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Date:	7 January 2010
Refer to:	L1000003-v1
Subject:	Advanced LIGO Review Committee Report: Ear Fabrication Readiness Review
To:	David Shoemaker, Carol Wilkinson
From:	Committee: G. Billingsley, T. Chalermongsak, D. Cook, R. Dannenberg, R. DeSalvo, R. Route, C. Torrie
cc:	Subsystem team D. Coyne, M. van Veggel, N. Robertson, A. Bell

### Response to the review committee's report

Accepted

For caveats or conditional acceptance, see document:

Not accepted for the following reason(s), or cite document:

Action item assignments (if needed); see document:

### **Recommendation**

We find that the design of the ITM/ETM ear is complete; design considerations are well thought out and well documented.

### **Background**

In January of 2006, a Preliminary Design Review was held to review the Preliminary design of the Ribbon/Fiber/Ear/Bonding for suspending optics. That design was approved as stated in LIGO-T050245-00-R.

In November of 2010, a committee was formed to review the Final Design of the ETM/ITM ears. That committee met once, and reviewed all questions from each member. Representatives of the SUS group attended and participated in the question review process. The questions from the committee were supplied to the Suspensions group and answered satisfactorily in T0900629-v2.

## Scope

This review is intended to review readiness of the Suspension Ear design for fabrication. This review does not cover fibers, ribbons or welding.

The specific areas addressed are:

- i. Concerns outlined in T050245-00 Preliminary Design Report
- ii. Completeness of the Final Design as outlined in M050220-09 "Guidelines for Advanced LIGO Construction Activities."

The documents under review are:

- LIGO-T0900447: [Final Design Document ETM/ITM Ears](#)
- LIGO-D090007: [Advanced LIGO, Suspension, ETM Test Mass, Test Ear Redesign with Recess](#)
- LIGO-D080751: [Advanced LIGO, Suspension, ETM Test Mass, Test Ear Redesign](#)
- LIGO-T0900595: [Production Readiness review for Test Mass and Suspension Mass Ears Questions from the Committee](#)
- LIGO-T0900629: [Response to questions from the review panel on the Final Design Review of the ETM/ITM ears](#)

Supporting documents (not specifically for review) include ...

[P0900084](#): "Finite element modeling of the mechanical loss of silica suspension fibres for advanced gravitational wave detectors"

[P0900053](#): "Thermal noise arising from bonds in the Advanced LIGO test mass suspensions"

## Findings

- 1) The committee finds the design of the ITM/ETM ear to be complete, with design considerations well thought out and well documented.
- 2) The suspension team addressed all issues regarding the design of the ears to the satisfaction of the committee.

## Actions

- 1) Monitor the Glasgow thermal noise experiment on bond noise.
- 2) Complete the fabrication procedures incorporating your experience from the Glasgow and LASTI suspensions.

### Review of Actions from the Preliminary Design phase T050245-00

Relevant to Ear/bonding Review	Description	Status
N	Develop requirements (in collaboration with ISC team) on positioning of the optics.	

N	Effects of violent impacts (including likely installation effects) on stability of silica suspensions. Evaluation of requirements of earthquake stops spring constant in light of impact effects.	
Y	Thermal noise effects of silicate bonding. In particular, directly measuring the mirror thermal noise effects of a silicate bond using an existing prototype interferometer, possibly the TNI or Glasgow interferometer, should be explored.	Submitted as analysis rather than direct measurement. Carried forward as action item 1.
N	Thermal noise effects of tapering of filaments, flame welding, and laser welding. The recent paper on suspension thermal noise from laser welded fibers addresses many inadequacies in our knowledge. It would also be desirable to explore the direct measurement of suspension thermal noise in a prototype interferometer, to allow for more direct research on effects from bonding, welding, tapering, etc, although this may not be feasible. Analysis of data from existing gravitational wave interferometers, particularly GEO, for thermal noise information should be pursued.	
Y	Possible non-Gaussian noise from silicate bonding, welding, and/or silica hood connections. This is another area where work with an existing prototype and GEO data can be potentially useful.	Carried forward under action item 1.
N	Research on the effect of long term loading in both vacuum and air on microcracking in silica. Examine existing plans and procedures for transport and storage of silica suspensions in light of any insights to determine if additional planning is necessary	
N	Continuing work with laser welding, including the planned development and assembly of the noise prototype for LASTI. This includes the need for further testing on lap welding, rather than the butt welding which GEO used.	
Y	The material to be used in penultimate mass. This may require studies of effects of silicate bonding on other types of (cheaper) glass. Needs to be done along with planning for the suspension method for the penultimate mass, whether silica hooks or wires.	Complete All fused silica
N	Details of the necessity and method for violin mode damping. The ongoing plan involving modeling and integrating the GEO experience should be encouraged.	
N	Keeping the spread in violin mode frequencies down below 5% is desirable for filter design. The GEO experience may not be directly relevant here as Teflon coating was used in GEO, which is only being considered for Advanced LIGO, so some additional research may be required.	
N	The necessity for annealing ribbons after welding to equalize stress across the weld.	
N	Further development of the optical profiler to be used to characterize ribbons after being drawn.	