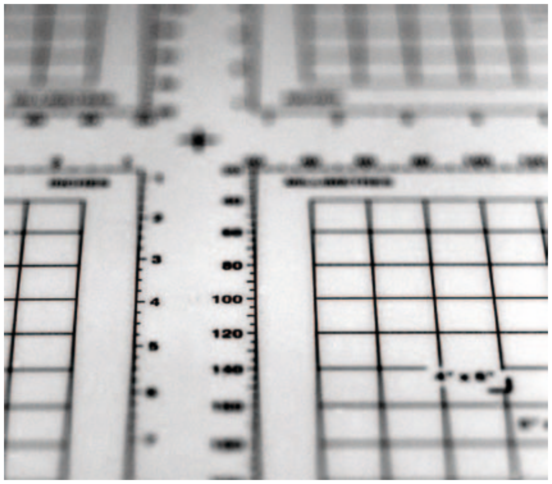
Critical Focusing

What you see is what you get?

Prior to picture taking, we typically focus the image on a view screen, and during the actual exposure, the image is projected onto the film plane. While doing so, we take for granted that view screen and film plane, despite residing at two different locations, have the same distance from the lens.

Camera manufacturing is about balancing process capabilities with customer expectations to achieve a required mechanical accuracy within acceptable tolerances. In addition, all mechanical devices are subject to unavoidable wear and tear, which require periodic adjustment or replacement. To manufacture within tolerance is no guarantee that the product will stay that way forever. Within twelve months, we once had to adjust a professional medium format SLR, two medium-format rangefinders and a well-known make of 35mm rangefinder. One of these cameras was brand-new. After being adjusted, they all focus perfectly, putting the initial camera setup in question, and proving that the following test method is valid.



What Is Reasonable?

Take, for example, a 90mm, f/2 lens on a 35mm rangefinder. Clearly, the f/2 aperture is not for viewing brightness, but is designed for picture taking. The tolerances of the camera body, lens and photographer add up. The human element in any focus mechanism provides opportunity for error, but it is not an unreasonable assumption that the mechanical focus accuracy should be within the depth of field at the maximum lens aperture. With the 90mm lens at the minimum focus distance, the acceptable depth of field is 10 mm at most. For a portrait, this is the difference between acceptable and unacceptable eye sharpness. The alignment between view screen and film plane must be well within the depth of focus, which in this example, is a tight tolerance of less than ±0.05 mm.

A Simple Focus Target

For any kind of focus check, we need to be able to set up the camera with perfect repeatability. A good focus target must be easy to focus on and, at the same time, indicate the magnitude of error in focus. This suggests a series of horizontal markings along the optical axis. However, since most split-image and rangefinder screens are better at determining vertical than horizontal lines, adding a series of vertical lines makes good sense. Put these together and you get a grid.

Rather than drawing a unique grid, we can use a piece of graph paper, our cutting-mat scale or the grid on our enlarger easel, all of which make adequate focus targets. For this example (fig.1), we use the grid on an enlarging easel, which is a white piece of plastic with fine, black grid lines in 20mm increments.

The camera is set up on a tripod and carefully focused on the 100mm mark, using the vertical lines for critical adjustment. Additionally, the camera is at an angle of about 30° to the easel plane and close

fig.1 The grid of an enlarging easel or a cutting board makes a perfect focus target for checking critical camera focus.

film type	film thickness
roll film	0.004 - 0.005
sheet film	0.007 - 0.009

film format	film holder depth	tolerance
4x5	0.197	± 0.007
5x7	0.228	± 0.010
8x10	0.260	± 0.016
11x14	0.292	± 0.022

fig.2 Typical film thickness and ANSI film-holder dimensions in inches

to the minimum focus distance. One benefit of focusing rangefinder cameras is immediately apparent when viewing the grid. Since the rangefinder and viewfinder window have a different perspective on the grid, the vertical grid lines have different slants and seem to cross over at the point of focus. Consequently, this enables extremely accurate focus adjustment. With split-image viewfinders, position the split line on the focus point.

As can be seen in fig.1, the gradual blurring of the vertical lines clearly identifies the focus point along the scale, aiding accurate focus measurement. At the same time, it is possible to estimate the range of useful focus at this short range.

We suggest that you repeat the test a few times to ensure your technique. With rangefinder cameras, try arriving at perfect focus from near and far distance settings, to check for any play in the mechanism.

Improving View Camera Focus

When using a view camera, the image is composed and focused on the ground glass. One surface of the ground glass is textured to provide a means for focusing the image. It is important that this textured surface faces the lens, because it is the image forming side. To take an exposure, the ground glass is replaced by the film holder. At this point, the film must be in the same plane as the ground glass was during focusing, so the negative is perfectly sharp. Camera backs and film holders are machined to tight tolerances to ensure this condition (fig.2).

A well-focused image and full utilization of the intended depth of field are achieved if these tolerances are close to zero. Small deviations can be tolerated, because the depth of focus for view cameras is relatively large (1 mm or 0.040 inch for a 4x5 negative at f/5.6), but even small tolerances will shift the focus and depth of field. It is, therefore, important to keep the ground glass in perfect alignment with the film plane. Fig.2 shows typical film thickness and the ANSI standard dimensions for film holders in inches. However, experience shows that many cameras and film holders deviate enough from these standards to warrant a simple check.

The previously discussed focus target works well for SLRs and rangefinder cameras, but is not ideal for view cameras, the reason being that each test exposure checks only one side of one film holder. It is not uncommon to have a dozen film holders or more, and making dozens of test exposures is time consuming and costly.

A Simple Check

In his May/June 1999 *Photo Techniques* magazine article, Jack East Jr. proposed a simple but effective alternate method to check whether the ground glass and the film plane are within acceptable tolerance.

Place a piece of film into a holder and insert it into the camera back. Remove the back from the camera, and lay it flat on a table as shown in fig.3. Rest the edge of a rigid ruler across the camera back. Hold a toothpick or cocktail stick vertically against the ruler, lower it until it touches the film and clamp or tape it to the ruler, thereby identifying the film plane location. After doing this with all film holders, leave the toothpick positioned for an average holder.

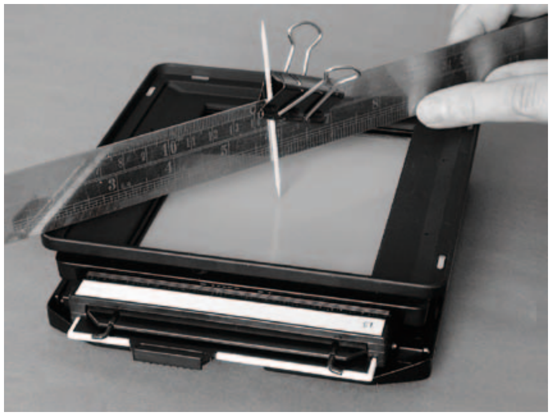
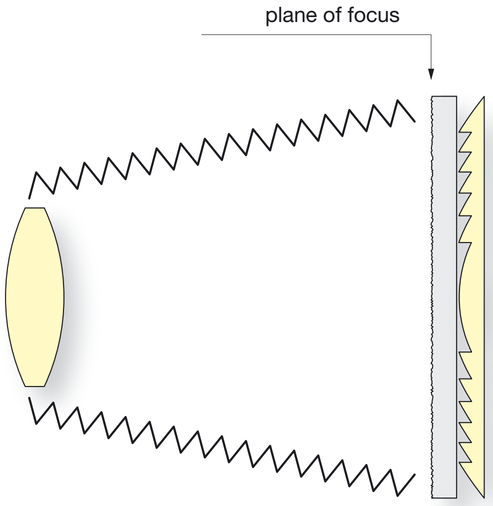


fig.3 (right) A steel ruler, a toothpick and a paper clamp are used to measure the location of the film plane in a 4x5-inch sheet-film holder in relation to the open camera back.

fig.4 (far right) The same setup is used to check for a proper ground-glass location after the film holder is removed, and the toothpick is clamped to an average film-holder depth.



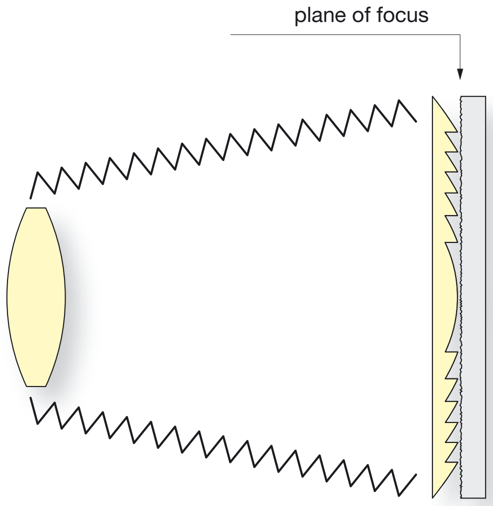


fig.5a (far left) A Fresnel lens can be added to an existing camera back simply by placing it behind the ground glass, in which case, the ground glass maintains its alignment with existing film holders. However, image formation on two separate surfaces can make accurate focusing difficult.

fig.5b (left) The Fresnel lens can be added in front of the ground glass as well, so image formation takes place on only one surface. However, the ground glass is no longer aligned with the film plane, and the camera back must be machined or otherwise adjusted to regain proper focus.

Now, remove any film holder from the camera back, and compare the average film plane with the ground glass location (see fig.4). If the toothpick just touches the ground glass, then no adjustments are required. Knowing that a sheet of regular writing paper is about 0.1 mm (0.004 inch) thick provides a convenient measuring device to quantify any offsets. If the toothpick touches before the ruler, then you can shim the ground glass with paper. If there is an unacceptably large gap between toothpick and ground glass, then professional machining of the camera back is required.

With the toothpick still positioned to identify the average film plane location, measure all film holders for variation. According to the standard in fig.2, a tolerance of ±0.007 inch, or two layers of paper, is acceptable for the 4x5 format. Discard or avoid film holders outside this tolerance.

Using a Fresnel Lens

One variation in ground glass design is the addition of a Fresnel lens. Its purpose is to provide even illumination over the entire ground glass, making focusing, especially in image corners, significantly easier. A Fresnel lens is typically a flat piece of plastic, with one side built up from a series of thin concentric rings, which function like a lens. The rings are usually barely perceptible to the naked eye, but become obvious when viewed through a focus loupe.

A Fresnel lens equalizes image brightness when placed either in front of or behind the ground glass, and there are some pros and cons with each setup. When a Fresnel lens is added to an existing camera back, it is far simpler to place it behind the ground glass as shown in fig.5a. The ground glass retains its position, and the alignment with existing film holders is maintained. However, in addition to image formation on the textured surface of the ground glass, it is possible to focus an image on the ridges of the concentric rings of the Fresnel lens. The image formation on two separate surfaces can make accurate focusing difficult, but with practice, this is rarely an issue.

Alternatively, the Fresnel lens can be added in front of the ground glass as seen in fig.5b. This has the advantage of image formation only taking place on one surface, since the ridges are in contact with the textured surface of the ground glass. However, if the Fresnel lens is added to an existing camera back, the disadvantage is that the ground glass, and the associated focus plane, is out of its original position. Consequently, the focus plane is no longer aligned with the film plane, and the camera back must be machined or adjusted to allow for the Fresnel lens thickness. In either setup, make sure that the textured surface of the ground glass faces the lens and is aligned with the film plane, and that the ridges of the Fresnel lens are facing the ground glass.

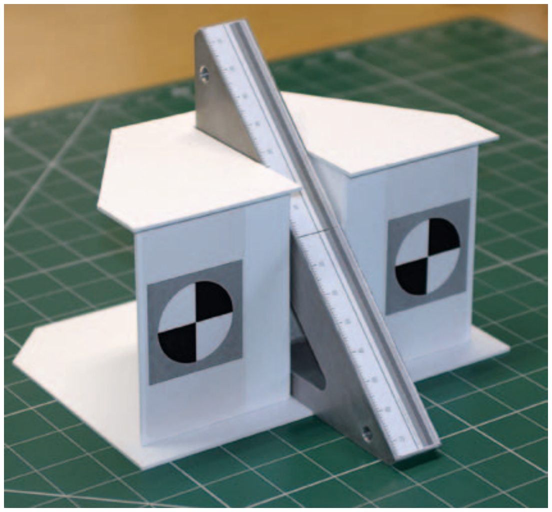


fig.6 An advanced focus target provides quantifiable results.

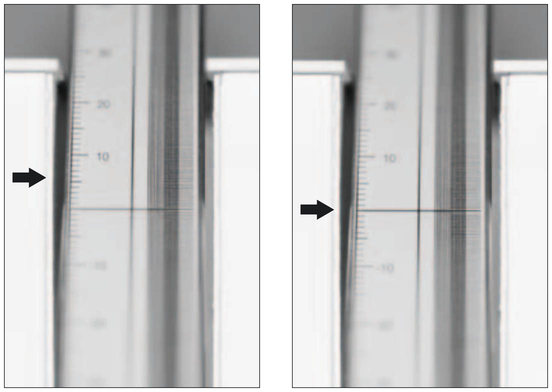


fig.7 These test images were taken from a distance of 935 mm at f/1.8 with an 85mm lens (m=0.1). The image on the left shows a far-sighted focusing error of about 5.5 mm (0.6%), prior to camera adjustment. The image on the right verifies perfect focus after adjustment.

An Advanced Focus Target

A simple focus target, such as the grid on our enlarger easel in fig.1, is more than adequate to verify camera focus once in a while. But, if you intend to conduct a lot of focus testing, or you need quantifiable results, you might want to invest the time in building a more sophisticated focus target. As an example, our advanced focus target in fig.6 provides repeatable and quantifiable results and is easily made within an hour.

As shown in fig.6, take some mat-board scraps and construct a 45° triangle from it. Make it about 25 mm thick and 150 mm tall. Then, copy the focus scale in fig.8 and glue it to the long side of the triangle. The focus scale is elongated along the vertical axis to be at the correct dimensions if viewed foreshortened under 45°. Building the surrounding support is an option, which makes repeatable focusing a lot easier. When using a support, make sure the focus planes of the support structure line up with the zero marking on the focus scale, before you level the camera and take the picture with a wide-open aperture.

Fig.7 shows two sample test images. The image on the left shows a far-sighted focusing error of about 5.5 mm, prior to the camera adjustment. The image on the right verifies perfect focus after such adjustment.

A Practical Hint

Focusing a camera in low-light situations is not an easy task. We would like to share a proven technique, which works well even in the darkest church interiors.

Purchase two small flashlights for your camera bag. Mag Instrument is a popular brand, which comes in many sizes. Unscrew the tops, which turns them into miniature torches, and place them upright into the scene at the two extremes of the desired depth of field (fig.9). Focusing on the bright, bare bulbs is simple, no matter how dark the location is.

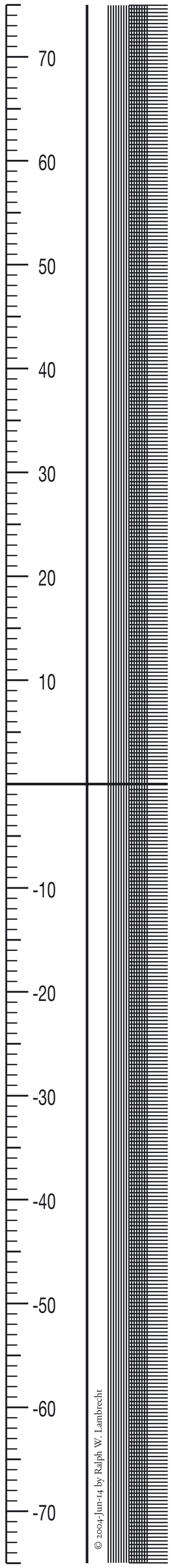


fig.8 This is our advanced focus scale at full size. It is already elongated along the vertical axis to be at the right dimensions if viewed foreshortened under 45°.

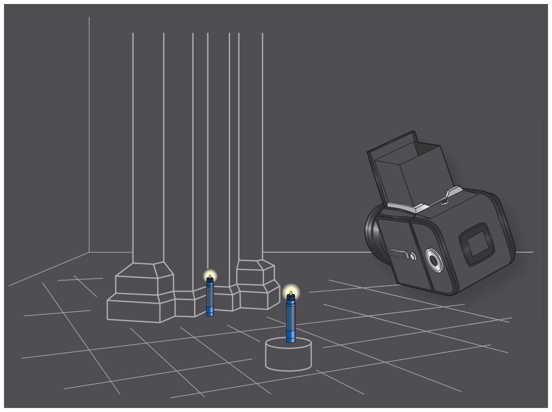


fig.9 Focusing on the bright bulbs of miniature flashlights is simple, no matter how dark the location is.