Initial LIGO Earthquake stops

- Earthquake stops are required because LA, WA and CA get earthquakes.
- Designs have a long history. Many versions were prototyped and tested
  - » Spring tipped screws
  - » Teflon screws
  - » Conductive Teflon screws
  - » Viton corks and tips in screws
  - » Teflon capped screws

Initial LIGO Earthquake Stops

- Current Initial LIGO ES stops:
  - » SOS – viton tipped and spring tipped screws
  - » LOS – viton tipped screws in vacuum, teflon tips for some assy work.
- Currently prototyped two glass tipped screw designs. Testing on-going.
- Earthquake and Safety Stop Design Requirements, LIGO-E021000-05.
- Quantitative limits of motion were defined to determine the min. distance of the ES tip and the optic.

Initial LIGO Earthquake Stops

- Earthquake Stops Function

  1) The stops are used to **facilitate suspending and balancing** of a mass or optic. For example, Teflon-capped screws are positioned under the LOS optic prior to suspending to support the optic. The wire is strung around the optic and then the stops are slowly moved out from under the optic, so that the optic hangs by the wire. The Teflon caps rotate with little friction on the optic. Prior to final alignment in-situ, these caps are removed and replaced with vacuum compatible Viton tips. The stops are used during the balancing process to protect the optic from swinging too much.

Initial LIGO Earthquake Stops

- Function
  2) The stops are used to **clamp** the optic(s) in place prior to transport. This type of stop must secure the optic, in its balanced position within the structure, to facilitate safe transport, either by cart or by crane. It must secure the optic throughout the structure positioning operations in the vacuum chamber.
  3) After the suspension has been moved into position on the optical table, the stops then perform a new function. They are used to **protect** the mass or optic, and the objects around it, in the event of an earthquake or other sudden movement. Generally, the stops are placed within 0.5 to 1mm of the optic.

Initial LIGO Earthquake Stops

- Requirements

  1)The stops must have sufficient mechanical compliance to keep impact stresses minimal on the mass or optic.

  2)The stops must have low runout error so that the contact point does not wander with axial adjustment. We require that the axial variation due to the runout be less than 1/10 of the intended gap or __.

  3)The stops must have contact geometry that is axisymmetric with respect to the axial adjustment axis.

  » 4) The stops must have very smooth, fine axial position adjustment. Adjustment resolution should be less than or equal to 1/10 of the gap between the end of the stop and the optic.

Initial LIGO Earthquake Stops

- Requirements, continued:

  5a) The stops must have sufficient conductivity of TBD to bleed off electrostatic charge, but be resistive enough not to cause eddy current damping.

  OR

  5b) The stops must have a contacting tip that is the same material as the optic such that electrostatic charge will not be transferred. The tip must be backed by vacuum compatible compliant material so that damage to the optic is minimal. See technical discussion below.

  6) The stops must be designed to allow for installation of baffles, targets and other components that are positioned near or on the suspension structure.

Initial LIGO Earthquake Stops

- Requirements, continued:

  7) The stops must be designed to damp the optic in 10 bounces or less, to the point where the stops are no longer contacting the optic.

  8) The stops must be designed to set a gap between the tip of the stop and the optic between .18mm and .53mm for the SOS and .01mm and .62mm for the LOS. See technical discussion on this issue below.

  9) There must be provisions to measure each of the gaps with sufficient accuracy to meet the requirement in # 8. It is permissible to use the motion of the optic (for example using an optical lever, a theodolite or the sensor/actuator readouts) to determine the make/break contact event

Initial LIGO Earthquake Stops

- Requirements, continued:

  10) The stops shall have a non-rotating tip or shall have a maximum coefficient of friction between the stop tip and the optic of 1.

AdLIGO Earthquake Stops

- Function:
  - » Instead of the ES facilitating suspending and balancing, the catcher will provide this function.
  - » It would be helpful if the ES could providing clamping of the optics for transport. However, the catcher may be used for this function too.
  - » The ES must protect the optic after installation.

AdLIGO Earthquake Stops

- Stop requirements must be separated into stops for metal and stops for fused silica or sapphire
  - » Electrostatic buildup
  - » Eddy current damping