A SYSTEMS APPROACH TO SOLVING LITHOGRAPHIC PROBLEMS

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Abstract: The lithographic system is complex and provides many opportunities for further understanding. The interactions that occur at the various roller and cylinder nips of the press and their effects on the final saleable print are important to this understanding.

The development and use of bench tests to predict press performance is the subject of this report.

The tests can require a modest investment in testing equipment. However, some tests can be run with basic equipment. Each individual test provides data that, when combined with previous historical data, other bench tests and sample history will lend direction to the solving of lithographic systems problems.

Introduction

The lithographic printing industry has made many advances in recent years. Significant improvements in press equipment, press design, and materials, including inks, dampener chemistry and systems, plates, papers and blankets are among the advances. This has provided an opportunity for the printer to improve both productivity and product quality.

A number of test procedures have been established over the years to characterize components used in the press system. Some of these procedures have provided parameters or guides for materials used in printing. Our laboratory has used a number of these tests to evaluate press room samples and to solve lithographic systems problems.

The goal of this testing is to help press room personnel solve day to day problems resulting from various adverse interactions that occur during the printing process.

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A typical press room usually has several materials in close proximity to the press. The use of these materials has provided temporary fixes to press problems. These include acids, caustics, organic solvents, cleaners and organic compounds. However, in many situations, applications of these materials can result in detrimental effects to the press system. This can result in reduced productivity, quality, and general overall frustration by the user.

Sources of Information

The interactions at the nips of the press are complex and usually more than one component of the press system may be interacting to produce an undesirable effect. Many lithographic raw material suppliers have a technical service group that can provide help in troubleshooting specific problems. The printer has the responsibility to the business to minimize adverse press interactions by seeking technical advice within the business or from outside suppliers.

Various graphic arts periodicals and publications contain articles about solving lithographic problems. They also have provided tables outlining cause and effect situations. Many monographs are available through vendors and technical associations who support the printing industry.

Many organizations also provide problem solving, technical and hands-on training courses to broaden the knowledge of lithographers.

One additional source of information is the inhouse laboratory. Some large printers do have this source since they formulate their own inks. Others need a small laboratory to insure the quality of the raw materials. However, the need for incoming quality inspection may decrease as U.S. industries employ Just In Time and total quality control techniques.

Testing Methods

No one testing method in most cases can provide adequate information in solving lithographic problems. Many test methods are available; however, the following methods have provided a broad range of information for solving lithographic press system problems.

Wear

Ink Wear (Sutherland Rub) Test

This test measures the abrasive characteristics of an ink with a lithographic plate. The ink, which is diluted to reduce its tack is added to a tray containing a sample plate. The Sutherland rub tester is run for a period of time using a weighted block with a felt pad in contact with the ink plate interface. The plate sample is then compared to a laboratory standard to determine the extent of image wear. Abrasive inks with either large or small particles (pigments, fillers, etc.) will wear the image area.

Fineness of Grind

This test describes the milling quality of an ink. This includes a measure of particle size, and number of large particles in an ink. ASTM[1] Procedure D1316-79 is the standard test method used for this procedure. Inks containing coarse pigment particles or undispersed agglomerates can cause piling or caking on press rollers, plates, and blankets. Sometimes they can cause wear of the plate image, filling in of halftones, and scumming.

The particles may be either hard or soft, depending on the ink formulation. Hard particles, in most cases, have a tendency to wear the image area of the plate. Also, nonimage wear could occur in some press situations. The test results, which are in tenths of one mil, are reported where 2, 4, and 10 scratches occur on the NPIRI production grindometer. The grindometer has two depressions which vary in depth from 0.0 to 1.0 mils. The higher the mil thickness number where scratches are present, the more granular the ink. It is important that the drawdown blade be held perpendicular to the grindometer surface during the drawdown procedure. Also, for most lithographic inks, the drawdown time should be in the 7-10 second range.

Grindometer Ranges

1.0 - .7 mil -- Indicates large particles
.7 - .4 mil -- Indicates medium size particles
.4 - 0 mil -- Indicates small particles

Tack

Dry Tack (Can Tack)

Tack is the force required to split an ink film between two surfaces. Tack affects the ability of an ink to trap or adhere to another ink on the printed surface. The tack is measured at a speed on the inkometer which should correspond to the consumer press speed. An electronic or mechanical inkometer can be used to measure tack.

Dry Tack Ranges

Dry tack at 1,200 rpm, 90° F

Web -- 7.4 - 18.7

Sheetfed -- 16.7 - 24.0

NOTE: The typical ranges discussed in this report were obtained from a wide variety of ink samples tested in Kodak laboratories.

Dry tack for newsprint inks is usually below 10.0 tack units at 1200 rpm. Dry tack can be measured at various inkometer speeds. The tack of an ink will increase with increasing roller speed. The rate of increase will vary with the rheological characteristics of the ink. The higher the temperature, the lower the tack number for a particular ink. If the dry tack is too low or too high, the following can be expected:

TOO LOW	TOO HIGH
Misting	Misting
Smudging	Low Ink Density
Image Spread	Blinding
Tinting	Paper Piling (Could result in wear of plate image)
Toning	Paper picking, tearing or splitting
Set-off	
Bleed-through	
Waterlogging of ink-snowflaking	
Excess emulsification of ink	
Mottling of solids	
Scumming	
Dot spread	

Tack Stability

The tack stability test provides additional information about the performance characteristics of an ink. The tack of an ink sample is monitored over a ten minute period using the mechanical or electronic inkometer. The tack stability curve can be described by the following illustration:

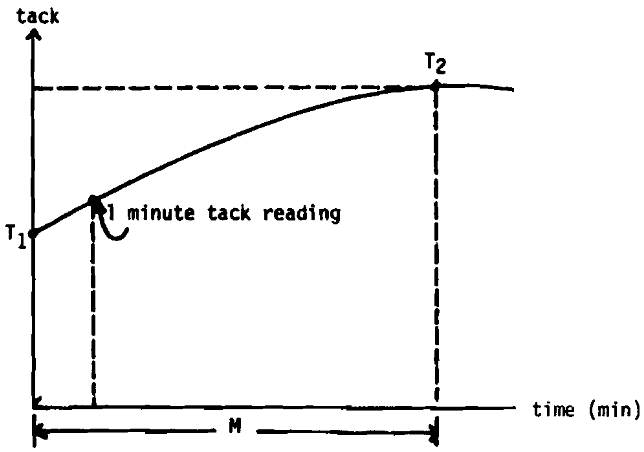


FIGURE 1 - TACK STABILITY CURVE

The tack rise (TR) value can be obtained from this curve by using the following relationship:

$$TR = \frac{T_2 - T_1}{M_1}$$

Where TR = Tack Rise
T_2 = Tack at Maximum Point
T_1 = Tack at Start
M_1 = Time Interval Between T_1 and T_2

Tack rise (TR) values for typical lithographic inks are as follows:

Web inks at 1200 rpm, 90°F	1.0 - 2.0
Sheetfed inks at 800 rpm, 90°F	0.5 - 1.5
News inks at 1200 rpm, 90°F	0.0 - 0.5

The tack rise values observed with web inks are due to the evaporation of solvents contained in these inks. This is part of the mechanism by which these inks "dry" on the printed sheet. Most web inks will reach their maximum tack within the ten minute period. The decrease in tack after the maximum is reached is due to the ink drying on the inkometer rollers. Process inks used on multicolor presses should provide tack stability curves which are parallel to one another for at least six minutes into the test (Figure 2). Those inks which have tack stability curves which cross one another before six minutes have a high probability of causing trapping problems on press (Figure 3).

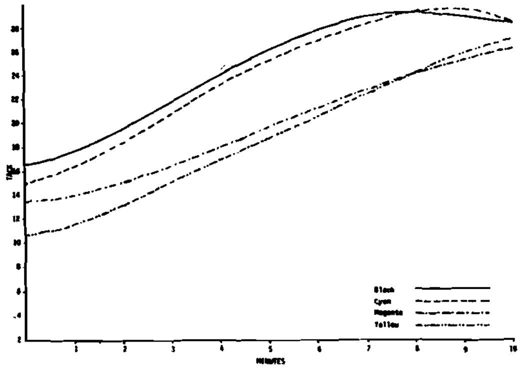


FIGURE 2 - GOOD TACK STABILITY

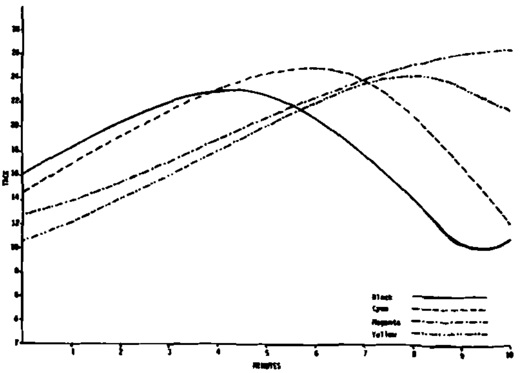


FIGURE 3 - POOR TACK STABILITY

Wet Tack (Press Tack/Emulsified Tack)

This is a measure of the tack of an ink which has been emulsified with dampener solution. The inks are emulsified using the standard method for emulsification.[2] Ink emulsified to the two minute point is used in the test. Wet tack should be higher (up to 10%) for an individual ink than dry tack at the same inkometer speed, with all other variables being equal. This is due to water acting as a pigment in the emulsified ink. In addition, the ink may reach the dry point sooner. Wet tack dry point of web inks is often lower in tack than with can tack. This is because the dampener solution is aiding the evaporation of ink solvents much like a steam distillation. This test provides more meaningful information as to what is actually going on in the press system, since one is working with emulsified inks rather than dry inks. A set of process inks should have similar water takeup values in order to insure the same relationship between the stability curve of each ink.

Wet tack values are very dependent on the amount of surface water on the inkometer rollers. Surface water will result in a low number due to roller slippage. This can be reduced by using inks which have not been emulsified to the equilibrium point in the mix emulsification test. Again, correlations can be made with process inks for multicolor presses by comparing the tack stability of these emulsified inks.

Emulsification

Ink Emulsification Mix[2]

This test measures the water takeup rate and capacity of an ink. This is shown in Figure 4. The (a) parameter is a measure of the rate of water takeup, and the (b) parameter is a measure of the amount of water takeup. A good ink-dampener solution combination will reach equilibrium (zero slope) at or near the curve showing excellent ink/water balance. This ink-dampener solution combination will work with a wide variety of press conditions (i.e. wide press latitude). The further away a particular ink-dampener solution emulsification curve is from the excellent curve, the narrower the press latitude (i.e. the smaller number of press conditions in which the particular ink-dampener solution combination will produce acceptable prints).

INK EMULSIFICATION TEST (MIX)

Sample____

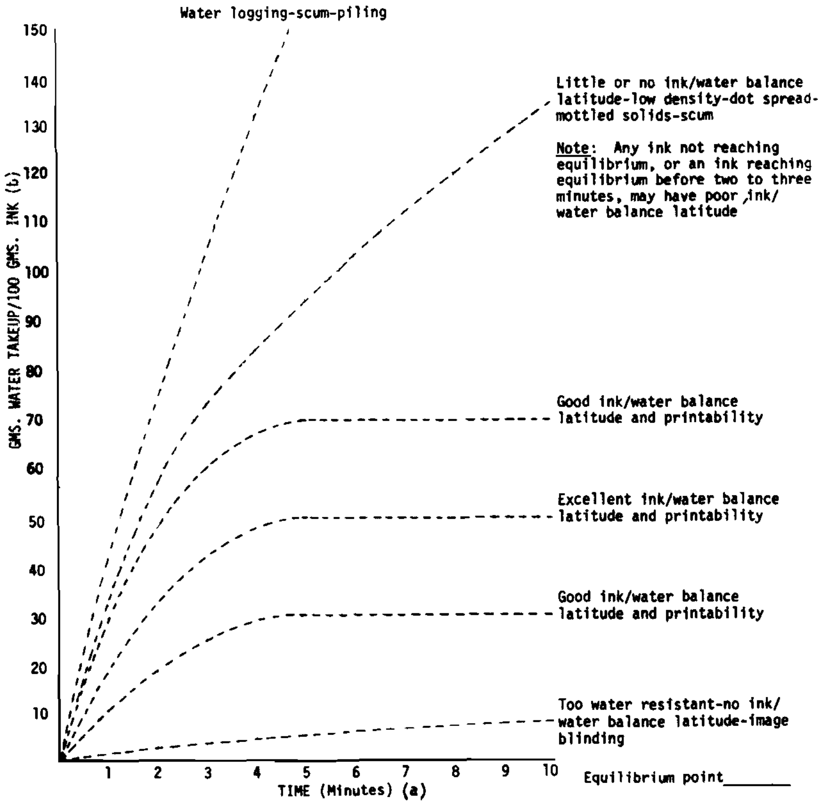
Solution__________________________________By____________Date______________

________oz/gal ________water   Alcohol concentration _________%

pH before _______ pH after _______ Δ _______

Conductivity before______μMHO after_____μMHO Δ ______

Pigment Bleeding____________ Ink in Water Emulsification ____________________



Equilibrium point_______

FIGURE 4 - MIX EMULSIFICATION DATA SHEET

The pH and conductivity values of the dampener solution are recorded throughout the test. This provides information about the ink-dampener solution compatability. Components leaching out of the ink into the dampener solution can cause scumming. The pH and/or conductivity of the dampener solution may be altered and result in reduced protection to the nonimage area of the plate. When the mix emulsification curve is significantly above the excellent curve, the following may occur:

Reduced density	Tinting
Water logging	Scumming
Mottled solids	Ink piling and caking
Dot spread	

When the mix emulsification curve is significantly below the excellent curve, the following may occur:

Reduced density	Image blinding
Mottled solids	Snowflaking
Dot sharpening	Stripping (roller)
Scumming	

Ink Emulsification Shake

This test also provides a measure of ink-dampener solution compatability. Emulsification shake ranges for the test are as follows and are shown in Figure 5:

Emulsification	Rating
None/Very Slight	Good
Some	Satisfactory
Moderate	Poor
Excessive	Unsatisfactory

The results are subjective, but do provide a quick determination of ink-dampener solution compatability. A printing ink must not form an "ink-in-water" emulsion. Therefore, any breakdown in the ink (scum, discoloration, ink particles, etc. in the dampener solution) can contribute to plate sensitivity. Water resistant inks, although potentially troublesome, may test "good" in this test.

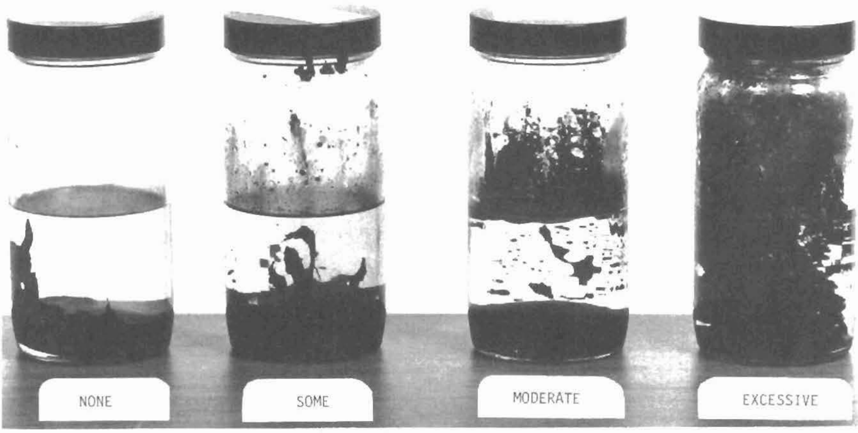


FIGURE 5 - SHAKE EMULSIFICATION TEST EXAMPLES

Viscosity

Viscosity is the measure of the internal friction of an ink. Viscosity indicates the resistance to flow of an ink and can be defined as the ratio of shear stress to shear rate. ASTM D4040-81 "Viscosity of Printing Inks and Vehicles by the Falling Rod Viscometer"[1] is the method used to measure viscosity using the Laray viscometer.

<u>Viscosity Ranges</u>

Web	64-305 poise
Sheetfed	190-485 poise

The following can be expected on press if the viscosity is too low or too high:

TOO LOW	TOO HIGH
Misting	Slow roll-up
Smudging	Possible blinding
Scumming	Mottling of solids
Filled in halftones	Ink caking and piling (on rollers, blanket and plate)
Bleeding (tinting)	Paper picking
Mottling of solids	

Shortness Ratio

This value describes a flow characteristic of an ink as indicated in the following relationship:

$$SR = \frac{\text{yield value}}{\text{viscosity}}$$

Yield value = minimum shear stress to get an ink moving.

Typical values for web offset inks are as follows:

Average ink	--	10-15
Long ink	--	5
Short ink	--	20

Short Ink

With inks of small pigment particle size, and therefore with relatively high surface area, the following can be expected on press:

- Dot sharpening
- Blinding
- Plate wear due to lack of ink lubrication

Long Ink

With inks of large pigment particle size, and therefore, with relatively low surface area, the following can be expected on press:

Misting

Plugged halftones

Excessive dot gain

Ink Film Thickness

An ink film thickness gauge can be used to measure the ink film thickness on a press. The thickness of ink films in lithographic printing is important. The thicker the ink film on the printed sheet, the longer the drying time, and the greater the likelihood of setoff. An ink film thickness gauge enables the press operator to check the amount of ink being carried by the inking system. It provides precise control of printed ink density and color.

When an offset press is adjusted for good printing, the ink film thickness is usually about 0.25 to 0.60 mil at the form rollers. If the ink density on the sheets is low while the ink film thickness is 0.60 mil or more, it may indicate a piling condition. Such a condition might be due to too much water emulsified in the ink or the ink may have poor transfer characteristics. Another problem detected by ink film thickness is setoff which is due to an overly thick ink film ($>$0.60 mil). Low ink film thickness can cause plate wear by not providing adequate lubrication for the plate.

Ink Staining Test

Inks may contain pigments or additives which are water or alcohol soluble, resulting in the presence of these components in the dampener solution. This may lead to staining or toning of the nonimage area of a lithographic plate. A stained background may become ink receptive causing scumming on the printed sheet.

The ability of an ink to stain the nonimage area of a plate and whether the stain is ink receptive or not is determined with this test. A sample of the subject ink is applied to the nonimage area of a lithographic plate with a Brayer roller. The plate is subjected to specific time and temperature conditions. The excess ink is then cleaned off with a common ink solvent. A visual examination is made and the plate is treated with rub-up ink to determine ink receptivity in the nonimage area.

Paper/Moisture Resistance

Dampening moisture on plates and blankets can sometimes loosen fibers or soften coating adhesives on the paper surface to the extent that fibers or coating are picked up and pile or build on the nonprinting areas of the blanket.

Lack of sufficient moisture resistance for both coated and uncoated papers can lead to lifting of coating and/or fibers from the surface of the paper. This can lead to blanket piling which could result in plate scumming and plate image and nonimage wear.

Paper Scumming

This measures the contribution of a paper to sensitivity. The paper is moistened with demineralized water and placed in contact with the nonimage area of a clean plate. The area is then treated with rub-up ink to determine ink receptivity. The unknown paper is compared with a paper whose scumming tendency is known, and its relative scumming tendency is determined. A comparison of inks and dampener solutions is also possible.

Paper pH

This is a measure of the hydrogen ion concentration of a slurry of paper in demineralized water, expressed in terms of pH value.

The low paper pH (less than 4.8) can cause ink drying problems; if too low, it can possibly contribute to sensitivity by altering fountain solution pH. A higher paper pH (for example, a pH of 7 or above) can neutralize the acid in a dampener solution, making it difficult to maintain at a level of weak acidity.

Ink Absorptivity

This is a measure of the ink absorbing characteristics and uniformity of absorbency of a paper or paper coating. The subject paper is smeared with the test ink. The ink density is measured with a densitometer. The absorptivity of the paper is then calculated.

A paper that is too absorbent may not produce a desirable printed density. A paper that is not absorbent enough may experience ink drying problems. An uneven absorbency can create a mottled solid in the print.

Analytical Testing

Analysis of samples can provide additional information in problem solving in lithographic systems. The most commonly used techniques include instrumental analysis and microscopy.

Instrumental methods are available including x-ray diffraction, x-ray fluorescence, elemental analysis, infrared analysis (FTIR) and UV analysis, which will characterize the chemical structure of materials.

Microscopy, including SEM, TEM and optical methods, is a method used to produce magnified images of objects. These methods are used to evaluate surfaces including plates, paper, blankets, and ink train rollers. The presence of foreign matter in the press system can ruin a printed job and microscopy is a valuable method in detecting these materials.

The methods described use both sophisticated and expensive equipment which one would not find in even the largest of printing manufacturers. Many metropolitan areas have laboratories in which these tests can be run.

Solution of Systems Problems

The following examples illustrate the information that can be obtained in the evaluation of press room samples. All are typical examples of press room problems which require a variety of tests to reach a general conclusion as to the cause. In some cases the exact cause of a problem may not be pinpointed. However, in most cases, direction can be given to allow the printer to troubleshoot a problem area which results in a solution.

Case No. 1

Problem: A consumer experienced a severe wear problem on a lithographic plate.

Conditions: Four color press, continuous dampening system, coated paper.

Tests: Fineness of grind, Sutherland rub, Microscopy.

Results: The inks (samples from the can and ink fountain) were acceptable for grind and exhibited low wear ratings on the Sutherland rub test. Photomicrographs of the plate, blanket, shop rags, printed paper, tape pulls from the form roller and air filters were taken. The analysis of these photomicrographs showed the presence of iron particles imbedded in the plate, blanket, paper and form rollers. The source of iron was traced to shop rags which had been recycled. They were previously used by a machine shop. The consumer had recently changed suppliers as a cost savings measure. The following pictures illustrate the problem encountered by the consumer.

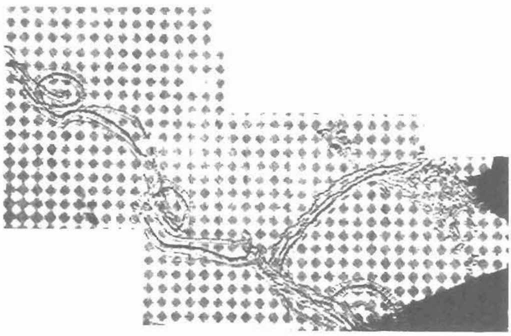


FIGURE 6 - PLATE

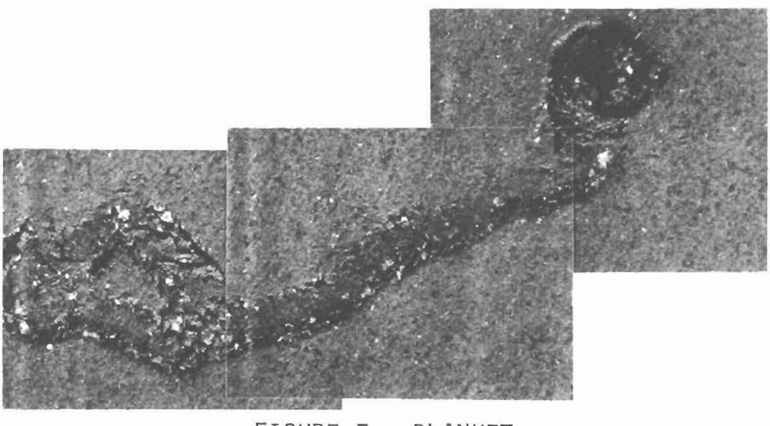


FIGURE 7 - BLANKET

Case No. 2

Problem: A consumer experienced a sensitivity (scumming) problem.

Conditions: Single color sheetfed press, 1/2 oz. of concentrate plus one oz. gum/gal., no alcohol, continuous dampening system.

Tests: Dry tack, viscosity, shake and mix emulsification, staining test.

Results: Both dry tack 16.0 and viscosity 144 poise were lower than expected for a sheetfed press. Unless the press speed is high (8000 IPH), low tack and low viscosity inks could lead to scumming problems. The ink produced a stain in the nonimage area of a test plate and was found to be ink receptive.

Considerable ink-in-water emulsification was observed on the shake emulsification test.

High water takeup by the ink was observed on the mix emulsification test indicating a narrow ink-water balance range on press. Addition of isopropyl alcohol at a 20% concentration improved the ink-water balance. Also, the addition of isopropyl alcohol eliminated ink-in-water emulsification. The pH of the dampener solution decreased from 5.16 to 4.26 indicating leaching of components from the ink.

The conductivity of the dampener solution was low indicating the use of demineralized or distilled water. This may be the reason why the consumer only used 1/2 ounce of dampener concentrate.

The recommendation to the consumer included addition of 15-20% isopropyl alcohol to the dampener solution. Consideration should be given for the addition of a buffering agent (sodium bicarbonate) to the dampener solution so that the amount of concentrate added can be increased. It should be noted that the consumer was trying to use a web ink for the printing job.

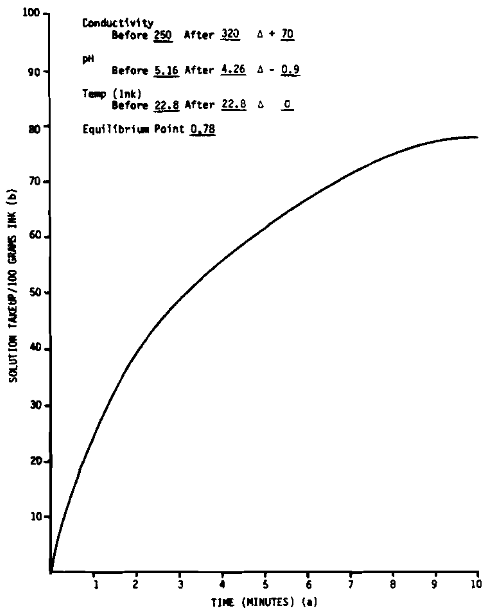


FIGURE 8 - BEFORE ADDING IPA

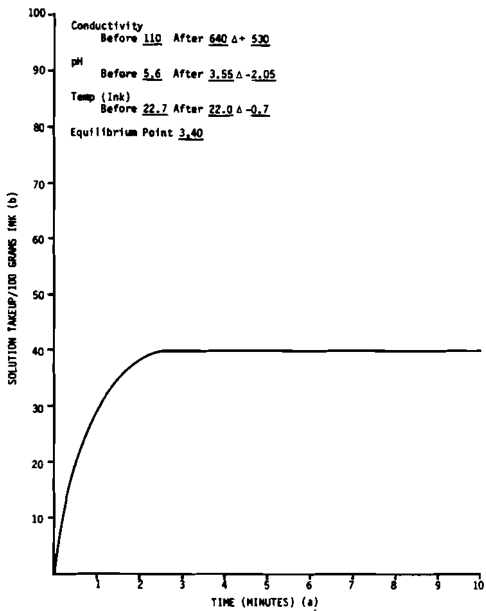


FIGURE 9 - AFTER ADDING IPA

Case No. 3

Problem: A background sensitivity problem with the magenta plate experienced by the consumer.

Conditions: Six color sheetfed press, continuous dampening coated paper 1 oz. concentrate + 1 oz. gum arabic, pH 4.5, 25% IPA.

Tests: Wear, dry tack, viscosity, mix and shake emulsification, staining.

Both magenta inks were the same formulation except one contained an additive to improve scratch resistance.

Results: The viscosity, dry tack and wear characteristics were normal for both inks.

The ink additive affected the ink emulsification curve considerably resulting in reduced lithographic latitude. Figure 10 is the magenta ink without the ink additive, and Figure 11 with the anti-scuffing additive. The ink continues to take up dampener solution through the eight minute point in the test. The initial water resistance would cause difficulty in establishing and maintaining ink-water balance on press. The press operator may need to reduce water feed or increase ink feed to overcome excess surface water. This could result in the scumming problem encountered by the consumer.

Severe pigment bleeding was observed with both inks as well as a considerable rise in dampener solution pH (+ 2.13 pH units). Pigment bleeding in the dampener solution can cause plate background tinting or toning, especially with long press runs. Components which leach out of the ink into the dampener solution that cause significant pH changes could lead to precipitation of gums or other materials re ulting in poor protection of the nonimage area.

A more compatible ink-dampener solution combination was recommended.

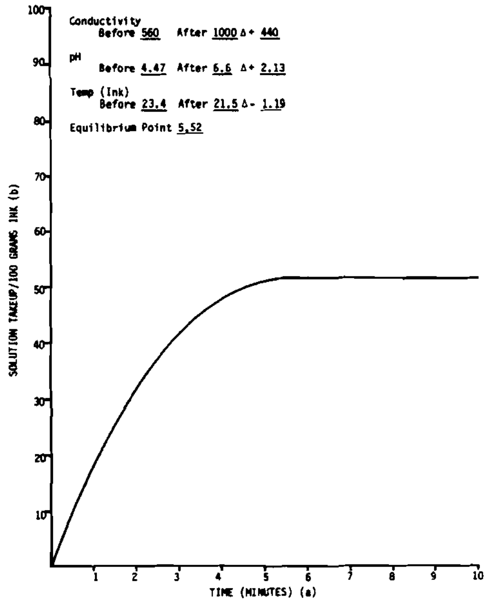


FIGURE 10 - MAGENTA INK WITHOUT ADDITIVE

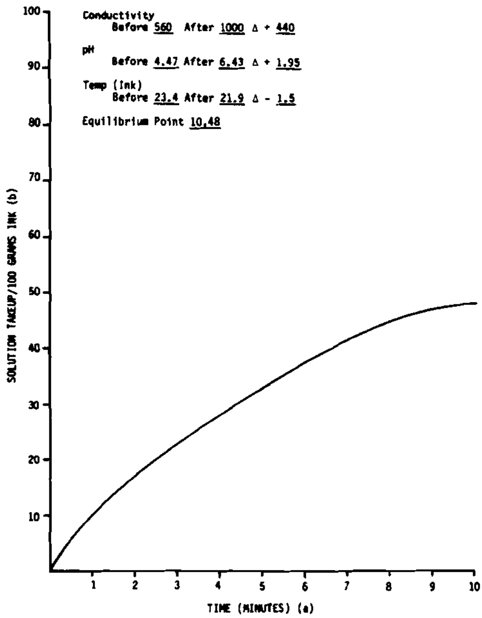


FIGURE 11 - MAGENTA INK WITH ADDITIVE

Case No. 4

Problem: The consumer experienced a blinding (trapping) problem on press.

Conditions: Five color web, black, cyan, magenta, yellow, coated paper.

Tests: Microscopy, dry tack stability, emulsion tack stability, mix emulsification.

Results: No foreign materials were found by Microscopy Techniques. Examination of the press sheets revealed a trapping problem especially with the magenta printer. The inks did not appear to be tack graded as shown by the following illustrations.

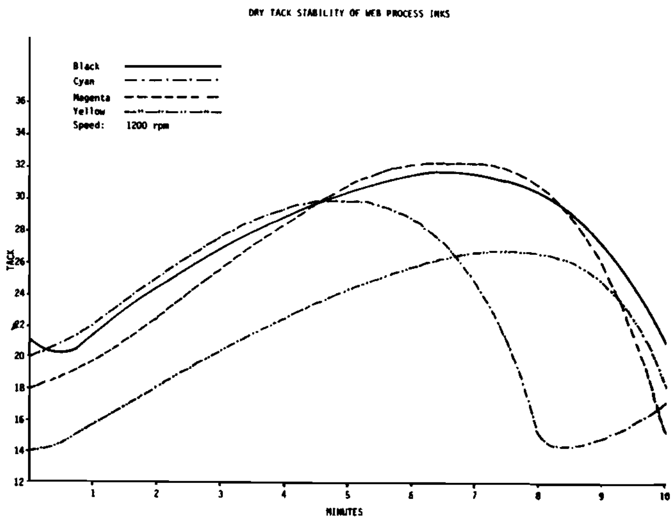


FIGURE 12 - DRY TACK STABILITY CURVES

Figure 12 shows the dry tack stability curves for the process inks. The black, cyan and magenta inks have the same tack at 4-1/2 minutes into the test. Trapping problems can be expected on press due to the poor stability of these inks.

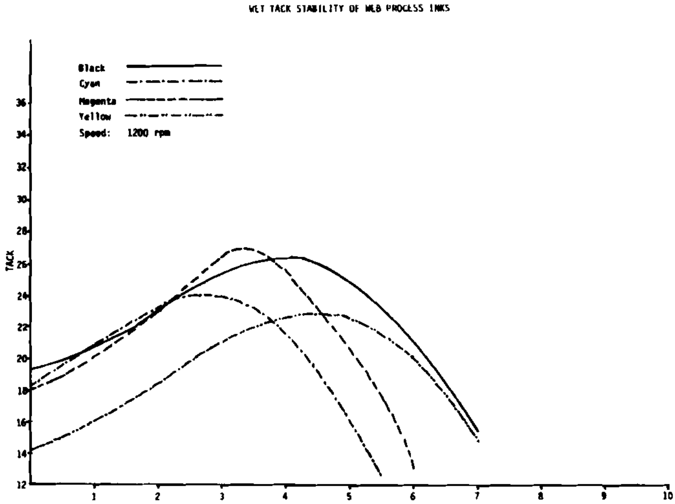


FIGURE 13 - WET TACK STABILITY CURVES

Figure 13 shows the same inks, however, they were emulsified with the consumer dampener solution using the mix emulsification technique. Again, the tack curves of the black, cyan and magenta inks cross one another indicating that potential trapping problems would exist with these inks.

An improvement in the tack grading of these inks is necessary in order to eliminate the trapping problem.

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1) The American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

2) Surland, A., "A Laboratory Test Method for Prediction of Lithographic Ink Performance", T.A.G.A. Thirty-Second Conference May 4-7, 1980.