Film Reciprocity

Text and photos by Jack and Sue Drafahl

More here than meets the eye?

Over our years of film testing for *PHOTOgraphic* Magazine, we have devised a method for standardizing our results. In each of these film reports we explain the new features of the emulsion and show you the results of our extensive location testing. We briefly mention a term called reciprocity failure, and explain how it relates to the film we are reviewing.

It was recently brought to our attention that many readers don't completely understand what reciprocity is or how to correct for it. We decided it was time to tackle this assignment, so we started reviewing and researching. Boy did we open a can of worms! There is tremendous confusion amongst the photographic world on how to identify and correct the effects of film reciprocity. Everyone seems to have an opinion, including the film manufacturers, and many of the solutions conflict with one another.

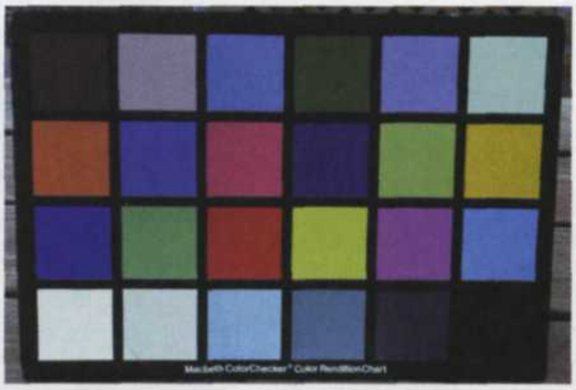
This prompted us to go back to the beginning and start with the definition of film reciprocity and expand our research from there. The reciprocity law states that the intensity of light that strikes the film multiplied by the time the shutter is open, equals the amount of exposure. This is the root of the exposure system in photography.

We all learned in Photography 101 that to achieve a correct exposure, you must set the proper shutter speed and f-stop. As you increase one, you must decrease the other to maintain a good exposure. For example, 1/125 at f/16 provides the same exposure as 1/250 at f/11. As you work you way up and down the f-top and shutter speed scales, everything must stay in balance.

The reciprocity theory speculates that the density of film will be constant if the quantity of light is constant, regardless of the rate at which the light is supplied. Sounds right, huh? Well there comes a point in time where the reciprocity law fails. This change in exposure, color balance and contrast starts to show when your exposures exceed one second and worsens as you lengthen your exposure. At the other end of the scale, the law also fails when your exposures are shorter than 1/1000 second.

This failure of the reciprocity law is due to the physical makeup of film and how each reacts to light during very long or very short exposures. The problem comes into play because each type of film reacts differently to the failure of the reciprocity law. It would be nice if there was a simple

Fujicolor ISO 160 negative film exposed at meter setting. Time = ½ second.



Fujicolor 160 color negative exposed at meter setting + 1 stop. Time = 2 minutes.

Fujicolor 160 exposed at meter setting + 1 stop. Time = 2 minutes. Image corrected in Adobe Photoshop using Pictographics iCorrect Pro.

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This Kodachrome image was taken in late afternoon in winter. Meter = 10 seconds Actual = 15 seconds.

Here's the same Kodachrome image after adjustment with Adobe Photoshop plug-in filters.

equation that would fix the problem, but there are so many variables that it is tough to accomplish predictable results.

This confusion prompted us to run a few tests just to see what was really going on. Considering the fact that there are more than 100 different 35mm films, a total investigation was not feasible, so we just picked a couple of slide and negative films. We used a Nikon F5 and Minolta Auto Meter IIIF to lock in our exposures and ran a variety of color chart tests. After processing the film in fresh chemistry, we compared our results with the film data sheets various photographers had posted on the Web. Not surprisingly, our results were quite different. So now what?

We proceeded with our investigation by examining some long and short exposures we had previously taken, just to see how we had corrected the problem. About all we could distinguish was that there were more exposure variables than we cared to think about. The only thing we both agreed on was that this whole reciprocity process was extremely confusing. To give you an idea, we made a list of some possible variables that might affect the final results of reciprocity tests.

1. Results vary if you use the same brand of film but different emulsions. In our tests we found that two emulsions reacted differently with reciprocity failure. If you found a viable reciprocity solution with a specific film, you would have to freeze several rolls to insure consistent results.

2. Exposures change as lighting conditions vary. We found a difference in color balance when photographing with overcast skies and with clear night skies. If you had a mix of clouds there would be no way to color correct the final image.

3. Another problem is changing conditions over long time periods. When running an eight-minute exposure test an hour after sunset, the exposure reading dropped two full stops. You would need a special computer program that could calculate the exposure readings so you could modify your final exposure.

4. Camera meters are unpredictable over long periods of time. We found that camera meters became very unstable when forced beyond 30-second exposures. A hand-held meter was necessary for these longer exposures.

5. There is also a problem with the color temperature of the light source changing. If your light source is something

Heavy neutral density filters were used to permit a long exposure time in sunlight. Time = 10 seconds.

A normal sunlight exposure on ISO 100 color-negative film. Time = 1⁄100 second.

Here's the 10-second image after adjustment with Adobe Photoshop plug-in filters.

other than outdoor skylight, you will find yourself looking through dozens of charts and graphs trying to calculate the exposure time for each type of light source. The variables here are endless.

6. Not every exposure fits into the 1/10/100-second pre-established charts. Even if you have a chart showing exposure and color corrections, what do you do if you have times other than those listed on the charts? The world of long exposure doesn't always fit neatly into those three pigeon holes. So do we go back to educated guessing?

7. Even if you can correct the exposure and color balance problems, you still have a change in contrast that normally cannot be fixed during the photo process.

8. When you take close-up flash pictures, the flash can achieve durations as brief as 1⁄40,000 second. Unfortunately, there is no record of what speed the flash is using unless you use a manual flash setting. That sort of defeats the purpose of having a fancy flash, right?

If you start combining all these variables, and then add several more that we haven't mentioned, you still don't have a reliable way of computing long or short exposures that will be affected by reciprocity failure. So, you have to ask yourself a question. Do you want to spend more time perfecting your long and short exposures, or do you just want to have fun taking pictures? You see the problem is technology itself. Sometimes people get so wrapped up understanding the technology that they forget the real reason why they love photography.

We're not advising that you ignore the extensive research that is available, just that you use the fastest and simplest means to a solution. For example, if you look at all the charts and graphs that have been created, the consensus is that you can use a +½- stop correction for 1 second, 1-stop correction for 10 seconds, and 2 stops for 100 seconds. Use these values as a starting point when you bracket your exposures.

Bracketing your exposures is the easiest and simplest method for solving the problem of reciprocity failure. Slide shooters will have to bracket the most since slide film has such a narrow exposure latitude. If you absolutely must

Star trails require long exposure times, which can require compensation for reciprocity failure. The exposure here was 30 minutes at f/2.5 on ISO 400 color-negative film. The diagonal streak is the ISS space station passing through.

Close-up image of a fly using normal TTL flash exposure. Flash duration was very short. Reciprocity failure occurs at very short exposure times as well as at very long ones.

Here's the same subject with the exposure increased ⅔ stop to compensate for reciprocity failure. No color adjustment was needed.

have the shot, then try using color negative film. Since it has a wide exposure latitude, a +1- or +2-stop bracketed exposure will guarantee you results. Color balance only becomes a problem with color slides, since you can correct for any color shift with color negative film during the printing process.

If you are working with an electronic flash at high speeds, you can generally get a good exposure by setting the bracket function to +⅓, +⅔, and +1. If your camera will only bracket on either side of what it thinks is the correct exposure, set the exposure compensation to +⅔ and then use the ±⅓-stop bracket mode to accomplish the same results.

The first half of the solution is to bracket your exposures and the second half is to utilize software. In addition to the films we test for *PHOTOgraphic*, we also review software. We have been doing research on Adobe Photoshop plug-in filters for an upcoming article and have discovered a couple of software solutions to reciprocity failure.

The Digital ROC plug-in from Applied Science Fiction, is designed to restore old faded images where the scanner cannot fix the fading. Since reciprocity failure looks similar to a faded image, we gave it a try and achieved spectacular results.

Next we tried the iCorrect program from Pictographics on the same image. The results were very close so we loaded in every image we could find that was taken with long exposures. When one plug-in didn't work, the other did. These two together were a perfect duo for salvaging images with reciprocity failure.

We looked at many other plug-in filters, including those in Photoshop, and none did as well as these two. Eventually though, we found an image that neither program could fix, since the image had a major crossover in the blue-green area. We had to resort to using the Curves editor in Photoshop to fix the problem.

When doing all our research, not one person or company ever suggested the possibility of using software to help correct the reciprocity-failure problem. Granted, the final image was not achieved the old-fashioned way, but just think about how many photos we took by not fixating on the technical process involved. ■