

A Practical Guide to Film Characteristic Curves – Part 2

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On July 28th I took a Hasselblad 500 CM with an A16 back and an 80mm lens with a yellow filter to Fort George Island at around noon. I used a roll of Fuji Acros 120 (effective ISO 80) to get sixteen 4.5x6 cm images. All of the images were taken with some parts of the scene in broad daylight. The exposures were primarily based on Sunny 16.

The roll was developed in Xtol 1+2 for 9:30 at 75°F and scanned on an Epson V750 at 3200 PPI.

Here are some of the results:

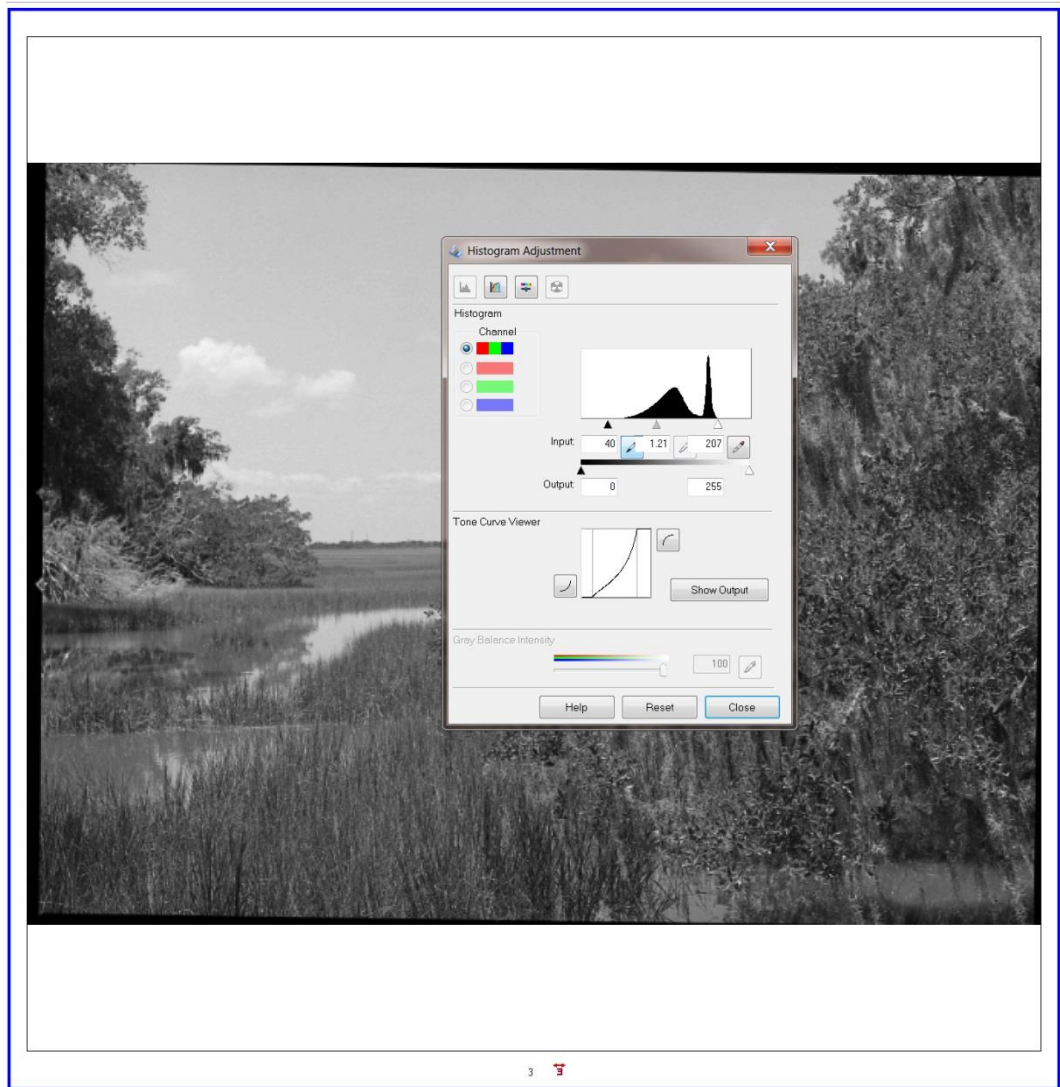






How were these scanned with the Epson V750?

Notice that each image shows a full range of tones from print Zone 0 through Zone X. However, some of the scenes apparently had a dynamic range (DR) of less than 7 stops while others probably had an actual DR of well over 10 stops. But they all were scanned into a JPEG range of 0-255. This was done by setting the ranges in the Epson Scan histogram.



First the black point was found using the first eyedropper on the Input row by clicking outside of the image in the film margin. This gave a value of 40 for the FB+fog. Then the upper limit of 207 was found by sliding the white marker to the right end of the histogram. The Output range was set to 0 through 255. This ensures that, regardless of the width of the histogram, the full range of tones recorded in that negative will get a JPEG value between 0 and 255 and the print zones will range from Zone 0 through Zone X. You might (rarely) want to adjust the middle triangle to change the mid-tone brightness during the scan.

In effect, the scanning process implemented a full range of Zone System plus or minus development on a single roll that got normal development.

How was the ISO and development determined?

Conventional advice when shooting B&W film has always been to, “Expose for the shadows and develop for the highlights.” That was when we were printing in the darkroom on photosensitive paper.

For digital photography and transparency film the situation is reversed. We have to expose for the highlights so that they don’t get blown out and then develop for the shadows with post processing.

But what if you are going to scan the film? You need to know a bit more about the relationship between exposure and development for each film/developer combination.

A scanner can read a wide range of densities from film base plus fog (FB+fog) to beyond the maximum density that the film is capable of recording.

Testing can show us that film actually has a very wide dynamic range, much wider than digital. We can expose film for a range of twelve 1-stop exposure zones from 0 through 11 with middle gray at 5. The steps are achieved by changing either the aperture or shutter speed by a full stop between test shots. This can be challenging if you are using a camera with a limited range of shutter speeds and apertures. It’s a lot easier with a 35mm camera that has an electronic shutter – more on this later.

The lens used was the Planar 80mm f/2.8 which has a minimum aperture of f/22 and its fastest shutter speed is 1/500. The target was a Viltrox L116T LED panel with the output set to 25% and color temperature to 5200k providing a brightness of 13 for middle gray. These settings are for testing a film at ISO 50.

Frame #	1	2	3	4	5	6	7	8	9	10	11	12
Zone	0	1	2	3	4	5	6	7	8	9	10	11
Seconds	1/500	1/250	1/125	1/125	1/125	1/125	1/125	1/125	1/60	1/30	1/5	1/8
Aperture	f/22	f/22	f/22	f/16	f/11	f/8	f/5.6	f/4	f/4	f/4	f/4	f/4
EV	18	17	16	15	14	13	12	11	10	9	8	7

ISO 50 is a useful setting for testing with this LCD panel. The LED panel output cannot go lower than 20%. If the output is doubled the ISO assumption would be 25. Double it again and it drops to 12.5.

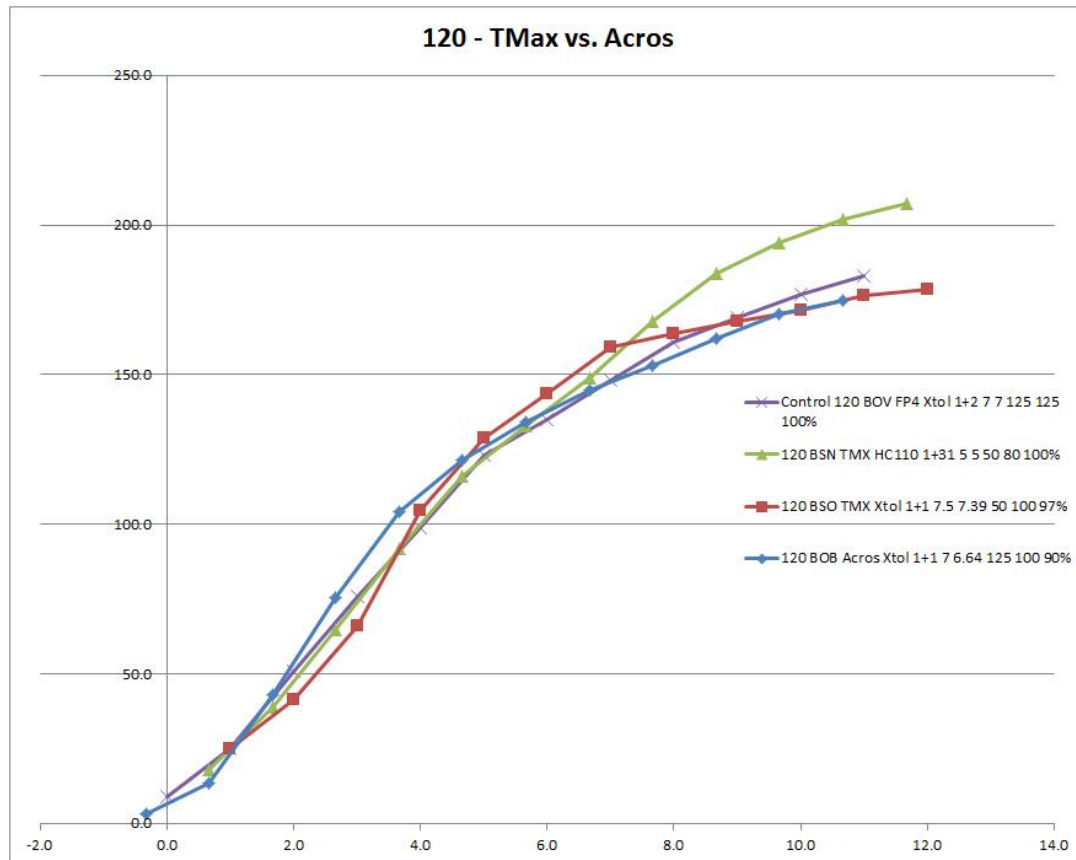
The darker EV range (18-13) helps determine the effective film speed and the lighter EV range (12-7) shows whether the film has been overdeveloped or underdeveloped.

Note that the exposure zones are not the Zone System print zones that are designated as 0 (maximum black) through X (paper white or maximum white) with middle gray in Zone V.

Exposure zones can actually be lower than 0 (if that doesn't go below FB+fog) and greater than 11 and still record on film.

The initial development times were based on the Massive Development Chart and the adjusted ISO and times were based on the techniques described in [A Practical Guide to Film Characteristic Curves](#). The chart's times for normal development at the films' claimed (box) ISO were very close to the adjusted results. Some developers do not reach box ISO while others actually surpass it based on the resulting curves between exposure zone 0 and 5. The reason for the testing is also to narrow down the target developer dilution and time needed to achieve a normal characteristic curve.

Here is a sample of four film/developer combinations for 120 film.



Each of these combinations achieves about the same range of densities from FB+fog up to middle gray.

The previously established Control curve was for Ilford FP4 exposed at ISO 125 and developed for 7 minutes in Xtol 1+2 at 75°F. Other film/developer combinations may need a slight adjustment to the ISO, development time or concentration to come close to the Control. All of the films were developed at 75°F or very close to it in a small stainless steel tank and reel with one minute of initial agitation followed by ten seconds every minute thereafter. Continuous agitation would reduce the development time.

Tmax 100 and HC110(B) produced an effective ISO of 80 with 5 minutes of development but the maximum density gets a lot higher in the brighter zones. The overall curve is much straighter than the control. But 5 minutes of development is close to the minimum time recommended by Kodak. A lower concentration will call for a longer and safer development time.

Tmax 100 in Xtol 1+1 needs about 7.4 minutes of development and it achieves an ISO of 100. However the contrast drops noticeably in the brighter exposure range.

Fuji Acros 100 in Xtol 1+1 with about 6.6 minutes of development also achieves an effective ISO of 100. It is close to the Control for most of its range although the contrast is also higher below middle gray than above it.

All film/developer combinations achieve useful contrast throughout their range from FB+fog to the maximum. With some adjustment to the tone curve after scanning, they all can provide close to the same result. However, the objective is to get the proper tone curve directly from the scanner without having to touch the tone curve in post processing because that might compromise the quality of the image.

A camera with an electronic shutter can simplify the process of getting the twelve test frames. Here is an example using an F100 at ISO 125 with the target being a white screen on a calibrated monitor.

Frame #	1	2	3	4	5	6	7	8	9	10	11	12
Zone	0	1	2	3	4	5	6	7	8	9	10	11
Seconds	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2
Aperture	f/5	f/5	f/5	f/5	f/5	f/5	f/5	f/5	f/5	f/5	f/5	f/5
EV	18	17	16	15	14	13	12	11	10	9	8	7

The camera was set to Manual mode, 1/125s and the aperture adjusted until the meter was at the right aperture for middle gray at ISO 125. That was found to be f/5. The test could now be run by adjusting only the shutter speed.

Any ISO setting can be used so long as you can find the right aperture. With the 50mm f/1.8G and the screen at its current calibrated level that would be from ISO 64 (f/2) through ISO 3200 (f/16).

Conclusion

How does this modify our understanding of, “Expose for the shadows, develop for the highlights?”

Exposing for the shadows still holds because it determines the effective ISO.

But the right development for scanning is one that provides a normal characteristic curve.

So rather than developing for the highlights we can scan for the highlights so that they end up where they belong, possibly in print Zone VIII or IX where there is still some detail and tonality.