MODERN PHOTOGRAPHY

How to Test Your Lenses

Testing Your Lenses the Modern Way

For several years, MODERN PHOTOGRAPHY has been offering its readers Lens Test Kits based on a simple, flexible method worked out by our Technical Consultant and columnist, Bennett Sherman. While we have great respect for the optical instruments now being used in many laboratories, including ours, to evaluate cameras and lenses with advanced electronic-optical methods, we have been less than satisfied with the grossly inadequate and overly complicated test charts made with ordinary printing-press methods. These are not precise enough, and instructions are often useless.

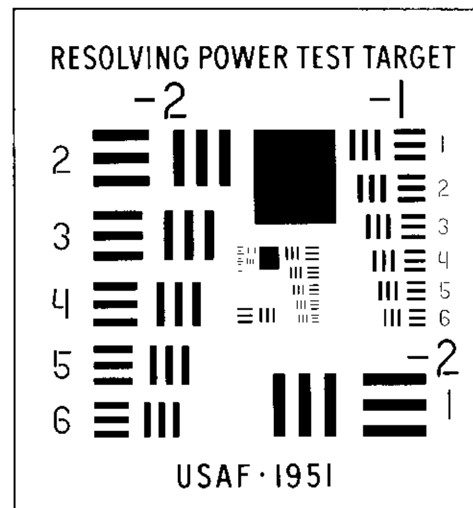
In order to test a camera lens, pictures should be taken with it. To translate these test pictures into numerical values useful for comparison and image quality judgments, the test object should be a plain, but precise, uniform target with easily understood calibrations and finely-divided graduations from large to small target details. Using precision photographic reproductions of the U.S. Air Force Resolving Power Test Target and a simple but adequate magnifier supplied with our kit, you may now perform critical and objective lens tests similar to those which editors and technicians at MODERN PHOTOGRAPHY have made for many years while testing hundreds of lenses.

Using a glass master target made for MODERN by the W. & L.E. Gurley Engineering and Scientific Corp., Troy, N.Y., we have produced, by carefully controlled photographic processing, test targets which are ideally suited for these resolving-power evaluations. The magnifier supplied with the kit is satisfactory, but for those who wish a more advanced magnifier, we can recommend the MODERN PHOTOGRAPHY Light Scope microscope or other similar high-performance optics. Be sure to select a magnification of around 20X to 30X, the best range for reading.

—THE EDITORS

1 How to Read the Lens Test Chart

The chart consists of sets of three lines, each triplet at right angles to its triplet "pair." The line spacings gradually decrease (more lines per millimeter on the test negative), but the pairs are separated into groups of six. Each group has a large number above the largest line pairs. Also, each line pair has its own number—to the left or right of the line triplets. Thus, every line pair is designated by its group and pair number. The largest lines on the chart are: group 2 pair 1. The smallest lines are: group −1, pair 6. Practice identifying the group and pair numbers of the line triplets quickly so that you'll be able to find them later on the test negative. The figure below shows the arrangement of the groups and pairs on the USAF 1951 target. Also, at bottom, is a table of the lines per millimeter for the chart itself, *not* the reduced image on the test film.



	PAIR					
Group	1	2	3	4	5	6
2	.25	.28	.31	.35	.40	.44
1	.50	.56	.63	.71	.80	.90
0	1.0	1.1	1.2	1.4	1.6	1.8
1	2.0	2.2	2.5	2.8	3.2	3.6

2 Arranging Your Lens Test Charts

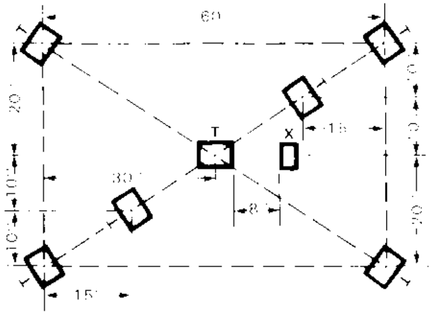
In order to properly test your lens with these seven charts, they must be mounted on a flat surface or wall. There are various placement patterns to be used, depending upon the format size of your camera. When you are testing 35mm camera lenses, you should use the target arrangement shown in diagram A, for lenses with focal lengths up to 400mm. Since the target distances for long tele lenses may be very large and inconvenient, the arrangement of targets shown in diagram B should be used for testing lenses with focal lengths greater than 400mm.

Diagram C shows the target arrangement for testing 2¼ x 2¼ lenses, while diagram D applies for tests of lenses on 4 x 5 cameras. We suggest you mount the charts with masking tape to avoid damage to the charts or the wall. The test room must have window shades or blinds so that it can be darkened (but not necessarily totally dark). Be sure to pick a room affording an adequate distance between the wall and the camera. See page 7 for a list of the camera-to-target distances for these tests.

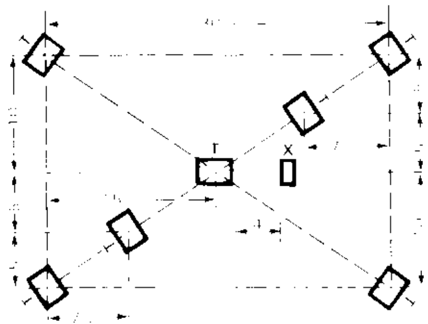
Also, the room you select should allow for an unobstructed area from the test target wall. While testing a 50mm lens requires only 8 ft. 4 in. (2.55m), a 135mm lens requires 22 ft. 7 in. (6.9m). Mount the central chart on the wall at about eye level for comfortable focusing. Be sure to use a very *sturdy* tripod. Set the camera so that the lens is at the same height as the center chart, and use a sensitive bubble level to put the camera on a horizontal line with the target wall.

When mounting the charts, place them so that their bottoms face toward the central target as shown. Notice also the special simple paper strip "X" to the right of the center chart. The distance from the inner target at the left is used to measure the actual magnification on the negative. Be sure to measure the distance "X" on the wall accurately to 1/16 in. If the wall is white, use black tape to emphasize the *right* edge of the left inner target and the *left* edge of the special simple strip. Measure all distances between other targets to about ¼ in. or so. When not in use, store the targets flat between heavy books.

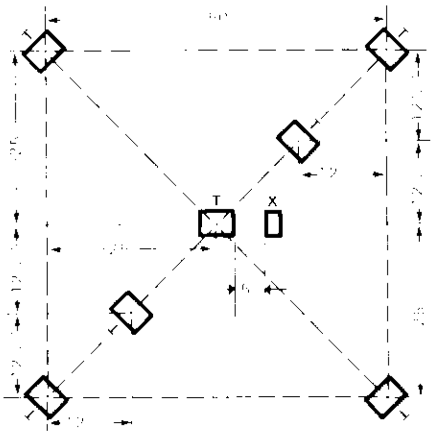
T = top of lens target. Targets should be placed as indicated with top facing direction shown by letter "T". Distances are measured from center of target, except distance "X" which is measured from edge of center target.



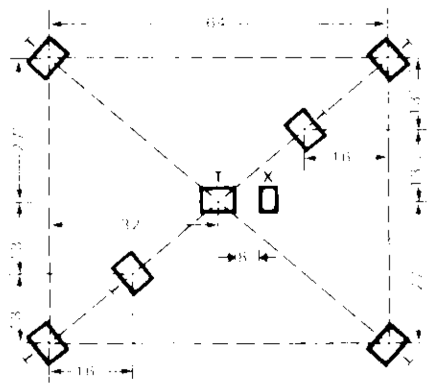
A: For 35mm camera lenses up to 135mm. To test lenses from 135mm to 400mm, use the five central charts. M = 50×



B: For 35mm lenses over 400mm, place the charts at the given distances. M = 25×.



C: For 2¼ × 2¼ camera lenses, place the charts at the above distances.



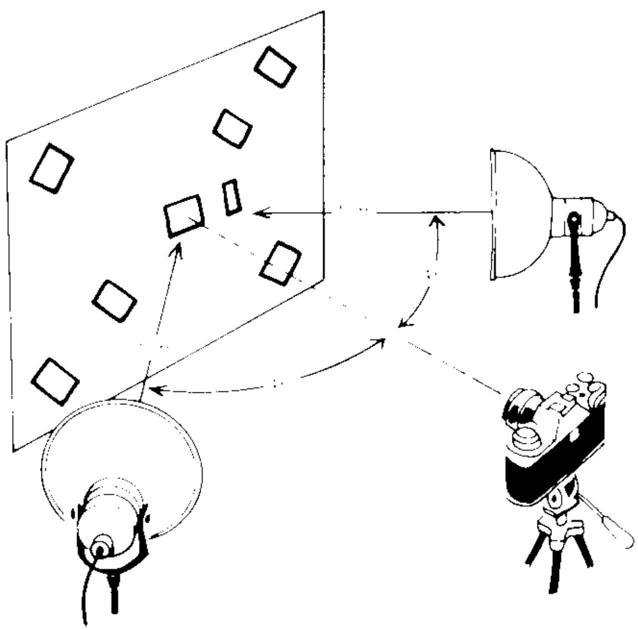
D: For 4 × 5, 5 × 7, 8 × 10, 2¼ × 3¼ and 3¼ × 4¼ camera lenses, place the charts at the above distances. See text for magnification.

3 How to Position Your Camera and Lights

You'll need only two lights for the test exposures. Use ordinary 115-volt household lamps with 60 watts of power. These should be mounted in wide-bowl, satin-finished reflectors held on stands or clamped to the backs of high chairs. The lamps should be at the same height as the center chart—10 ft.—and at a 45° angle as shown in the diagram. They should not be moved during the tests.

The camera and test lens should be mounted on a very heavy sturdy tripod. You can test the presence of shake or vibration by using a telephoto lens and sharply tapping the top of the tripod with a pencil, while observing the targets through the SLR view screen. If there is a noticeable and lasting shake, use heavy blankets to damp down the vibration. Set the tripod at its correct position, but along a line accurately square to the target wall. Use a large triangle to help find this line on the floor.

We strongly recommend that you standardize your photographic tests with Kodak Panatomic-X film. This fine-grained film will show accurate comparisons between lenses being tested. If you select other fine-grained films, the performance values we've obtained in our tests at MODERN may not be compatible with yours, and the evaluations given on the following pages will not be as accurate as you'd want.



4 Pick the Right Distance to Your Lens

From the tables at right, select the proper distance from the camera to the targets, depending on the focal length of the lens being tested. You can measure the distance from the central chart to the front edge of the lens. The error, as compared to theory, should be very small. For all 35mm camera lenses up to 135mm focal length, the complete target set will be observed. When lenses from 135mm to 300mm are tested, you'll see the inner targets only. For lenses with the focal lengths longer than 400mm, use the target pattern shown in Fig. B (page 4). For medium-format (2¼ inch) cameras, all targets will be seen. When using this test setup for 4 × 5 camera lenses, the distance must be exactly 16 times the focal length of the camera lens. If your lens' focal length is between values in the table, you can find the correct distance by a simple interpolation. For example, if you have a 58mm lens, multiply the focal length (58mm) by 51. You'll get the distance in millimeters (2958mm) or roughly 2.96 meters or 9 ft. 8 in. from the target to the front of your lens. With lenses over 135mm and for 2¼ camera lenses, multiply the focal length by 26.

35mm CAMERA LENSES

FOCAL LENGTH	LENS-TO-WALL DISTANCE	
21mm	3 ft. 6 in.	1.07m
24mm	4 ft.	1.22m
28mm	4 ft. 8 in.	1.43m
35mm	5 ft. 10 in.	1.79m
50mm	8 ft. 4 in.	2.55m
58mm	9 ft. 8 in.	2.96m
85mm	14 ft. 3 in.	4.34m
100mm	16 ft. 9 in.	5.10m
105mm	17 ft. 7 in.	5.36m
135mm	22 ft. 7 in.	6.88m
200mm	17 ft. 1 in.	5.20m
300mm	25 ft. 7 in.	7.80m
400mm	34 ft. 1 in.	10.40m
600mm	51 ft. 2 in.	15.60m

2¼ × 2¼ LENSES

FOCAL LENGTH	LENS-TO-WALL DISTANCE	
65mm	5 ft. 6 in.	1.69m
75mm	6 ft. 5 in.	1.95m
80mm	6 ft. 10 in.	2.08m
105mm	8 ft. 11 in.	2.73m
135mm	11 ft. 6 in.	3.51m
180mm	15 ft. 4 in.	4.68m
200mm	17 ft. 1 in.	5.20m
250mm	21 ft. 4 in.	6.50m

5 Exposing for Maximum Sharpness

Here's the table for making the necessary exposure times for each lens aperture. Note that the exposure times are relatively long. This means that the least shake or vibration of the camera or tripod during exposure will be deadly. Use the heaviest and sturdiest tripod you can get and add heavy blankets over the camera (neatly, please). Use the pencil test described earlier to check the stiffness of your setup. Darken the room and turn on the lights. Focus as closely as you can using the SLR screen. For the widest openings, it may be a good idea to adjust the focus slightly between exposures, and make three or more shots at the same aperture, each with a very slight focus shift. Always use a fairly long cable release—at least 10 in. long. It is a good idea to mount a card which lists the name of each lens, its focal length and apertures, and the date of the test—all printed in large letters (use magic marker)—near the center chart for positive identification of the test negatives.

Exposure and processing should be carefully controlled to maintain optimum resolution on the film. We recommend using our own system: Kodak Panatomic-X film is exposed at an E.I. of 400. This rating is based on the use of an 18% grey card target or the use of a handheld meter to read incident light. This rating is not a "pushed" exposure. Rather, it is designed to prevent the build-up of dense areas between the test patterns of the target and thus make a critical evaluation difficult.

If your camera has a built-in meter, set the exposure (ASA) control for 400 and bring the camera close enough so that your reading is from the grey card, not the test set-up.

Development is in fresh undiluted Kodak D-76 for six minutes at 68° F. Agitate five seconds every 30 second. Fix, harden and wash your test negatives as usual.

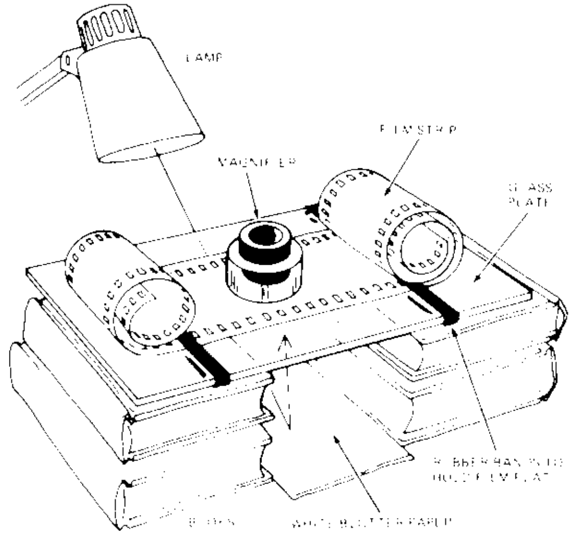
Keep all solutions—developer, fixer and wash — at 68 deg. F to ensure completely uniform results.

EXP. NO.	F/NUMBER	EXPOSURE TIME
1-3	f/1.4	1/8 sec.
4-6	f/2	1/4 sec.
7	f/2.8	1/2 sec.
8	f/4	1 sec.
9	f/5.6	2 sec.
10	f/8	4 sec.
11	f/11	10 sec.
12	f/16	20 sec.
13	f/22	45 sec.
14	f/32	90 sec.

6 Important: Examine Negatives Carefully

The diagram below shows you how to set up for viewing the test negatives. Arrange the desk lamp so that it does not shed light above the glass. Point it at the white blotter paper below. It is generally difficult to focus a powerful magnifier sharply. However, the magnifier supplied with your MODERN TEST KIT is designed to help overcome this annoying problem. Simply set the outer rubber case on the negative and gently draw the inner metal barrel of the magnifier up (or push down) until the sharpest view is observed. The magnifier will now stay in focus for all of the testing. If you have purchased an Omag microscope or another similar high-performance optic, be sure that the bottom which comes in contact with the negative clean and smooth.

When the magnifier is in sharp focus, begin by examining the center chart of the first exposure. The larger lines should be well separated and easy to see. Now search down through the smaller lines until you cannot see any of the triplet lines separately. The previous (larger) triplets should just be resolved. Be sure to avoid a common mistake; do not accept *two* lines seen in place of three. This is a false resolving power. Be aware of any situation where you see the vertical triplet resolved, but not the horizontal triplet next to it. This is caused by astigmatism. Be fair and impartial in finding the smallest resolved lines. If there is a doubt, take the group and pair numbers for the larger resolved lines.



7 How to Read the Results

Now you must translate your observations into a resolving power in lines per millimeter. Examine the central and outer target images carefully. Make up a table of target positions and smallest group-pair numbers of the lines you resolve. Find the equivalent resolving power from the table below, or you can use the magnification number shown to the right of each target-placement diagram (see pages 4 and 5). Simply multiply the basic USAF chart lines per mm, given on page 3, by this setup magnification. Do not expect the edge and corner charts to show the same resolving power. The evaluation standards on pages 12 to 24 will show you how the center and corner resolving powers are related for excellent, very good, good or acceptable lenses.

For example, if you are testing a lens for a 35mm camera and you read the line pairs in group 1 # 6 (.90 on the chart on page 3), you would multiply this reading (.90) by 50 to get a resolving power of 45 lines/millimeter. When testing medium-format and large camera lenses, find the value of "M" by using the steps outlined in sections C and D, below.

It is important that one person (you) do all the reading of the negatives. Other people may read different resolutions from the same chart. The results might often be less consistent.

For all 35mm camera lenses with focal lengths up to 135mm, use the resolution chart on this page; for lenses from 135mm to 400mm, divide the chart values in half. For all 2¼ × 2¼ camera lenses, divide the chart values in half. For all others, use the following simple procedure of calculation:

A: Measure the distance between the lens front and the target wall in millimeters. Divide by the lens' focal length. Subtract one. This results in the approximate working magnification.

B: Read the group-pair-number chart on page 3 and multiply the values by the calculated magnification.

For another way of determining working magnification, do the following:

C: Measure the distance between the inner edges of the special paper strip and the right edge of the center target, as you see them on the negative, with a micrometer.

D: Find the value "X" on the target set-up you are using (see pages 4 and 5). Divide this by the measurement you made on the negative. This is the actual working magnification.

Sample Test Result Chart

Resolution: lines/mm

	PAIR					
Group	**1**	**2**	**3**	**4**	**5**	**6**
2	12	14	16	18	20	22
1	25	28	31	35	40	45
0	50	56	63	71	79	89
1	100	112	126	141	159	178

8 Evaluating Your Test Results

When you have filled out your table of resolving-power results from the test negatives, you can make a basic comparison with similar lenses tested by MODERN Find the type of lens you tested among the evaluation charts on these pages. You'll find the categories listed for the various apertures and for central and corner resolving power.

Don't expect excellent ratings from your lenses at all openings. Even very high-grade optics reach this level only at some of the apertures. Don't be surprised if you test two lenses of the same type and find different values. Some variation is expected in any production run of complex camera lenses.

Watch out for large (two pair numbers or more) differences in resolving power between the left edge and the two corner charts in one negative. This can be a sign of camera-lens misalignment, or it could mean that you set the camera off-center during the test exposures. A repeat test, with extra care to set the camera on the center line of the target, may be required.

We have also included Modern Photography's laboratory evaluations of the photoelectric measurements of fine-detail image contrast for general interest only. These are based on the measured contrast of the black-and-white bars at 30 lines per mm in the image. You might refer to these tables wherever Modern Tests publishes contrast test results. It is possible to obtain some contrast values by precise laboratory measurements of the photographic test negative, but, this requires the use of a microdensitometer—a complex scientific instrument for measurements of photographic negatives. If you wish, you can look for the line-triplets which are closest to 30 lines per mm in your test negative, and look at the line clarity and contrast. Compare the appearance of those lines with Modern's published photoelectric contrast measurements. This can give you a rough idea of how clearly your lens reproduces fine details in the original subject.

6 · 7cm Camera Lenses (continued)

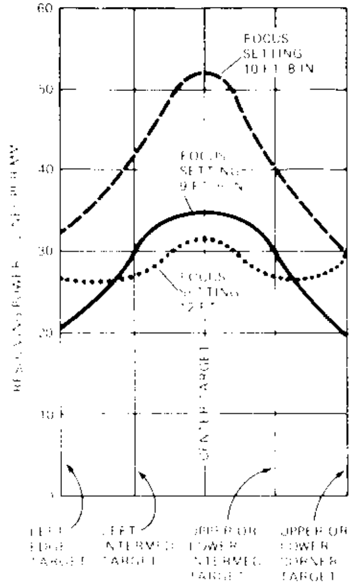
RESOLUTION

Super Tele (500mm and longer)			
Aperture	Center Lines/mm		Corner Lines/mm
Maximum	16–17 18–22 22.5–24 25+	Accept Good V. Good Excellent	11–13 14–15 16–17 18+
Next	18–19 20–24 25 27 28+	Accept. Good V. Good Excellent	12.5 13 14–17 18–19 20+
Middle	20 24 25–27 28–31 32+	Accept. Good V. Good Excellent	14–17 18 22 22.5–24 25+
f 11 f 22	22.5–24 25–27 28 31 32+	Accept. Good V. Good Excellent	16–19 20–24 25–27 28+

CONTRAST

Super Tele (500mm and longer)			
Aperture	Center %		Corner %
Maximum	16–19 20–29 30+	Low Medium High	9–11 12–15 16+
Next	20–24 25–33 34+	Low Medium High	12–14 15 19 20+
Middle	24–28 29–35 36+	Low Medium High	14–17 18–23 24+
f/11–f/22	26–29 30–35 36+	Low Medium High	16–19 20–23 24+

9 Plotting Your Lens's Field Curvature



Of course, not every single example of image unsharpness is due a lens's specific design, since most lenses characteristically yield lower resolving power toward the edges. This is often the result of the "best" focus field of the lens actually being curved, while the film is designed to lie flat. Using the same test arrangement employed for the regular resolving power tests, you can easily check a lens for "field curvature" as well. First, however, you must affix an auxiliary scale, made from masking or adhesive tape, to the lens focusing scale. The illustration on page 27 shows how this is done. Mark the tape with lines about 1/16 in. apart and key each line with a small subscript letter. Make ten marks, with the fifth mark longer for reference. Now find the lens-to-wall distance from the table on page 7. Carefully place the tape on the distance scale of your lens so that the long mark is close to the distance specified in the table. Don't worry about getting the tape precisely in position. You'll be making a whole set of step-by-step exposures along the series of focusing marks on the tape in order to be sure to pass through the "correct" focus setting. Now select the widest openings (lowest f/numbers) and make a series of exposures at each aperture, changing *only* the focus setting to coincide with each successive mark on the tape. Make a complete set for each of the two or three largest lens openings. After processing the film, make a series of graphs (shown on page 25), using dashed and dotted lines to indicate the observed resolving powers across the film for the various focus settings. Don't graph test negatives which are obviously far out of focus. You should wind up with graphs similar to those shown on the facing page. The diagram shows the results of a field-curvature test on a 162mm f/4.5 Tessar mounted on a 4 x 5-in. camera. The plot is for f/5.6 only. The distance marks opposite each curve are read from the lens barrel directly under the tape—you can actually read the distance-scale markings without lifting the tape if the tape you use for recording your own reference focusing marks is narrow enough.

Notice how a shift in focus affects both the center and edge resolving powers. At the "E" setting (corresponding to 10 ft. 8 in. on the barrel, in our example), both the center and edge resolving powers are highest. But this relationship doesn't hold at a closer-than-optimum (across the field) point of focus (9 ft. 6 in.), as compared to a farther-than-optimum point of focus (12 ft.). In other words, edge resolution remains high when the lens is moved closer to the film, resulting in a more distant point of focus. This shows that the "best" focus point for optimum edge resolution seems to favor setting the focus at a somewhat longer-than-actual subject distance. This is an indication of the curved shape of the best focus point across the field, commonly known as field curvature. However, off-axis aberrations tend to bring the best focus for the edges back to pretty much the same point as that for the sharpest imaging at the center of the field. You'll find this to be true for most lenses. Also, the field curvature effect is considerably more pronounced when a "normal" lens is used for extreme close-up photography. To prove this, try some exposures with the tape affixed to the lens barrel of a normal lens using the close-up target arrangement shown in Fig. B (page 4). Move in toward this target until the target almost completely fills your negative area. You can calculate the working magnification using the methods described on page 9 and read the resolving power values in the usual manner from these negatives, thereby estimating field curvature at close distances.

10 A Simple Check for Astigmatism

At times, both three-line target pairs corresponding to a given set of resolution readout numbers will not be in focus at the same distance setting (especially at the edges of the field). For example, the lines pointing toward the center of the target may be sharp, but the other three at right angles to them are not. This is caused by astigmatism, which is a typical off-axis aberration exhibited by almost every lens. You can test your lens to determine its astigmatic level by combining the field curvature test graph already described with a graph of the sharp-focus setting for each of the two three-line pairs. When you've made a series of "through focus" test exposures using the marked tape as a setting guide, read the corner targets carefully and plot (on graph paper) or list the settings at which each of the two three-line pairs is sharpest. For example, you may find that, at focus setting "E," the lines pointing toward the central target are sharpest, but at focus setting "G," the other lines (at right angles to the first three) are sharpest. If the differences in these focus settings fall within the depth-of-field marks on the lens barrel (they're usually right alongside the focusing scale), then the astigmatic level is probably small enough to ignore. Don't expect to find a lens that's completely free of this aberration, however. You'll usually be able to observe the effect of astigmatism most strongly at an aperture setting two stops from maximum. (If your lens is f/2, the desired setting is f/4; if it is f/1.4, set your lens at f/2.8. For purposes of this test, consider an f/1.7 or f/1.8 lens the equivalent of f/2.) At wider apertures, other aberrations may mask the astigmatism.

You can also conduct most of the tests described herein with a red or green filter over your lights, to find out if there are changes in lens sharpness or focus setting when the color of the illumination is changed. We do not recommend putting a color filler in front of the lens, however, since you'll then be testing filter quality, not just lens quality. Use large Wratten, or other, gelatin filters to cover the lights. A piece of cardboard with a hole that's slightly smaller than the filter will enable you to cover the lights completely. Use exposures that are about 4 to 8 times normal. And remember, rock-steady camera mounting is most important in all tests.