KEEPING PACE

A Monthly Newsletter Devoted to the Darkroom Arts

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Do The Math

Do the math.

Ever since the dawn of photography, mathematics has played a large role in it's development and function.
Similar to the old adage about a pilot flying by the "seat of his pants" I seriously doubt that you would entrust your life or the lives of your loved ones to such a pilot of a large jet liner.

Making images by the "seat of your pants" is not the safest way to go.
The production of a sheet or roll of film begins with making exact mixtures and coatings.
The lowly black and white roll of film is processed at a given time and temperature so that the following print will exhibit some kind of recognizable image.
Let us take an example of mathematical accuracy.
The roll or sheet of film has a specific speed.

How was this determined? Quite simply. A series of different exposures were made on the same sheet of film, It was then processed for a given amount of time in a specifically mixed developer. When the processing was complete, the film was examined with an instrument called a densitometer. The subsequent readings indicated what the required exposure for the dark areas of the film should be, and the development time indicated how long a roll of film could be developed. Scientists were able to determine the gamma of development (comparative contrast between the scene and the films contrast range.)

This is all well and good. But what about the early beginning of any one person just learning how the process works?
I must admit it. I began in complete ignorance and I learned from experience just what a good negative should look like. I worked for an image bank company and after a while I recognized which images would print better then others.
However, I was still in the dark.
Later on, when I joined a color print firm, I used my experience to determine when a set of separation negatives "looked good."

Remember, densitometers were as "scarce as hen's teeth" in the early days of my color printing experience. I would process a set of negatives by the "seat of my pants" and sometimes they looked feasible and sometimes they did not.
Then we purchased a densitometer.
The whole world opened up to us. Almost.
Now we could understand how Kodak was able to tell us what the exposure should be for a specific film, time of

day, and how long to develop the film in the developer of their choice.
We were still in the dark, however.
If by some quirk of nature, we produced an exceptional negative we would be thrilled.

At the beginning, exposure meters were toys. One such meter was called an extinction meter. It worked on the assumption that when viewing the image through this device we could actually determine the correct exposure. Did it work? Not on your life.
it was soon discovered that a separate light source must be used as a reference.
Eventually, the modern light meter was invented.
The status in the darkroom was totally different.
Films were produced that had specific speeds and that these speeds were reliable.
If we tried to expose a black and white print, all we needed was the eye and a good timer. But if we decided to expose a sheet of film in order to make a negative, things became trickier. We needed to establish the correct exposure times and development times in order to produce a negative that had a chance of producing a good print.

How was this to be done.
The few books written about gamma and development were not easy to understand as they were written by scientists and not the average person trying to understand the process.
We even had the nerve to expose a set of color separation negatives in a strange looking camera called a "one shot camera."
We processed the film by the "seat of our pants."
When we did finally get a set that was workable, we would then **forever** never change the method of exposure or the times of development.
From that time on, we exposed a set of separation negatives in the exact fashion. But If another technician tried to process the film and end up with the same results, we were in deep trouble. For some unexplainable reason, the results were different. (The differences were caused by the different agitation techniques used by each individual.)
Today, we have a challenge not to make a good exposure. The cameras have their own exposure meters linked to the shutter speeds, and if color film is being exposed, the labs have the chemistry, time and developing temperature all worked out. In fact, the manufacturer has worked it all out so that we poor souls do not have to do anything except point and shoot.
Do I sound bitter? Not really, because for most of us, the chore of being exact is not a simple matter.
Let us take the production of a simple color print such a Cibachrome print.

The manufacturer has produced the color print paper and deserves a solid round of applause for being so careful and repetitive. However, the production of a print is a different matter.
Let us begin with the transparency in the enlarger. It has been enlarged to it's final size and is awaiting our input.
We have no idea what color pack or correct exposure time is right for this particular print. So we make a test exposure using a test filter pack and various exposures.
The processing is academic.
We must follow the rules laid out by the manufacturer.
The first test tells us that one of the exposures looks fine for density, but the color balance is off considerably.
Mathematics is about to take over. However,we could get tied up in too much math at this point.
The image is removed from the enlarger carrier and the enlarger light is turned on.
We have not yet touched the f stop, or the timer. Using an easel meter, such as the ones sold by Speedmaster or ZBE, a reading of the light level is taken and recorded.
The we use our imagination and change the filter pack for the better (we hope) and adjust the f stop until the easel reading is the same as it was before.

Do not touch the timer unless you want to make a density adjustment. Replace the image and the carrier into the enlarger and expose again.
The next print should be much better. If it still needs improvement, repeat the same steps again.
The world of mathematics is about to make it's debut.
Let us say we are making a Cibachrome print and we have a 20 second exposure and want to lighten it up about 1/4 of an *f* stop. We want to do it using math rather than the actual *f* stop on the enlarger lens.
How much is 1/4 of an *f* stop?
If we wanted to increase the exposure one full stop, the new exposure would be 40 seconds.
A 1/2*f* stop increase in exposure time would have been 30 seconds.
Therefore, the 1/4 *f* stop increase would be 25 seconds. A 1/4 f stop is actually a 25% increase. 125% X 20 seconds equals 25 seconds.
Why is it important to understand this point?
The Cibachrome process is devilish. If an exposure is longer than 30 seconds, making judged increases may not work because of the subject failure of the material. This is called **reciprocity.**
If you want to increase the exposure by 50% you may have to really add about 75% or longer to get the correct density. At the same time, the color will shift.
What about reducing the exposures?
If you want to reduce the exposure by 25% what are the correct numbers?
A full *f* stop change is equal to a 10 second exposure.
A 1/2 *f* stop change is equal to a 15 second exposure.
A 1/4 *f* stop change is equal to a 17.5 second exposure.
Remember this little exercise in reverse math.

Let us get back to the old days. We are about to go out and shoot a series of images for a possible show. We would like to be able to produce a set of negatives that we could print on a single grade 2 paper. This means that we must have the correct contrast in the negative if we want to be successful.
This is not easy. However, with a spot meter it is an easy chore to find the extremes in the lighting of the image.
Without getting too technical, here is a simple way to use a spot meter as a contrast tool.
You must do this chore on different days.
On a cloudy day, choose one scene and shoot 5 different sheets of film. All of the exposures are the same. Read the extremes in the image. Make sure that you record them.
Back at the lab. process the 5 sheets at different times. If necessary, mark the different films using a edge film punch.
One of these 5 sheets should be able to produce a good print on the # 2 grade paper.
Record the processing time and the exposure time and especially the difference in the two readings with the spot meter. This is important.
The next time you make a series of exposures do it on a less overcast day and do the same thing with the film and the processing.
Do this again when the sun is shining and repeat the steps.
Now you have three different climatic scenes with which you can choose the correct exposure and developing times and produce a great # 2 grade paper print.
A simple chart can be made that you can use to determine what gamma you wish to develop your film to in order to capture all of the image possible while still using a grade #2 paper.
Fortunately, there are enough paper grades and variable grade papers available so that even if you are off base with your calculations, you can still make a presentable black and white print.

Calculations are one way of using math to get to the bottom of problems.

The real use of mathematics is clearly evident when making a color print.
Here is a situation where most of the work has been done for you.
The material is produced in such a fashion that all you need to do is to find the correct level of exposure and the correct filter pack.
Begin by making a print by trial and error.
After the first test is made you can look at the results and determine what to do.
The use of math becomes increasingly important.
The choice of filtration is all yours. The choice for exposure however, is not all yours.
You must produce a print that has the correct degree of density. Every time you change the filter pack, the exposure must be adjusted so that the density does not change, unless this is your desire.
So far so good.
But a large problem has suddenly occurred. Contrast.
The contrast of the Cibachrome process is the major cause of producing major headaches for the labs. Contrast can be controlled. How? By masking.
However, in order to make the correct mask so the Ciba print exhibits all of the needed details in both ends of the density spectrum, the masks must be made with complete accuracy.
Math is the answer.

All of the steps that are necessary for producing spectacular prints can be achieved my masking.
A chart that can be used a a guide for exposures and processing times can be produced with relative ease.
How does the making system work?
You must first know what your specific enlarger can produce. Every enlarger will produce a different degree of contrast because of the different variables that are part of the daily work day.
A condenser enlarger will produce more contrast than will a diffusion enlarger. How much difference? It all depends.
The air and water alone will make difference. So will the electrical voltage, color of the bulb, the kind of glass in the enlarger carrier and so on, and so on.
If you think this is an exaggeration, you are mistaken.
The steps required to make a detailed chart that can be used as a guide are as follows.
Mount a 21 step grey scale in a sheet of opaque material, such as exposed and developed litho film, place it in your enlarger and make a series of different exposures of the grey scale onto a sheet of Cibachrome paper and process it normally.
Then just look at the results.
How many steps are visible in the test prints? Where do the high and low ends of the scale disappear?

Find the steps that begin to show some kind of tone.
Do you have densitometer?
If so, use it. I suggest that you purchase a densitometer. There are a number of used systems available through Graphic Arts supply companies. Read the densities of the same exact chosen steps on the original grey scale in your enlarger.
Subtract the lower reading from the higher reading and the result will be a number.
This number is the aim point that you must use in order to make a correct mask.
Let us assume that the density number is 1.75.
This means that any transparency that you use from now on must have a density range of 1.75. If it is higher than 1.75, then a mask must be made to lower the density range of the transparency to 1.75.
Here are the steps needed to arrive at the correct aim point.

If your new transparency has a density range of 2.35, then subtract the aim point number from this 2.35 range and and the answer is 0.60
If we can make a mask with a density range of .60 and add it back to the transparency the overall density range will be reduced to the aim point of 1.75.
This is pure simple math.
No "hocus pocus" at all. The eye cannot discern between good and bad masks unless they are so far off that it is a

visible error.
The mask is made by contact, exposed to the correct time and processed to the exact gamma so that a mask of .60 is produced. Is this a far fetched idea? Not on your life. It has been used for many years by my staff and all of my students with great success.
The necessary charts that are used to find all of the correct exposures and developing times can be made with great accuracy.
For an example, if two sheets of film are identically exposed to a simple 3 step grey scale, using white light, or even a colored filter light source, and processed at different times, it would be easy to find the best exposure times for the two different developing times.
Drawing a line from one accurate developing time to the other and drawing a line between one accurate exposure to the other will allow tou to find all of the other necessary times in order to make a correct mask.

The best use of math is the ability to find the correct exposure with a fixed light source and when the densities on each sheet of film are different. Here is an example.
From a transparency with a highlight area density reading of .65 you make a series of contact exposures on a sheet of Super XX film in order to find the proper exposure time for the proper density for a white shirt, and the result is 10 seconds.
Now a new and different transparency is about to be exposed.
This time a white shirt is in a shadow area and has a totally different density reading of .95. However, you want the same density in the negative so that the final image will look somewhat like the first one. What is the new exposure?
This requires a little bit of knowledge of Logarithm.
The measurements of densities are done with a densitometer, but the differences in exposures are calculated by logarithm. A simple adage that all color printers know is that a difference of + .3 requires a doubling of the exposure (from 10 sec. o 20 sec.) and a -.3 requires cutting the original time in half. from 10 sec to 5 seconds.
So far it sounds simple, and it is. But what do you do when the densities are not in .3 increments?
The simplest way that I know of is to use a simple scientific calculator such as the Texas Instruments TI-30.

Let us assume the difference between the first transparency (.65) and the second (.95)
is easy to calculate. simply double the exposure.
But now we have a second transparency of .83 and the difference between the first image (.65) and the second image is image (.83) is **.18.**
How do we use this inexpensive calculator?
Follow me:
Step 1. Press the difference **(.18)**
Step 2 .Press the button **(INV)** *some calculators use the # 2 nd button instead of INV.*
Step 4**.** Press the button **(X)**
Step 5. Press the button **(=)** to get the new answer.

If you wanted to reverse the procedure then a new step is added to the list. Here is how.
This time you want to reduce the exposure by a density of .18.
Follow me, again:
Step 1. Press the difference **(.18)**
Step 2 Press **INV or 2nd button**
Step 3 .Press the button **LOG**
Step 4 Press the button **1x**
Step 5. Press the original exposure time of **10 seconds**
Step 6. Press the button **(=)** to get the new answer, which is **6.60 seconds.**

This time is very accurate. In fact, you will need an enlarger timer with a 1/10 th of a second accuracy.

This fairly simple math can be used on many occasions. Suppose you are making Type C prints or Type R prints and do not own an

easel meter (which is hard to imagine) and an additional .20 filter is added to an existing filter pack, how can you find the new exposure?
A small problem here. If the filter is yellow, the amount of overall exposure time will hardly be affected, but if the filter is cyan, then the previous set of instructions will work. Try it. If the original exposure again, was only 10 seconds then the new time would be 15.8 sec. However, buy a simple easel meter. It will keep you from getting grey hair.
However, there are many instances where the calculator can be a life saver.
Suppose you are making a Dye Transfer print (no, the process is not dead, not by a long shot) and you want to make paper black and white prints from each separation negative in order to establish a color balance and a density level.
If you know what the difference is in exposure time between the paper print and the matrix exposure you have already worked out a factor. If you have not done the homework and never knew the differences here is how it is done.
Make a series of different exposures on a sheet of matrix film and process the sheet normally. After processing and drying, place the sheet into a tray containing Cyan dye. Let it rock for 5 minutes, then transfer the image to a sheet of Dye Transfer paper.
Then make a great black and white print that you feel is acceptable. Looking at both prints through a red (#29) filter find the strip on the dye transfer paper that closely resembles the black and white paper print.
If the paper print required 10 seconds and the matrix image that you like received 20 seconds then the factor for the matrix exposure is 2.
If the exposure for the matrix was 18 seconds then the factor is 1.8.
Does all this seem complicated? It really shouldn't.

The way I have made quality color prints for over 50 years is an interesting story.
I began like so many others and did eveything by rote.
Once we established the exposures for a set of separation negatives, and they worked well, we didn't change a thing.
It worked occasionally, but we frequently worked many nights trying to find what we were doing wrong.
I remember the anguish I felt because I had promised the print by a certain time and didn't want to be late.
Slowly but surely, I was headed for the mathematical solutions that I knew must exist. Then one day, I had a job that seemed impossible to print. It consisted of a man's head with extremely contrasty lighting. I couldn't open up the shadow side of his face.
This job was instrumental in making me aware that there were other people having the same trouble.
The leading engravers had similar problems, as did my competitors.
I thought to myself, why not change the exposures of the separation negatives in order to get the necessary density in the shadow areas of the image. I tried it. It worked. But at the expense of the highlight areas. Of course, masking helped, but at this time in my photographic career, I was only making masks that exhibited a 25% range. This was Kodak's recommendation.
I began to use math to find the correct levels of density and it began to make sense.

Later on I was introduced to Cibachrome.
What a delight. The material needed no registration pins, no hot water wash down, apparently, no masking, and it was simple to process.
However, the process had many faults, (and still does) and needs corrective masking to make it work the way it should.
It then dawned on me.
Make a contact mask to the correct strength and add it back to the original in order to make a print. It worked.

So did the mathematical energy that I had. I had to figure out a working plan.

I worked out a system that I could use in the production of separation negatives. Here is what I came up with. Instead of trying to adjust the contrast of the separation negatives by processing, I decided to use the method I employed in producing Ciba prints. Premask the original image to a point so that when the separation negatives were exposed and processed I reached the correct aim point that my enlarger required.
Here is an example of the math that it required.
I determined that my matrix film and enlarger combined needed a specific density range in order to make a quality Dye Transfer print. Let us say that I wanted a 1.20 range.
I then realized that I had to process my separation negatives to a given gamma. I couldn't afford to over develop the negatives and have a chemical fog situation occur.

(Chemical fog.) This is where development has reach a point of no return and won't develop the darkest parts of the film any longer. Sure, the rest of the image will still develop but not the highlight areas of the negative. The shadow and middle tones will keep on getting darker and darker until the shape of the film's curve is destroyed.

I chose to develop my separation negatives to a gamma of .75. This meant that I had to produce masks that would place me in the position of simply exposing my negatives to the prescribed time and the results would be fine.
Follow me now:
If I needed separation negatives of 1.2 in density range, I would have to have to make my masks to a specific range so that when combined with the transparency they would be in the correct range for making the negatives.
Again, follow me closely.

I decided to process the separation to a gamma of .75 .

Divide the density range requirement of the negatives (1.2) by the gamma of development of the negatives (.75) and the new answer you get is 1.60.
Now here is the trick.
1.60 is the **new** desired density range aim point.
If we make our masks with this aim point in mind, then after they are made and combined with the original transparency, and the negatives are exposed and processed to a gamma of .75, we will have reached our goal of a 1.2 separation negative.
Read this point over again. It took me a while to figure out this approach.

This approach has led me to making very accurate masks and separation negatives. The beauty of this system is that it allows you to be more creative.
The mathematics are necessary because they force you to place the images on the straight line portion of the negative film. This will allow you to hold details in the shadows and the highlight areas with ease.
If you want a darker or lighter print, be my quest. However, suppose you want a slightly snappier print than the film image displays, you can become creative and make a print that jumps. Simply re-adjust the gamma of the mask to a lower degree and you will automaticlly get the desired degree of contrast you are looking for.
The numbers are required so that the image is faithfully recorded on separation films, however, the second part of print making is where the emotions and sensitivity takes place. This makes your work a work of art.

Not many forms of photography take on such problems. Most people are satisfied to see the image at the drug store counter, but you, my dear reader are different. You wouldn't be reading this newsletter otherwise. Numbers can be exciting. This I know from experience.

The Dye Transfer problem is nearing a final solution. I spoke to Dr. Patterson today and he explained that the formula was indeed a bit more complicated than we had thought. He has Kilborn Photo in Iowa making a test run of the matrix film. I was promised a sample to test myself so that I could give it a fair trial.
Dennis Ivy, a lab enthusiast and a former student of mine is on the process of experimenting with the retouching capability of the dyes.
However, I am not too concerned with the ability of being able yto retouch a Dyre Transfer print. It took 25 years for an amazing group of Dye Transfer retouchers to solve the questions of what chemicals should be used, and they all came up with their own special solutions that worked.
I once produced a print for an Ad agency for Chef Boyardee. The shot consisted of a plate of food and brown gravy. The brown gravy was the ingredient that we had to print with accuracy.
We were asked to purchase a can of the gravy and use it as a guide to matching the color.
Well, I spilled some gravy on a test print and after I wiped it clean, I discovered that it removed some Cyan dye from the print.
The best was yet to come. One Monday morning, I arrived at the lab early. I noticed a bottle of PhotoFlow had tipped over and the cap was slightly loose. The Photoflow spilled over a dozen discarded prints. I noticed a green area that did not exsist on the original print. When I wiped the print clean, I noticed the magenta on the wipe.
Egads, I discovered a new toy for our arsenal.
Up until this time, we used a piece of cotton slightly moistened with our own saliva. Ths was a decided improvement. I exp[erimented with a few prints and found that it not only worked well but didn't soften the image. I told my boss, Glen Peterson and the rest of the boys at the lab.
Within two weeks the entire field knew about this remarkable find.
Other materials work well and even better, but again, these are secrets that the retouchers would rather take to their graves than to divulge their knowledge to the rest of the rerouching community.

I have found that there are really no secrets in our color print businesses. It simply takes taste and committment to producing a quality effort.
I have never kept a secret from anyone that asked me about a specific problem.
Life is too short to worry about secrets.

Darkroom and Creative Camera has seen fit to publish a review written by Fred Newman about my Ciba book and Video.
For this I am extremely grateful.

I am sure that an announcement about the new Dye Transfer process will soon be forthcoming.
There have been many labs that have closed their doors because of the digitized revolution. Remember, the Dye Transfer process was only really kept alive by the Advertising agencies and their quest for the finest prints possible.
With this important market drying up, it leaves little for the Dye Transfer lab to do.
But the reward for the individual who is involved with this process is that he can make his own prints and defy the world. To hell with the agencies.
Here is to the fine artist who is eager to make prints in his own lab and has to account to no one.
One of the finest Dye labs in the country, Wawrzonek labs in Massachusets, is about to go digital. He is considering the UltraStable process.
Good luck. John.

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