

Reciprocity Failure: Film Versus Digital

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The ability to accurately adjust an exposure's shutter speed, aperture, and/or ISO value is predicated on the concept of "Reciprocity." Reciprocity is defined as "a law stating that exposure remains constant as long as the product of time and intensity remains constant" [1]. Basically, reciprocity allows a photographer to compare apples to oranges or in other words, make equally-valued changes in one's camera settings in order to maintain or obtain a properly-balanced exposure. During low-light or nighttime endeavors, this reciprocal relationship starts to fail, which is known as "Reciprocity Failure."

Reciprocity failure occurs because of a decrease in sensitivity to light in the film's emulsion (light gathering ability of the film's chemical compounds). Essentially, after a few seconds of exposure time, the reciprocal or equivalent relationships between apertures and shutter speeds stop working in a truly reciprocal manner. Thus, film ceases to be influenced by additional light during long exposures as one would expect during typical daytime exposures. This reciprocity failure offers a great benefit for crime scene investigators by providing a great deal of latitude and making it rather difficult to overexpose a nighttime composition. However, with the switch to digital imaging, the question that many have is: Does reciprocity failure still occur when recording low-light images with a digital camera?

The short and simple answer is that reciprocity failure does not apply to digital imaging. Because a digital imaging chip does not possess a silver-halide chemical emulsion, the imaging chip will continue to record light after the first few seconds in the same manner it does while photographing much shorter exposures. Figure 1A was recorded at ISO 100, f/5.6, for one second. The overall appearance of both the film and digital recordings of Figure 1A was identical. However, the intentional overexposure of the composition by five stops of light was drastically different. Remember that a one-stop change in light is equal to one-half or twice the value of light as compared to the next full stop. Figure 1B was recorded on Fuji color film at ISO 100, f/5.6, for 30 seconds. 30 seconds is a five stop change in light value from 1 second: 1 second – 2 seconds – 4 seconds – 8 seconds – 15 sec-

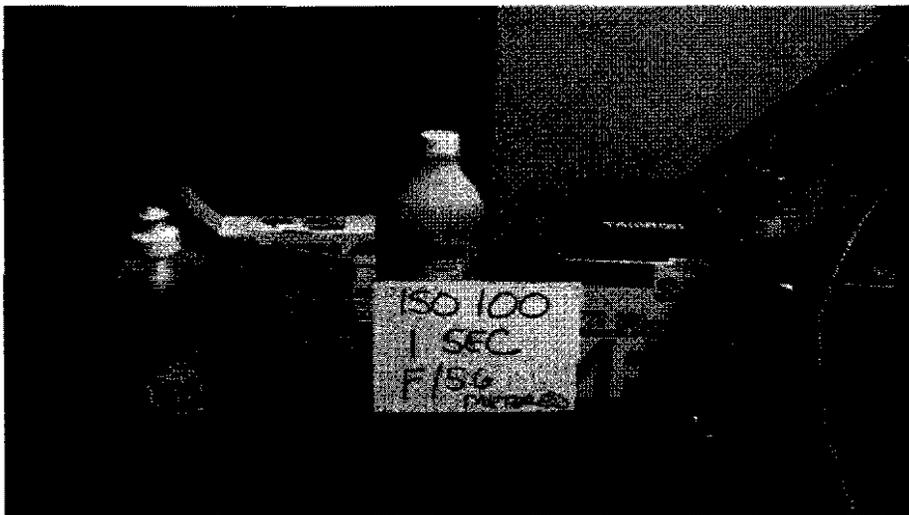


FIGURE 1A

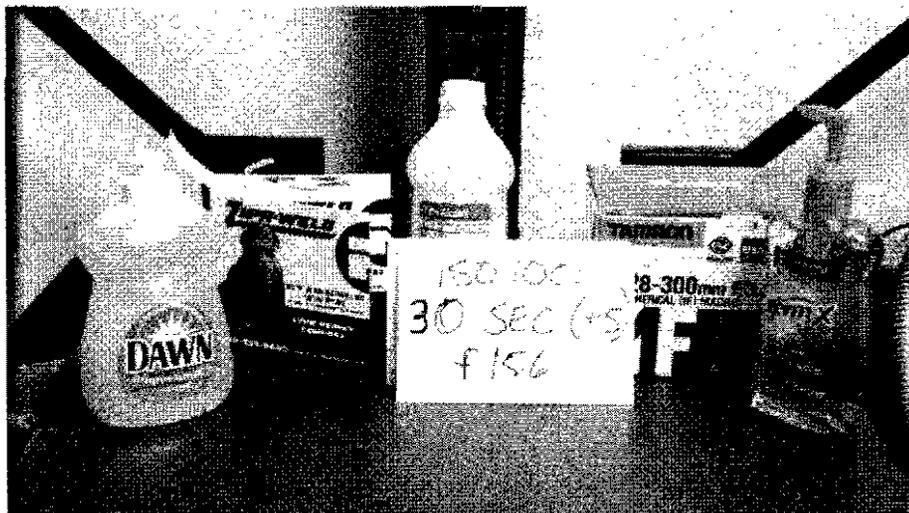


FIGURE 1B

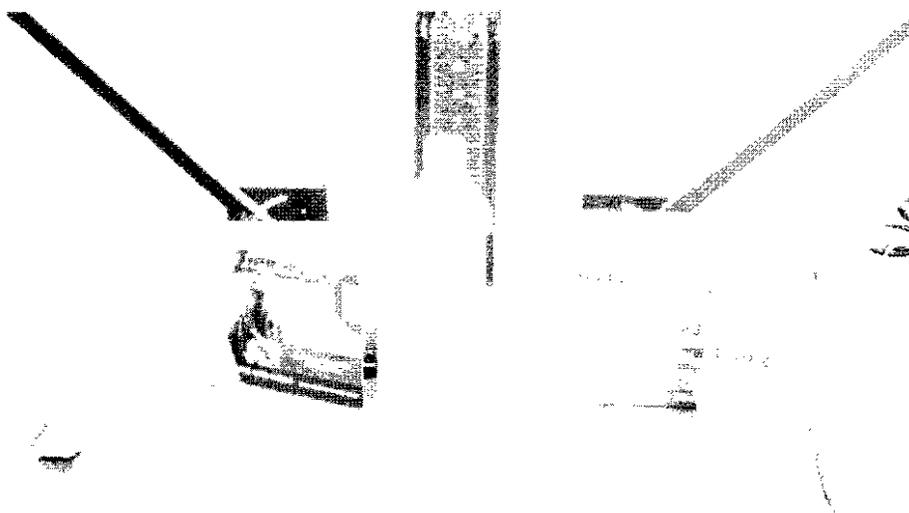


FIGURE 1C

onds — and finally 30 seconds. Figure 1C was recorded at the exact same values as Figure 1B (ISO 100, $f/5.6$, for 30 seconds), but was recorded with a Canon D40 digital camera. Reciprocity failure (the decrease in sensitivity of the recording film to light) clearly occurs in the film image (Figure 1B), but light continued to have an impact on the digitally recorded image throughout the exposure. Although there is a slight over exposure in Figure 1B, the overall composition was not destroyed by a five-fold increase in light. In contrast, the digital image (Figure 1C) was completely washed out by the additional light. Figure 1C is similar to what one would expect during a daytime composition that was overexposed by five stops.

It is important for crime scene photographers to recognize that reciprocity failure does not carry over when switching from a film-based system to digital imaging. Although one is sacrificing the latitude or room for error when capturing low-light images with a digital camera, the tradeoff is that one can more accurately predict or calculate a nighttime composition. With film, one could estimate their time exposures and bracket their compositions in the hope that enough light was recorded. However, digital-exposure calculations are very straight forward and are the same in the daytime as they are in low-light compositions. Figure 2A was recorded in extremely low light, requiring an ISO of 3200, an aperture of $f/8$, and was exposed for one second. Figure 2B was recorded at ISO 100, $f/32$, and was recorded over the span of eight full minutes. The change in ISO value from 3200 to 100 was a loss of five stops of light. The change in aperture value from $f/8$ to $f/32$ was a loss of an additional four stops of light, for a total loss of nine stops of light between Figures 2A and 2B. In order to balance the exposure in a reciprocal fashion, a total of nine stops of light were added to Figure 2B by increasing the length of the exposure from one second to eight minutes: 1 – 2 – 4 – 8 – 15 – 30 – 60 – 120 – 240 – 480 seconds. Notice how the light values of the two images are similar and how the depth of field improved in Figure 2B. Such an adjustment could be quite advantageous to a crime scene photographer. Oftentimes, photographers give up on depth of field in low-light conditions because their cameras will not meter exposures with extremely small apertures. However, an inves-

tigator requiring an extensive zone of sharp focus can predict with certainty the length of an exposure outside of 30 seconds. The first step is to open up the camera's aperture and increase the ISO value to the point where the camera can obtain a proper exposure. Next, meter the ambient light and determine a balanced exposure for those wide-open aperture, high ISO value settings. Finally, make reciprocal adjustments in the settings so that the large aperture can be decreased to a desirable opening. This process is what was achieved to record Figures 2A and 2B. Figure 2A was metered with the ambient light and then the reciprocal changes were made to achieve an equally-illuminated image in Figure 2B.

There are a number of tradeoffs when choosing between digital and film imaging. As far as low-light and long time-exposures are concerned, the main tradeoff is the choice between the predictability of digital imaging and the exposure leeway offered by film imaging. Fortunately, with a little deliberate and creative composition, a digital photographer can have the best of both worlds. As long as one arranges their composition in a way that keeps harsh light sources out of the image, then unintentional overexposures are not going to be as damaging as what might occur during a daytime exposure. Unintentional overexposures may occur when the length of an exposure is not known until after the photograph's recording is complete. For example, when an investigator needs to paint their scene with light or reconstruct the scene of a shooting with lasers and during those times, the exact length of an exposure may not be known until the composition is complete. Certainly, one can bracket the photograph's capture, but by keeping harsh light sources out of the image, an accidental overexposure will not unduly harm a photograph. Of course, one must still be mindful of underexposing an image. Compare Figure 3A to Figure 3B. Figure 3A's exposure evaluation was determined by the camera and was recorded at ISO 100, $f/5.6$, for 1 second. Figure 3B was intentionally overexposed by three stops and was recorded at ISO 100, $f/5.6$, for 8 seconds. Although Figure 3B is brighter, the overall composition did not degrade as much as one might expect from a daytime image overexposed by three stops. One of the great benefits of digital imaging is the ability of the average person to adjust exposures with ease



FIGURE 2A



FIGURE 2B



FIGURE 3A



FIGURE 3B



FIGURE 3C

during post-capture editing. Figure 3C was an intentional overexposure of the same image by five stops of light and was recorded at ISO 100, f/5.6, for 30 seconds. However, with a small amount of exposure correction with Adobe Photoshop®, an acceptable image was easily obtained. It should be noted that if a photographer anticipates exposure difficulties or is dealing with drastic contrasts in their composition, then it would be advantageous to record the digital image in a RAW (uncompressed and unprocessed) format. RAW images have greater bit depth and consequently, record greater information that is extremely valuable for adjusting exposure levels.

A vast majority of agencies are making the conversion from film to digital and individual photographers are typically dependant upon what their agency dictates as the method of capture. However, digital photographers may not want to toss their old film cameras into the trash just yet. Digital cameras suffer from “noise” during long exposures. Noise refers to the unwanted artifacts or random pieces of information added to photographs during long exposures. Noise can also be found in images recorded at high ISO values (ISO 1600 and higher). Most frequently, noise occurs in the form of unwanted red, blue, and green pixels added to a digital photograph. Some digital cameras have built-in noise-reduction filters, but these noise-reduction filters can only do so much and they do not come close to the sharpness and clarity that film has to offer. In addition to the noise-reduction filters found on the camera, post-capture editing programs such as Adobe Photoshop® have noise-reduction filters that can be used to create even better images. Figure 4A was recorded at ISO 3200, f/22, for 16 minutes and was captured without any noise-reduction filters applied. Figure 4B was recorded at the exact same settings, but high speed and long exposure noise-reduction settings were selected on the camera. The details visible in Figure 4B are far superior to those found in figure 4A.

Crime scene investigators should utilize all the tools available to them in order to accurately document their crime scenes, as well as capture the sharpest possible images. Digital cameras certainly can capture crystal-clear images, even in the nighttime. Furthermore, low-light exposures can be accurately calculated even in the dimmest



FIGURE 4B

of conditions. Digital image files can also be easily processed in order to improve the overall quality of the image. However, there are still times when extended time exposures are necessary and the fact that reciprocity failure can be quite beneficial to a photographer and to the final recorded image. Film's failure of reciprocity helps prevent overexposures. Film also offers the advantage of not adding extraneous noise to long exposures. Consequently, investigators should consider keeping a film camera or two in their arsenal for those times when exposures lasting sev-

eral minutes become necessary. Whichever photographic format is used to capture low-light images, photographers can improve their images through careful composition and deliberate exposure calculations.★

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1. Davis, P. *Photography*, Seventh edition; McGraw Hill: Boston, 1995; p 424.

ADDITIONAL READING

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Frost, L. *The Complete Guide to Night and Low-Light Photography*; Amphoto Books: New York, 1999.

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SUSTAINING LIFE ACTIVE - 27

SUSTAINING LIFE ASSOCIATE - 6

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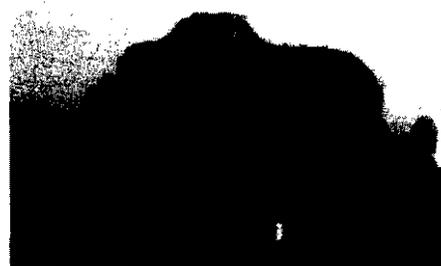
Dollie S. Woods

CORRECTIONS TO THE FALL 2009 CHESAPEAKE EXAMINER

The editor regrets the following errors and appreciates that they were brought to her attention.

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On page 14 of this article figure 4A was inadvertently omitted from the publication. The referenced image is below.



A Review of Split Testimony Cases Resulting From Admissibility Challenges by Joel Zlotnick, M.S.F.S. & Laura Tierney, M.F.S., U.S. Immigration and Customs Enforcement, Forensic Document Laboratory McLean, Virginia

This article was inadvertently formatted incorrectly. A properly formatted pdf of the article was sent via email to the membership in December. Please email the editor, Laura A. Hutchins (lahutchins@comcast.net) if you would like the article resent.

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