CALIFORNIA INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project

To/Mail Code: Distribution
From/Mail Code: W. Althouse/18-34
Phone/FAX: 395-4481/304-9834

Refer to: LIGO-L970483-00-P
Date: August 8, 1997

Subject: **Beam Tube Bakeout Design Requirements Review - Responses to Recommendations**

The review board for the Beam Tube Bakeout Design Requirements Review (DRR) made a number of recommendations in their report, L960879-00-F dated January 11, 1997. The recommendations are reproduced below with a description of what actions have been taken since the time of the DRR.

1. **Recommendation:** Some types of insulation could present a life safety problem at high temperatures. The DRD (sec. 3.2.1.2) requires that insulation does not emit toxic gases at high temperature, but does not include other hazards such as particulates. This requirement should be expanded to include other hazards which can affect personnel safety.

   Response: This language has been incorporated into the Design Requirements document, LIGO-E960123-03-E, paragraph 3.2.1.2

2. **Recommendation:** The DRD contained no requirements related to partial pressures of hydrocarbons. Hydrocarbon partial pressure requirements should be derived based on the Qualification Test.

   Response: Incorporated into paragraph 3.1.1.2

3. **Recommendation:** The radial temperature gradient requirement is driven by the response of the tube to the gradient along the horizontal and larger temperature gradients can be tolerated along the vertical axis. Include separate requirements for the vertical and horizontal components of these gradients.

   Response: Incorporated into paragraph 3.1.1.3

4. **Recommendation:** There may be ground-fault-interruptible power supplies that can be borrowed from one of the national laboratories. A point of contact should be established. (Coles to follow up.)

   Response: Mark’s efforts were successful and we have subsequently arranged to borrow six Transrex 500KW power supplies from Fermilab.

5. **Recommendation:** The conceptual design specification for 120V, single phase step-down transformer is too restrictive. Consider use of 208/120 V, three-phase transformer to provide more options in selection of vacuum/monitoring apparatus.

   Response: Incorporated into E960123-03-E, paragraph 3.1.3.1.2 and the Preliminary Design description, T970148-00-E, paragraph 3.2.1

6. **Recommendation:** Conceptual design specifies a low-temperature insulation next to bellows. Revise design to use high-temperature insulation next to bellows.

   Response: Knauff Pipe and Tank insulation (rated for 454 C) is now specified (T970148-00-E, paragraph 3.1.2)

7. **Recommendation:** Conceptual design currently specifies that beam-tube module being grounded only at the ends. Consider grounding the beam-tube module at its midpoint, where the RGA is attached, as an alternative.

   Response: Incorporated into E960123-03-E, paragraph 3.1.3.1.2

8. **Recommendation:** Inductance in bakeout power circuit might cause problems during switching in power supplies. In specifying power supplies the design should consider robustness in the presence of the expected inductive loads.

   Response: The inductance in the beam tube application results in a time constant (L/R) of 20 ms. The Fermilab supplies are designed for use with inductive loads, but may require fine tuning for our application.

In addition to the recommendations, the review board's report contained questions and answers for which the answers have changed since the time of the DRR:

Q3: Are you buying special vacuum pumps to maintain vacuum during bakeout?

A: Yes. The cryopumps and the turbo pump are all special. They will be moved from module to module for bakeout. Roughing pumps will be provided by others. (The scope of this document assumes that the beam tube is initially in a roughed down state.)

Update: Because of the baffle retrofit activity, the bakeout activity now assumes responsibility for roughing down those modules left at atmospheric pressure, using the roughing pump sets acquired with the Vacuum Equipment.

Q4: Why not use turbo pumps available elsewhere in LIGO?

A: It is preferred to use a clean, dedicated pump. If the beam tube installation schedule permits the use of turbo pumps that CBI would otherwise be using, that is a possibility.

Update: We now plan to use the main turbos acquired for the Vacuum Equipment.

Q6: Has GNB specified a maximum temperature gradient acceptable on the gate valves?

A: No. LIGO should obtain from GNB a maximum temperature ramp rate that the valve will see so that it is not damaged. It is recommended that PSI be contacted to see how they plan to address this issue as part of VE bakeout. This same consideration applies to all vacuum equipment attached to the beam pipe during heating.

Update: PSI has furnished us with their design analysis for baking out the Vacuum Equipment and gate valves. We plan to copy their design.

Q9: Do we check for electrical continuity from a beam tube to the support?

A: No - but we should. (The following action resulted from an issue that was raised during the discussion of the Conceptual Design. Although the beam-tube supports have been designed to prevent accidental grounding of the beam tube, there is currently no quality assurance in place to verify the supports are being properly installed. We need to verify that the beam tube is not electrically shorted to ground through any of the support structures.This requirement will be separately conveyed to CBI by the Facilities Group. This assumption is implicit in the bakeout design

process.)

Update: We now plan to check electrical isolation at each support connection as part of the bakeout activity.

Q11: What attention has been given to grounding for personnel and equipment safety? Note that cryopumps and the RGA float electrically.

A: Electrical safety will be looked at seriously as part of the design phase. However, the safety issue does not appear to prevent the accomplishment of any of the design objectives presented.

Update: The RGA is now grounded. The cryopump housings will have DC voltages as high as 70 V, but only when the housings are also at bake temperature, so the thermal insulation will block human contact. We still have homework to do to ensure that there are no other electrical paths from the cryopump housings to the outside.

Q13: There is a concern about the performance of the viton seals in the 10" gate valves after baking at 170C. Could a metal gate valve be added at the midpoint on a separate port?

A: We don't know enough about the expected performance of the viton gate valves. The metal valve is not a requirement. This possibility will be thought about to see what it might buy.

Update: We studied this possibility and concluded that the potential benefits do not justify the approx. $200K expense. We will learn to make the required measurements in the presence of the Viton-sealed valves.

Q14: Will the data acquisition and monitoring equipment be the same as what Rolf plans to use for the PEM system?

A: This will be checked. It would make sense to use compatible equipment if possible so that the we have adequate spares for later during operation of the observatory.

Update: No. The CDS has an extensive infrastructure and equipment needs to satisfy large-scale needs. We have chosen equipment suited to a stand-alone configuration with the particular needs of the bakeout.

Q16: Who checks out all of the bakeout instrumentation, software, cabling, etc. to make sure it all works together before trying to install and operate it in the field?

A: Albert and Bill will do this at Caltech as part of the detail design process before the equipment is deployed in the field.

Update: We plan to assemble the equipment and software on the first module to be baked (TBD: X1 or Y1) and check it out in-place, using LIGO Hanford personnel.

Q17: The review committee would like to see a logic table developed as soon as possible which describes the functions planned for the control and data acquisition system prior to beginning the design.This will assist in the conceptual design phase so that the number and kind of control points and sampling rates can be determined so that a test control specification can be presented at the PDR. Some examples of entries in the logic table are given in Table 1. [Table follows...]

Update: An example control logic table is provided in the Preliminary Design description, LIGO-T970148-00-E, paragraph 3.2.3 (Table 1). A preliminary list of data acquisition parameters is provided in paragraph 3.4 (Table 3).

wea, fba, barish, rolf, coles, coyne, fischer, franklin, johng, jasnow, ljones, lazz, phil, mski, otto, fjr, riesen, sanders, dhs, sibley, gerry, tyler, stan, weiss, worden, mike

Distribution:

B. Barish	L. Jones	O. Matherny	D. Shoemaker	R. Weiss
M. Coles	A. Lazzarini	F. Raab	A. Sibley	S. Whitcomb
D. Coyne	P. Lindquist	R. Riesen	G. Stapfer	J.Worden
C. Franklin	M. Lubinski	G. Sanders	W. Tyler	M. Zucker
E. Jasnow				

cc: Chronological File
Document Control Center: /home/dcc/docs/L970483-00.pdf