

Color Negative Scanning

- **Why color negative films defy ICC profiling**
- **How to scan negatives effectively anyway**

Summary

Unlike photographic transparency or color print materials, photographic color negative (c-neg) films do not represent a constant color space, and therefore cannot be used in the normal sense to produce a typical scanner-specific ICC profile.

Color negative IT8.7/1 targets are available from a few sources, however a profile created from such a target will not behave like a normal transparency or color print profile. A color negative profile will attempt to characterize either the neg/pos printing process ('Print Matching') or the negative's relationship to an actual scene ('Scene Matching'), however usually neither type of profile will be of much value due to the large number of uncertainties in c-neg photography, processing and printing.

This paper begins with a brief summary of the two possible approaches to c-neg profiling, however be warned, the results are NOT likely to be worth the effort, except if you have absolute control over the exposure and development of the negative, for example in a tightly-controlled closed-loop reproduction process.

The good news is that, in spite of the impracticality of c-neg profiling, *pleasing* reproductions can still be made quite successfully by the method described under *Practical C-neg Scanning*.

Profiling approach 1: 'Print Matching'

The first of two c-neg profiling approaches characterizes the appearance of a print made from a normal negative. To create such a profile, an IT8 or HCT scanner target is exposed onto negative film, both a print and a scan are made from the resulting 'negative target', the CIE Lab values of the print are measured, and a profile is created that correlates scanned RGB values (of the negative target) to 'printed CIE Lab'.

When the profile is assigned to the scanned file of the negative target, an accurately-profiled display should show a close approximation of the print made from the target, and when assigned to a scan from another negative, (for example a live image) the monitor should show how a print from that negative will look. The main problem is that the profile simply predicts one of many possible printing setups from that 'controlled' negative target, most of which would be unsuitable for any specific 'live' negative image. This is because the final appearance of any particular c-neg print depends on a host of printing variables including paper batch, dye spectra, printing exposure, printing filtration, etc., the last two of which are usually customized for every negative.

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Another disadvantage of this 'Print Matching' approach to c-neg profiling is that it cancels one of the main benefits of scanning negatives - the recovery of the negative's full dynamic range, much of which is lost in normal photographic printing. This is because typical photographic printing paper has a naturally high contrast which reproduces only a limited portion of a typical negative's dynamic range. Hence a profile that mimics the response of photographic printing paper will also typically lose highlight and shadow detail and exaggerate mid-tone saturation.

Such a profile will also mimic the loss of color purity introduced when a set of imperfect CMY dyes (in the neg) are projected onto photographic paper whose three dye layers have imperfect RGB sensitivity.

Profiling approach 2: 'Scene Matching'

The second approach to c-neg profiling is akin to modern digital camera profiling, and attempts to characterize the actual scene capture process. To create such a 'scene matching' profile a reflection scanner target (IT8.7/2 or HCT) is photographed onto c-neg film, the resulting negative is scanned, and a profile is made which correlates the scanner's RGB values to the original target's CIE Lab values. This is quite a different concept from transparency profiling, which only characterizes how the CMY dyes of a specific material look to the eye under standard viewing conditions, regardless of whether the transparency matches the scene (which is usually not the case).

While it may sound ideal, the scene matching approach to c-neg profiling is very unstable, because it captures all the peculiarities and variables of one particular film roll exposed under one particular lighting and processed through one particular chemistry batch. Frames from other films will generally not reproduce well, due to the fact that the high gain characteristics of the profile will magnify any slight differences between how the target negative and actual 'live' negatives were produced.

Another major limitation is that the original target usually has a much smaller color space than live scenes, so saturated colors may be inaccurately predicted.

This 'scene matching' approach is theoretically similar to profiling a digital camera, which is feasible only under tightly controlled conditions, but seldom accurate for general photography. Unlike digital photography, however, color negative photography is much less stable for several reasons;

1. The profile will only be valid for precisely the same exposure conditions as the target capture, including lighting color, lighting intensity, camera aperture, camera exposure time, camera filtration, etc. These variables are the same for digital camera profiles, except that digital cameras compensate more easily for changing conditions, usually with some form of automatic white balance control.
2. Even if lighting and exposure are perfectly controlled, different color negative film batches may have substantial differences in sensitivity and dye characteristics. By comparison, a digital camera sensor typically remains consistent session to session.
3. Even if manufacturing variables are ignored, (for example by re-profiling for each film batch), film development variations can yield quite different negatives at two different labs from the same film batch. Again, this is worse than both slide film (whose development is more tightly controlled) and digital capture (where

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- 'development' consists of camera settings - curves, filtration, white balance, etc., - that are simpler and easier to control.
4. The orange color correction 'mask' built-in to color negative films is not only exposure-dependent and different from emulsion-to-emulsion type, but also highly non-linear relative to exposure. Being produced from up to 12 separate emulsion/dye layers, the 'color space' of c-neg film is not a simple 3-D product, but vastly more complex and less uniform (in 3-D terms) than the color space of transparency slide film or a digital camera. To characterize this increased color space complexity, a c-neg film target should therefore contain many more patches than a normal scanner target.

Having said all this, if carefully controlled, the 'Scene Matching' method of camera profiling can work (for either negative or positive slide film as well as digital cameras) in certain demanding art-copy situations, but a separate profile is needed for each emulsion type and lighting condition. What you don't get is a general-purpose profile.

Practical C-neg Scanning

In spite of the flaws in both profiling theories, there is still hope. In fact one of the saving graces of negative scanning is that if no guide print is supplied a 'pleasing reproduction' is relatively easy to achieve if a methodical workflow is followed. The basic approach is to scan a full-range RGB file, assign a conservative working space like sRGB, then optimize each scan in Adobe Photoshop™ till it looks 'pleasing'.

Method:

1. Set the scanning software to color neg (if available) or leave it in positive mode, and select 16 bits per channel if available.
2. Produce a full-range scan of the negative with no clipping or plugging in whites or blacks (no RGB values above 254 or below 001). Be sure to include some of the clear negative border.
3. Open the scan in Photoshop and do the following;
4. Image - Adjust – Invert (if the scanner was not set to negative mode.)
5. Edit - Assign profile - sRGB (or any profile that makes the image look reasonable - you can change this profile later).
6. Create an Adjustment Layer set or group.
7. Inside the Layer set, create a Levels adjustment layer and click the black eyedropper on the clear orange border of the negative to neutralize the orange shadow cast
8. Create a second Levels layer and use the white eyedropper to set the highlight. (TIP: Hold down the Option key and slide the upper right triangle slider in the Levels dialog till the whitest image point appears, then click the eyedropper there.) **CAUTION: If there is no white in the image, clicking the white eyedropper may introduce an unwanted color cast, in which case you will have to adjust the white point manually till the result is pleasing. (NOTE: You may need to come back to this Levels layer again later.)**

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9. Create a third Levels adjustment layer and use the black eyedropper to set the shadow in the image (if different from the border). (TIP: Hold down the Option key and slide the upper left triangle slider in the Levels dialog till the blackest image point appears, then click the eyedropper there.) **CAUTION: If there is no black in the image, clicking the black eyedropper may introduce an unwanted color cast, in which case just leave the left triangle slider where it first revealed the blackest image point. (NOTE: You may need to come back to this Levels layer again later.)**
10. Create a Curves adjustment layer and adjust the overall density or contrast for a pleasing appearance.
11. Create a second Curves adjustment layer and use it to remove any color cast, using recognizable gray image areas as a guide. (TIP: Clicking the middle eyedropper on an image point that is supposed to be gray will automatically remove a color cast. If the correction is too strong, fade the opacity of this Curves layer.) **NOTE: Keeping this Curves layer separate from the previous one simplifies the work.**
12. Evaluate overall color saturation and, if necessary, change the assigned profile to improve overall color realism, for example assign AdobeRGB or DonRGB to improve a de-saturated image.
13. Create a Hue/Saturation adjustment layer (if needed) to correct any obviously flawed colors.
14. Save the layered file in case of later corrections.
15. Flatten the whole image to produce a working RGB file, and/or convert to CMYK.
NOTE: Although you could do most of the edits with a single Levels or Curves layer, separate layers let you tweak highlight, shadow, tone and cast edits separately, for example by adjusting the opacity or blending mode of each layer.

Using Don's 'C-neg' Photoshop Action

The manual process described above can be simplified with the action set 'DonzRGBactions' (free at www.hutchcolor.com/Utilities/html) which you can load into your Photoshop Actions palette. This includes an action called 'C-neg' which sets up the required layers automatically for the *Practical C-neg Scanning* process.

NOTE: The action set is free, but technical support for it is not.

Method:

1. Open the image in Photoshop and run the 'C-Neg' action.
2. Work the adjustment layers from the bottom to the top as follows:
3. The very bottom adjustment layer is ONLY to invert the image from neg to pos. If the scan was inverted in the scanner, turn this layer off.
4. The next layer is called 'Border'. Double-click on the black eyedropper, set it to 0, 0, 0 RGB and click on the orange border. This will make the border black. Do NOT do anything else with this layer!

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5. The next layer is called 'Highlight'. If you can find an area that is supposed to be white, click in it with the white eyedropper, otherwise adjust the layer until the highlight looks pleasing.
6. The next layer is called 'Shadow'. Often setting the border also sets the shadow correctly, but if the image is too light at the shadow point and you can find an area that is supposed to be black, click it with the black eyedropper.
7. If the image needs further lightening or darkening, begin by sliding the Gamma control (middle slider in the 'Shadow' layer) to the left (lighter) or right (darker).
8. The next layers can be used to fine-tune lightness, contrast, gray balance, color saturation, etc., the same as for positive originals.

Optimizing Negative Range on the Scanner

While the above methods can get good color from a negative that was scanned exactly like a transparency, it is usually better to change the scanner settings for each negative, because negatives vary much more than transparencies. (This is not necessary if scanning in 16 bits per channel.)

Here's a rough guide to optimizing a scanner for a particular negative.

1. Set the scanner up exactly as you would for transparency RGB scanning.
2. If possible, calibrate the scanner on the lightest part of the orange border of the negative. Calibration is called 'Basic Alignment' on Heidelberg drum scanners and 'Auto-Balance' on Crosfield/Fuji drum scanners.
3. If step 2 was successful change the highlight density (if available) to 0.00. (The normal highlight density value of about 0.05 to 0.10 will clip highlights.)
4. If the scanner cannot calibrate on the negative border, try setting and neutralizing the scanner's highlight (white point) on the negative border.
5. If both these fail, adjust the highlight controls till all three channels are about equal in the border but without any channel going over about RGB 250. If this doesn't work just leave the highlight settings the same as for a transparency.
6. If the darkest part of the negative (highlight) is easily seen, adjust the scanner's shadow controls to give about 90 - 95% CMY (25 - 12 RGB) in each channel.

NOTE: Steps 3 through 6 simply reduce the chance of banding or contouring in 8-bit per channel images. You can still get good color if you scan a neg exactly like a transparency (with no image-specific scanner adjustments), but the results may show excess grain or contouring after working in Photoshop.

7. Scan the image as normal to an RGB file.

Matching a guide print

The hardest challenge in negative scanning is to match a color print made from the same negative. The chances of achieving a perfect match in a reasonable amount of time are very small, because the complex variables in the printing process have no exact control equivalents in Photoshop. Attempting to match a scanned negative to a

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supplied print can involve complex masking and hand retouching that would raise the cost prohibitively above scanning a print or transparency.

If the client supplies a print as a critical color guide, it is often easier and cheaper to scan the print, even though other benefits (e.g. sharpness) may be lost. If you get this request, warn the client that (a.) it's going to cost more, (b.) it will limit the quality that might be extracted from the neg (especially highlight and shadow detail), and (c.) the chances of a perfect reproduction may still be impossible.

If possible, ask the client if they would accept an 'improved' reproduction where you attempt to get more out of the neg than the print shows, while matching the *approximate* appearance of the guide print.

If you are frequently asked to match a reference print, it may be worth starting with a profile created by the 'print matching' approach, but this involves a complex testing cycle, still requires extensive work in Photoshop with no guarantee of success. Even if you succeed, you're back to the limitations of printing paper - excessive contrast, clipped highlights, plugged shadows and contaminated colors.

An interesting idea which potentially restores some of the advantages of negative scanning while maintaining the color appearance of a guide print is to scan *both* the negative *and* the guide print and combine the two as follows;

Dual-scan approach:

1. Scan the guide print to the final size and resolution, assign a normal reflection profile (for that print material) convert the print scan to your working RGB space.
2. Scan the negative to the final size and resolution.
3. Adjust the negative scan for an approximate color match, but concentrate on tonal and sharpness qualities, then convert it to your RGB working space.
4. Precisely register the guide print scan as a new layer on top of the negative scan, if necessary distorting the guide print layer to fit the negative scan pixel-for-pixel.
5. Set the guide print scan 'Layer Mode' to Color.
5. Adjust the negative scan as needed to fine-tune the luminance match between the combined assembly and the Guide print.

Good luck.