61	68	64	86	77	52	47	47	58
SHEET 3	1.60	1.42	1.20	1.94	69	70	62	69	65	84	75	52	47	47	58
AVG.	**1.60**	**1.46**	**1.21**	**1.95**	**69**	**71**	**62**	**69**	**64**	**85**	**76**	**52**	**47**	**47**	**58**

SAPPI GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	M	Y	K	C	M	Y	K	R	G	B	C	M	Y	K
SHEET 1	1.70	1.52	1.24	2.05	75	77	66	76	61	83	73	47	41	44	52
SHEET 2	1.73	1.52	1.25	2.08	73	76	66	78	60	82	70	46	39	44	51
SHEET 3	1.71	1.49	1.24	2.02	74	77	66	79	58	80	66	45	40	43	46
AVG.	**1.71**	**1.51**	**1.24**	**2.05**	**74**	**77**	**66**	**78**	**60**	**82**	**72**	**46**	**40**	**44**	**50**

8% IPA DECREASED INK & WATER

BILT MATT

	DENSITIES					DOT GAIN AT 50%					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.33	1.21	1.13	1.63		62	66	58	64		64	83	80		53	49	48	56
SHEET 2	1.49	1.21	1.14	1.65		64	67	57	66		62	84	79		53	48	49	54
SHEET 3	1.37	1.21	1.11	1.63		63	67	58	66		63	84	79		53	49	46	56
AVG.	**1.40**	**1.21**	**1.12**	**1.64**		**63**	**67**	**58**	**65**		**63**	**84**	**79**		**53**	**49**	**48**	**55**

SAPPI MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.38	1.21	1.09	1.66		62	66	57	65		65	86	80		54	51	49	57
SHEET 2	1.36	1.19	1.09	1.63		62	66	57	65		66	86	79		54	49	49	58
SHEET 3	1.36	1.20	1.07	1.61		63	66	57	64		65	86	79		54	49	50	58
AVG.	**1.37**	**1.20**	**1.08**	**1.63**		**62**	**66**	**57**	**65**		**65**	**86**	**79**		**54**	**50**	**50**	**58**

BILT GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.39	1.23	1.10	1.62		66	68	59	66		68	89	78		52	48	47	56
SHEET 2	1.38	1.24	1.09	1.62		65	67	58	66		68	89	77		52	49	48	55
SHEET 3	1.38	1.24	1.10	1.63		65	66	59	65		67	88	79		52	48	48	56
AVG.	**1.38**	**1.24**	**1.09**	**1.62**		**65**	**67**	**59**	**66**		**68**	**89**	**78**		**52**	**48**	**48**	**56**

SAPPI GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
	1.42	1.26	1.11	1.62		68	68	60	67		61	82	72		51	48	47	55
SHEET 2	1.44	1.27	1.11	1.73		71	68	61	70		64	83	74		50	48	49	53
SHEET 3	1.41	1.27	1.11	1.66		68	67	60	68		63	82	72		51	48	47	54
AVG.	**1.42**	**1.27**	**1.11**	**1.67**		**69**	**68**	**60**	**68**		**63**	**82**	**73**		**50**	**48**	**48**	**54**

8% IPA OPTIMUM INK AND WATER

BILT MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.51	1.29	1.12	1.71		66	68	59	67		63	82	73		55	51	48	58
SHEET 2	1.52	1.30	1.11	1.69		65	68	59	68		63	81	75		55	48	49	57
SHEET 3	1.52	1.30	1.11	1.72		66	67	59	67		63	81	76		54	48	49	58
AVG.	**1.52**	**1.29**	**1.11**	**1.70**		**66**	**68**	**59**	**67**		**63**	**81**	**75**		**55**	**49**	**48**	**58**

SAPPI MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.53	1.30	1.13	1.76		67	67	60	64		63	83	74		56	48	50	60
SHEET 2	1.51	1.29	1.11	1.73		65	67	57	64		64	83	76		56	52	50	61
SHEET 3	1.50	1.28	1.12	1.76		65	66	58	65		62	82	75		56	51	49	61
AVG.	**1.51**	**1.29**	**1.12**	**1.75**		**66**	**67**	**58**	**64**		**63**	**83**	**75**		**56**	**50**	**50**	**60**

BILT GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.47	1.34	1.13	1.74		67	69	60	66		67	86	76		54	49	49	57
SHEET 2	1.52	1.36	1.14	1.73		67	69	60	66		66	86	76		53	47	48	55
SHEET 3	1.52	1.36	1.13	1.74		68	71	60	69		67	88	77		51	47	47	56
AVG.	**1.50**	**1.35**	**1.13**	**1.74**		**67**	**70**	**60**	**67**		**67**	**87**	**76**		**53**	**48**	**48**	**56**

SAPPI GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.55	1.38	1.16	1.84		69	71	61	68		62	82	74		52	47	45	56
SHEET 2	1.51	1.31	1.14	1.73		67	69	60	68		61	82	71		51	48	48	58
SHEET 3	1.54	1.37	1.15	1.83		67	70	60	69		61	83	75		52	47	47	58
AVG.	**1.53**	**1.35**	**1.15**	**1.80**		**68**	**70**	**60**	**68**		**61**	**82**	**73**		**52**	**47**	**47**	**57**

8% IPA INCREASED WATER ALONG WITH INK

BILT MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.52	1.34	1.20	1.82		70	72	62	71		63	87	76		52	46	47	56
SHEET 2	1.54	1.36	1.19	1.86		67	71	61	71		61	85	77		54	47	48	57
SHEET 3	1.53	1.36	1.20	1.82		68	71	61	71		62	83	76		54	47	48	58
AVG.	**1.53**	**1.36**	**1.20**	**1.83**		**68**	**71**	**61**	**71**		**62**	**85**	**76**		**53**	**47**	**48**	**57**

SAPPI MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.53	1.34	1.21	1.80		69	72	62	70		65	84	74		52	46	48	55
SHEET 2	1.58	1.35	1.21	1.81		69	72	63	70		66	85	75		53	47	47	56
SHEET 3	1.56	1.35	1.21	1.83		69	72	62	70		64	86	77		52	47	48	57
AVG.	**1.56**	**1.34**	**1.21**	**1.81**		**69**	**72**	**62**	**70**		**65**	**85**	**75**		**52**	**47**	**47**	**56**

BILT GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.60	1.38	1.24	1.86		70	73	63	73		65	87	77		51	46	46	56
SHEET 2	1.60	1.37	1.22	1.86		71	72	62	71		66	87	76		52	46	47	55
SHEET 3	1.62	1.38	1.24	1.86		71	73	63	72		65	87	75		51	45	47	56
AVG.	**1.61**	**1.37**	**1.23**	**1.86**		**71**	**73**	**63**	**72**		**65**	**87**	**76**		**51**	**46**	**46**	**56**

SAPPI GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.65	1.41	1.27	1.91		75	73	65	74		62	83	70		49	43	45	55
SHEET 2	1.70	1.43	1.28	1.99		78	74	66	77		63	82	70		47	43	44	54
SHEET 3	1.67	1.42	1.28	1.91		75	73	64	76		62	81	70		49	44	46	54
AVG.	**1.67**	**1.42**	**1.28**	**1.94**		**76**	**73**	**65**	**76**		**62**	**82**	**70**		**49**	**43**	**45**	**54**

12% IPA DECREASED INK AND WATER

BILT MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.45	1.18	1.07	1.59	65	68	60	66	65	83	76	52	47	50	56
SHEET 2	1.39	1.17	1.09	1.57	65	67	59	65	67	84	76	51	47	49	54
SHEET 3	1.43	1.14	1.05	1.58	65	67	59	66	68	85	76	51	47	49	54
AVG.	**1.42**	**1.16**	**1.07**	**1.58**	**65**	**67**	**59**	**66**	**67**	**84**	**76**	**51**	**47**	**49**	**55**

SAPPI MATT

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.41	1.17	1.07	1.55	63	66	58	65	68	85	76	53	48	46	56
SHEET 2	1.34	1.19	1.05	1.57	63	65	60	65	66	85	78	53	51	40	55
SHEET 3	1.37	1.16	1.05	1.58	63	67	58	65	65	84	79	52	47	49	55
AVG.	**1.37**	**1.17**	**1.06**	**1.57**	**63**	**66**	**59**	**65**	**66**	**85**	**78**	**53**	**49**	**45**	**56**

BILT GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.38	1.21	1.06	1.60	65	67	59	67	69	87	77	51	48	45	55
SHEET 2	1.37	1.21	1.06	1.59	65	67	60	66	69	88	79	50	47	46	54
SHEET 3	1.36	1.19	1.03	1.58	66	67	59	67	69	90	79	51	46	47	55
AVG.	1.37	1.20	1.05	1.59	**65**	**67**	**59**	**67**	**69**	**88**	**78**	**51**	**47**	**46**	**55**

SAPPI GLOSS

	DENSITIES				DOT GAIN AT 50 %				TRAPPING			CONTRAST			
	C	**M**	**Y**	**K**	**C**	**M**	**Y**	**K**	**R**	**G**	**B**	**C**	**M**	**Y**	**K**
SHEET 1	1.44	1.23	1.06	1.72	73	69	61	72	67	85	73	48	46	46	54
SHEET 2	1.42	1.22	1.16	1.66	71	68	61	70	66	85	74	48	46	45	55
SHEET 3	1.41	1.20	1.04	1.62	68	66	61	67	64	83	73	51	47	47	56
AVG.	**1.42**	**1.22**	**1.09**	**1.67**	**71**	**68**	**61**	**70**	**66**	**84**	**73**	**49**	**46**	**46**	**55**

12 % IPA OPTIMUM INK & WATER

BILT MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.52	1.27	1.09	1.66		67	68	57	66		62	82	74		53	47	45	53
SHEET 2	1.52	1.30	1.11	1.69		67	68	58	68		63	77	74		53	49	48	58
SHEET 3	1.52	1.28	1.10	1.67		68	68	58	66		61	80	75		54	47	48	47
AVG.	**1.52**	**1.28**	**1.10**	**1.68**		**67**	**68**	**58**	**67**		**62**	**80**	**74**		**53**	**48**	**47**	**53**

SAPPI MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.49	1.29	1.10	1.70		66	69	58	66		61	82	75		55	47	48	55
SHEET 2	1.48	1.29	1.10	1.69		65	68	58	66		63	84	77		53	48	46	57
SHEET 3	1.49	1.29	1.10	1.68		66	68	59	66		61	82	76		54	48	48	57
AVG.	**1.49**	**1.29**	**1.10**	**1.69**		**66**	**68**	**58**	**66**		**62**	**83**	**76**		**54**	**48**	**47**	**57**

BILT GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.48	1.34	1.11	1.74		67	70	60	69		65	85	76		51	47	47	54
SHEET 2	1.47	1.35	1.11	1.73		66	71	60	68		65	88	75		51	48	47	56
SHEET 3	1.47	1.34	1.10	1.70		68	70	60	69		64	87	77		51	48	47	54
AVG.	**1.47**	**1.34**	**1.11**	**1.72**		**67**	**70**	**60**	**69**		**65**	**87**	**76**		**51**	**47**	**47**	**55**

SAPPI GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.50	1.36	1.14	1.76		70	69	61	70		60	82	71		50	48	46	55
SHEET 2	1.54	1.39	1.14	1.86		71	70	61	72		60	83	73		49	46	46	55
SHEET 3	1.56	1.40	1.12	1.83		72	72	63	77		60	83	73		47	47	46	50
AVG.	**1.53**	**1.39**	**1.13**	**1.82**		**71**	**70**	**62**	**73**		**60**	**83**	**72**		**49**	**47**	**46**	**53**

12 % IPA INCREASED INK & WATER

BILT MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.59	1.31	1.17	1.86		70	72	63	71		66	85	75		51	45	45	56
SHEET 2	1.67	1.36	1.18	1.88		70	72	63	72		65	84	75		51	45	45	56
SHEET 3	1.59	1.34	1.18	1.85		70	71	63	71		65	84	75		52	45	49	54
AVG.	**1.62**	**1.34**	**1.18**	**1.86**		**70**	**72**	**63**	**71**		**65**	**84**	**75**		**51**	**45**	**46**	**55**

SAPPI MATT

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.58	1.32	1.17	1.87		69	71	63	71		65	84	76		52	47	46	51
SHEET 2	1.58	1.34	1.17	1.32		68	71	63	71		64	84	76		51	47	46	54
SHEET 3	1.55	1.33	1.16	1.86		69	71	63	70		66	85	75		52	44	47	56
AVG.	**1.57**	**1.33**	**1.17**	**1.68**		**69**	**71**	**63**	**71**		**65**	**84**	**76**		**51**	**46**	**46**	**54**

BILT GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.55	1.39	1.19	1.87		71	72	64	73		67	87	78		51	44	44	53
SHEET 2	1.57	1.35	1.18	1.89		69	71	63	73		67	86	76		50	44	44	55
SHEET 3	1.56	1.36	1.17	1.88		71	72	64	73		67	86	95		49	45	45	54
AVG.	**1.56**	**1.37**	**1.18**	**1.88**		**70**	**72**	**64**	**73**		**67**	**86**	**83**		**50**	**44**	**44**	**54**

SAPPI GLOSS

	DENSITIES					DOT GAIN AT 50 %					TRAPPING				CONTRAST			
	C	M	Y	K		C	M	Y	K		R	G	B		C	M	Y	K
SHEET 1	1.61	1.38	1.20	1.98		75	74	66	76		64	84	72		46	53	44	52
SHEET 2	1.56	1.37	1.20	1.88		71	72	65	74		63	84	73		50	44	45	55
SHEET 3	1.55	1.36	1.21	1.87		72	72	65	73		62	84	72		48	44	45	54
AVG.	**1.57**	**1.37**	**1.20**	**1.91**		**73**	**73**	**65**	**74**		**63**	**84**	**72**		**48**	**47**	**45**	**54**

GRAY BALANCE

5% REDUCED

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	63	63	63	**63**	64	63	63	**63**	63	63	63	**63**	57	57	54	**56**
CMY	**a**	-3	-2	-2	**-2**	-3	-3	-3	**-3**	-3	-4	-3	**-3**	-5	-6	-6	**-6**
	b	-5	-5	-2	**-4**	-4	-4	-4	**-4**	-4	-5	-5	**-5**	-6	-7	-6	**-6**
		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
K	**L**	63	63	64	**64**	64	64	64	**64**	64	64	64	**64**	57	57	55	**57**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	0	0	0	**0**	0	0	0	**0**	0	-1	0	**-1**	-1	0	-1	**-1**

5% OPTIMUM

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	63	63	59	**62**	56	63	63	**61**	62	61	61	**62**	61	61	60	**61**
CMY	**a**	-2	-2	-2	**-2**	-5	-2	-2	**-3**	-3	-3	-3	**-3**	-3	-4	-3	**-3**
	b	-5	-6	-7	**-6**	-7	-5	-6	**-6**	-6	-6	-6	**-6**	-6	-7	-7	**-7**
		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
K	**L**	65	64	64	**64**	55	65	66	**62**	64	63	63	**64**	62	61	62	**61**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	-1	-1	0	**-1**	-1	-1	-1	**-1**	-1	-1	-1	**-1**	-1	-1	-1	**-1**

5% INCREASED

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
CMY	**L**	60	60	60	**60**	60	61	61	**61**	60	60	60	**60**	55	56	57	**56**
	a	-3	-3	-3	**-3**	-3	-3	-2	**-3**	-4	-4	-3	**-4**	-4	-5	-5	**-4**
	b	-6	-5	-6	**-5**	-6	-5	-6	**-6**	-5	-5	-5	**-5**	-8	-7	-7	**-7**
		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
K	**L**	61	61	61	**61**	62	63	63	**62**	60	62	61	**61**	55	55	52	**54**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	-1	0	0	**-1**	-1	-1	-1	**-1**	-1	-1	-1	**-1**	-1	-1	0	**-1**

8% REDUCED

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
CMY		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	65	65	65	**65**	65	66	66	**66**	65	65	65	**65**	64	63	64	**64**
	a	-4	-3	-3	**-4**	-4	-3	-3	**-4**	-4	-4	-4	**-4**	-5	-5	-5	**-5**
	b	-5	-4	-4	**-4**	-5	-5	-4	**-4**	-5	-4	-4	**-4**	-6	-6	-5	**-5**
K		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	64	65	64	**64**	64	65	65	**65**	64	64	64	**64**	62	62	63	**62**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	0	-1	0	**0**	0	0	-1	**-1**	-1	-1	-1	**-1**	-1	-1	-1	**-1**

8% OPTIMUM

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
CMY		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	62	63	63	**63**	63	64	63	**64**	63	62	62	**62**	61	62	61	**62**
	a	-4	-4	-3	**-4**	-4	-4	-4	**-4**	-4	-4	-4	**-4**	-4	-5	-4	**-4**
	b	-6	-6	-6	**-6**	-6	-6	-6	**-6**	-6	-6	-6	**-6**	-6	-6	-6	**-6**
K		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	63	64	64	**64**	65	66	65	**65**	63	61	62	**62**	63	62	62	**62**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	0	0	-1	**0**	-1	-1	-1	**-1**	-1	-1	-1	**-1**	-1	-1	-1	**-1**

8% INCREASED

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
CMY		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	60	61	61	**61**	60	60	60	**60**	59	60	60	**60**	58	58	59	**58**
	a	-3	-2	-2	**-3**	-3	-3	-3	**-3**	-4	-4	-4	**-4**	-5	-4	-5	**-5**
	b	-5	-5	-5	**-5**	-4	-5	-4	**-4**	-4	-5	-5	**-5**	-6	-6	-5	**-6**
K		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	60	61	60	**60**	60	60	61	**60**	59	60	59	**59**	58	57	58	**58**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	-1	0	-1	**-1**	-1	-1	-1	**-1**	-1	-1	-2	**-1**	-2	-2	-2	**-2**

12% REDUCED

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
CMY		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	65	65	66	**65**	65	65	65	**65**	65	65	64	**64**	63	64	64	**64**
	a	-4	-4	-4	**-4**	-4	-4	-4	**-4**	-4	-4	-4	**-4**	-5	-5	-5	**-5**
	b	-5	-5	-5	**-5**	-5	-5	-4	**-5**	-5	-5	-5	**-5**	-5	-5	-6	**-6**
K		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	64	63	64	**64**	65	64	64	**64**	63	63	64	**63**	61	61	63	**62**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	0	0	0	**0**	0	0	0	**0**	-1	-1	-1	**-1**	-1	-1	-1	**-1**

12% OPTIMUM

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
CMY		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	63	63	63	**63**	63	63	64	**63**	62	62	61	**62**	62	62	60	**61**
	a	-4	-4	-4	**-4**	-4	-4	-4	**-4**	-4	-4	-4	**-4**	-4	-4	-4	**-4**
	b	-6	-6	-6	**-6**	-6	-5	-5	**-5**	-5	-6	-6	**-6**	-6	-6	-6	**-6**
K		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	64	63	63	**63**	63	63	64	**63**	61	62	61	**61**	62	61	59	**61**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	0	0	0	**0**	0	0	-1	**0**	-1	-1	-1	**-1**	-1	-1	-1	**-1**

12% INCREASED

		BILT MATT				SAPPI MATT				BILT GLOSS				SAPPI GLOSS			
CMY		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	60	60	59	**60**	60	60	60	**60**	60	60	60	**60**	59	60	60	**59**
	a	-4	-4	-4	**-4**	-5	-5	-4	**-5**	-5	-5	-5	**-5**	-5	-5	-5	**-5**
	b	-6	-6	-5	**-6**	-5	-5	-5	**-5**	-5	-6	-5	**-5**	-5	-5	-5	**-5**
K		1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**	1	2	3	**AVG**
	L	60	59	58	**59**	58	58	59	**59**	59	58	58	**58**	57	58	57	**57**
	a	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	b	-1	-1	0	**0**	-1	-1	-1	**-1**	-1	-1	-1	**-1**	-1	-1	-1	**-1**

FOUNTAIN SOLUTION PRINTING PROBLEMS

- **Build-up on the rubber mat:** Attack on the paper coating from acidic dampening solution
- **Blank runs:** Coating on rollers, the rubber blanket, and the plate
- **Plate deterioration:** The printing layer is destroyed. The additives are too aggressive. Incorrect machine calibration.
- **Plate corrosion:** Plate oxidizes protection of the plates by means of additions is not sufficient. Over emulsifying pH-Balance is too high, too much water, the water is too soft, the additives are too high, the rollers are incorrectly adjusted, too much IPA, very little ink reduction.
- **Lathering:** Circulating detergent, operating performance too high, additives are foamier.
- **Poor drying:** pH-Balance too low, incorrect print substrate ink combination, pH-Balance of the substrate to be printed is too low
- **Poor Freewheeling:** pH-Balance is too high, the IPA is too low, plate protection is insufficient, roller calibration is incorrect, ink/dampening solution mixture is not correct
- **Slime, Odour:** An underdose of the additive, germ infested water, the formation of resistant bacteria.
- **Smearing:** Too little dampening solution, dampening solution no longer fit for use, contaminated, incorrect machine adjustment.
- **Spattering:** Overemulsification, incorrect balance of ink/dampening solution
- **Scumming:** pH-Balance too high, plate protection insufficient, plate poorly deployed, ink-guide set too high, deposits on the plate or rubber blanket, IPA too low, the ink/dampening solution balance is incorrect, tempering is incorrect
- **Tapered mullers:** Too little hydrophylic substance in the dampening solution, chromium is taking the ink.
- **Accretions:** Wrong mix, over-emulsification, pH-Balance too high, IPA too low.