ADJUSTING DEPTH-OF-FIELD

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One upon a time, in the land of serious photographers, I too, believed in the myths of depth-of-field. By the myths of depth-of-field, I mean to refer, of course, to the definitions, rules, tables, graphs and charts found in almost every serious book on the subject of photography. After about three decades of failing to achieve my goal of confidently producing really sharp, detailed images, the light finally dawned. And I have lived rather more happily with this subject ever since.

I used to switch back and forth between medium format and 35 mm, trying to capture that quality I sometimes achieved, apparently by accident. If anything, my medium format photographs were *less* detailed than the 35 mm photos, but prettier—nicer grays and such.

Then one Friday night it hit me: the depth-of-field rules told me how to achieve the “minimum acceptable sharpness”. And that’s exactly what I was getting: *minimum* acceptable results: amateurish results and sometimes down right fuzzy results.

How might a photographer reliably achieve super-sharp results all the time? In this article I’ll try to explain what the photography books didn’t tell you about depth-of-field and sharpness, and I hope this will help you to achieve the results you really want.

For those who may not be familiar with the concept of depth-of-field, I offer this brief explanation. According to the theories of geometrical optics, a lens focused at distance ‘X’ will require that, for maximum sharpness, the subject be positioned exactly at distance ‘X’. In practice, it is found that if the subject is a little closer or a little farther away, even the best scientific instrumentation will not be able to detect the difference in sharpness. So, in practice, there is a zone within which any subject will be imaged “sharply”, or with acceptable sharpness. That zone of lens-to-subject distances is the depth-of-field. Countless books and magazine articles will tell you how to determine how big that zone is.

A related useful concept is that of the hyperfocal distance. If a lens is focused at its hyperfocal distance, the depth-of-field is claimed to extend from one-half the hyperfocal distance to infinity. Hyperfocal distance depends upon the focal length of the lens used, upon the *f*-stop used and upon the criterion used for acceptable sharpness.

Before we get down to serious business, let me explain what I believe to be the three most serious and erroneous myths associated with the subject of depth-of-field. Number one is the “one-third rule”. Have you ever read that you should focus one-third of the way through the field you want to be sharp? It’s in many books; I’m sure you have. Well, it’s almost *never* true. Mathematically it is true under precisely one condition: when the far limit of depth-of-field is precisely twice as far from your camera lens as is the near limit of depth-of-field. Under any other conditions, the math (as opposed to the myth) says you should find some other point on which to focus. So much for that one.

Number two is: “if you want to maximize your depth-of-field, focus your lens at the hyperfocal distance for the *f*-stop you are using.” This rule is mathematically correct, but it may not give you what you expect. We’ll study this one in detail a bit later, along with its corollary: “if you’re not happy with the results you get this way, close the lens down a stop or two extra.” It is my view that this rule was once true, but is today outdated by superior films and lenses.

Myth number three is that for best results one should not use the depth-of-field scale on the lens; rather use pre-calculated tables: they are more accurate. It’s hard to say that this one is wrong, but it’s not as right as you might think. And worse, tables tend to be misleading. The depth-of-field scale on your lens is actually very helpful; it gives you a lot more information and flexibility than any single table ever could.

The main trouble with depth-of-field tables is that they give a false sense of what to expect. For example, the depth-of-field table for the 200 mm Micro-Nikkor, says that at an *f*-stop of *f*/5.6 and with the lens set at infinity focus, the depth-of-field will extend from “1929.22” meters to infinity. Note that the inner limit of depth-of-field is specified to one centimeter, or about three-eighths of an inch. Let’s suppose I have a model out there—over a mile away—at 1,929.20 meters. Am I supposed to call her up on the cellular phone and say “Would you mind stepping back by about three-quarters on an inch? The wind is blowing your hair towards the camera—it’s just a tad out-of-focus—... Ah, that’s it,... beautiful!” This is patently ridiculous. She could walk closer to the camera by *a quarter of a mile*—or more—and I wouldn’t be able to see the difference!

The fact that tables sometimes specify distances to six significant digits tends to make one think that things are *that* critical. They are not. The reason the tables have so many figures in them is that it’s *easy to calculate* tables to that degree accuracy. But tables are not that accurate in the first place. For a start, we generally don’t know the focal length of our lens that accurately, or it’s actual *f*-stop for that matter. Furthermore, residual aberrations in lenses cause the distance at which the lens is actually focused to change with all sorts of things like *f*-stop, temperature, and even subject contrast. And where the lens is focused will probably affect our image far more than anything else. For close-ups, tables might be useful. For anything else, a well designed depth-of-field scale on the lens is probably more useful.

So, on with the main thrust of this dissertation: what’s wrong with the time-honoured treatment of depth-of-field? Why was I unhappy with my photographs? The answer lies in the assumptions that were made. The theory, the mathematics: they’re adequate. It’s the application of the theory with which I take issue.

Assumption number one is that a circle-of-confusion of one-thirtieth of a millimeter diameter or less is adequate for 35 mm photography. (The circle-of-confusion is the perhaps best explained in the present context as the out-of-focus disk image produced by the tiniest of point objects.) This number, one-thirtieth of a millimeter, was derived, I believe by Leitz, in the 1920s or ’30s when that was the best resolution (or, in their words “thickness of outline”) that the best films of the day could produce.

You will also find justification for this figure on two other grounds. I have seen articles written in the 1940s

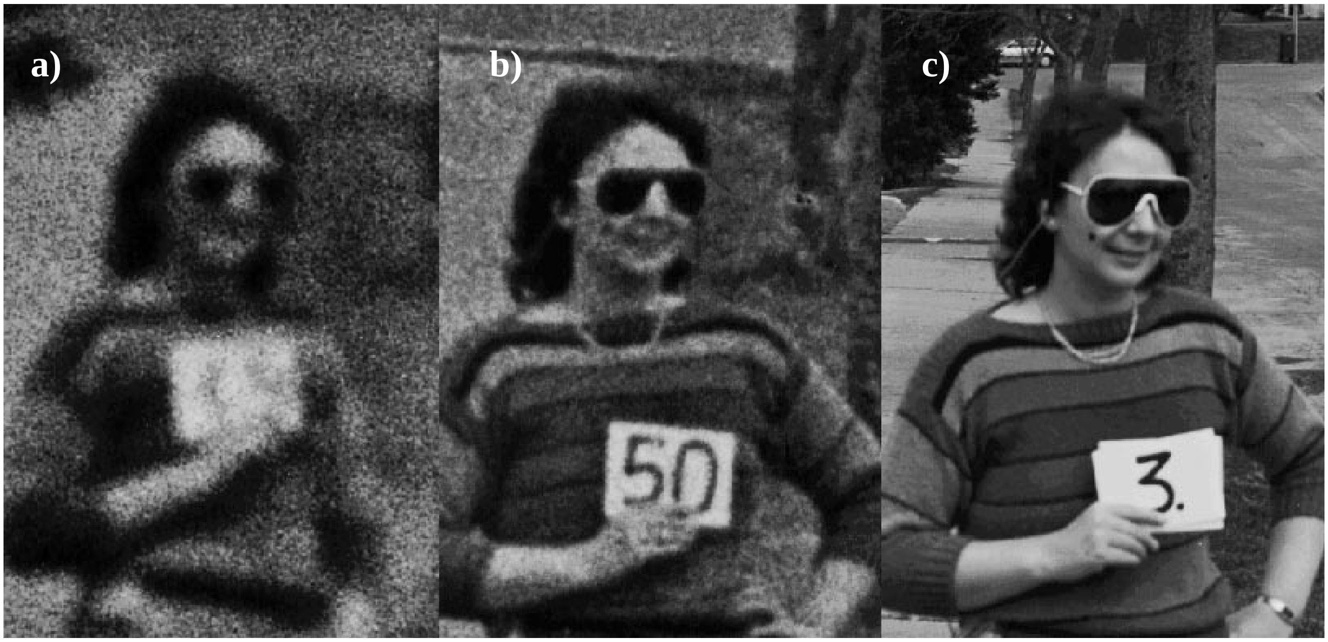

Figure 1: My sister-in-law, June, as photographed under various conditions as follows. a) June is at a distance of about 160 ft; the 50 mm f/8 lens is focused as shown in Figure 2 at its hyperfocal distance. b) As for a) but with the lens focused at infinity. The enlargement factor for both of these photos is about 120 times. c) Here the lens is still focused at infinity, but June has walked forward to within 10 ft. of the camera. For c) the enlargement factor was reduced to result in the same size image as for the other two examples.

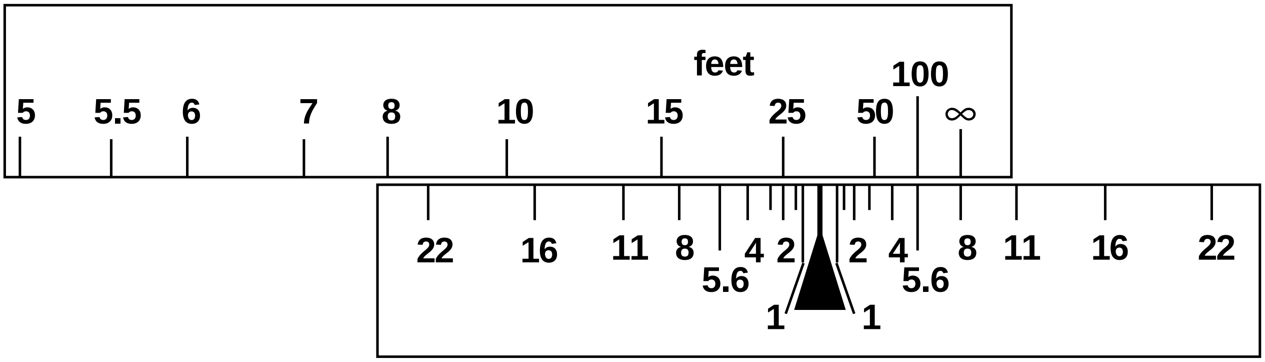

Figure 2: Here's what the distance and depth-of-field scales might look like on a 50 mm lens focused at its hyperfocal distance for f/8. The depth-of-field scale has been drawn for apertures as large as f/1 and for an allowable circle-of-confusion one-thirtieth of a millimeter in diameter. (This diagram was printed incorrectly in Shutterbug.)

which state that the average lens, at its best aperture, can produce a circle-of-confusion no smaller than one-thirtieth of a millimeter. The explanation most commonly seen these days is that the human eye, looking at an 8 inch by 10 inch photograph at normal viewing distances, can detect spots no smaller than one-hundredth of an inch. Given that a 35 mm negative would have to be enlarged by a factor of eight to produce the print, the equivalent spot size on the negative would have to be one-eight-hundredth of an inch. That is, expressed in millimeters, one-thirty-second of a millimeter.

My problem with this is two-fold. Never mind the eight-by-ten, when I look at a $3^{1}/_{2}$ by 5 in. print, taken using the rules for a $^{1}/_{30}$ mm circle-of-confusion, it looks slightly fuzzy to me. And my eyes are not all that good. Second, when I analyzed those accidental prints with which I was happy, I discovered that my desired standard corresponded not to $^{1}/_{30}$ mm, but rather to $^{1}/_{150}$ mm. Taking into account the loss in quality due to the enlarging lens, the diameter of the circle-of-confusion on the negative would have to be no larger than about $^{1}/_{200}$ mm. That is, I was demanding a sharper negative by a factor of about seven! And getting it—sometimes. Clearly today's films and lenses are much better than they were in 1930s and '40s!

My next step was to ask: in order to achieve a circle-of-confusion seven times smaller than that assumed by my depth-of-field scale, how many stops would I have to close the lens down by? The answer is about six! No wonder closing the lens down by only one or two stops didn't do the trick.

Another way to express the result is as follows. Let's say I am really using a 50 mm lens at an aperture of *f*/8. Is there an mark on my depth-of-field scale I can use to estimate the true depth-of-field for my revised assumption about the maximum acceptable diameter of the circle-of-confusion? The answer is yes: if I want to improve definition by a factor of 7, that is, use $^{1}/_{210}$ mm instead of $^{1}/_{30}$ mm for the diameter of the circle-of-confusion, I should divide the *f*-number I am really using by 7 and use the depth-of-field marks for that aperture. 8 divided by 7 is about 1.1. I should use the depth-of-field marks for *f*/1.1! But my lens is an *f*/2 lens; there isn't a pair of *f*/1.1 marks on the scale. OK, the depth-of-field scale—as you might have noticed—is a linear scale. The *f*/8 depth-of-field marks are twice as far from the focus pointer as are the *f*/4 marks. The *f*/22 marks are twice as far from the pointer as are the *f*/11 marks, etc. And so the *f*/1 mark would be half-way between the focus pointer and the *f*/2 marks.

Can I revise my hyperfocal distance? Yes, multiply it by 7! If for an allowable circle-of-confusion of $^{1}/_{30}$ mm in diameter, my hyperfocal distance at *f*/8 is 32 feet, for a permissible circle-of-confusion of $^{1}/_{210}$ mm, the hyperfocal distance would be 224 ft.

Seems like I don't get much depth-of-field doesn't it. Well, it's not so bad as you might think. Remember what I said about the model walking a quarter of a mile inside the supposed inner limit of depth-of-field and my not being able to see the difference. It turns out that under many circumstances we can tolerate the subject being well inside the calculated inner limit of depth-of-field as shown in Figure 1 c). But that's another story.

In summary, it is my contention that the standards used for calculating depth-of-field are no longer appropriate. Today's lenses and films are much better than those of the days when the image quality standards were derived. My experience suggests that today's films and lenses are about seven times better than typical depth-of-field tables assume. And that's the case for 35 mm cameras. Medium format results are probably even better.

If we were to revise our depth-of-field scales for seven times the assumed resolution, depth-of-field would seem to just about vanish. Yet my tests show that many subjects are quite adequately resolved well inside the calculated inner limit of depth-of-field. Further adjustment to the theory would seem to be in order.

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