


**CALIFORNIA INSTITUTE OF TECHNOLOGY**  
Laser Interferometer Gravitational Wave Observatory (LIGO) Project

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Subject: Beam Tube Information for Site Operations

## Maintenance Requirements

This is a very passive system. Its only requirement is for a periodic inspection for differential settlement of the slab, between supports. The total allowable differential, from a combination of misalignment and settlement, is:

14.7 mm during bake, and  
25.7 mm during normal operation

CB&I's GPS alignment data shows a maximum differential misalignment of 5 mm, so the settlement limits should be:

9.7 mm during bake, and  
20.7 mm during normal operation

I would recommend that an annual visual inspection be made of the beam tube slab, looking for displacement at joints or cracks that approach the 20.7 mm limit. Any location showing such should be checked by comparing optical level elevations of the questioned support ring tops with the expected module slope according to drawing D950140.

If settlement exceeds acceptable limits, offending supports should be adjusted to correct. Special wrenches, jacks, etc. were left by CB&I at LLO for this purpose. Nominal adjustment range is +/- 75 mm, laterally and vertically.

If a second bake is ever called for, the tight limits on differential settlement may likely require a survey for alignment confidence. Expected failure mode would be buckling, and the listed limits still provide a factor of safety of 1.55. See Section 2 of FDR DRD #9, Item II (Viewgraphs & Assessment) and Section 6 of FDR DRD #9, Item IV (Design Calculations & Analyses) for further details.

## General Information

Two papers have been written so far, and are available from the DCC:

LIGO-P990007-00-B: LIGO Beam Tube Module Design, Fabrication & Installation

LIGO-P990023-00-B: LIGO Beam Tube Component and Module Leak Testing

One paper is still in process:

Precision Alignment of the LIGO 4 km Arms Using Dual-Frequency Differential GPS

## Drawings, Specifications & Procedures

The latest versions of these documents are in the DCC, and are listed under the Beam Tube Modules Master Document List, LIGO-C950496 (I believe that its latest version is 08). I am keeping a copy of each of these documents at my campus desk until retirement, at which time I'll pass them on to the DCC as an integrated beam tube package.

## Fabrication & Installation Information

As-built data, including mill test reports, leak check data, dimensional check data, expansion joint spring rates, baffle locations and nonconformance reports are stored at each respective site as well as in the DCC for both sites. Site copies were turned over to Sibley and Worden for safekeeping.

Coupon hydrogen outgassing reports and FTIR reports are available from the DCC.

Module alignment data is available from the DCC; I am in the process of sending my copies of the respective site alignment data notebooks to Sibley and Worden this week. These (but not the DCC data packs) include Zip drives of archived GPS data and precise ephemeris data using Trimble Navigation GPSURVEY software; however, we do not have the Trimble software and cannot access the data now. Also in the notebooks are PC floppies with Excel files of CB&I's reported alignment positions.

## Pump Port Policy

Our original intent was that all 250 mm pump port gate valves would be left open during normal operation, depending on the blank Conflat flanges and their 40 mm metal sealed utility valves to do the sealing.

Note that the pump port flange is a 13.25" OD CF (there's also a 12" OD CF that's used on a 10" tube; that would require an adapter).

## Open Issues

There is some interest in (eventually) adding holes in the top of the BT enclosure sections at LHO, to match what was done at LLO. This would make sense if there's ever to be a comprehensive alignment check or a realignment at LHO.

It was decided to not purchase CB&I's surplus GPS equipment, but to rent equipment or contract the task if and when any realignment would be required (which would be far enough in the future to obsolete any present equipment).

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