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Action Item Response Report:

FIRST ARTICLE FABRICATION READINESS REVIEW for the

Seismic Isolation System (SEI):

Title

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ACTION ITEM RESPONSE FOR THE FIRST ARTICLE FABRICATION READINESS REVIEW OF THE SEISMIC ISOLATION SYSTEM (SEI): *IN VACUO HARDWARE*

First Article Fabrication Readiness Review Background and Context

The first article fabrication readiness review is envisioned to be a series of four or five reviews on different aspects and components of the design. This staggered review approach is in response to the need to proceed as rapidly as possible in bringing this critical path activity into fabrication as well as the recognition that many elements of the SEI subsystem have a fair degree of autonomy from one another. The five focus areas are:

- In vacuum hardware (BSC + HAM)
- External to the vacuum structural hardware (BSC + HAM)
- Actuator hardware (incl. air bearings and flexures)
- Assembly and maintenance fixtures/tools and assembly sequence steps
- Spring and spring seat

This report is a response to the action items that arose from a Fabrication Readiness Review[1] of the first area, in-vacuo hardware.

1. Review Board, "First Article Fabrication Readiness Review, Seismic Isolation System (SEI): In-Vacuo Hardware", LIGO-M970082-01-D, 6/30/97.

RESPONSDE TO RECOMMENDED ACTION ITEMS

Action 1.Optics table hole array as potential trapped volumes.
The 2" by 2" array of holes on the face of the optics tables (BSC and HAM SEI units) are intended as a flexible arrangement for mounting optical elements anywhere on the table. However, the mating faces of these optical components can "plug" holes in the array. To vent these holes by adding grooves to the mounting surfaces of the optical components (at a spacing which is no greater than the hole width, 1/4") seems impractical. For this reason (as well as a cleaning concern discussed below in #3) we recommend that the 2" by 2" array be through tapped holes with venting through the cavities formed by the table core. (Note: Obviously the holes which have mating bolts can be vented by bolts with through holes. This will not solve the problem for holes which are simply blocked by the base of a component.)

Response: We have rejected the suggestion to use through tapped holes in the optics table facesheet (for reasons cited in the response to action #3). Our solution to the need to vent blind, tapped holes (which can become blocked by the mounting faces of optical/optomechanical components) is to machine narrow (~ 0.016" deep and wide) slots on the surface through the 2" by 2" hole pattern. In order to prevent the slots from making a sharp edge on the starting thread of the hole, each hole in the 2" by 2" array will have a slight countersink.

Open: Pending receipt and review of revised drawings.

Action 2. Optics table hole array galling.
We continue to be concerned about the potential for galling of screws which are repeatedly inserted and removed (albeit at low frequency) into the 2" by 2" array on the optics table. We are aware that Hytec has performed some tests intended to determine the acceptability of tapped holes into the 6061-T6 with subsequent stress receiving heat treatment. Presumably these tests indicate that a standard 1/4" bolt will fail prior tapped thread failure in the hole, or as a minimum that there is no failure of the tapped threads in the hole at a maximum recommended torque value for the bolt.[1] Since it is common practice to use inserts in threaded holes in aluminum for applications with either high preload (as in our case) or repeated removal and insertion (which might characterize our situation when one accounts for the fact that we are using completely unlubricated threads), we recommend preparing all holes in the 2" by 2" array for helicoil inserts. Inserts will then be placed when and where needed in situ. (Of course the inserts will have been properly cleaned and vacuum prepared prior to insertion.)

Action: Hytec to convey to LIGO the results of the aluminum tapped hole tests performed to date by 7/2.

Response: Hytec's test results[2] on the strength of tapped 1/4-20 UNC and 1/4-28 UNF holes in 6061-T6 (stress relieved per the intended schedule for the SEI optics tables) indicates that the

1. Of course in the later case, the torque value could be quite high with modest bolt tension if the friction between the bolt and the aluminum is high. Ultimately what we need is high bolt tension.
2. B. Weinstein, Torque Tests, LIGO-TN-21, Hytec Inc., July 97.

bolts fail prior to shear failure of the aluminum threads.

Action: LIGO to consult with others on the experience with helicoils in UHV and the compatibility of SS bolts and the alloy used in helicoil (or other inserts) with regard to cold welding and magnetization by 7/7. (Note: Seiji Kawamura is in the process of defining the limits of magnetic materials in proximity to the suspension coils).

Response: Consulted John Worden (LIGO VE) and Frank Spinos (LANL) who agreed that galling will occur with SS in Aluminum under squeaky clean conditions. However, they felt that you could obtain good reliability by silver plating the bolts. Several dozen cycles should be obtained from the plating. For the safest performance Spinos suggested class 2 thread fit, silver plate SS bolts and, if really worried, using rolled threads on the bolt. Both were concerned about virtual leaks with helicoil inserts and the difficulty and messiness of a repair should an insert become damaged; They thought that repair of a galled thread in an aluminum hole would be much cleaner and easier.

Action: Telecon for decision on 7/8.

Response: A telecon was held 7/9/97 between LIGO/CIT and Hytec. A concern that the introduction of inserts would double the stressed surface area leading to an increase in the rate of ‘creak’ events (discrete creep events). According to the helicoil literature, tapped holes are strengthened because the inherent flexibility of the insert provides a more balanced distribution of dynamic and static loads throughout the length of the thread engagement. This flexibility also compensates for variation in lead and angle error allowing each coil to carry its share of the load. Maximum clamping action and bolt tension are assured with minimum torque, because of the mirror smooth surface finish of Heli-Coil inserts. There some logic to these statements, but we are not sure if they've been proved. If correct, the fact that we double the number of contact surfaces (bolt to insert and insert to substrate) which could 'creak' may be more than offset by a reduction in the maximum stress.

Hytec investigated alternative coatings. Galling is minimized by making the two materials as dissimilar as possible in hardness. Although silver plating of the stainless steel bolts (making it softer than the aluminum substrate) is one possibility. Another possibility is adding a very hard coating, like Titanium Nitride (R > 70), to the bolt (by a plasma vapor deposition process). (One potential source is Magnaplate.) Hytec will get samples for LIGO testing.

The addition of inserts appeared to add some risk and complication without due justification since the strength and wear life of the tapped holes appear to be adequate and since other plating alternatives exist to minimize the risk of galling. The decision was to <u>not</u> use inserts.

Closed

Action 3. Cleaning considerations for blind tapped holes.
It was considered essential that the 2” by 2” array of holes in the optics table facesheet be precision drilled and tapped after the facesheet has been welded to the core. The principal reason for

using blind tapped holes for the array is that the debris (chips and cutting lubricants) would fall into the cells of the table core and be extremely difficult to remove/clean. We question whether the 2” by 2” array of holes needs to be precision drilled and tapped. The alignment of the optical components mounted to the table will not be reliant (to any significant degree) upon a precision requirement of perpendicularity of the tapped hole axis to the table surface. If the perpendicularity precision is relaxed, then perhaps we can drill and tap through the facesheet, and clean the holes, prior to welding the facesheet to the core. This approach would eliminate hole venting problems (see #1 above), improve the ability to clean the tapped holes (as compared to a blind tapped hole), and may slightly reduce the cost of the array of holes (blind tapped might cost more). We calculate that it would take over 1/8” of distortion over the surface of the table to cause a problem with a class 2 thread. If necessary to accommodate the welding distortion induced angular tilts of the through tapped holes, we could switch from to class 1 threaded bolts (1/4-28 UNF-2A to 1/4-20 UNC-1A bolts). The coarse thread (1/4-20 thread is typical of optics tables) is stronger and less susceptible to galling in UHV applications. The class 1 thread will permit a greater tolerance for non-perpendicularity. (Note: The ribs in the eggcrate core do not coincide with the 2” by 2” hole pattern, so the ribs do not interfere with a change to through holes.)

Action: CIT to define acceptable tolerance on the perpendicularity of the tapped hole axes relative to the table surface.

Action: Hytec to either (a) use the weld samples (if practical) to determine the welding induced distortion (locally) and infer the hole axis non-perpendicularity relative to a (subsequently machined flat) facesheet surface, or (b) define and conduct a test of the achievable perpendicularity tolerance of the tapped holes as limited by subsequent welding induce distortion.

Response: Hytec is concerned about the dimensional accuracy of the weldment (see action #5). The suggestion to tap and drill the optics table facesheet prior to welding the facesheet onto the ‘eggcrate’ core:

- adds considerable risk of unacceptable non-perpendicularity of the threaded hole axes with respect to the table surface), and
- potentially adds increased ‘creak’ event rates at the top, isolated stage via a local stress enhancement under the head of the (now cocked) bolt (or adds the complication of a ‘mechanism’ at each bolted joint to load spread)

The benefit is only a perceived reduction in the effort to clean the blind tapped holes (and a probably slight reduction in the cost of blind versus through tapped holes). Given the very real possibility of an increase in the rate and severity of ‘creak’ events versus the modest increase in the difficulty of cleaning the blind tapped holes, we choose to keep the blind tapped holes. It should be noted that if in the course of fabricating the first article the concerns regarding welding distortion do not materialize, we can always switch to through tapped holes in the facesheet prior to welding for the balance of the production run.

Closed

Action 4. Alignment and safety pins.
The method of "locating pin" (LIG-12005-7) insertion, removal and then insertion of a "leg screw" (LIG-12005-1, -3 or -5) or a "safety pin" (LIG-12005-9) seems prone to galling problems.[1] We recommend that the safety pin be installed once and that if necessary, a sleeve for alignment purposes be slid over the safety pin.

Response: See the discussion on galling in the response to action #2. The pins will be appropriately coated to minimize the risk of galling.

Closed

Action 5. Welding distortion.
The manufacturability of the weldments in Hytec's design is a concern. We would like to know if Hytec is confident about meeting the weldment dimensional requirements and tolerances as designed, or if there is a significant risk. (A welding expert at CB&I has been contacted by Larry Jones to get another opinion.)

Action: Hytec to discuss with LIGO via telecon week of 6/30 -- time & date TBD.

Response: Discussed in a telecon with LIGO and Hytec on 7/9/97. Nothing new is known about the potential for welding distortion. It should be noted that the dimensions and tolerances in the Hytec drawing are for the finished weldment; It is the manufacturer's responsibility to insure that the finished dimensions are met. In a few drawings, the callouts for plate dimensions will be changed to minimum finished dimensions. Hytec is concerned about the welding induced distortion and has assumed significant machining will be required after welding to meet the final dimensions. Hytec has also issued and awarded RFQs for welding samples in order to evaluate (albeit in a limited sense) not only the welding quality with the geometrical constraints imposed by the design, but also welding distortion (on a small spatial frequency scale).

Closed

Action 6. Weldment plate rubbing.
There appear to be a few locations in the weldments where two adjoining plates are in contact and yet not welded together. These situations can give rise to stiction release events and should be eliminated. One location appears to be the interface between the crossbeam members of the BSC SEI downtube weldment (LIG-12006, items 7 and 8) and the leg pads (item 9). It this example, it would not be acceptable to simply weld along the adjoining edges, since there will be a large contact area where a face of the crossbeam and a face of the leg pad touch. This problem could be alleviated by machining one or the other face to recess all but the welded edge. (Other locations where this situation may also arise will be conveyed via marked up drawings.)

1. The LIGO 40m lab had a bad experience with an "earthquake stop pin" which cold welded to an isolation stack and couldn't be removed; it required dismantling the stack and re-machining and cleaning. In the 40m lab LIGO does not use separate alignment pins -- the earthquake or safety pins are installed once.

Response: The design intent is to preclude weldment plate rubbing. In the specific case cited, the leg pads have a machined relief; The drawing will be revised to make this clearer.

The use of welds opposite to the area of weld preparation is unusual practice (presumably to reduce the potential for abutting faces which are not welded together). Is this standard UHV practice? Have we received any feedback from welders on the advisability of this approach?

Response: The weld preparation is standard UHV practice and cited in the SLAC vacuum specification[1].

Open: Pending receipt and review of revised drawings.

Action 7. Conflat flanges.

The conflat sizes specified should be standard. The tolerances on the conflats should be in conformance with industry practice, e.g. the radius is (by default) 0.015” -- is this correct? The conflat flange mating surfaces should have a very smooth surfaces finish, much better than the 250 microinch rms (default) value specified. The mating surfaces should also be called out as lathe cut and not milled. The knife edges may require special heat treatment for hardening.

An assembly sequence should be developed for the bellows/conflat and support tube. Provisions for a He leak test orifice should be made (if possible). A method for retaining the Cu gasket during assembly needs to be devised. Should also specify bolts, nuts and tool access (e.g. 12 pt external socket bolt and dual nut plates). The orientation of the mating He orifice and Cu gasket retaining spring slot on the chamber side of the large conflat flange should be accounted for in the drawing.

Action: Hytec to confirm that all conflats are standard dimensions. Hytec to confirm tolerances are within industry standard specifications. Hytec to add surface finish requirements (lathe cut & surface rms spec.) Hytec to determine appropriate heat treatment.

Response: Hytec will revise the drawings as follows:

- an acceptable radius of curvature for the knife edge will be determined and called out
- the surface finish appropriate for a conflat flange will be determined and specified
- a lathe cut (not milled) will be called out for the sealing surfaces
- heat treatment/hardness of the knife edge will be determined and specified as appropriate

The dimensions are per the SLAC vacuum specification (cited above).

An assembly sequence and method has yet to be developed. Baseline is to use vacuum putty to hold the smaller gasket in place (from the non-vacuum side).

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1. J. Khaw (ed.), “Technical Specifications for Vacuum Systems”, SLAC-TN-86-6, Jan 87. Also: M. Baldwin, J. Pope, “SLAC Vacuum Specification: SSRP User Specifications for Vacuum Systems and Components which Interface with the SPEAR vacuum system”, SLAC-TN-73-13, Oct. 73 (filed as LIGO-T970004-00-D)

Open: Pending review of revised drawings and development of an assembly method.

Action 8. Surface Finish.
Common practice at the 40m lab is 32 microinch rms surface finish. The 250 microinch rms surface finish that is specified in the drawings may be adequate for UHV practice in general, though some concerns were raised. However, the top facesheet surfaces of the optics tables should be specified to have a surface finish with 32 microinch rms or better.

Action: LIGO to accept 250 or define another default surface finish by 7/7.

Action: Hytec to specify the optic table facesheet top surface with a 32 microinch rms finish.

Response: Hytec has switched to 32 microinch finish as a default.

Open: Pending confirmation in revised drawings.

Action 9. Drawing Configuration Control.
Hytec must use the LIGO configuration control system. For drawings, this means that Hytec should obtain a block of numbers from LIGO for use in numbering drawings and parts. In addition, Hytec should file a Document Change Notice (DCN) form, including the drawing, with the LIGO Document Control Center (DCC) when each drawing is released and each time it is revised. Draft or preliminary versions of the drawings need not be filed. The DCN defines the changes and the necessary approval signatures. Approval signatures should include Hytec personnel, the LIGO SEI Task Leader, Mike Fine, and the LIGO Chief Engineer, Dennis Coyne.

For documents which relate to the procurement specification, such as a fabrication or cleaning specification, the same procedure applies.

Action: LIGO to send Hytec the LIGO document numbering system and the procedure for using a DCN, including a DCN form by 6/30.

Response: Hytec agrees to comply with the LIGO document control system. LIGO has sent Hytec a description of the document control system, the DCN process, a DCN form and is helping Hytec to establish the capability of electronically filing drawings (as AcroBat *.pdf files). LIGO has also assigned Hytec the block of drawing numbers D972xxx.

Open: Pending update of the drawings to show the LIGO drawing numbers. The drawings will not enter configuration control (via initial release with a DCN) until after the RFQ packages are out, but before release for fabrication. Hytec specifications also require LIGO document numbers and need to be entered into configuration control prior to release for fabrication.

Action 10. Assembly drawing showing the support table captured with the downtube.
The BSC downtube weldment (LIG-12006) and the BSC support table (LIG-12011) are shown as

independent weldments. In fact the two assemblies must be pieced together before the final welding is performed on the downtube weldment. This needs to be conveyed in the fabrication documents. (Other than the use of “field weld” symbols on LIG-12006, sheet D3.) One method is to include notes on both weldment drawings indicating the need to piece them together before welding the crossbeams of the downtube weldment and referring to another assembly drawing showing the final product with the two weldments captured together.

Response: Hytec has developed an assembly drawing which indicates how the two weldments are captured together.

Open: pending review of the new drawing

Action 11. Missing Bill of Materials (BOM) and Drawing List.
It’s difficult to establish the completeness of the drawing package in the absence of a good top-level assembly drawing, BOM and drawing list. Some of this information is provided in the two top level assembly drawings (LIG-20001 and LIG-10001).

Response: Hytec will create a BOM and drawing list.

Open: pending receipt and review

Action 12. Missing the HAM Bellows drawing.
The HAM expansion bellows drawing (which includes the mating conflat flanges welded to the bellows) is absent from the package.

Response: Drawing was pending completion of the bellows testing; The welded bellows has recently successfully completed testing.

Open: pending receipt and review

Action 13. Slotted holes for the (BSC and HAM) support tables?
The support tubes are joined to the support tables in both the BSC and the HAM SEI via two sets of threaded holes at 90 degrees from one another. Standard practice would slot one set of holes in the support tables. If slotted holes are not used, are the tolerances sufficient to allow assembly?

Response: Slotted holes are one way to go, round holes another; Round holes are cheaper. Hytec will revise the hole size to allow for tolerances in assembly.

Closed

Action 14. Pin thread lengths are too long.
The threaded lengths on the locating pins, the safety pins are 0.75” long but the mating holes in

the support table are only 0.625” deep. Threaded length should consider need for slotted washer -- see #15.

Response: Hytec has corrected this discrepancy on the drawings. The pins will have a slot for venting incorporated, rather than use a separate slotted washer.

Open: pending receipt and review

Action 15. Incorporate a slotted washer.
UHV practice (at least at the 40m lab) calls for the use of a slotted washer (either a split ring lock washer or a flat slotted washer) in order to vent the top portion of a threaded hole (even though the bolt has a vent hole through its center). This should be incorporated into the SEI design.

Action: LIGO to provide Hytec with the split washer source for the 40m work.

Response: This is not necessary for the optics table components since the slot will be incorporated into the optics table surface (see response to action #1). For the support table to support tube bolting, a washer should be avoided for this high stiffness, structural joint. The welded inserts in the support tube will have slots for venting machined into their mating surfaces.

Open: pending receipt and review

Action 16. |Pin tolerances appear to be incorrect.
The 0.050” nominal clearance for the space between the holes in the leg elements and the safety pins and leg screws seems to be inadequate based on 40m experience and the dimensional scale of the SEI. Furthermore, such accurate alignment may not be necessary.

The 1.000+/-0.01 tolerance locating pin dimension is meant to match at three locations to 1.00 +/- 0.03 holes. The positional accuracy of these holes is 0.017” diametrically. Clearly there is a tolerance problem. Once again though we question the need to so accurately position the location of the leg elements.

Response: Hytec concurs that the leg elements do not need to be positioned very precisely and that the tolerances are not correct. The drawings will be revised.

Open: pending receipt and review

Action 17. Support tube threaded insert weld.
The threaded inserts for the support tube are shown to be welded with a 0.25” fillet and yet they stand proud of the tube surface by only 0.125”. Does this imply a weld preparation which requires grinding into the surface of the support tube, or that the threaded inserts and weld fillets are subsequently machined as much as 0.125” in order to match the profile tolerance?

Response: Hytec will correct and clarify the drawing. (The welded insert will actually stand 3/8" proud of the support tube. The weld preparation calls for a conical bevel which is welded flush with the support tube surface.)

Open: pending receipt and review

Action 18. Leg orientation.
There appears to be a problem with the orientation of the holes (1" dia. with 2" dia 90 degree chamfer) which mate to the 3rd leg element screw. The assembly level drawing (LIG-12001, PDR vintage) appears to show the orientation correctly, but the recently submitted downtube weldment drawing (LIG-12006) does not appear to be correct; the hole pattern is clocked 180 degrees. This has resulted in the need to make a 2.5" dia. hole in the BSC cross beams, which should not be required.

Response: The leg orientation is as intended by Hytec for improved load transfer (stiffer arrangement) from the leg elements to the cross beam when the entire stack is lifted as an assembly. The assembly drawing will be revised to show this new orientation.

Open: pending receipt and review

Action 19. Part and serial number marking.
The drawings have a standard note regarding marking with a part number. The part should be marked with not only the part number, but also a serial number. The part number (which includes the revision number of the drawing) must comply with LIGO serialization and part numbering requirements (defined in LIGO document L970196-00). There are restrictions on how the parts in vacuum can be marked -- these should be pointed out in the note via reference to the Hytec fabrication specification, TN-03.

Action: LIGO to transmit the part & serial number marking requirements to Hytec by 6/30.

Response: LIGO document L970196-00 has been transmitted.

Closed

Action 20. Pin spanner or hex instead of slot for the leg screws.
A pin spanner or a hex broached into the leg screws would appear to be a better arrangement for applying torque to the leg screws than the slot currently called out in the drawings.

Response: A slot is easier to clean than a hole. One can easily generate more torque than the threads can tolerate, i.e. the torque will be limited by a torque wrench not by the tool used to assembly the "leg screws". Decision is to leave the design as is.

Closed

Action 21. Sheet numbering.
The drawings should be changed from “sheet 1, 2,.... n” to “sheet 1 of n, 2 of n,... n of n”

Response: Accepted.

Open: pending receipt and review

Action 22. Missing isolation stack assembly drawing.
and missing assembly hardware like silver plated SS screws to attach the support table to the support tubes.

Response: Agreed -- pending

Open:

Action 23. Optics table surface height.
One of the key interface dimensions is the position of the optics table relative to the chamber. It was not possible to check this dimension given the drawing information provided, yet it effects the dimensions of the overall assembly. In order to place the BSC optics table surface at 600 mm above the laser centerline (500 mm above the projected BT centerline), the compressed spring and seat height would have to be 1.57” long -- which is clearly not correct. There appears to be a dimensional error somewhere in the assembly.

Response: A dimensional error in the downtube length is acknowledged; It does not have any impact on the performance assessment. The compressed Constrained Layer Damped (CLD) coil spring length under load is 2.462” (when on molded viton seats). In addition, the shim plate will be used to compensate for height variation of the compressed springs and seats in production versus the prototype units.

Open: pending receipt and review

Action 24. Four optics table tapped holes too close to edge.
Four tapped holes on the BSC optics table are too close to the edge of the table and should be removed from the pattern (LIG-12006, sheet D2, view A-A).

Response: Will add note to the drawing that no holes closer than 1/2” from the edge of the table.

Open: pending receipt and review

Action 25. Cable clamp hole patterns are not needed on the optics tables.
The tapped hole pattern required for the cable clamps (a pair of #10-32 holes with 1.5” center separation) are properly positioned on the elements of the BSC and HAM isolation systems. How-

ever, they are not required on the optics tables -- it is intended that the 2” by 2” hole pattern will be used on the table (with a different cable clamp).

Response: Removed from the drawing.

Closed

Action 26. Fabrication & Cleaning Specification (Hytec-LIG-TN-03)
a) Adopt PSI’s cleaning procedure for aluminum (e.g. the cryopump)
b) The blacklight test is not sufficient for all hydrocarbons
c) have to develop a correlation from FTIR to outgassing
d) consider waterbreak test (but doesn’t work if detergent is left on the surface)
e) don’t use tape or heat seal on the bags -- tie or band the double bags of “CP Stat” (not Ameristat as originally stated).
f) specify no castings for in vacuo elements
g) add marking restrictions for in vacuum components
h) add serial number and part numbering requirements
i) Add “referenced documents” section and list Mil-C-104B, Mil-Std-? (for clean rooms), others?
j) Drop the “acknowledgment” section
k) Add the requirement to handle only with Nitrile gloves -- give source for nitrile gloves in the appendix
l) change “vacuum bake” to “clean air bake” and drop reference to “residual gas analysis”
Also include the following (which were stipulated in L970061):[1]
m) nozzles shall be used to spray cleaning fluid at high pressure/rate into blind holes and the vented sandwich core cells of the optics tables
n) The SLAC cleaning procedure for welded bellows shall be used for the welded bellows
o) add the requirement for passive shock witness gauges for transit of all material with a shock level of TBD
p) add a separate section of the spec. for viton cleaning & baking or limit the scope not to include the viton seats. This also applies to the constrained layer damped springs.
q) Add a residual gas analysis (RGA) qualification test for the welded bellows to be done simultaneously with a leak integrity test
r) grinding (with abrasive wheels, cloth or stones) is not permitted

Action: LIGO to provide marked up copy of the fab/cleaning spec. by 6/30.

Response: With regard to the Fabrication and Cleaning specification specific comments:

- (a) the cleaning specification is appropriate for both aluminum and steel
- (b) blacklight while not sufficient is a good step
- (e) thru (m) and (r) have been incorporated

1. D. Coyne to W. Miller through M. Fine, “Specification Guidance for Seismic Component Cleaning, Baking and SHipping Preparation”, LIGO-L970061-00-D, 10 Feb 97.

- (n), (p) and (q) are to be incorporated into separate specifications (not within the scope of this spec.)
- (c), (d) are pending as part of the Statement Of Work (SOW) for qualification of a cleaning process (not within the scope of this document)
- (o) is rejected as not necessary

The specification has been re-written twice since the FRR based on LIGO input.

Open: pending receipt and review

Action: LIGO to define approach to qualify a clean air bake and a traceable FTIR test by 7/7 and to address the procurement strategy implications by 7/9.

Response: The need for an approach to qualify an air bake and to address the cleaning qualification in the procurement strategy are recognized. The dates will lag those quoted above.

Open:

Action 27. Silver plate stainless screws when mating surface is stainless steel.
The support beam (BSC and HAM) are attached to the support plate via a number of bolts into a stainless steel insert. These bolts should be silver plated for dry lubrication and to prevent cold welding. The plating will increase the thread dimensions of the bolt and this should be accommodated in the tolerancing of the mating tapped holes, i.e. if the hole is class 2B, perhaps the bolt should be class 1A. There is some experience in the 40m lab where the plating has caused some problems.

Response: These bolts will use a vacuum compatible dry plating such as silver. The specific coating is TBD.

Open: