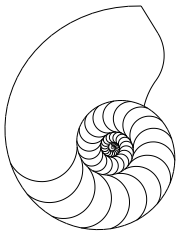

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Application Note

Finding the Required Exposure Changes When Changing Both Size and Paper

This paper describes a method for finding the required exposure change when moving from a small work print on one paper to a final large print on a different paper. Test strips, f-Stop timers or enlarging meters are not needed. The only tool required is a yardstick, and even that is optional.

When moving from a work print to a final print three compensations need to be made:

- The VC filter needs to be changed so the contrasts of the work print and the final print match;
- The exposure needs to be changed to accommodate the difference in paper speed between the two papers;
- The exposure needs to be changed to compensate for the increase in print size.

The information in Darkroom Automation's "Paper Speed Charts" is used with this method.

"Paper speed" in the Darkroom Automation system is the amount of exposure, in stops, that needs to be given to a paper to achieve a given tone. The speed value increases as tones get darker.

An explanation of the Darkroom Automation exposure system is provided in the appendix.

The Adjustments

A concatenation of the relevant portions of the "paper speed" charts needed for the example in this application note is provided below:

Zone	Tone	OD	FBWT #1	RC #3
IX	White	0.05	6.23	4.85
VIII		0.12	6.59	5.53
VII	Highlite	0.27	7.02	6.03
VI	Skin	0.47	7.44	6.61
V	18%	0.70	7.87	7.15
IV		1.00	8.35	7.55
III	Shadow	1.32	8.85	7.89
II		1.60	9.37	8.20
I		1.90	9.99	8.60
0	Black	2.10	10.32	9.22
	White	Black	4.10	4.37
	VIII	Black	3.73	3.69
	VIII	I	3.40	3.07
	VIII	II	2.78	2.66
	VIII	Shadow	2.26	2.36
	Highlight	Black	3.30	3.19
	Highlight	I	2.97	2.58
	Highlight	II	2.35	2.17
	Highlight	Shadow	1.83	1.87

Matching contrast

The HD curves for the two papers need to match over the range of tones that are important to the image. Commonly this range will be ZVII highlights to ZIII shadows. This isn't always the case and the important tones should depend on the subject matter and the mood you wish to convey.

It doesn't matter what the exact tones are, all that matters is the slope of the HD curve in that general range of tones.

The paper speed charts give the difference in paper speeds for common pairs of tones, this is shown in the numbers in the lower portion of the chart.

So, to find the right VC filter for the new paper find the the grade of the final print paper that has the same paper speed difference (contrast) as the paper used in the work print.

Matching exposure

The change in base exposure will be given by the difference in paper speed for the two papers. Pick a tone that is key to the image and read the paper speeds for this tone for the two papers and grades. The adjustment needed is the difference in paper speeds for the tone.

Compensating for the change in print size

The formula for the required change in exposure is

$$(M + 1)^2 / (m + 1)^2$$

where M is the new magnification and m is the old magnification.

This is not that convenient a method and a calculator may be needed in the darkroom. Even then this method is a bit of a PITA. Finding the magnification usually means knowing the size of the negative carrier cutout, measuring its projected size and dividing the two measurements. This needs to be done at the initial size and the final larger size. Some enlargers simplify the procedure by providing magnification scales of the enlarger column. Once the magnifications are known the the calculations, above, can be performed.

An easier way is to use the magnification exposure correction ruler provided by Darkroom Automation at

http://darkroomautomation.com/support/stopsruler.pdf
http://darkroomautomation.com/support/stopstableforruler.pdf

The scales in the file are cut out and pasted to a yard or meter stick.

To use the ruler:

- Using the ruler, read the values shown for the easel to lens distance at the two print sizes.
- Subtract the two numbers - this gives you the needed correction in stops.
- The table on the back of the ruler shows the time multiplier to apply for the larger print. If you use an f-Stop timer the ruler value is used to modify the timer's base exposure.

A minor inconvenience in using the ruler is that the distances need to measured from the easel to the lens front nodal point. The estimated location of the lens diaphragm is a good enough stand-in for the nodal point. As an example, the distance from the front of the lens to the diaphragm of an El-Nikkor 50mm f2.8 lens is 1.1" (28mm). A pointer attached to the enlarger's lens board showing the location of the nodal point/diaphragm can be a help.

An Example: The Making of Two Prints

In this example, the work print is on 5x7" MGIV Resin Coated paper, the final print is to be on 11x14 MGIV Fiber Base Warm Tone (FBWT) paper.

The tones that need to match are highlights at Zone VII and shadows at Zone III. In practice you would use the tonal range where the photo's interest lies. This can be highlights to shadows for most pictoral subjects, deep shadows to almost-

white for snow scenes or deep shadows to 18% grey for lowering clouds.

For this example you can use the combined paper speed chart provided earlier in this paper. Or you can use the PDF paper speed charts provided on Darkoom Automation's support files web page

http://www.darkroomautomation.com/support

Step 1 - Find the matching grade/filter

Look at the "RC #3" column in the example paper speed chart and the "Highlight | Shadow" row at the bottom of the column. The value of 1.87 stops gives the paper's contrast between these two tones. The value is in stops of exposure.

1.87 stops is the difference in light intensity producing these tones in the work print. We don't care where these tones are located on the print and we don't need to take any measurements.

Now looking at the column headed FBWT #1. Note that the "Highlight | Shadow" entry is 1.83 - a #1 VC filter when printing on FBWT will have the same contrast for these two zones/tones as a print made with a #3 filter on RC paper.

So, changing the VC filter from #3 to #1 when switching between MGIV RC and MGIV WTFB should result in the two prints having the same contrast and hence appearance in the Highlight-shadow tones.

Step 2 - Find the needed adjustment to the base exposure due to the change in papers from RC to FBWT

Use the top portion of the paper speed chart.

The highlight paper speed for RC #3 is 6.03

The highlight paper speed for FBWT #1 is 7.02

So, to match highlights the exposure for FBWT needs to be increased by 0.99 - call it 1 - stop.

Step 3 - Find the adjustment due to increasing the print size, using the DA magnification adjustment ruler

This example uses distances measured when making full-frame 5x7 and 11x14 prints from a 35mm negative.

At the 5x7 print size the ruler reads 2.75 stops

Raise the enlarger's head so the image fits an 11x14" print. The ruler now reads 0.73 stops.

To compensate for the increase in print size the exposure needs to be increased by 2.75 - 0.73 = 2.02 stops - call it 2.0 stops.

The required changes are

Change the filter from #3 to #1

Increase the exposure time by adding 1.0 stop to compensate for the change in paper speed and an additional 2.0 stops to compensate for the increase in print size. The total increase is 3.0 stops.

From the back of the ruler, a 3.0 stop increase is equivalent to increasing the exposure time by 8.0 times, from, say, 8 seconds to 64 seconds.

Caveats

Matching the mid-tone contrast of the two papers can lead to errors in exposure for the blacks and whites of the final print. If the mid-tone speed difference is different from the white and black speed differences then either a contrast compromise or additional burning and dodging may be needed.

It can be a good idea to slice a sheet of the final paper into small test coupons and make an exposure check with a few of the coupons to make sure the midtones, shadows and highlights render correctly.

Larger prints can sometimes loose contrast. This isn't anything intrinsic in making a larger print but is due to stray light. Stray light is any light falling on the paper that doesn't come from the lens. The biggest source of stray light is light bouncing off the paper, on to the walls and ceiling and back on to the paper. Small light leaks from the enlarger are largely irrelevant. To appreciate this bounced light, turn on the enlarger and gaze around to see how the walls and ceiling are lit up when the enlarger is turned on. The reason this lowers contrast on larger prints is that the quantity of bounced light is the same and independent of print size. A small sheet of paper that is brightly by the lens lit will reflect the same amount of light as a large sheet that is dimly lit. However, as print size increases the exposure time increases and this gives more time for the bounced light to act on the printing paper.

Obviously, using a meter to find the exposure correction for magnification changes is faster and easier. Metering will compensate for stray light as it will be incorporated into the meter reading. Using an f-Stop timer negates the issue of calculating exposure times, just add the correction in stops to the timer setting for the work print. But this paper is all about how to do it without any instrumentation.

Appendix

The Darkroom Automation Exposure System

The fundamental principle of photographic exposure is:

exposure = light intensity * time

and any combination of intensity and time that results in the same total exposure will produce the same density on a negative or tone on a print. If light intensity and time are both measured in stops, a logarithmic quantity, then:

exposure (stops) = light intensity (stops) + time (stops)

Darkroom Automation's f-Stop timer, and timing charts, relate time as measured in stops and seconds as:

0.0 stops	1 second
1.0	2
2.0	4
3.0	8
3.1	8.6
9.9	955
10.0	1024

The meter displays light intensity in stops. The range of readings is as:

9.9 stops	Maximum black in ~1 second on MGIV RC #2
0.0	Maximum black in ~955 seconds on MGIV RC #2

Note that the meters are calibrated to a standard light source and not actual RC paper. The times shown above are approximate.

Adding the meter reading and the timer setting gives the total exposure. Using MGIV RC as an example, any meter reading and timer setting that sum to 9.9 will produce a maximum black.

In Darkroom Automation's parlance 9.9 is the 'paper speed' for Zone 0 (maximum black) for Ilford MGIV RC and a #2 contrast filter. As an example, the paper speed for an 18% gray is 7.3 stops and any combination of meter reading and timer setting that adds to 7.3 stops will produce an 18% gray on the paper.

Darkroom automation publishes paper speeds for popular papers. The charts indicate the exposure required to produce a given tone on a given grade of paper. They also show the difference in paper speed exposure for common tone pairs for determining paper grade.