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Design document for the PM wire break-off prisms

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2 Document history

Version v1	*23rd July 2010*	*First draft of report for comment (M. van Veggel)*

3 Introduction

This document serves as a design document for the aLIGO SUS ETM ITM quad PM wire break-off prisms.

It contains a section about the design requirements (linking the relevant documentation to the design of the prism stated in D080479), a section on the production techniques used and a section stating the method in which the prisms will be incorporated with the PM assembly.

4 Reference documents

D080479	aLIGO SUS ETM ITM quad PM wire break-off prism
T080042	ALIGO SUS ETM Production of grooves in Noise Prototype break off prisms
M1000137	PUM Break-off Prism dimensions
T010103	Advanced LIGO Suspension System Conceptual Design
T080266	Suspending optics on steel wire loops
M080134	E/ITM and BS/FM pitch frequencies and d-values
D1001592	EAR BONDING JIG ASSEMBLY
D1001623	aLIGO ETM/ITM penultimate mass prism holder assembly
Q1000008	Inspection document for the primary wire break-off prisms for the beamsplitter/folding mirror

5 Design requirements

In the advanced LIGO suspension system conceptual design the following requirements for the suspension of the Penultimate Mass for the quadruple suspension were defined.

On page 8 it stated that the penultimate mass was to be suspension of 2 steel wire loops from the maraging steel blade stage above. On page 11 it stated that the steel wire loops were to be inside the silica suspension fibres for the suspension of the test mass.

The method in which wire break-off is achieved is using wire break-off prisms with grooves to define the physical break-off position of the wires accurately.

The document was updated in 2006 to include more up to date numbers for the position of the flexure points of suspension wires and fibres. For the penultimate mass wire break-off prisms these are defined by parameters si, d2 and n3, which are schematically, represented in section C 2.3 on page 35 and 36 of T010103. On page 38 the values set in June 2005 can be found. Only the value for si is still up to date. Parameters d2 and n3 have been updated since through two separate RODA's M080134 and M1000137 respectively. Leading to the following values:

si = 0.0030 m = 3.0 mm (The grooves should therefore be 6.0 mm apart).

d2 = 0.0003 m = 0.3 mm (according to M080134 d_2 will be 0.3 mm above the COM to meet pitch requirements).

n3 = 0.1771 m = 177.1 mm (according to M1000137 the prism height was increased to create sufficient clearance between the wire and the ear, such that there is a minimum of 1.3 mm clearance. The prism height is defined in this document to be 14.2 mm at the apex. Calculating back this leads the wire edge at d_2 = 0.3 mm above the COM will be at 176.8 mm from the vertical axis. When the wire radius of 0.3 mm is added to this the centre of the wire will be at n3 = 177.1 mm in the flexure point of the wire).

In document T080266 "Suspending optics on steel wire loops" other requirements are discussed. For the penultimate mass in the quad suspension the conclusion is drawn that a single sapphire break-off prism with grooves is required on each side of the mass. Furthermore is defines a preferred shape for the groove and that the grooves shall be manufactured through laser ablation, following experiences both in Glasgow (T080042) and at MIT (T080270). The groove shape should scale with the wire dimension. The shape shown differs slightly from the simple isosceles triangle proposed by Weiss et al, to reflect the fact that using laser ablation produces a large radius in the base of groove.

To limit thermal noise caused by the wires the grooves are designed such that the wires do not touch the bottom of the groove, but only have two line contacts on the sides of the grooves.

6 Design and production methodology

The requirements stated above have led to the design specified in D080479 with a 17 x 15 mm base. The prism is 14.2 mm high at its apex such that the edges. This shape is machined to size and all sides are polished to attain a inspection polish (roughness Ra < 5 nm). The apex has a 0.6 mm flat top to aid with focussing the laser beam for laser ablation.

The prisms are then taken to a different vendor to have the grooves laser abladed as described in T080042.

One side is marked to indicate the reference surface from which the prism is measured and referenced during assembly.

7 Quality control

Quality control is done by measuring the distance of each groove to the referenced side of the prism, the height of the apex to the bottom and a visual inspection of the surfaces. The grooves are inspected using imaging with a Hitachi TM 1000 table top SEM for surface defects in the grooves and the dimensions as well.

Similar quality control documents have already been made for the BS/FM primary wire break-off prisms that were manufactured using the same technique (Q1000008).

8 Assembly with PM

The PM wire break-off prisms shall be glued onto the PM with the replacement adhesive for VacSeal using the ear bonding jig (D1001592) and a dedicated holder for the prism (D1001623) to aid in its alignment. The prism will be inserted into the prism holder and together they will be lined up against reference edges on the ear bonding jig that is sitting on the flat of the mass. Details of procedure can be found in T080245 and T1000188.

The alignment of the prism shall be such that it's position in horizontal direction is symmetrical to the vertical line through COM of the PM. In vertical direction it shall be such that d_2 = 0.3 mm above the COM. Since document T0900374 states that the flexure length of the actual wire of radius 0.3175 mm is 2.9 mm, the prism apex should be aligned such that it is 2.6 mm BELOW the COM.