LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
-LIGO-
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Procedure	**LIGO-T050080-00-W**	05/13/05

Report of the Quad Suspension Installation Fixtures and Articulating Arm Design Requirement Review Committee

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SCOPE

This document is the report of the committee charged with reviewing the Advanced LIGO Quad Suspension Installation Fixtures and the Installation Arm for BSC chambers. It mainly addressed these two special purpose fixtures, the Payload Polar Positioning Fixture (P3P) and the Articulated Installation Arm. Actual drawing details will follow this review. This was not a complete review of the installation requirements.

PURPOSE

Review and agree that the conceptual design requirements have been met, and are complete and appropriate at this time, to move forward with prototype construction to do the ETM installation at LASTI.
Review and approve the design, indicate changes, advisories and possible action items needed.

REVIEW COMMITTEE

Doug Cook (chairman), Ken Mason, Harry Overmier, Gary Traylor, John Worden.

PRESENTATIONS (Applicable Documents)

Dennis Coyne - Overview
“Advanced LIGO SUS Installation into BSC Chambers: Mechanical Fixtures” G050245-00 05/04/05.
D. Coyne
“Stress Analysis of Lower BSC Chamber with an Installation Fixture Cantilevered from the Main Port Flange”, T040234-00, 12/17/2004.

Oddvar Spjeld – P3P Fixture
“Advanced LIGO Quad Suspension Installation Fixtures Design Review” T050071-00, 04-26-05.

Ken Mailand – Articulating Arm
“Advanced LIGO Lower Quad Suspension Installation Arm Design Review” T050073-00, 05-02-05.

Several Advanced LIGO members and others offered comments during the review that were greatly appreciated.

RESPONSE OF THE COMMITTEE

The committee unanimously agreed that the team presentations were well done and both designs were well thought out and generally agreed that we should move ahead.

1/ With regard to design requirements (summary in Oddvars doc):
   a. The design requirements should be checked or reworded for accuracy and compared to actual needs.
   b. The load capacity for both fixtures was not consistent or well defined.

c. Vertical deflection of .0005 was reinterpreted to mean resolution of P3P positioning. .0005 may be extreme and hard to meet.
d. Horizontal linear translation of 120 inches is not center to center positioning of the table, it is understood to be from the out board edges. This allows for plenty of travel.

2/ With regards to P3P:

a. Confirm that the installation of the fixture is possible after the optic (Quad) is in place – especially the vertex chamber.
b. Analyze the stability when a high CG load is mounted - should there be a backup safety chain or cable?
c. Consider Teflon or phosphor bronze for bushing material.
d. Confirm that the linear drive lead screws can be synchronized to prevent binding. Coupling joints may be needed to accommodate this.
e. Consider the use of hand wheels for linear drives.
f. Investigate the .250 Support Ring clearances to BSC chamber wall to allow for chamber roundness and diameter inconsistencies.
g. Address concerns that the support ring will not align in height. It could be difficult to lift the quad and tooling over a ridge. We should verify that shims alone will align them or if we need shims and a pin to assure they align and stay together.
h. To install the quad, you have to predetermine the angle at which the quad is placed on the support table, then rotate the support beam below the final optic position. We will want as much angular adjustment as we can get. Perhaps increased from ± 10 deg to ± 30 degrees?
i. Support beam must be able to be locked in place on support ring.

3/ With regard to Articulated Arm –

a. The design requirements should be checked or reworded for accuracy and compared to actual needs.
b. It may be possible to use the Timken roller bearings in a non-lubricated condition for a small number (1000?) of near static cycles. Retain the sealed feature to keep particulate away from the bearing surfaces. (LIGO gate valves use non lubricated ball bearings) Ask Timken if they can provide ratings for our conditions.
c. Shafts are called out of 1040 steel - rust will be a concern - consider chrome plating or SS shaft material (Nitronic 60 Alloy was suggested).
d. Positive mechanical stops are required for transport and installation.
e. The conclusions in the stress analysis report specifies that the arm span ~39 inches between attachment points. Either rerun the analysis at the actual spacing or change the design to span 39 inches.
f. Provide >3 sq in disks for back of flange to assure we do not have point or localized contact as mentioned in the conclusions of the analysis report.
g. We need to cover the entire sealing surface and possibly the ID of the flange to assure we do not hit far side or bottom of flange.
h. Put positive mechanical pin detents in the folded and open configurations, also guide handles and pinch guards.

STRESS ANALISIS

ALGOR software (Solidworks) was used to determine loading and stress moments and reviewed by LIGO engineers.

It was determined that 6061-T6 Aluminum has a 5% reduction in its yield strength due to heating in the bake oven (120deg.C). Source was through Larry Jones.

RELATED ASSEMBLY ISSUES not in the SCOPE

1/ Parts should be cleaned and air baked to the proper contamination control plans, prior to assembly. Use only a very small amount of vacuum compatible grease (Krytox?) where absolutely necessary and exposed grease should be shielded from any chances of migration to other surfaces.

2/ The bearings can be baked to 120C according to the specs.

3/ Close slip fits for the inner and outer races will be ok. With the separation of the bearings and the loading in one direction, play will not be an issue.

4/ Ken Mailand action item response to dry bearing use:

"The response from 'Jim Lee' @Timken is that they would not recommend using the bearings is non-lube condition excessive wear would occur.
I have cleaned one of our bearings here and it squeaks turning, when in dry condition. This is a tapered roller bearing, the thrust is on the top edge of the roller, against the lip of the race. We could try a dry setup to see how it behaves, the bearings are easily changed out, and are about $20 ea."

5/ Confirm outstanding quotes and specifications for linear drives and other out sourced items.

6/ Conduit needed for housing air and electrical lines in situ.

7/ Personnel safety needs to be reviewed.