

Depth of Field For View Cameras—Part II

by Harold M. Merklinger
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In the previous installment (*Depth of Field for View Cameras—Part I*, *Shutterbug*, November 1993), we saw two ways in which tables could be used to outline depth of field for view cameras. The limits of depth of field were defined either in terms of angles or as fractions of the lens-to-subject distance. In this final article on the topic, we will look at two ways to estimate depth of field without resort to special tables. It is indeed possible to use standard depth of field tables, as prepared for ordinary cameras. (By ordinary cameras I mean those having the lens axis fixed perpendicular to the film plane.) It is also possible to apply to view cameras the object-field method of estimating out of focus effects as described in *Adjusting Depth of Field*, Part III (*Shutterbug*, June 1992).

I will also to explain, as promised, the circumstances under which focusing farther away makes some near objects sharper.

Let's start with how to use standard depth of field tables. Figure 1 illustrates. It's very simple, but my experience is that one often has to think twice when applying it. A ray is drawn from the lens to some point on the plane of sharp focus near which we wish to know the depth of field. We determine the distance, R , from the lens to the plane of sharp focus along the ray. We look up the near and far limits of depth of field for that distance and for the aperture and focal length of the lens we are using. The near and far limits so determined are just that: the distances to the near and far limits of depth of field along that ray. To avoid unnecessary complexity, Figure 1 shows only the near limit, so calculated. Notice here, however, that the depth of field determined this way does not give you the depth of field measured perpendicular to the plane of sharp focus. The numbers one gets can be deceiving when the ray makes a small

angle with the plane of sharp focus. The depth of field can be numerically large and still be almost non-existent for some purposes. I have found that my brain seems to assume that the depth of field will be given in a direction perpendicular to the plane of sharp focus. I have to keep reminding myself that this is not so for 'along the ray' estimates. One also needs to be careful not to use "infinity" as the distance from lens to plane of sharp focus, when the distance is really beyond infinity.

This adaptation of standard depth of field tables is appealing because we need nothing new. The tables provided with our lens, or available in books, already apply. The difficulties are two-fold. First of all, the answer one gets applies for those few rays along which the lens to plane of sharp focus distance is R . For any other rays we must measure the new value of R and do the calculations (or use the table) again. A more serious po-

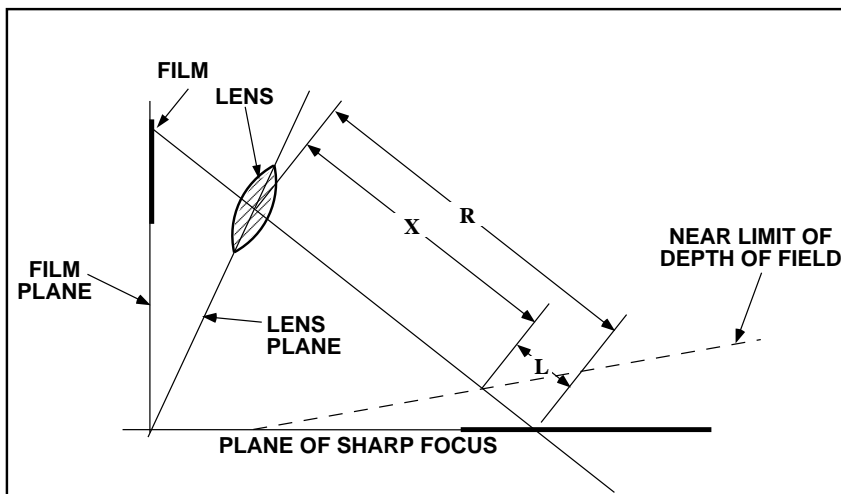


Figure 1: We can use standard depth of field tables to estimate depth of field along any ray that passes through the plane of sharp focus. If the lens-to-plane of sharp focus is R , we simply look up the depth of field for that distance and for the appropriate f -number in a standard table. The table should tell us the distance, X , to the near limit of depth of field, as well as the distance to the far limit, which is not shown here. L is the depth of field on the lens side of the plane of sharp focus.

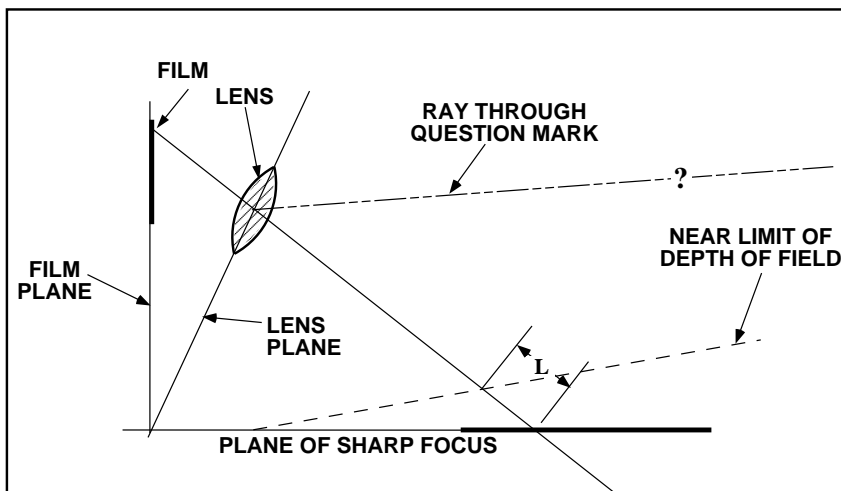


Figure 2: The simplified method described in Figure 1 cannot tell us directly whether or not an object located at the question mark is in acceptable focus or not. We must establish the inner limit of depth of field using at least one ray which passes through the plane of sharp focus. As shown, the question mark would not be in acceptable focus. If it were moved far enough to the right, however, it would be. Yet a ray from the lens to the question mark would still not pass through the plane of sharp focus.

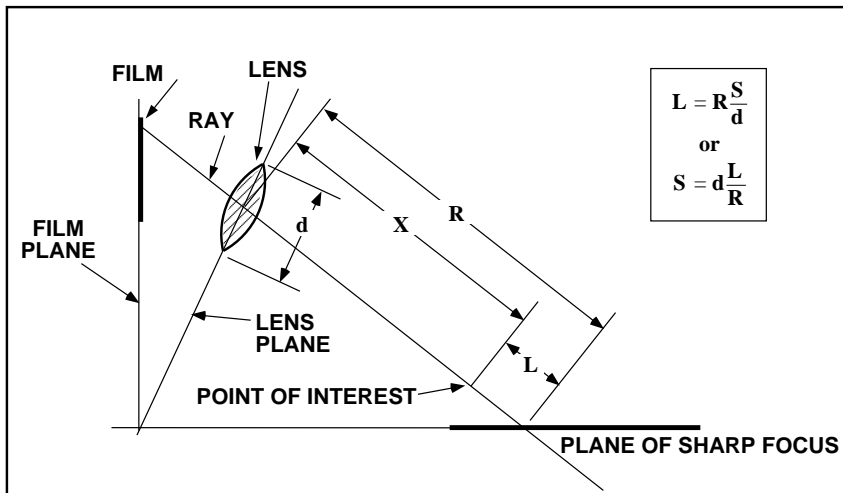


Figure 3: The 'Object Field Method' of estimating depth of field described in an earlier article (June 1992) can also be adapted for view cameras. Here we use that method to estimate the resolution possible at distance, X , along a ray which passes through the plane of sharp focus at distance R . S is the estimated size of the smallest object that will be registered at full contrast in the image. The diameter of the lens aperture is d . L is simply the difference between R and X .

tential problem is that this method cannot tell us directly whether an object will be in acceptable focus or not, if the ray from the lens to that object does not pass through the plane of sharp focus. This is related to the "beyond infinity" problem I mentioned. The question mark in Figure 2 is an example of an object for which the lens-to-object ray does not pass through the plane of sharp focus. In order to establish whether or not the "?" is in acceptable focus, we have to draw the limits of depth of field. We could use two rays which do intersect the plane of sharp focus, and draw lines between the results. Or we can use one ray and our knowledge that the depth of field is zero at the hinge line, as shown in Figure 2. Notice that the "?" as shown in the figure is not in acceptable focus, but if it were moved sufficiently far to the right, in a direction parallel to the plane of sharp focus, it would be.

It might be tempting to reason that the lens-to-plane of sharp focus distance for a ray passing through the question mark is infinity. In fact, the true optical distance is beyond infinity. If we were to use tables or calculations based upon infinity we

would not get the right answers. We can use the table values for infinity focus only for those rays that are parallel to the plane of sharp focus.

A question I often used to ask myself is: "How is depth of field affected by using lens tilt to tilt the plane of sharp focus?" As this simplified description helps to explain, depth of field along any given ray is not affected by tilting the plane of focus. But one must be careful not to take this as saying that depth of field measured perpendicular to the plane of sharp focus does not change. If we measure depth of field perpendicular to the plane of sharp focus, tilting the plane of sharp focus will always reduce depth of field. Depth of field measured perpendicular to the plane of sharp focus will become very small whenever the plane of sharp focus passes close to the lens.

The second simplified method of evaluating depth of field utilizes the "object field" method. With this scheme we calculate the resolution 'spot size' in front of the camera. If an object is larger than that spot size, the object will be recorded in the image. If the object is smaller than the calculated spot size, it will be missed: contrast will be too low for the object

to be seen distinctly in the image. This object field method was described for ordinary cameras in "Adjusting Depth of Field—Part III" (Shutterbug, June 1992). Applying this method to tilted planes of focus, we can again measure the lens-to-plane of sharp focus distance, R , as shown in Figure 3. Then, for a lens of (stopped down) aperture diameter, d , and an object at distance, X (measured along the ray), an object must be of a size equal to or greater than $S=dL/R$ in order to be resolved. L is simply the difference between distances X and R . Alternatively, in order to resolve objects of diameter S , they must lie within a distance L (measured along the ray) of the plane of sharp focus, where $L=RS/d$.

A somewhat more general result is obtained for the object field method if we measure all distances in a direction perpendicular to the plane of sharp focus. The distance from lens to plane of sharp focus is denoted as D . And the depth of field, L , is simply equal to DS/d (on either side of the plane of sharp focus) everywhere. This is the same formula we obtained for ordinary cameras. Figure 4 illustrates this scheme. This method has the advantages that no tables are

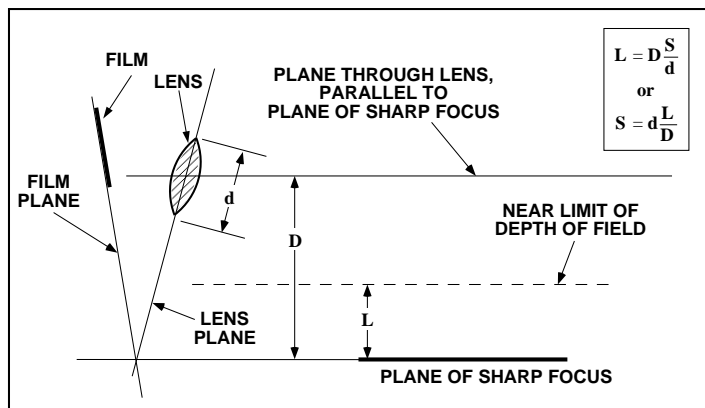


Figure 4: The Object Field Method can be generalized by measuring all lens-to-object and lens-to-plane distances in a direction perpendicular to the plane of sharp focus. For a constant resolution spot size, S , the inner and outer limits of depth of field are parallel to the plane of sharp focus. Only the inner limit is shown here. The outer limit will be the same distance, L , on the lower side of the plane of sharp focus.

necessary and that it valid everywhere.

You may recall that in Part IV of "The Scheimpflug Principle" (Shutterbug March 1993) I provided a formula for determining the distance D. Often it is easy to estimate D, but not always. Sometimes it is actually easier to use that formula for D.

The object field description for depth of field will help us understand how it happens that a subject can be imaged more sharply by focusing farther away. For the ordinary camera, the depth of field distance, L, can never be greater than D for objects on the camera side of the plane of sharp focus. This limitation is not necessarily true for view cameras.

Let's suppose that an object lies a distance 10 feet from the plane of sharp focus (as for the "?" shown in Figure 5), and that the lens aperture diameter is one-quarter of an inch. Using the formula $S=dL/D$, we find that if D is equal to 5 feet, the resolution spot size, S, is equal to 2d, twice the diameter of the lens, or one-half inch. If we now focus farther away, so that D is now 20 feet, the distance,

L, becomes 25 feet. And calculating d, we find the resolution spot size is 25/20 times the lens diameter, or 0.3125 inches. Focusing farther away has improved our resolution, even though the lens-to-object distance has stayed exactly the same. Under what circumstances does this phenomenon occur? The answer is whenever L, on the lens side of the plane of sharp focus, is greater than D. For ordinary cameras, this situation would put the object behind the camera where it could not be seen. With the view camera, the situation can arise easily. The effect is most pronounced when D is very small, that is, when one is using significant amounts of lens tilt.

My tongue-in-cheek use of the term "behind the camera" perhaps needs a little explanation. Imagine a plane passing through the lens and oriented parallel to the plane of sharp focus. Any object on the opposite side of this plane from the plane of sharp focus is 'behind the camera'. The definition is illustrated by the shaded area in Figure 5.

I had thought that this 'behind the camera' effect would be a minor

one—a technical curiosity. But when I was taking pictures of that cement plant (used for illustrations in Part I of "Depth of Field for View Cameras" and Part IV of "The Scheimpflug Principle") I quickly learned that the effect is very real and that it can make a pictorial difference. The tops of the trees in the foreground got significantly sharper when I reduced the lens tilt from 12° to 6°, pushing the plane of sharp focus away from the lens by a factor of about 2.

Having an object lie 'behind the camera' is not a sufficient condition to ensure that it will be "acceptably well rendered" in the traditional depth of field sense. By a strange quirk of the mathematics, a second necessary (but still not sufficient) condition is that the object must also lie farther from the camera, measured perpendicular to the film plane, than one hyperfocal distance! Thus, that tree I used as an example in the previous article, had to be more than one hyperfocal distance from the camera to even stand a chance of falling within the conventional depth of field. Acceptably sharp or not, all objects lo-

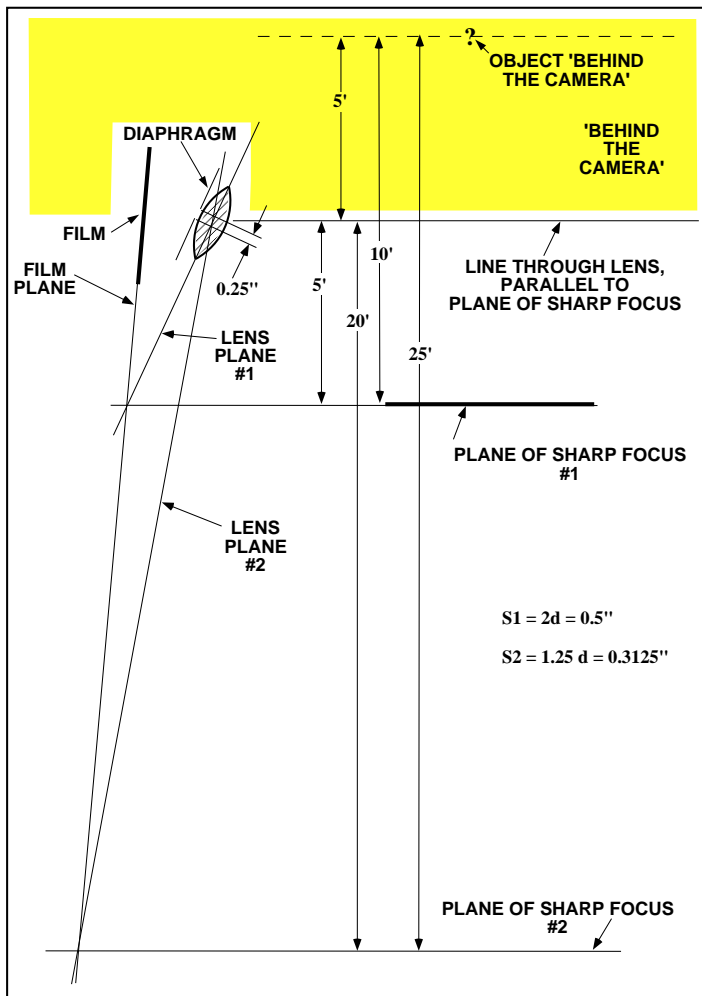


Figure 5: Here we illustrate how increasing the lens-to-plane of sharp focus distance from 5 feet to 20 feet improves resolution by a significant degree for an object 5 feet 'behind the camera'. The resolution possible at the "?" is S1 (0.5") when the plane of sharp focus is 5 feet from the lens and S2 (0.3125") when the plane of sharp focus is at 20 feet. A bonus is that with less lens tilt being necessary, the "?" should lie more comfortably within the coverage circle of the lens.

cated 'behind the camera' will be more sharply rendered by focusing farther away.

The traditional depth of field method and the object field method are complementary to one another. I often find that I use both. First I use the traditional methods to obtain a rough estimate of depth of field, then work out whether critical elements of the image will be resolved or not using the object field method.

Before concluding, I should probably comment on the depth of field calculators one finds on some view cameras. Usually the calculator consists of a scale (marked in f-numbers) that rotates with the knob that moves the camera back. One typically focuses on the most distant point to be acceptably sharp, sets the scale to zero, and then focuses on the closest object. The scale then indicates the recommended f-number. One continues by turning the knob back to one-half the recommended f-number, thereby putting the film half-way between the two extreme focus positions. These calculators will give an indication of the conventional depth of field so long as the focusing motion moves the film in a direction per-

pendicular to the film plane. If the film plane and direction of focusing motion are less than 25° or so off perpendicular, the results will be accurate enough. If the angle should become 45° or more, the results recommended by the calculator should be considered suspect. This all assumes, of course, that you know what criteria the manufacturer used for the acceptable diameter of the circle of confusion, and that you agree with it. One of my biggest 'beefs' concerning depth of field tables and scales is that manufacturers do not always tell us what criteria were used to determine the scales or tables. To make matters worse, manufacturers are not always consistent from lens to lens. I have been told by collectors that different depth of field scales are sometimes found on otherwise identical lenses.

I hope you have found these articles useful in gaining some insight into the behavior of depth of field and focus for view cameras. Information on the topic is scarce, and it is important to understand these things in order to make best use of tilts and swings. I have not attempted to explain everything; emphasis has been

on those topics not described elsewhere. As I observed earlier, the math and the calculations can get a bit tedious, but the underlying principles are easy to understand. Even a basic knowledge of the principles should help you improve your photographic images. Since I made up the tables for lens tilt and depth of field, I have found that I use them extensively—more than I would have guessed beforehand. For me, an occasional view camera user, they shorten the set-up time appreciably.

Someday, tables will be a thing of the past. The view camera will sense all its settings and send the results to a computer. The computer will draw for the photographer a 'map' of situation, and give precise numbers as and where requested. The photographer will then have a choice: change the settings on the camera and watch what happens to the map, or change the map and listen as little micro-motors in the camera adjust its movements to provide the suggested changes.

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