ADJUSTING DEPTH-OF-FIELD — Part IV

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as published in *Shutterbug*, July 1992.

To focus, or not to focus? That is the question we'll discuss in Part IV.

In Part I (October '91), it was observed that modern lenses and materials permit resolution far exceeding the 1/30 mm criterion often used in calculating depth of field. (Actually, the standard is usually 1/1500th of the image diagonal—1/30 mm for full-frame 35 mm only.) My tests have shown that I sometimes achieve recorded detail as small as 1/200th of a millimeter on slow, high resolution films. I can adjust the depth of field scales for this new standard, but the new scales suggest there will be almost no significant depth of field. Yet experience shows me I do achieve useful detail over a significant interval, especially inside the calculated inner limit of depth of field. Why?

In Part II (May '92) I explained that infinity focus results in uniform resolution of subjects at all distances. With my lens focused at infinity, any object in my field of view will be resolved in the image so long as the object is larger than the lens aperture in use. It was this rule that allowed me to state in Part I that (with lens focused at infinity) a model could walk towards the camera from the 'inner limit of depth of field' and I would not see any change in the detail of her features. Often, in scenic photography especially, it makes sense to shift focus from the hyperfocal distance to infinity, sharpening the rendition of distant objects, and showing negligible degradation to foreground objects. Focusing at the hyperfocal distance, by comparison, noticeably blurs distant objects while providing little improvement to subjects very near the camera.

In Part III (?? '92) we learned how we might calculate what will or will not be resolved when the lens is focused closer than infinity. There is a simple formula that can be used to estimate the spot size which can be resolved at any particular distance. The formula is: $S = (d \times L) / D$ or $S = (d/D) \times L$. S is the spot size (size of smallest object to be recorded), D is the distance at which the lens is focused, d is the diameter of the lens opening, and L is the depth of field measured either side of distance D. (The total depth of field is 2L.) We can also write the formula as $L = (S/d) \times D$. You may think one needs a calculator to use these expressions. I hope I can persuade you otherwise.

The main question is: when can we focus at infinity, and when do we have to focus closer? Is there a simple rule that I can use—without resorting to a calculator?

There is a rule, and it is a very easy one. There are three simple questions to ask: What size objects do I wish to have recorded in my image? How large in diameter is the lens opening I intend to use? And, are the objects bigger than, or smaller than, the physical diameter of that lens opening? If the objects are bigger than the lens opening, one might as well focus at infinity. This will ensure that distant objects being photographed are resolved as sharply as possible. We do not need to bother with depth of field considerations in this case. If, on the other hand, the objects are smaller than the lens opening, one must focus. And in this latter case, we have no choice but to contend with the depth of field issue.

Several readers have asked if I carry a calculator with me when taking pictures. No, I never have. The math is much too simple. And really, that's one of the points I have been trying to make in this series of articles. Depth of field scales, and especially tables, tend to make us think depth of field is a critical sort of thing. It takes major changes in lens aperture to make noticeable changes to the image. One, or even two stops, is often almost insignificant in terms of how sharp an object appears. If, according to the above rule, I have to focus closer than infinity, then I probably have a depth of field problem no matter what I do. Typically, I can control the total depth of field by a factor of ten or so, and that's all. Using f/22 instead of f/2, makes the zone of acceptable sharpness 10 times greater: 10 feet instead of one foot, for example. The only other factor under my control is where to set the focus. To maximize depth of field, I usually find that the best strategy is to focus half way through the field and stop down as much as I dare.

So how do I approach the difficult problems? Most of my pictures are taken with rangefinder cameras or with SLRs having a manual stop-down feature. But I don't use the stop-down feature in the way you might think. Step one is to stop down the lens and look in the front of it. I make a mental note of the aperture diameter. Then I look at the scene to be photographed: what is the smallest detail I want to record in the image? Is it a piece of gravel, a blade of grass, a grain of sand, the pupil of an eye, a single hair, or a bush on the side of a mountain? If the smallest object to be recorded is bigger than the (stopped-down) lens aperture, I simply focus at infinity and get on with the job of composing and shooting.

If the smallest object to be recorded is smaller than the lens aperture, how much smaller is it? Whatever the fraction it is, that is the number to remember. Let's suppose the the lens aperture is twice the width of my thumb, and the smallest object to recorded is a pebble in the foreground about one-half as big as my thumb, or *one-quarter* as big as the lens aperture. Remember that fraction: *one-quarter*. The pebble is about twenty feet from the camera. In the distance, about a hundred feet away, is a stone building. I want the mortar in the stonework to be clearly delineated. The mortar between the stones is, I estimate, also about half as wide as my thumb. Next question is where to focus. Wherever I focus, my permissible depth of focus is, on either side of the point of exact focus, *one-quarter* of the distance from lens to point of exact focus. If I focus at 30 feet, the zone of acceptable focus extends from 23 feet to about 38 feet—7.5 feet (*one-quarter* of 30 feet) either side of 30 feet. That's almost enough depth on the near side, but nowhere near what I need on the far side. Something has to change.

I must stop down the lens. I stop down two stops. The lens aperture is now one thumb in diameter; the desired resolution is still half a thumb or *one-half* of the revised lens aperture. Depth of field is now double what it was before: 15 to 45 feet (30 feet plus or minus *one-half* of 30 feet). At 100 feet, my resolution limit is now 2 and a bit thumbs (100 minus 30, divided by 30): inadequate by a factor of about 4. I shift focus to 60 feet; my lens opening is still one thumb in diameter. The zone of acceptable sharpness is now 60 feet plus or mi-

Figure 1: This photograph was taken with a 28 mm lens at f/8: adequate to resolve the lettering on the front of the locomotive even with infinity focus. In fact, focus was on the near end of the main part of the station. Infinity focus would have yielded slightly superior results.

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nus *one-half* of 60 feet: 30 feet to 90 feet. I'm getting close. My resolution size at 100 feet is now two-thirds of a thumb (100 minus 60, divided by 60, times one thumb). At 20 feet, it is also two-thirds of a thumb. I can either decide to live with this, or I can stop down one more stop. I probably should stop down the extra stop, unless the light prevents it.

Of course diffraction just might be a problem. You may recall back in Part III it was stated that a 5 millimeter aperture allowed a one millimeter resolution at 25 feet. At 100 feet the limit would be four times as great: 4 millimeters. So long as my thumb is at least 8 mm in width—so that half-a-thumb is greater than 4 mm—all should be OK. (My thumb actually measures about 20 millimeters, so we are OK.)

It is interesting to note, however, that if I had decided to stop down the lens to half-a-thumb at square one—just one stop smaller than I ended up using—I could have just focused on infinity, and all would have been taken care of.

The photograph accompanying this article shows a diesel locomotive in front of an old station of stone construction. The mortar in the stonework was one of my considerations. The foreground criterion was that I should be able to read the notices printed on the front of the locomotive. The letters in the printing have about a four millimeter stroke width. In this particular situation, using a 28 mm lens, f/8 was adequate to achieve my needs for infinity focus. As I recall, I did use f/8 but I focused on a point only part way along the station. This was a mistake. Infinity focus would have resulted in improved detail at the far end of the station. As it is, detail smaller than an inch or so is not visible there. I should have been able to do better by a factor of about two.

If you are still with me, you may have found you had to concentrate a bit. Yes, it is not exactly intuitive at first. With a bit of practice though, I'm sure you'll catch on. But think what we've just done. We have calculated the depth of field from first principles, taking into account the needs of the specific photo being taken. We even considered diffraction limits. And the result holds no matter what lens is being used, and no matter what the film format is. The method even works for zoom lenses that don't maintain a fixed f-number. We didn't need to consider the f-number at all. We just look at the lens, look at the scene, and reason it out in our heads! The lens didn't need to have a depth of field scale. We didn't need to know what the lens designer assumed when he created the depth of field scale. And we didn't need tables of any kind. I think that is quite an accomplishment.

One does not need calculator accuracy. Approximate calculations are good enough. It does take a bit of mental discipline to do the calculations, but the calculations themselves are almost trivial. It's not as quick as setting focus to the hyperfocal distance using a depth of field scale. But then, that method doesn't give us results we can interpret quantitatively either. By quantitative interpretation, I mean the ability to determine precisely which details will or will not be recorded in the image. I will admit that I sometimes scribble on the back of my business card to do the simple math, but that's about it. No calculator, no note pad.

If I can leave you with two or three basic thoughts, they are these.

The most effective way to maximize depth of field is often to stop the lens down to the size of the smallest detail to be recorded in the image. Then focus at infinity and shoot. If it is not reasonable (by virtue of the fine detail desired, or by lighting conditions) to stop down that far, focus half-way through the field and stop down as far as you can.

For selective focus, we all know we have to shoot with a small f-number. Here again, the rule is usually simple: use the largest diameter lens opening you can. Unless you are changing shooting distance as you change lenses, you need not worry about focal length, f-number or format. The largest diameter lens you have is the one to use. If it is necessary to change shooting distance with focal length so as to keep the image size on film the same, use the lens with the numerically smallest f-number.

Give it a try. It jusy might work for you!