Elastomeric Mounting of Lens Elements

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Overview

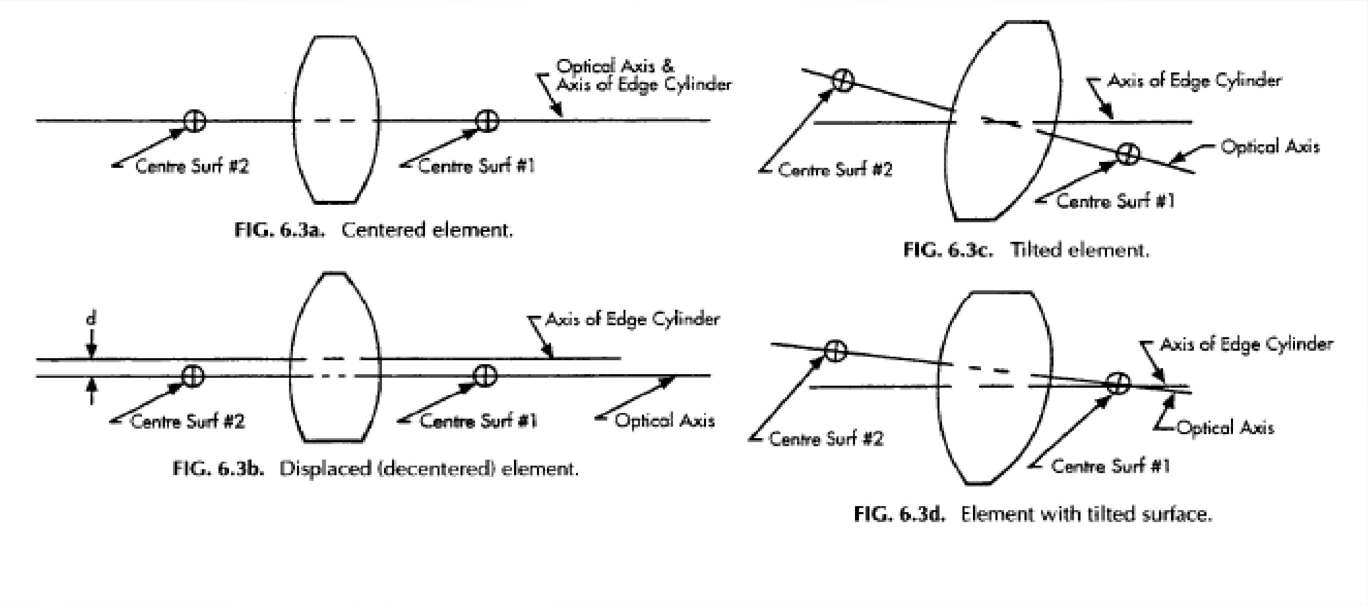
- Lens Mounting and Centering Basics
- Assembly Methods of Centering Lenses
  - Drop-in assemblies
  - Mechanical Shimming
  - Optical Centering Machines
- Advantages of Using Elastomers
- Elastomeric Lens Example

Mounting Lens Elements

- In mounting a lens in a cell there are only two fundamental considerations that must be met.
  - First, it must be held tightly and accurately
    - Its position must stable so that it will not shift during environmental conditions such as shock, vibration, or thermal shifts.
  - Secondly, it must be held so that it will not break, and so that the stresses on the components will not introduce any distortions or deformations. This includes environmental conditions.
- Ways to hold a lens in place
  - Mechanical – retaining rings, clamp, flexture
  - Bonding – Elastomers, Epoxies
- Before bonding/retaining the lens, need to center the lens elements in their barrels/cells.

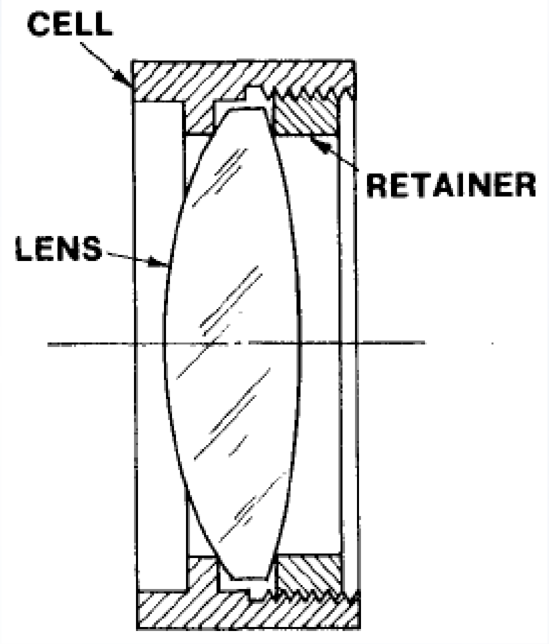
Lens Centering – Sources of Errors

- An optical centering error occurs when the optical axis of a lens differs from the mechanical axis.
- The optical axis is defined by the line connecting the two centers of curvatures of the spherical surfaces, and the mechanical axis is defined buy the ground edge of the lens.
- An optical centering error in lens system can be due to wedge or decenter in the lens element itself, or due to a wedge or decenter of the lens element as it sits in the housing. See Figure below (ISO 10110)



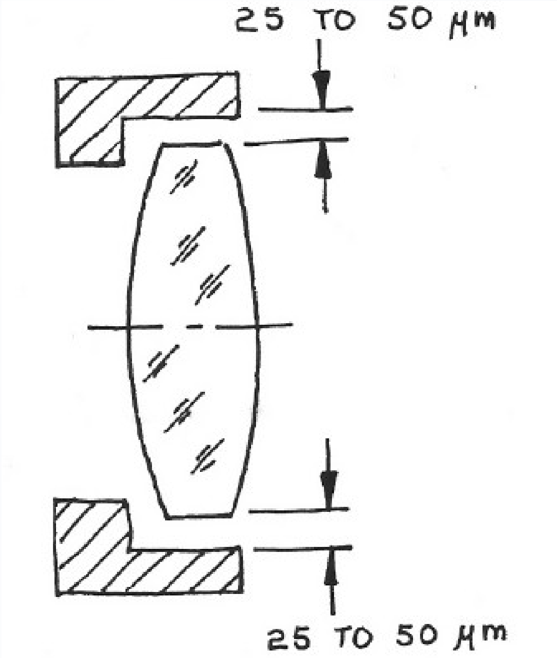
Methods of Centering – Drop-in Assembly

- In the simplest case of low precision systems with loose tolerances, the lenses can be dropped into their barrels without any adjustments.
- For assembling multi-elements, the individual lenses can be inserted one at a time, separated by spacers, and secured by a retaining ring or snap ring. An example of a single lens assembly with retaining ring can be seen below (Yoder, 2006).
- This is the cheapest and easiest way to assemble a lens



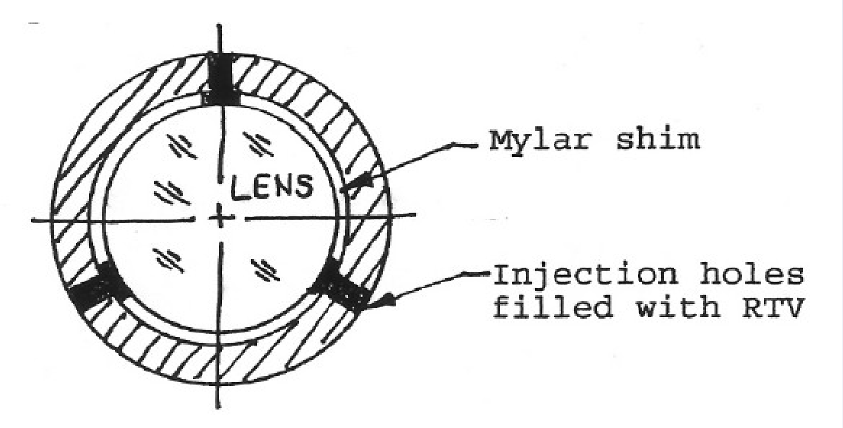
Drop-in Assembly Rule of Thumb

- The inner bore of the lens barrel will need to be larger than the outer diameter of the optics by some margin so the lenses will fit into the barrel without difficulty.
- Too tight of a bore tolerance may cause the lenses to get stuck during assembly, which may cause a residual element tilt due to the fact that the lens will be wedged in the bore instead of being properly seated against the controlled mechanical surfaces.
- A rule of thumb is that the gap should not be much tighter than 25um to 50um. (Vukobratovich, 2003)



Centering By Shimming

- Shiming is used in systems with tighter tolerances, in which a drop-in lens build is not sufficient to meet the performance requirements
- In performing a mechanical shimming operation, the assembler centers each lens element by aligning to the mechanical axis as defined by the edges of the lens.
  - Element wedge should be tightly controlled on lens drawings
- Method of Assembly:
  - The lens is first pushed all the way to one side of the bore and the largest shim possible will be fit into the gap.
  - Once the correct size is found, that number is halved and the shims are cut to size and placed into the gap between the lens and the cell.
  - Preferred method is to use three shims spaced 120 degrees apart. Once the shimmed, can be secured mechanically or with elastomer injected into holes drilled into housing. (Vukobratovich, 2003)

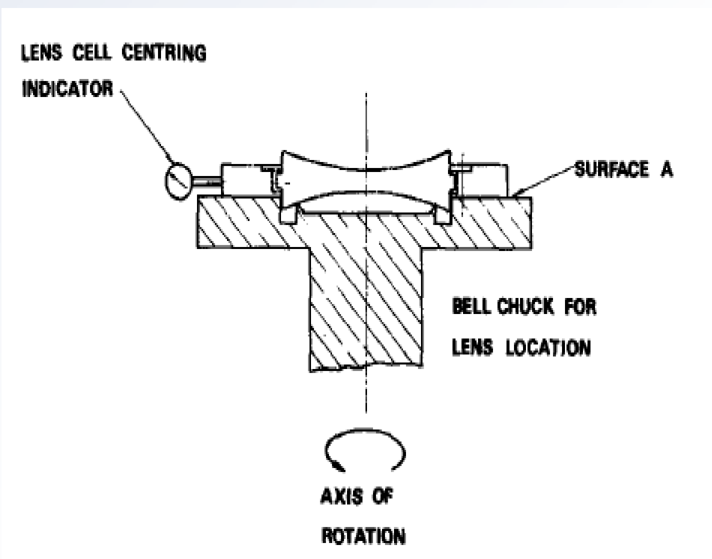


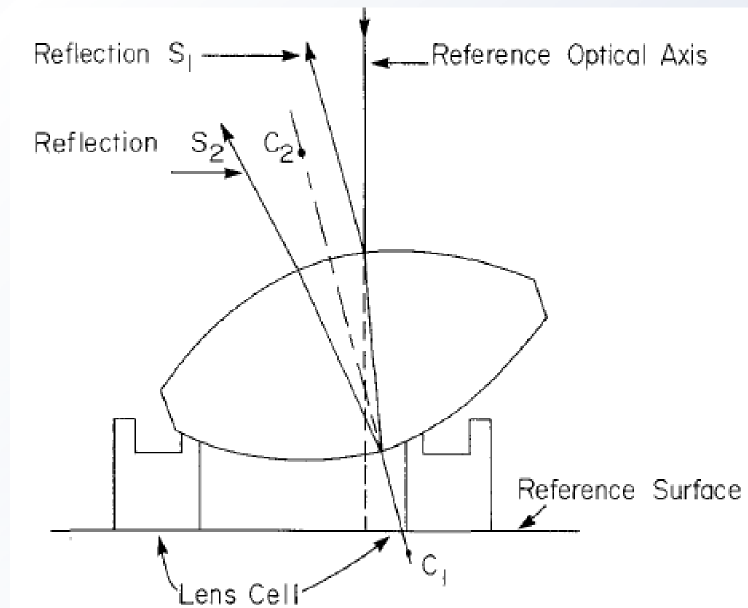
Optical Centering Machine

- Highest performance Lenses (tightest tolerances) require a build on an Optical Centering Machine. This consists of:
  - a motorized precision air bearing rotation table with stepper motor control,
  - Autocollimator
  - CCD camera with frame grabber
  - Analysis software.
- TriOptics OptiCentric is shown
- (www.trioptics.com)

Optical Centering Machine

- The optical centering machine works by projecting a reticle through an autocollimator
  - The system under test is then rotated on a precision air bearing table.
  - When the surface is centered, the image of the reticle will not move during rotation. But if a decenter or wedge exists, the image of the crosshairs will precess in a circle about a center point.

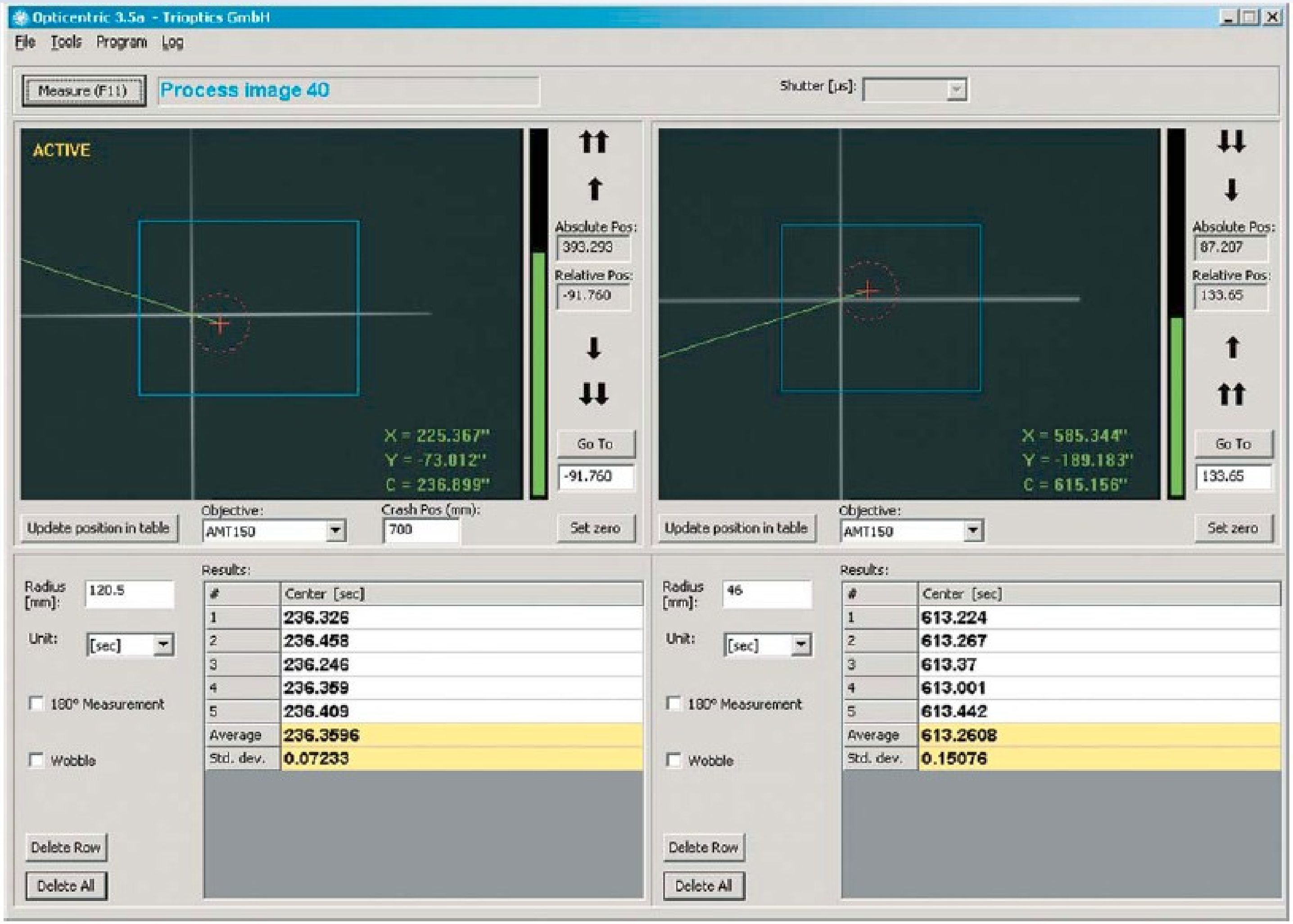




- (Jones, 1975) (Hopkins, 1984)

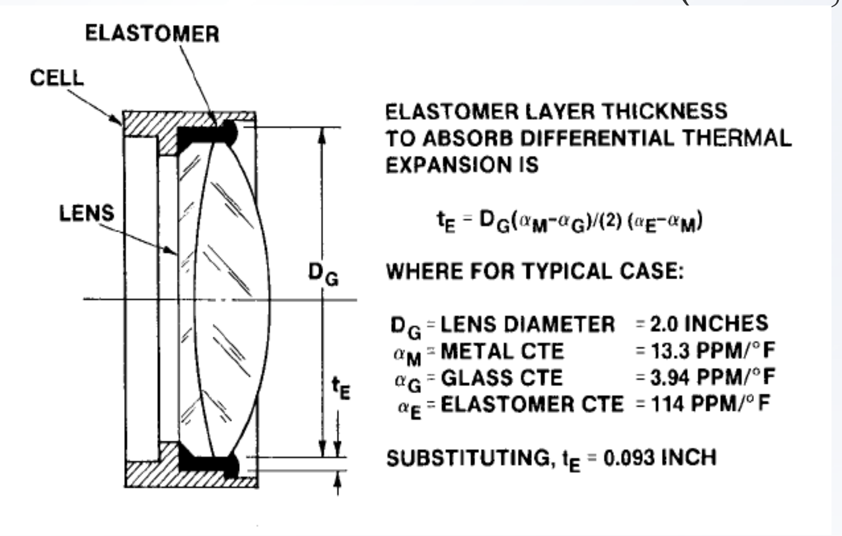
TriOptics Software

- An example of TriOptics Software (www.trioptics.com)



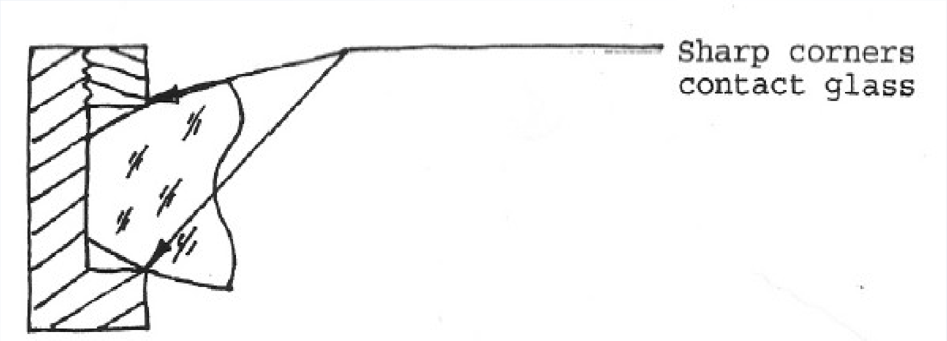
Advantages of Elastomeric Bonding - Thermal

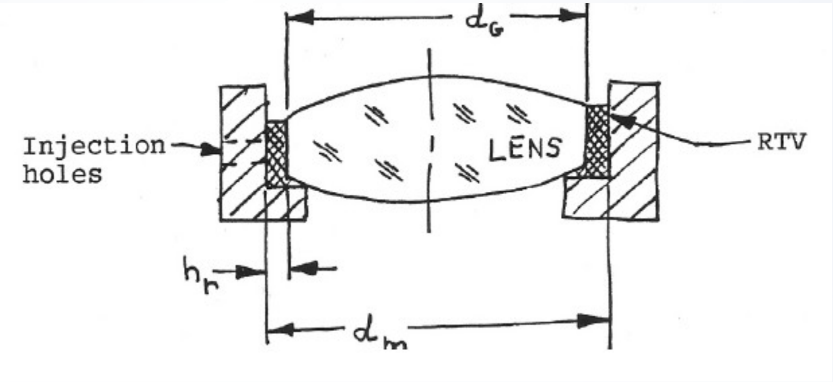
- Thermal changes will cause both the glass and the metal to expand. If the CTE of the metal and the glass differ, additional stress will be put on the components during extreme temperature changes.
- This may cause the lens position to shift, or cause the lens to crack or break.
  - The best way to minimize this problem is to either use materials that have very low CTE's, or match the CTE of the glass and mechanical housing. However, this is not always possible
  - An elastomer layer will to null out the effects of thermal expansion. The optimal thickness can be calculated using the diameter of the lens, the CTE's of the two materials, and the CTE of the elastomer. (Yoder, 2006)



Advantages of Elastomeric Bonding - Shock

- High contact forces at the interface of the glass and metal will cause stresses in the lens can become problematic over thermal shifts, shocks, and vibrations.
- Elastomers provide a compliant cushion that will buffer over shock loads. (Vukobratovich, 2003)





Elastomeric Bonded Lens Example

- An example of a successful elastomeric projection lens design is described in the paper "Case Study of Elastomeric Lens Mounts" by Robert E. Fischer.
- This design had very tight performance requirements over the temperature range of -55 to +95 degrees C.
- Due to these wide thermal requirements, an elastomeric design was selected with each lens built into individual cells known as poker chips. The material for lens barrel and the cells were made of stainless steel
- The lenses were actively centered and then bonded into their cells with a compliant elastomer. In the final build step, the individual cells were then assembled into the outer housing.

The lens reportedly performed excellently and met performance requirements on all counts.

Figure 10 - Final subcell housing design