Directions For Photographing the PLI Lens Test Wall Chart

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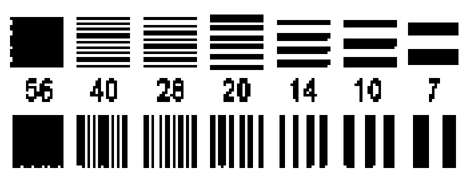
The Photo Lab Index Lens Test Chart is a poster size paper document that is printed with various test patterns. Its use involves photographing these test patterns at a specific distance and then examining the developed film to see how it renders the test patterns. This chart includes patters that test for the most serious and common lens flaws – including basic resolving capabilities, spherical aberration, chromatic distortion, coma, linearity, and diffusion. These common flaws will prevent a camera lens from creating an accurate reproduction. Knowing the behavior of a lens/film/developer combination will allow the photographer to use these tools with foreknowledge, creating either the sharpest image, the softest image, or the best compromise between sharpness and depth of field.

The PLI Lens Test Chart is available from Morgan & Morgan publishing. If the PLI Lens Test Chart is not available to you, the same results can be tested by duplicating the test pattern below. Placing copies of this test pattern in the center of the field of view as well as the edges of the field of view will allow you to test for basic resolving power, spherical aberration and coma. This will also allow you to test various film/developer combinations. This test pattern must be produced at life size for the numbers to be accurate.



Find a clear area where you will have plenty of room to work. Put the wall chart up on a wall about waist high. Mount your camera on a tripod with film loaded. It is important to use the same film for all lenses you test so you can have more accurately comparable results when comparing lens to lens. Later you can also use this test chart to compare film/developer combination for sharpness, too. However, I recommend starting with one film and testing all your lenses with the same film so you have a base line for accurate comparisons. For a true test of your photographic "system" (i.e. lens, film, enlarging lens, paper, projector, screen, etc.) you should conduct the test with the film and processing system you will normally use. If you don't have a “normal” combination, this test can help you determine which is the best film/lens/processing combination from an optical quality point of view.

With the camera on the tripod, adjust the tilt of the camera to a dead level. Then adjust the height from the center of lens to the floor to equal the center of the large red letters PLI in the center of the chart to the floor. Next, adjust the horizontal swing to parallel the wall.

Next measure two points equidistant on the wall at least five feet left and right of the center of the chart. These should be the same height from the floor as the center of the PLI letters. Now measure from each point to the center of the camera and move the entire tripod from right to left as needed to make these two distances equal. This will put the camera at perfect right angles to the wall chart.

Finally adjust the distance from the center of the letters “PLI” to the back of the camera lens (where the lens mounts to the camera body) to exactly **26 times the focal length of the lens** or the first test results will be off. Note that the focal length of most camera lens are measured in millimeters. Below is a chart of common lens lengths and 26 times this value.

Focal Length in mm	26 times in mm	26 times in inches
28	728	28 11/16”
35	910	35 13/16”
50	1300	51 3/16”
52	1352	53¼”
55	1430	56 5/16”
80	2080	81 7/8”
100	2600	102 3/8”
135	3510	138 3/16” (11’ 6 3/16”)
200	5200	204 11/16” (17’ 0 11/16”)
300	7800	307 1/16” (25” 7 1/16”)
400	10400	409 7/16” (34’ 1 1/16”)

Although daylight is ideal, it is sometimes inconsistent and difficult to predict. Therefore, the use of daylight balanced flood lights is recommended. Do not use flash. If flood lights are used, have equal intensity lamps on each side of the chart at equal distances and no greater than a 45 angle between the wall and the lamp.

The lights should be adjusted to the height of the “PLI” letters. Next adjust the light's horizontal swing until you get the same meter reading on all corners and the center of the chart.

All exposure metering should be done on an 18% reflectance gray card as direct meter readings of the chart will be underexposed. Alternatively, you can use an incident meter to read the light itself.

Adjust the distance of the lights to obtain a meter reading on the gray card of f/8 at 1/30 second with your ASA rating. With most 35mm cameras this will allow you to shoot the full range of f/stops by simply compensating with shutter speeds

f/stop	shutter speed		f/stop	shutter speed
1.4	1000		11	15
2	500		16	8
2.8	250		22	4
4	125		32	2
5.6	60		45	1
8	30		64	2

Exposing Test Set #1

Now that everything is set up, shoot a series of pictures using all the f/stops (but not the “in-between” f/stops that some lens have indicated by a click between the f/numbers). Be sure to allow a few seconds after advancing the film for the camera vibrations to subside. Also, it is best if you can manually stop down the lens with a depth of field preview control and lock your mirror up. Not all cameras have these controls, but if yours does, it will help eliminate a few more vibrations. (Incidentally, this chart can help you determine if your mirror and diaphragm vibrations are causing any blurring in your pictures!)

Exposing Test Set #2

Now move the camera closer to the chart until the field of view is just filled by the chart only. Check to see that the camera is at perfect right angles as for the first series of shots. The lights should remain in the same positions.

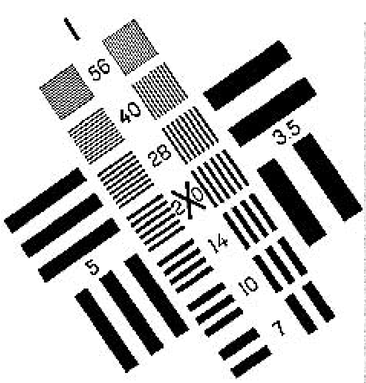
Again shoot a series of pictures using each f/stop as before.

Finally, process the film in its normal manner.

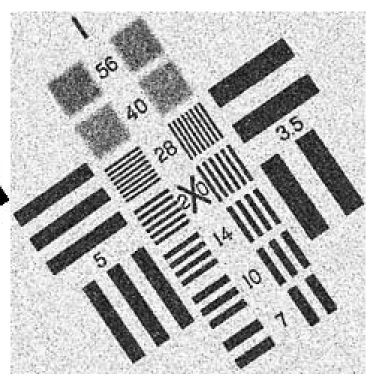
Directions for Interpreting Results from the PLI Lens Test Wall Chart

For the best analysis of 35mm negatives you will need a magnifying glass or microscope of 20x to 40x magnification. A slide projector may be used but may introduce some error inherent in the projecting lens. Even hand-held slide viewers may work for all tests except curvilinear distortion.

Of the seven common aberrations, five will be determined by the resolution patches like the ones below. The analysis will key on the ability to determine at which point the lines are not resolved in various patches. In the example below, the lines numbered 28 are said to be resolved where the lines numbered 40 and 56 are not resolved.



Original Test Patch 1



Result resolving 28 lines

Although these numbers are actual resolving powers in "lines-per-millimeter" when photographed at 26-times the focal length of the lens, the second set of our tests are photographed at other distances. Therefore, caution should be used when using these figures. In most tests they will be used for relative comparisons only.

If the results seem somewhat disappointing, remember that you are not measuring the resolution of the lens only. You are actually measuring the combined resolution of the lens and film combination as well as the inaccuracies of the camera, equipment, rangefinder, etc. In the simplest case, where, say, a lens has a resolution of 100 lines per millimeter and the film has a resolution of 100 lines per millimeter also, the net measured resolution of this combination will be only 50 lines per millimeter. The formula for this calculation is;

$$\frac{1}{R_{(system)}} = \frac{1}{R_{(film)}} + \frac{1}{R_{(lens)}}$$

In practice, the resolution will show even lower, because of camera errors, etc. A better lens, then, will not show a proportionate improvement. For example, a lens capable of 200 lines per millimeter resolution (which would be unusually good) measured with a 100-line film, will give a net results of 66 lines per millimeter — an only *somewhat noticeable* improvement over the 100-line lens mentioned above. Clearly the best way to improve *system resolution* is to improve both the lens and the film.

Part One

Before we can conclude any results, we will need to collect the data from the test negatives. First look at the negatives that were shot from a distance of 26-times the focal length of the lens. Fill in the chart below with the number corresponding to the finest sub-patch that is resolved. Note that each sub-patch consists of two sets of lines that face each other in opposite directions. If *either* of these sets of lines can be seen as lines, it is resolved. Ideally, both sets should be resolved. If you have only one set resolved you have astigmatism. Some lens have their longest aperture in-between the normal apertures (i.e. 1.7, 1.8, 3.5, etc.) Just cross off the indicated f/number and replace with your largest aperture's f/number as found on your f/stop ring.

Table I

f/stop	Center Black	Center Green	Center Blue	Center Red
1.4				
2				
2.8				
4				
5.6				
8				
11				
16				
22				
32				
44				

Test 1: Resolving Power.

Your actual resolving power is influenced by all seven of the aberrations we will look for. Also, remember we are looking at the resolving power of your lens/film combination (and to a certain degree by your choice of developers in B/W) and not that of your lens only. However, your lens-only information is not that meaningful anyway since we don't create photographs with lens only! If we're interested in finding out the smallest thing "that can be seen" by our photographic system our test should include the deterioration introduced by the enlarging lens, paper, etc. right through the final processes.

To determine your best resolution on the negative, look at the column "Center Black" in Table I. By comparing the numbers representing resolved lines from a wide open to the smallest aperture you can identify the f/stop with the best resolution. This is your maximum possible resolving power. Any patch of a different color, or any patch farther from the center, or any different f/stop will probably introduce some aberration and deterioration of resolution.

Test 2: Spherical Aberration.

Theoretically, the highest resolving power should be attained at the largest aperture of the lens. This will not, however, usually be the case; it will be found when examining the various exposures, that the resolving power improves during the first two or three negatives, then remains constant to at least f/8. The poor resolution at the largest aperture is due to the slight traces of a different kind of aberration known as diffraction. If the image is simply soft, the lens is under-corrected. If the image at the biggest aperture appears to have a hard core surrounded by a halo, the spherical aberration is somewhat over corrected. The more rapidly the resolution reaches a maximum and remains constant, the better the lens.

Again looking at the figures in Table I "Center Black" column. At which f/stop does the resolution stabilize? You should reach your maximum resolution at f/8 or f/11, but you may also see marked improvement by f/4 or even f/2.8. Some of the best lens even show f/2.8 with the same resolution as f/11.

Test 3: Chromatic Aberration.

Again on Table I, compare maximum resolutions at each f/stop for "Center Black," "Center Blue," "Center Green," and "Center Red" columns. A lens without chromatic aberration will show identical resolutions at each f/stop for each color. Since chromatic aberration is not corrected by stopping down the lens, all f/stops should show the same figures. If not, your chromatic aberration results are probably being influenced by astigmatism, and, at the smaller apertures, diffraction. Your lens has chromatic aberration if any of these colored patches fails to show the same resolution as the black patch.

Part 2

Now we must construct another table similar to Table I but using the set of negatives shot at full frame.

f/stop	Center Black	Upper Left Black	Upper Right Black	Lower Right Black	Lower Left Black
1.4					
2					
2.8					
4					
5.6					
8					
11					
16					
22					
32					
44					

Again fill in the last sub-patch that is resolved using the same criteria as in compiling Table I. Although the actual numbers used in this portion of the tests will be meaningless as far as actual resolution, they will work just fine for relative comparisons.

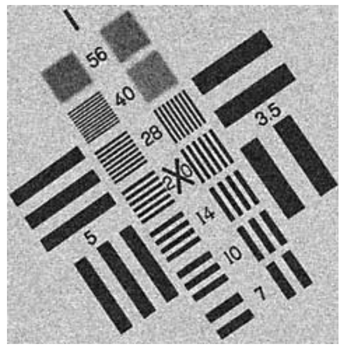
Test 4: Curvature of Field.

Since curvature of field can be corrected by stopping down the lens, we must test for it with each f/stop. Compare the “resolution” in the “Center Black” column to the rest in Table II. If the resolution decreases at the corners you have curvature of field. Curvature of field may be easily confused with coma. Look carefully. At which f/stop does curvature of field disappear or reach a minimum?

Fortunately curvature of field is not a very serious matter and many excellent lenses show curvature of field at close working distances such as those used to photograph this chart. At the more usual distances, though, their field is practically flat. Curvature of field can, however, produce very serious consequences in close-up photography and is particularly noticeable in “close-up lens” that screw onto the front of a normal lens like a filter.

Test 5: Astigmatism.

As in curvature of field, astigmatism can be eliminated by stopping down the lens. Look at each f/stop and again examine the image of the charts in the extreme corners of the field. Note that each sub-patch has two sets of fine lines with one set at right angles to the other. Find the finest block of lines that can just be resolved and note whether the corresponding set at right angles is also resolved. If the lines running in one direction are resolved but the lines at right angles to these are not resolved, the lens has some astigmatism. Check also the colored patches near the corners of the chart. Astigmatism may be worse for one color than for another, which indicates a poorer correction for both chromatic aberration and astigmatism. By comparing f/stops, at which f/stop do the effects of astigmatism disappear?



Test 6: Coma.

Again note the charts at the corners of the field, and particularly examine the finest spacing of lines. Note if the blur is even or if it is a “smear” outwards into the corners. If you see the later, the lens has some coma. This is very often the case with some very large aperture lenses for miniature cameras like 35mm. It may be present only at the largest aperture, and will probably disappear when the lens is stopped down. At which f/stop does coma disappear?

Test 7: Curvilinear Distortion.

Check the border lines that run completely around the chart. Note if they are parallel to the edge of the frame on the film or if they bow inward or outward. An inward bow is called “pincushion” distortion; and outward bow is called “barrel” distortion. It is not important in some types of picture taking, such as landscapes or portraits. On the other hand, it can be very serious in architectural photographing and mapping. A number of otherwise excellent wide-angle lens have some barrel distortion, which helps to equalize the illumination over the entire frame. Zoom lens often have pincushion distortion. If your lens has curvilinear distortion, at what f/stop is it eliminated?

Test 8: Lateral Color.

Lateral color (or *lateral chromatic aberration*) differs from ordinary chromatic aberration in that it appears only at the edges of the field, and that all colored images are of equal sharpness but of different sizes. Examine the images of the colored blocks at the edges of the sheet. Are they of equal size? Do the black lines run straight through? Most lens are fully corrected for this aberration and it is rare. If your lens does have it, at which f/stop is it eliminated?

Part 3

Conclusion

Lens design is very much a matter of compromises. As a result, all lens will have some elements of most aberrations. This method will, at least, give you an idea at which f/stops you are likely to get your best results. It can also be used to compare lens of different focal lengths or manufactures. It must be noted, though, that there are several outside factors that can influence your results.

- camera vibrations
- color of lighting
- film development
- film acutance
- contrast
- human error

Even with all these variables, the results should be of some use. This chart can also lead to tests of your enlarging lens, your ability to hand-hold a picture, comparisons of film developers, and many others.

Recap of Results

1. Best resolution _________________________ lines per millimeter.

2. Spherical aberration least at f/ __________________________

3. Chromatic aberration in colors__________________________

4. Curvature of field eliminated at f/ ______________________

5. Astigmatism present in colors __________________________

   Astigmatism eliminated at f/ ___________________________

6. Coma eliminated at f/ ________________________________

7. Curvilinear distortion eliminated at f/ ___________________

8. Lateral color eliminated at f/ ___________________________ .