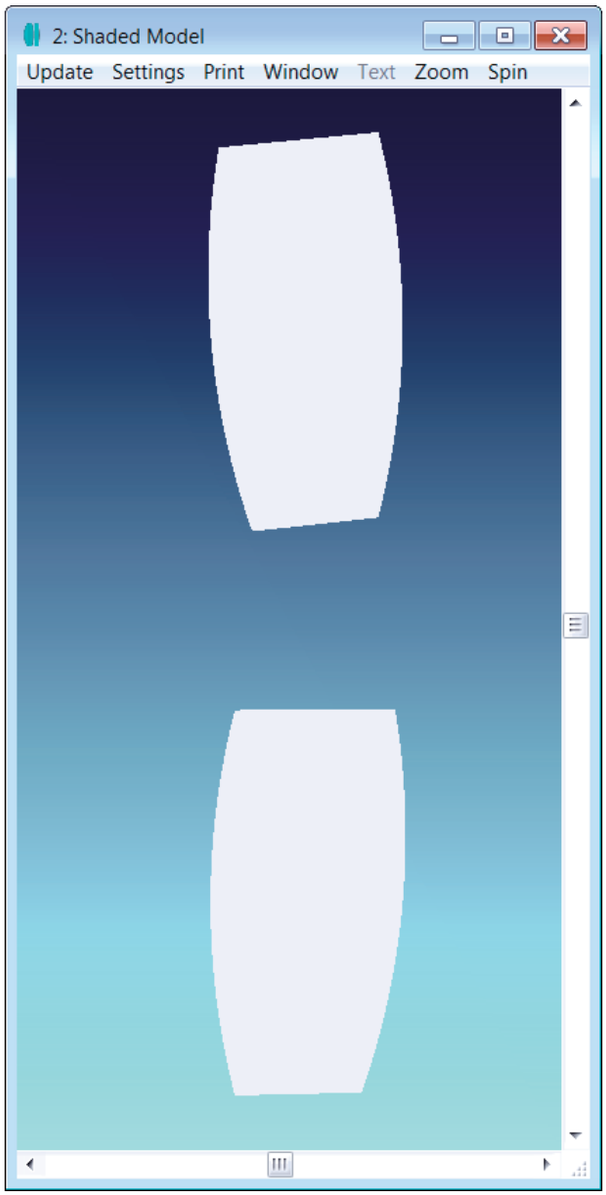
How to Tolerance for Element Roll



Imagine a simple singlet lens, with both faces nominally spherical. When it is made, it has a wedge error. When it is mounted into a lens holder that wedge can be oriented anywhere in the full 360 degree circle. What's the easiest way to describe this in the Tolerance Editor?

This is a frequently-asked question, because it is easy to get confused between 'surface' errors and 'element' errors. It works best to think about the manufacturing process one step at a time.The more you know about how the lens will be made and tested, the better.

Let's assume this singlet is made by traditional polishing methods. One side is polished first, then the second, and then the lens is placed in a vacuum chuck and one side is worked 'into' the other. This means that one side is the reference, and the other side is wedged with respect to it. So, you should have only one surface decenter/tilt per singlet.

The graphic shows a singlet with a huge wedge, so it can be seen clearly. Whichever face is held in the vacuum chuck, the other is wedged with respect to it. The top lens is held by its rear face, the bottom lens by the front face. Only one wedge angle is needed per glass element.

Next, ZEMAX gives you three different ways to describe surface wedge: decentration, tilt angle, and indicator run-out. Which to use? Well, the least helpful for spherical surfaces is usually decentration. In an aspheric surface, there is a single well-defined axis of rotation. Think of a parabolic mirror for example: it has only one axis of rotation. A sphere has an infinite number! Surface decentration error is useful for aspheres, but not for surfaces that are nominally spherical.

So which tilt method to use? Again, it depends on the test method. As the lens is rotated in the chuck, one method is to fire a laser beam though its center, and observe the radius of the circle the spot marks out on a distant target as it precesses. This gives us tilt angle, and should be measured using TSTX or TSTY. Another test method is to rotate the lens, and measure how the edge thickness varies with a dial gauge. Use TIRX or TIRY to define the edge thickness variation in this case.

You would usually choose to use x OR y tilts, and to choose whichever one is worst-aligned to the field points in the nominal design for sensitivity analysis. When the lens is mounted, we do not know (necessarily) where the wedge is pointing. During Monte-Carlo analysis, use the TETZ operand to allow the lens element to rotate around z by 360 degrees. This will model the random variation of the lens wedge in the mount.

In some cases the lens is marked on the edge to indicate the wedge axis, and the assembly technician orients the wedge within some much smaller range. In this case TETZ can be used with the appropriate range, or omitted entirely.

Please visit our Knowledge Base, Tolerancing category for articles that give detailed examples illustrating these guidelines.