Computerized Process Color Measurement

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Abstract

This paper illustrates how measuring technology can be used to streamline production stages for process color. From Scanner through press, when parts of the process do not fit, there is a price to pay at the press stage. The price is not only dollars, but compromises of color quality.

Measuring that was once prohibitively expensive in terms of production time and salaries for highly qualified research personnel, is now within the grasp of most process color production operations. Computerization that makes use of densitometer readings formerly 'used once and thrown away' opens the door to practical color measuring.

The computerized measuring system, like the genie of the magic lantern, is capable of numerous possibilities. The trick will now be to choose the ones that improve quality while reducing cost of production.

Using computerized measuring technology as a tool, there is hope of arriving at a consistently predictable color production process. When that happens, something else is possible. The exciting possibility of controlling the color process at the initial prepress stage exists. That is not just controlling the prepress stage; but controlling the whole process at the prepress stage.

Based on the premise that 'what you can't see don't get fixed', this paper proposes using computerized measuring to 'line up' each stage of production to fit properly in the whole process. Because that may be a big bite to start with, the paper also suggests some less comprehensive applications that would be good starting choices for putting measuring technology to work.

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INTRODUCTION:
This paper begins with definitions of the basic terms used. The impact of computerized color measurement on the graphic arts process color printing industry is the basis of the discussion. Some present and future applications for color measuring are explained. Finally, rationale for top driven stable printing system is detailed.

DEFINITION OF TERMS:
These definitions apply to the meanings of terms as they are used in this paper. They are not intended to be a glossary of terms for the printing industry. Remarks are based on my experience and observations with wide band densitometry. However, because it is the output of measuring systems and how they are used that is significant, the principles of computerized color measurement should apply to alternate input devices.

Computerized (color) measuring:
Refers to density measurements that are managed by some level of computer processing. There are several levels of computerized assistance that depend on the instrument or system used to do the density readings.

1. Stand alone densitometer hand held
2. Calculating densitometer
3. Calculating densitometer with output to printer
4. Densitometer with output to computer analysis system

This chart represents the amount of assistance each type of device gives:

	1	2	3	4
calculations	manual	auto	auto	auto
sheet report	manual	manual	auto	auto
filing/retrieving	manual	manual	manual	auto
sorting/gathering	manual	manual	manual	auto
statistic reports	manual	manual	manual	auto

Full use of color measurements:
Full use for densitometer measurements involves many

operations. To start, three color filter readings are being used, not just the major filter. In addition to noting the three filter readings, the raw density numbers are used in calculations of print characteristics. Taking it further, the density readings and/or their print characteristic calculations are recorded. These are stored, not just as numbers, but annotated to indicate any significant circumstance attached to the measurement. The information does not just lie dormant in a storage drawer. It is sorted out, and the results charted so it can be understood. The charts are studied and conclusions drawn, then tested.

Full analysis system:

A full analysis system is a computer attached to a densitometer which reports on two levels. The first level represents an indepth look at a single piece of printing material. First level is capable of giving an on the spot report which includes a wide variety of print measurements such as dot gain, hue error primary and secondary, saturation, grayness, trap, etc. The second level is more powerful. It uses stored density numbers to generate historical overview analysis for the same print characteristics. And it allows the stored measurements to be sorted in ways such as paper type, blanket, press and other criteria.

At the present, while full information is presented, decisions about it are left to individuals. Future full analysis systems will provide expert knowledge and assistance as part of the computer program.

Press system:

The press system as opposed to the press alone is the collection of the press used, with its settings and pressures, the fountain solution, the ink, the blankets/packing combination, the paper, the plate, the plate processing, the film and the film processing etc. In short, the combination of all production factors that affects the final printed sheet is the press system.

Multivariate data factors:

"Multivariate data is a set of data that each have a number of independent variables." (see MIPS credit) In graphic arts we deal with multivariate data every press run. The factors described in the definition of 'press system' above are all variables. The collection of them represent multivariate data. For instance, if dot gain is measured at 18%, the factors that cause it are independent variables. Statistics

for dot gain represent a multivariate data factors.

Top driven control:

Use of powerful workstation and scanner capability to make process color decisions which hold true throughout a stable production process.

WHY FULL USE OF COLOR MEASUREMENT HAS BEEN EXPENSIVE:

After the button push to take the density reading, the time expense of full measurement use occurs at these operations:

Recording and identifying the density number
Calculations made from density measurement
Filing and retrieving the data
Sorting and choosing information for reports
Reporting, plotting, graphing the data

The expense involved in measurement use is the expense of the man hours required. Over time, the original investment in the measuring instrument becomes a small percentage of the total cost of using it. The more man hours required by an analysis report, the higher the cost of that report. This is further complicated since many of the manual operations must be done by a highly experienced professional. Therefore, any of the measurement operations that can be done by a microprocessor or computer will reduce the cost of using the original measurement.

Picture what 'full use' would cost the industry before computerized color measurements was available. The pressman, or somebody else would press the densitometer to take the reading. Then they would put the densitometer down and pick up a pencil. After locating the paper and the right place on the paper, they would have to write the number down. By that time, they might have to look back to the densitometer to verify it. The filters or the view window image would have to be rotated so that the three filtered readings could be seen. These would also be written down. When another press run was started, a new piece of paper identifying it would be started. In time there would be dozens of these papers. Someone would have had to take the density numbers and do calculations on them. Dot gain, hue error, grayness are all calculations of the original density numbers. When dozens of density numbers had been converted to hundreds of calculations on piles of papers, there would be too many numbers for any pattern to become apparent. The numbers would need to be arranged in some meaningful order. Only then could managers of the production facility could use the information to cut costs of operation, getting to quality

more directly.

Adding computerization to process color measurement assigns the clerical functions of full use to a machine well suited for it. Computers calculate, file and report with less expense, more quickly and more accurately. Experienced printing personnel are better suited to thinking about the information and using it as the basis of sound management production decisions.

Measurement instruments/systems vary in power to manage density readings. (Note the chart defining computerized color measuring in the definition section.) Hand held densitometers with no internal microprocessors become time intensive instruments when density readings are collected, calculated, compiled and plotted. Calculating densitometers can handle the number mathematics with sequences of button pushes. This reduces man hours required for analysis reports. If they are attached to printers, it will not be necessary to write down the calculations. That is a further time saving. However, to analyze several calculations for several jobs does require compiling and rewriting the numbers to a single sheet. The larger the number of press sheets measured, the larger the collection of isolated printer slips, and the more time required to make a compiled report, if they are done manually.

THE IMPACT OF COMPUTERIZED COLOR MEASUREMENT:

Computerization of process color measurement lowers the cost of getting and using color measurement in the graphic art industry. This makes widespread reports on large amounts of measurements possible. The increase in availability of color measurement impacts the industry's ability to notice, see and control process color production. With increased ability to control, less time/expense is involved in reaching previous quality levels of product. Or less or equal time/expense is involved in reaching higher quality levels of product.

In the past many process color operations could not afford full use of density measurements. Adding computer power to densitometer operation can and has changed that. Because the computer grabs the major density number along with minor color filter densities, calculates them and prints out the results, there is a lot of punch for the effort. Printing operations have been pressing densitometer buttons for some time at various parts of the plant. For press sheets, a single density number is commonly used. However, George

Leyda has made the point that computerized measuring takes a few densitometer button presses and gives back a large amount of information for the same price of getting just one number.

WHAT ARE THE NEW POSSIBILITIES?

Notes:
Computerized analysis systems have the potential to inform about almost every stage of the printing production cycle. Whether the purpose is to observe and study, or to monitor and control, computerized measuring systems have the ability to 'read' color bars on most of the graphic art materials. The potential is there to observe and control almost any production stage.

In process color production, a misfit of one stage causes grief at the next, and always at the last stage, the press run. Because computerized measuring notices what, in the heat of production we cant, and then remembers it, making each production stage fit properly to the next is a natural use of the technology.

Because computerized measuring systems easily express color as a set of print characteristic numbers, they are also a natural for communication tool between any two knowledgeable people talking about the color. And it is not as difficult to understand print characteristic numbers as it may seem. People in the printing industry have an understanding of what happens at their particular production stage. Each stage is talked about in terms familiar to the industry. What is new, is expressing what is happening in terms of numbers rather than words. However, by comparing what the eye sees to print characteristic numbers, the numbers take on the same meaning as the less precise words previously used. Computerized communication between locations and between cooperating companies is also there. In the future, communication may extend backwards of production through the publisher, agency, and photographer. With enough familiarization of printing measurements, even the customer may be drawn into the communication cycle.

In summary, there are two basic ways of using computerized color measuring in the graphic arts production cycle:

1. Control the entire production cycle
2. Control selected portions of the cycle

CONTROL SELECTED PORTIONS OF THE COLOR PRODUCTION CYCLE:

Notes:
It's nice to say that computerization of measurement has the potential to line up all production phases, and to communicate between each department, and each stage of the whole industry. It does have this potential. But actually doing it takes a lot of working out. Instruments, department procedure, programming, management philosophy, anxiety levels and phone lines are just a few of the things that must be in the same state of readiness before a mature use of measurement for communication will arrive.

The logistics of controlling an entire graphic arts production plant using computerized measuring as a tool can be overwhelming. To an operation just beginning to incorporate serious measurement into their system, it is a good idea to pick one place to start. It is like the old story about not serving the whole cow at one meal. Eating it a hamburger at a time is more reasonable.

Monitoring proofing systems, press checks, extensive press monitoring, troubleshooting sheetfed makeready, inspection of incoming materials, backing up completed jobs have all been applications of computerized measuring. The following list that describe uses for selected portions of production have all been done by operations using computerized measuring.

MONITOR PROOFING SYSTEM OUTPUT:
Color targets are proofed along with each proof sheet. Targets that include microline are useful for determining the effect of correct processing (exposure, film orientation, etc.) Targets that include quarter tone, mid tone and three quarter tone dots are useful in determining variations caused by density variations. The targets are identified by date, and exposure frame. They are collected by the computerized analysis system. Overview reports from this data can pin down if there has been a change in the proofing system over time. The reports will show whether any changes are drifting one way or the other. Once, I was told a proofing system had been drifting in color for the past two months. The first step in troubleshooting was to pull statistical reports for the proofs done for the last several months. The report showed there was no drift. That helped in more than one ways. It saved us time chasing down a blind alley trying to correct a drift that was not there. And it allowed us to look in

other areas immediately. Later, it was discovered that what looked like a color change in the proof was really a step plate system that occasionally misfired.

MONITOR SCANNER/CONTACT FILM:
A target placed on film during contacting can verify over time the consistency of a proofing frame/light system. Scanner linearization scales can be read into the computer. An on the spot report can show variation in the dot size from the standard. Over time, a statistical report can show if there is a trend to the dot variations.

EVALUATE INCOMING MATERIALS:
Once standards are set for the film, proofing and other materials use in process color production, the first material used from a new shipment can be checked. It would be convenient if there were a way to check the material without using it. However, most film, proofing materials, and plates do not show their performance till they are processed normally. If a check on a new box of material shows an unacceptable variation, it will also be necessary to verify the process it went through. The process is part of the final product. Film that is flopped will show excessive dot gain that is not due to the product, for instance.

EVALUATE NEW PRODUCTS:
Any product used in process color production has its own inherent quality level, and a level it can reach used with the rest of the plants system. The question for new material is what level will it reach used with the existing system. And, if changing the existing system will improve the products performance, how does that balance against the cost of making the changes? Computerized measuring makes it possible to evaluate the new product more accurately. There are two reasons. First, for a one time check, computerized measuring gives an objective, comprehensive report. Second, we all know that one time checks may not tell the whole story. Evaluating new products by checking many samples, and doing this over more than a single instance gives a more complete picture of the effect of the product. As with any testing, insuring that the new product is the only thing changed also allows more accurate test results.

INPLANT 'SCANNER TO PRESS' AUDITS:
A printing/scanning operation can keep a set of test film ready for press. Current scanner generated items can be restripped at each repeated audit, so that the audit will

reflect current scanner conditions. Computerized measuring can assist in gathering the information from the film, proof and press sheets. The computerized reports give quick feedback about the characteristics of the whole production system. A full analysis system capable of doing statistical reports for a good group of press sheets will be very useful in looking at the press run as a whole.

ONE JOB AUDIT FOR COMMUNICATION/DISCUSSION:
When the proof does not match the press sheet, or the other way around, it can become important to find out why. A computerized analysis system gives a large amount of comparative information. Comparing an indepth report for the proof to one for the press sheet, things often become clear that are not obvious to the observer's eye.

SALES TOOL:
With the viewpoint that a computerized measuring tool helps make things in production fit, the presence of such a tool has been used as one indicator of a quality minded operation. In many cases, the sight of the system has been enough to present that image. As customers of graphic arts companies become increasingly sophisticated in color measurement, they may begin to ask how the tool is used to bring about quality.

PREDICT INCOMING SEPARATION FILM PERFORMANCE AT PRESS:
If a printing operation knows the density/dotgain performance of their presses, and the colors of their inks, the proofs accompanying incoming film can be used as a starting point for evaluation. Density higher or lower than press standards flags a problem. Differing hue colors also flag a problem. The problem of proofs that are not made by the accompanying film is more difficult, and computerized measuring does not have a way to help there yet. Depending on the turnaround time of the operation, flagged problems trigger reproofing and/or film correction. Or, if there is not time, the data collected stands to help explain any questions that may result after printing. Better information is available if both the proof and press sheet have color targets with some dot tints, and overprints as well as solid colors. When proofs come in with color bars that contain tints, better information about dot gain is gained when there is clear communication between the sender and the receiving company about the film dot sizes on the target. If a proofed target looks like it should be a 50%, but the film that made the target on the proof was really 47%, then the report will show an extra 3% dot gain that is

really not there.

COMPUTERIZED SWOP REPORTS:
SWOP inspections forms are another application for computerized measuring users. The computerized system calculates density deviations from HI and LO, as well as total tonal density of the films. It produces a neatly printed report. And, if questions arise, the system provides a wide range of print characteristics reports.

TROUBLESHOOT SHEETFED MAKEREADY:
A very enterprising printing company discovered that is could do difficult makeready faster by stopping to do computerized measuring. I asked them why they were taking the time. I was told that because they got a comprehensive report on the present condition of the makeready, it was possible to reset all four ink colors with some degree of accuracy. Aside from makeready, for mysterious press problems, the reports showed the effect of diagnostic changes so clearly, that it greatly shortened the time to pin down press problems.

TRACK PRESS PERFORMANCE:

To set standards:
For an operation wanting to set tight quality standards, how can these be done without knowing what is normal for the press system. If a press normally varies in density +.06 and -.06, (that is if no one touches the ink fountain) trying to set density variation standards tighter means fighting uphill all the time. The tighter standards selected without information about the normal operation of the press could have opposite results. SPC experts tell us not to try correct for normal variation. Corrections to normal variation tend to over correct and make the situation worse than if nothing is done. Using computerized measuring to study a press over time is a good basis for beginning to set press standards.

To check production stability:
Once standards are established, computerized measuring allows frequent monitoring.

To evaluate/predict the need for press maintenance:
One web operation saw that dollars spent for remachining one of their cylinders had been well spent. Computerized plots clearly showed sharpening of the dot gain starting on the day the press resumed printing. Press maintenance costs in

down time and service can be based on observing how the press performs. Machinery gradually loses its ability to hold to specifications. By observing the press performance over a period of time, managers can become familiar with how reports look when the press is printing at top level. As the press performance diminishes, the reports will reflect that. Management decisions about when to pull maintenance based on the information can avoid the two pitfalls of doing it too early or doing it too late.

FINGERPRINT THE PRESS:

Audit vs fingerprint:

"Fingerprint the press" has become a popular phrase. Unfortunately, this may mean "run a test form and measure a few press sheets and once should do it". Doesn't. That is more like an audit. A one time test run for a press no more fingerprints the press than a single snapshot of your golf swing characterizes it. Both the press and my golf swing have a wide range of performance. Neither of use appear the same at the beginning of the run/swing as we do at the middle and end. Variation from day to day, and from beginning to end of the run is a fact of life. If "fingerprint" is to mean "identify" for a press as it does for people, more than a one time measurement is required. Taking the snapshot analogy farther, a movie would give a better picture of a golf swing than a single picture. A movie is made up a hundreds maybe thousands of snapshots taken in sequence. A movie with a plot combines sequence over sequence till watching the movie carries a message. Fingerprinting the press should follow the same idea. Test the press completely using a test form. Measure various stages of the run. Measure several sheets from each stage. Each sheet amounts to a snapshot. Use computerized measuring to create a report that combines all the measurements from the test run into a statistical report. That is like one sequence from a movie. Next, choose a press target small enough to run on the press daily. The small target will represent in abbreviated form the data from the large press test form. Measure press sheets daily over time. Every press run has the potential to be a test. There is a subtle advantage to doing this. When the big test form is run, it is just that...a test. We all know things happen a little differently for a test than they do during daily production. Measurements taken from daily production represent daily production. Using computerized measuring, produce statistical reports from press measurements taken over a long period of time. The identity

of the press will show up more accurately with that report. The report will give the whole story, just as a feature movie made up of thousands of snapshots organized into collections of scenes does.

CONTROL ENTIRE PRODUCTION CYCLE OF PROCESS COLOR:

Notes:
Because computerized measuring makes it possible to observe and control many of the production steps for process color printing, it becomes the tool that can make it possible to fit the steps together successfully. Failure to fit production steps correctly means that at the most expensive, and least flexible phase of production, the press, things are twisted back in an attempt to correct the misfit.

If we were to go to a skilled tailor and ask for a well fitting custom suit, the first thing he would do would be to get out a measuring tape. He measures, and then uses his skill to make the suit fit those measurements. Recent technology has given us skilled separation film systems. However, unlike the skilled tailor, operators at those powerful workstations do not know the measurements of the press that will use their work.

CONCEPTS:

Computerized measuring is a tool like a pair of glasses:

With the many benefits of a computerized measuring system, the big thing that it does is enhance our ability to see our production process and our production product. It acts somewhat like a pair of glasses. It can snap things into focus. There is a two fold operation to this pair of glasses. One operation is similar to a 90 power magnifying scope that lets us see things invisible to unaided vision. On the other hand, it also acts like a pair of binoculars used from a tall building to get an overview.

The Press is a system, not a machine:

To get the most out of computerized measuring, it is necessary to think of the press not as a machine, but as part of a system. Anything that affects the final product is part of the press system.

Therefore, while the press is a system of things that need to be observed and controlled, computerized measuring is a tool that enhances our ability to observe. What we can observe, we can begin to control.

AIM POINT OF CONTROLLING THE CYCLE: TOP DRIVEN PROCESS COLOR

TOP DRIVEN CONTROL - DEFINITION:
Controlling the process implies that color decisions can be made at the scanner that will not have to be adjusted later. At the scanner, color decisions mean that valuable press time can be conserved. It also means that there is little compromise. At press, for each color adjusted favorably, two other colors fall where they may. Top driven control is based on finding what IS the right film for the press, and what ARE the right results for that customer? And what does it take to get those results on that press.....And THEN, how to do it again tomorrow and next year.

TOP DRIVEN CONTROL - REQUIREMENTS:
A successful top driven control system for process color demands a stable press/production system. It needs a system that controls all variables except the dot sizes on the original separation film. That is, the process following the generation of the separation film does not change the final color as it was originally planned.

If system is stabilized it can be driven from the front. Altering color at the beginning or top of the production process has two major advantages:

less cost to control color
less compromise in controlling color

We drive our cars using a steering wheel that is about as far from the road as you can get in the car, just as the press is far from the scanner. However, we count on the steering wheel to be connected by a series of predictably rigid devices directly to the road. When we steer right, we want to car to go that way, and even though we are not touching the tires, we expect the results we plan. If the steering rod were made of a strong silly putty, however, other variables would enter into the steering cycle. We would steer left, and it would be anyone's guess which direction the car would go. In the graphic arts process, it would be very advantageous to reach the same sense of stability in the steps that connect the scanner to the press as we have in our automotive steering systems.

THE CONTROL TOOL OF A TOP DRIVEN COLOR SYSTEM:

The top driven system manipulates only one thing..dot size along the tone curve. It does that at the scanner or workstation equipment. Dot size is the only tool that scanners and workstations have to control color.

Understanding this has important implications. If the only tool to control color at the scanner/workstation IS the dot size, then it follows that everything else is controlled somewhere else. Or, if not, everything else is out of control. Hue of ink, the density of the ink film, its relative dot gain, the color it produces on overprints, and even gray balance is NOT controlled at the scanner. They are ASSUMED at the scanner. They are controlled at other parts of the production cycle. The only thing the scanner or workstation can control is the sizes of the dots on the separation film. Therefore, both the scanner and workstation require a stable press/production system in order to get the most out of the equipment.

Historically, the color process is controlled by adjustments at each production stage. It is the nature of the materials and processes used to alter the tone curve and there by the color of the final product. The industry adjusts to these conditions by watching as a job progresses through the various stages, and making corrections as needed. Press color adjustments complete the cycle.

In the future, a different emphasis may place control of all color adjustments to the top (beginning) portion of the process. However, existing production systems based on correction throughout the cycle may unpredictably alter and change the color decisions made at these scanner and workstations. The corrections made later in the cycle carry more compromise cost than those made at the scan stage. When this happens, much of the power of these color workstations is lost.

In the past, the loss was unavoidable. The expense involved in monitoring to stabilize production processes was prohibitive. Computerized measuring may be the final link in the collection of tools available to stabilize the process. And as it becomes more practical it will unleash the power of the investments in prepress workstations.

SCANNER/WORKSTATION CONTROL THROUGH DOT SIZE MANIPULATION:
There are three major areas:

- Tone curve
- Gray balance
- Aesthetic/decisions

The purposes commonly assigned to scanner and workstation differ. A scanner may be capable of controlling all three areas. However when used in combination with a workstation, emphasis in on the first two, tone curve and gray balance. Depending of the software, workstations may be capable of controlling all three. However, the emphasis is commonly on the third, art/aesthetic manipulation. The reason for outlining the obvious is to clarify that both types of systems do one thing, control sizes of dots. Therefore, when they are used together in the top driven control system, thought should be given to the function of each.

THE EFFECT OF COLOR CORRECTION DONE AT PRESS:
A standard such as SWOP sets aim points for the density and dot gain. These have been used on press. However, correcting color on press moves away from this standard. Because the relative density balance between the three process ink colors is altered it costs compromise in several areas to achieve correction of one color.

Changing density levels at press side affects:

- Gray balance
- Two additional colors for each intended color change
- Dot size

INK DENSITY CHANGE TO THIS ONE COLOR	AFFECTS THESE COLORS
CYAN	GREEN & BLUE
YELLOW	GREEN & RED
MAGENTA	BLUE & RED
RED	GREEN & YELLOW OR BLUE & MAGENTA
BLUE	GREEN & CYAN OR RED & MAGENTA
GREEN	BLUE & CYAN OR RED & YELLOW

Density adjustments at press made to correct one color also change two other colors.

HERE IS WHAT HAPPENS WHEN COLOR IS CORRECTED ON PRESS:

Gray Imbalance:
Density levels which are one factor in the control gray balance are assumed at the film's creation. However, density level adjustment is commonly made at press run. The gray balance assumed when the film was made ceases to exist. The press system no longer fits the separation. Depending on the subject matter, the gray imbalance may adversely affect the work.

Dot Size Alteration:
The dot size reproduced on the film carries the instructions of the workstation and/or scanner for good color reproduction. However density level adjustments at press have the side effect of changing the dot size. When press changes dot size, the color curve is lost. The press gains more in some dot areas than in others. Shadows, midtones and highlights are all affected differently. That means that a new color curve has been created by an instrument not as well equipped to do the work as the workstation and scanner. For some work, the new curve may be acceptable. For critical work, it will not be acceptable.

Undesirable Color Changes:
The problem is that the later in the system the compensation for an unstable system is done, the greater the cost of it. The cost is in terms of not only man hours, but also control of aesthetic quality. There is no green ink, and if the grass must be made more green at press for a lawn care advertisement, other things may fall. The grass may be made more green by reducing the magenta ink. Then the red apples above it suffer. Or the grass may be made more green by increasing the cyan and yellow. But a subtle blue suit inline with the lawn may suffer from the unbalance of the cyan/magenta.

That two color changes occur for each color corrected at press is not new information. But wouldn't it be cost effective to correct the color at a stage that would affect ONLY the color being corrected. Not only would the correction avoid an undesirable color shift penalty, but the correction would be done without the expense of extra press time and waste paper.

A top driven control system aims at doing just that. If the

press system is stable, the top driven scanner/workstation can determine:

Gray balance
Faithful reproduction of primary and secondary hues
Press dot size

TOP DRIVEN CONTROL - THE BUILDING PLAN:

1. STABILIZE THE SYSTEM
   (for each production step)
   IDENTIFY
   OPTIMIZE
   SET STANDARDS
   MONITOR
2. DETERMINE THE CUMULATIVE EFFECT OF ALL STEPS
3. COMPENSATE FOR NORMAL SYSTEM GAIN AT TOP OF SYSTEM
4. CONTROL THE AESTHETICS AT THE TOP OF SYSTEM

Notes:
It would be tough to put a top driven control system in place in one step. Familiarity with the concepts, the computerized tools, the reports, using scanner and workstation controls as part of the system, and coordinating throughout the production process is a big project. However, it is not impossible. Done one step at a time, each part can eventually fit together. And immediate benefits come from stabilizing any one part of production.

Drawing up a plan that tracks production steps with an effect on process color would be a first step. Or one could be picked at random, and the plan developed over time. The steps of identify, optimize, set standards and monitor will remain consistent for each stage of production, regardless of whether the project is to stabilize only one segment or everything. If the plan is to stabilize everything, it is necessary to do it one stage at a time anyway.

IDENTIFY:
Determine by observing over time the normal performance of the production step.

OPTIMIZE
Correct as needed so the system is performing at its best normal level. The normal level will be what the process can do without stretching its limits one way or the other. You know what the limits are because you have been observing it before and after corrections made over a period of time. When the process is optimized, it will perform well without

undue strain. It it won't perform well, or won't perform without undue strain, change the whole process.

SET STANDARDS
Decide in terms of measured numbers what is the acceptable performance level for the process. Based on the information from the previous two steps the lowest and highest measurement, and the aim point are a management decision.

MONITOR:
Just watch to be sure the process is staying within the standards, and to see if anything new is entering the picture.

DETERMINE THE CUMULATIVE EFFECT OF ALL STEPS:
Once all process steps have been fine tuned and stabilized by the previous steps, it is possible to know what effect each step normally will have on the dots in the separation film. Identify the changes made at each step and add them up to know the total change made to separations in a normal stable press system.

COMPENSATE FOR NORMAL SYSTEM GAIN AT THE SYSTEM TOP:
When it is known what changes the normal and stable press system will make to separation film, it is possible to make allowances at the scanner which allow the film to fit comfortably on the press.

CONTROL THE AESTHETICS AT THE TOP OF THE SYSTEM:

Success May Make Us Nervous:

It may take some getting used to. Highways are much larger than automobiles to allow for variations in steering. Some of the variation is due to the car's response to road conditions. Rough surfaces, bumps, slope of the highway and wind all affect the steering. But, what if cars came along that compensated for every thing that affected steering...except for the person at the wheel. And highway departments made road lanes just about the width of the car, based on the idea that all the variables were controlled. Wold that make you nervous. It sure would unnerve me to be driving with cars very close to either side. I would feel the burden of the responsibility for keeping the car in the tight lane. I would not be used to a system that responded so directly to each and every steering command I gave it. Even though steering would be easier, I would miss the leeway of the older less accurate system.

Possibly, we may experience the same reaction as we grow in our ability to control the press system. It will be something to anticipate and deal with.

DIFFICULTIES:

The question is: "Is it really possible to create a stable press system?" Some problems with the idea may include the following. "Press operators must vary ink setups to compensate for variations in the film sent them." "It would be too hard to watch a press run go off of its color and not manually reset the ink keys." "Film comes from too many sources." "And the film we get is probably not the set that made the proof." "We cannot run color bars, the customer won't pay for the paper to do it." "We're printing color, not numbers." "Those guys don't know what they're doing anyway." "It would take too much time." "There are too many variables to pin down." "It probably wouldn't work."

The last is the key. If it wouldn't work, then all the rest is right. But, if it would work, everything else falls into place. The customer won't feel the paying for color bar space if production costs are so low his over all price is not increased. Film from many sources and conditions can be standardized when it is worth the effort. And if it does work, who could afford NOT to spend the time doing it.

DEALING WITH MULTIPLE PRESS SYSTEM VARIABLES:

The great number and interdependence of variables in the graphic arts production cycle does appear overwhelming. Controlling them could appear to be out of the question. The variables in printing are not only numerous, many of them occur in layers. Those in lower layers do not appear till the variations on the top layers are controlled. But all this does not mean it cannot be done. It just means it is a massive job.

One member of our industry says that the amount of variables that affect printing does not discourage him from trying to control them. When a variable can be identified as having an effect on printing, then it can be managed. It is just another thing to control. One at a time, many things can be controlled.

TRENDS THAT WILL ASSIST IN THE FUTURE:

Just at the point graphic arts is beginning use technology from other fields, advances are being made in those fields and in ours that will help. Two areas that will be helpful in creating top driven control systems are:

Improvements in reporting techniques:
Improvements in generating data

The task of stabilizing press systems will have increasing help from new technology.

FUTURE - IMPROVEMENTS TO REPORTING TECHNIQUES:

Two point variation analysis:
This is what we are using in computerized measuring at the present. We plot density of press sheet vs dot size of the film target. Or we look at dot gain vs the portion of the tone curve. Hue error vs percent of jobs for each hue is another two point analysis. They are powerful ways of looking at printing. However, in printing several variables may all act together to affect dot gain or a change in hue. Analysis of multiple points would be a good tool to look at the real world printing happenings.

Multiple point variation analysis:
Multiple point variation analysis until recently was available only to scientists and engineers with access to large mainframes with major analysis programs. That kind of computing power would be prohibitively hard for most of the printing community to access. Recently, software has been developed that will plot three variables using a Macintosh II desktop computer. That means the door is opening for graphic arts to have a way to sift through the complex variables of the press system. The 'mystery' factor that plagues our processes will be easier to pin down.

FUTURE - BETTER VISUALIZATION TECHNIQUES:
Getting the meaning out of color measurements is becoming a necessary skill for graphic arts operations. Numbers are the most difficult way to understand data. Graphs help. There are already many good graphic report software available. Much is already built into full analysis systems. In addition to what is commercially available, the National Science Foundation is promoting research in the area of integrated visualization tools. Some software is already available for use by scientific computing, business, financial groups, engineering and programming. Graphic arts may be the next field to use strong visualization software tools.

FUTURE - IMPROVEMENTS IN GENERATING DATA:
While full analysis systems with hand held densitometers explode ability to generate color measurements, they create

a paradox. Because the systems are so powerful in calculating, sorting, plotting and reporting data, the densitometer button pushing can seem like a lengthy process in comparison. It is human nature to become impatient with doing things that take 1 minute or so, even though it may have taken several hours to do the same thing in the past. Some feel that scanning densitometers attached to full analysis systems will further the ability to use and manage color measurements. Others feel that on press densitometry with connections to both a full analysis system and a closed loop press system would be a desirable goal.

CONCLUSION:

I have been asked many times what type of graphic arts operations use computerized color measurement system. The question is whether publishers, separators, commercial shops with scanners or web operations have been more likely to put the technology to use. The answer is all have. The distinguishing characteristic of the companies is not the part of the business represented. It is a business personality characteristic. All that have jumped in at the beginning to use computerized technology have these two things in common: They feel measuring will affect the quality of their product, and/or the cost of producing it. And they have the kind of personality that is comfortable with not knowing all the answers up front. They have been pioneers. They had no guidelines or tried and true methods for using computerized measuring. Only the feeling that it should work, and it was worth a try.

ACKNOWLEDGEMENTS:

Some years ago, when I first began working with computerized process color measuring, looking for practical applications became my personal project. When I had found some starting applications, and began to see still more possibilities I found it was difficult to communicate them. Computerized measuring was not going to replace anything that had been commonly done in the graphic arts industry. It was about to open avenues to different things. So there was very little common language to describe the value of the technology. Along the way some members of our industry came up with good ways of talking about it. I found their analogies important, not only to communication, but as a basis for moving forward.

In the order of the contribution:

George Leyda: For the concept of the press as a system, not as a machine.

Cliff Gober: For the concept that measuring technology was a tool to make the various production phases fit together, so the expense of the fitting would not fall to the press.

George Leyda: For the point that a few densitometer button pushes can give a large amount of information if attached to a computerized analysis system.

George Huxley: For the photo vs movie explanation of press fingerprinting.

Larry Cooke: For the concept that learning to manage color information numbers is also timely preparation for learning to manage digital film information.

John Morton: For the concept that the large number of press and plant variables is controllable..once identified, one at a time.

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