EARTHQUAKE AND SAFETY STOP DESIGN REQUIREMENTS

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Scope

This document details the features and requirements for the earthquake and safety stops for a single or multiple pendulum suspension.

Applicable Documents

D960499 LOS Chamfer Stop
D970311 Safety Stop, Conductive
D970312 Safety Stop, Conductive, Small
D970313 Safety Stop, Conductive, Long
D970562 Beamsplitter Chamfer Stop
D970563 Beamsplitter Safety Stop
D990690 LOS Safety Stop
D010213 40m TM Short Stop

Function

The earthquake and safety stops, called stops for brevity, serve three functions, in order:

1) The stops are used to **facilitate suspending and balancing** of a mass or optic. For example, Teflon-capped screws are positioned under the LIGO1 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 installation, these caps are removed and replaced with vacuum compatible Viton tips. For a LIGO1 single pendulum, the stops are used during the balancing process to protect the optic from swinging too much. AdLIGO multiple pendulums will utilize a “catcher” type of stop that will protect the optic from falling in the event of wire, fiber and/or ribbon breakage. The catcher is positioned under the optic so as to support or protect. Like the Teflon caps, the catcher is removed prior to installation.
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.
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.

EARTHQUAKE AND SAFETY STOP DESIGN REQUIREMENTS

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 end nearest the mass or optic does not wander with axial adjustment.

3) The stops must have very smooth, fine axial position adjustment.

4) The stops must have sufficient conductivity to bleed off electrostatic charge, but be resistive enough not to cause eddy current damping (0.25 to 1 Mohm/square) **OR**

5) 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.

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.

Physical Configuration

One design need not serve all functions. Multiple designs may be utilized. For LIGO1, the stops are all screws. They range from 4-40 to ½-13. Redesign of the stops requires consideration of the screw threads. The screw tips touch the side, chamfer and outer front face of the optic. For AdLIGO, the catcher has rails upon which the optic sits. The other stops are screws. The test mass(es) also requires stops.

Material

All materials and processes used to fabricate the stops must comply with LIGO Vacuum Compatible Materials List, LIGO-E960050. If the stop is removed prior to installation in the vacuum chamber, other materials may be considered, as long as they do not contaminate the optic or other suspension components. Questions about materials should be addressed to the LIGO Vacuum Standards Board.

EARTHQUAKE AND SAFETY STOP DESIGN REQUIREMENTS

Background

The PNI suspension at MIT utilized ¼-20 screws with counter bores in the tips for stops. Into the counter bore, a compression spring was pressed. This type of stop is still used on the small optic suspensions (SOS.) It is not used extensively as the spring can cause more bouncing of the optic in the even of a sudden movement rather than damping of the movement.

A number of stop designs have been prototyped. Teflon screws were tried but the material is so soft that it is not appropriate for screw material because, when paired with metal internal threads, it peels away easily (creating “spaghetti”.) In close proximity to fused silica optical material, problems with electrostatic charging becomes worse.

Carbon-doped Teflon stop screws were prototyped. The conductive material removed the electrostatic problem but the screws themselves created particulate matter when screwed into metal threads.

Viton corks were fabricated and pushed into counter bores in metal screws. These corks are used on the LIGO1 LOSs. However, it is difficult to line up the centerline of the cork with the centerline of the screw. This problem makes the positioning of the cork 1mm away from the optic’s chamfer quite difficult. Also, there is quite a bit of friction between the optic and the Viton, so it is not used for suspending and balancing.

Rectangles made from Viton cable clamp liners are press fit into counter bores in screws. This stop design is used on the SOSs. Again, the centerline of the rectangle is often misaligned from the screw centerline, making positioning difficult. Again, the friction factor makes an alternate for suspending and balancing attractive.