CALIFORNIA INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project

To/Mail Code: Distribution

From/Mail Code: L. Jones

Phone/FAX: 395-2970/304-9834

Refer to: LIGO-L950355

Date: May 16, 1995

Subject: Review of Beam Tube Specimen Contract

The attached Specimen Contract for Beam Tube Modules is provided for your review in preparation for the scheduled review meeting at 1:00 P.M. Thursday, May 18th in the ECR.

LKJ:maa

cc:

B.Barish	R. Fischer	E. Jaznow	F. Raab
J. Warden	V. Schmidt	W. Althouse	D. Shoemaker
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ARTICLE 1, STATEMENT OF WORK

A. SCOPE

The LIGO project of the California Institute of Technology and the Massachusetts Institute of Technology requires the fabrication and installation of four beam tube modules at each of two LIGO sites. The two sites are Hanford, Washington and Livingston, Louisiana. The Contractor shall design, fabricate, install, insulate, bake, and perform acceptance test of the beam tube modules for the Hanford, WA and Livingston, LA facilities. The required effort shall be performed in accordance with the terms and conditions of this contract including this Statement of Work (SOW) and exhibits I-III. This SOW describes the detailed tasks to be carried out.

B. APPLICABLE DOCUMENTS

1. LIGO Documents (Exhibit II)

   - LIGO-C950328-00-P, Vacuum Equipment Contract, Exhibit III, Beam Tube Deliverables, Revision 00
   - LIGO-C950469, Beam Tube Contract WBS, Revision 00
   - LIGO-D950021, LIGO Arm Layouts, Revision 0
   - LIGO-D950027, Beam Tube Pump Port Hardware, Revision 0
   - LIGO-D950028, Beam Tube Terminations, Revision 0
   - LIGO-D950029, Beam Tube/Enclosure Interface, Revision 0
   - LIGO-D950030, Beam Tube Module Bake, Revision 0
   - WA-SK-100, Overall Site Plan, Hanford, Washington (Parsons)
   - LA-SK-100 Overall Site Plan, Livingston, Louisiana (Parsons)
   - 736-COV, LIGO Site-Hanford (J-U-B)

2. Detailed Design (Exhibit III)

C. PLANS

1. PROJECT MANAGEMENT PLAN: The Contractor shall develop a Project Management Plan to set forth and control the activities of this contract. The Project Management Plan shall be submitted for approval by the LIGO Project. The management plan shall include, but not be limited to, the following:

   a. Work Breakdown Structure (see LIGO-C950469 for outline); control and report costs to one step below this level
   b. Summary Schedule, showing pertinent milestones
   c. Configuration Management Plan (including documentation control); reflect requirement for LIGO Project approval of all changes to drawings, specifications, and procedures.
   d. Quality Assurance Plan

e. Cost Schedule by quarter
f. Procurement Plan

2. PROJECT IMPLEMENTATION PLANS: The Contractor shall develop and submit for LIGO Project approval plans for the effective implementation of the tasks within this contract:

a. Subcontract plan: make or buy decisions for all items
b. Fabrication plan, including the following items:

- Fabrication location(s)
- Coil purchase and coupon test schedule, with number of outgas test chambers required
- Spiral mill size, location and operation
- QA monitoring of vendors
- Qualification of new equipment: modified outgas test facility, spiral mill, purge dam, tube shipping fixtures, plastic end caps, tube facing/circumference sizing machine, leak check hoods/sleeves, cleaning end closures, cleaning spray rig and alcohol distilling equipment
- Shipping and storage plans for tube sections

c. Installation plan, including the following items:

- Qualification of new equipment: vacuum box, clean room enclosure, and weld enclosure
- Staged start of installation/practice working with equipment: clean room enclosure, weld enclosure, pre-cleaning areas, and beam tube section

d. Insulate & Bake plan, in accordance with LIGO-D950030 and including the following items:

- Method to assure a high reliability of maintaining temperature of LN_2 traps
- Trial insulate and bake: first 238 m portion of the first module, to confirm proper insulation and auxiliary heating designs
- Pre- and post-bake measurements of outgassing rates

e. Acceptance Test plan, including leakage measurements, location techniques and repair techniques (see M.4. for location concept using air signature)

D. DESIGN

The contractor shall conduct the following design tasks and submit the designs for LIGO Project approval prior to fabrication and installation. These tasks are beyond what is provided in the Beam Tube Module Design (Exhibit III).

1. Design of terminations: design module terminations in accordance with LIGO-D950028, including an interface control document for gate valve weld neck details. This task includes the design/specifying of temporary buildings to protect valves and pumps from the elements.
2. Revise module length in accordance with Drawing LIGO-D950021, LIGO Arm Layouts.
3. Design pump port hardware in accordance with LIGO D950027, including an interface control document for pump connections. Determine spares list for the operation phase. Revise module leak check procedure as appropriate.
4. Revise spiral weld procedure to ensure adequate penetration; develop procedures to effectively monitor weld quality.
5. Review design of leak check hoods; change as appropriate for best production tests of beam tube sections.
6. Design fixtures and equipment for cleaning beam tube sections in accordance with the Beam Tube Module Detailed Design (Exhibit III).
7. Generate a procedure for QA monitoring of the beam tube section cleanliness by making FTIR measurements of the solvent rinse effluent. Specify measurements of the first ten tube sections and every tenth tube section thereafter.
8. Design enclosures to protect the tube sections adjacent to the anterooms of the field clean room enclosures and weld enclosures. These are for the purpose of excluding direct sunlight and wind-blown dirt while hosing off the slab and the tube ends.
9. Improve design of vacuum box for leak checking module girth seams for more efficient application.
10. Design of module bake: design module insulation and bake in accordance with the plan developed in C.2.d. above.
11. Generate a procedure for leak localization of a beam tube module using the equipment shown in LIGO-D950027 and LIGO-D950030 and the plan developed in C.2.e. above.
12. Generate a Beam Tube Module Acceptance Test procedure for the post-bake Air Signature Leak Test of Module Leakage.
13. Design an alternative GPS alignment check procedure for use during observatory operation, which would not require holes in the enclosure cover sections.
14. Review beam tube design for corrosion risk; recommend mitigation as appropriate.

E. FABRICATION

The Contractor shall fabricate and deliver the beam tube module components to the two LIGO sites. This effort shall be conducted in accordance with the Beam Tube Module Detailed Design (Exhibit III) and items included in Sections C. Plans and D. Design, above. Each beam tube section shall demonstrate a helium leakage rate of less than 1×10^{-10} atm cc/s prior to shipment for installation.

F. INSTALLATION

The Contractor shall install and leak check the beam tube modules at the two LIGO sites. This effort shall be implemented in accordance with the Beam Tube Module Detailed Design (Exhibit III) and items included in Sections C. Plans and D. Design, above.

G. INSULATION AND BAKE

The Contractor shall insulate and bake the beam tube modules at the two LIGO sites. This effort shall be implemented in accordance with the Beam Tube Module Detailed Design (Exhibit III) and items included in Sections C. Plans and D. Design, above, including procurement of spare pump port hardware.

H. ACCEPTANCE TEST AND CERTIFICATION

The Contractor shall demonstrate the acceptability of the beam tube modules by acceptance testing at the two LIGO sites. This effort shall be implemented in accordance with the Beam Tube Module Detailed Design (Exhibit III) and items included in Sections C. Plans and D. Design, above. Each beam tube module must demonstrate a helium leakage rate of less than 1×10^{-9} atm cc/s.

The Contractor shall certify that each beam tube module was fabricated and installed with a minimum clear aperture of 1.19 m. Clear aperture is defined as the diameter of the cross section of a right circular cylinder between beam tube terminations, whose volume is unobstructed.

I. SITE CLEANUP

The Contractor shall conduct the on-site cleanup and restore the site construction area at both LIGO facilities to their original condition. This shall include, but not be limited to, disposal of all rubbish and other articles and the receipt of clearance from the Institute prior to final departure from each site.

J. MEETINGS AND REVIEWS

The Contractor shall conduct monthly project review meetings at the Contractor's facility. The purpose of these meetings is to review the technical progress made to date, to review schedule status and financial data, and to identify and resolve any concerns. The required documentation for each review shall be prepared and minutes of proceedings as indicated in Exhibit I shall be documented and distributed.

The Contractor shall conduct a Design Review to present and substantiate the designs completed as described in D. Design, above.

The Contractor shall conduct readiness reviews prior to the start of fabrication and prior to the start of installation at each site. The purpose of these meetings is to demonstrate that all planning, procedures, equipment and personnel are ready for the initiation of a major phase.

The Contractor shall conduct a Completion Review (CR) at the Contractor's facility after the completion of beam tube module installation at each site. The purpose of the Review is to discuss and address all aspects of the as-built design and associated fabrication, installation, and testing of the LIGO beam tube modules. Required documentation for review shall be prepared and minutes of proceedings as indicated in Exhibit I shall be documented and distributed.

K. TECHNICAL DIRECTION

The Contractor shall accept and implement in-scope technical direction as provided via Technical Direction Memorandum (TDM), or documented in TDM after the fact. Such direction shall be accepted only from the Contract Technical Manager. The Contractor shall respond to each TDM within five (5) calendar days by returning the TDM acknowledgment copy to the Contract Administrator. Failing to respond within the specified time will be construed as acceptance of the TDM.

L. DELIVERABLE DOCUMENTATION

The Contractor shall prepare and submit all plans and documentation in accordance with the requirements of Exhibit I, "Deliverable Documentation". Exhibit I consists of the following:

1. Contract Data Requirements List (CDRL), listing and establishing delivery requirements, schedules and approvals of deliverables generated under this contract.

2. Data Requirements Description (DRD), describing the basic requirements for documentation to be delivered under this contract.

M. INSTITUTE FURNISHED EQUIPMENT AND SERVICES

The Institute will:

1. Provide enclosure slabs and covers in accordance with LIGO-D950029.

2. Provide pump carts and gate valves in accordance with LIGO-C950328-00-P, Exhibit III.

3. Provide reference monuments at the Hanford site in accordance with Drawing 736-COV. Similar monuments will be provided at the Livingston site.

4. Provide a plan documenting the concept of leak localization with air signature testing of a beam tube module using the equipment shown in LIGO-D950027 and LIGO-D950030.

5. Provide limited trailer parking and "laydown" area on the sites.

ARTICLE 2, DELIVERY OR PERFORMANCE

A. The point of inspection, acceptance, and delivery of all supplies deliverable under this contract, with the exception of the hardware, shall be California Institute of Technology, Attention: LIGO Project, Pasadena, CA 91125. The hardware, except for material samples, shall be delivered, installed (in most cases), inspected and accepted at the two LIGO field sites. Material samples shall be shipped to California Institute of Technology, 391 S. Holliston Ave., Pasadena, CA 91125, ATTN: LIGO Project, X2966.

B. All supplies shall be packaged to insure safe delivery, clearly marked with the contract number, and shipped prepaid to Caltech. All articles of hardware shall be FOB destination. All reports and data shall be FOB California Institute of Technology.

C. Time is of the essence in the performance of this contract.

D. The Contractor shall furnish and deliver the supplies and perform the services required by Article I (Statement of Work), in accordance with the following schedule:

1.	Project reviews, as required in Article I, paragraph J.	Monthly, except when monthly reviews are preempted by the Design, Readiness, and Completion Reviews
2.	Design Review, as required in Article 1, paragraph J.	In place of the second Monthly Progress Review
3.	Cleaned outgas screening coupon set, one from each coil of processed material.	Fifteen working days after coupon shearing
4.	Fabrication Readiness Review, as required in Article 1, paragraph J.	After preparations have been made, prior to the start of fabrication
5.	Hanford Installation Activities/ Deliverables:	
	Installation Readiness Review (Article 1, paragraph J)	After preparations have been made, prior to the start of installation
	Module bake data record for each module	Five working days after completion of post-cooldown RGA readings
	Hardware Acceptance Tests (Article 1, paragraph H)	10/23/97
	Cleanup (Article 1, paragraph I)	Ten working days after completion of acceptance testing

Completion Review (Article 1, paragraph J)	Ten working days after completion of cleanup

6. Livingston Installation Activities/ Deliverables:

Installation Readiness Review (Article 1, paragraph J)	After preparations have been made, prior to the start of installation
Module bake data record for each module	Five working days after completion of post-cooldown RGA reading
Hardware Acceptance Tests (Article 1, paragraph H)	11/13/98
Bake/leak check pump port hardware, including spares	On completion of final module Acceptance Test
Cleanup (Article 1, paragraph I)	Ten working days after completion of acceptance testing
Completion Review (Article 1, paragraph J)	Ten working days after completion of cleanup

ARTICLE 3, PRICE AND PAYMENT

A. Total Fixed Price: "TBD" Partial payments will be allowed in accordance with General Provisions Article 57, Payments and Discounts. (Not sure about this sentence) Partial payments will be made upon acceptance for the sole purpose of making partial payments of the following items required by Article 1, Statement of Work:

Partial Payment Schedule	Amount
Design Review	$ TBD
Fabrication Readiness Review	$ TBD
Hanford Installation Readiness Review	$ TBD
Beam Tube Modules Fabricated and Installed:	
Hanford Site, modules 1 & 2	$ TBD
Hanford Site, modules 3 & 4	$ TBD
Livingston Site, modules 1 & 2	$ TBD
Livingston Site, modules 3 & 4	$ TBD
Beam Tube Modules Insulated and Baked:	

Partial Payment Schedule	Amount
Design Review	$ TBD
Fabrication Readiness Review	$ TBD
Hanford Installation Readiness Review	$ TBD
Hanford Site, modules 1 & 2	$ TBD
Hanford Site, modules 3 & 4	$ TBD
Livingston Site, modules 1 & 2	$ TBD
Livingston Site, modules 3 & 4	$ TBD
Beam Tube Modules Completion Review:	
Hanford Site, modules 1-4	$ TBD
Livingston Site, modules 1-4	$ TBD

B. Partial payments will not be liquidated until acceptance of the final Completion Review under this contract.

C. Any taxes levied on this contract will be paid by the contractor as part of the Total Fixed Price in paragraph A. above.

D. Limitation of the Institute's Obligation

1. Of the Total Fixed Price in the paragraph A. above, a sum of $TBD is presently available for payment and allotment to this contract. It is anticipated that additional funds will be allocated in accordance with the below schedule until the Total Fixed Price of this contract is allotted.

Schedule for Allotment of Funds

Date	Amounts
TBD	TBD*

*To be established on a Federal Fiscal Year basis.

The Contractor agrees that it will plan its work so that it can be performed within the scheduled allotment shown above, and that if the work so performed exceeds the scheduled allotment it shall be solely at the Contractor's risk. If the Contractor has reason to believe that a change in this scheduled allotment would be in the best interest of the project, the Contractor shall notify the Institute in writing to that effect, together with the requested change. If the Institute agrees with the change, the contract scheduled allotment will be revised.

2. The Contractor agrees to perform work up to the point at which, in the event of termination of this contract for the convenience of the Institute or the Government, the total amount payable by the Institute including termination liability would not exceed the amount actually allotted. The Contractor shall not be obligated to continue performance of the work beyond such point. The Institute shall not be obligated in any event to pay or reimburse the Contractor in excess of the amount allotted to the contract.

3. When additional funds are allotted for continued performance of the work under this contract, the provisions of paragraph D.2. above shall apply to such additional allotted funds.

4. If the Contractor incurs additional costs, or is delayed in the performance of the work under this contract, solely by reason of the failure of the Institute to allot additional funds in accordance with the above schedule, if such failure prevents timely performance of this contract, and if additional funds are allotted, then an equitable adjustment shall be made in the total price of said contract or in the time of delivery or both. If additional funds are not allotted, the Institute will, upon written request of the Contractor, terminate this contract on the date set forth in the request, pursuant to the General Provision entitled "Termination for Convenience."

5. The Institute may at any time prior to termination, and with the consent of the Contractor, after notice of termination, allot additional funds for this contract.

6. The provisions of this Article 3, with respect to termination, shall in no way be deemed to limit the rights of the Institute to pursue remedies in the event of Contractor's default.

7. This paragraph D. shall become inoperative upon the allotment of funds for the Total Fixed Price effort, except for rights and obligations then existing under this Article 3.

ARTICLE 4, SPECIAL PROVISIONS

A. The Contractor warrants that it has been duly authorized to operate and do business in the States of California, Washington and Louisiana; that it will obtain at no cost to the Institute all necessary licenses and permits required in connection with the contract; and that it will fully comply with all laws, decrees, labor standards and regulations of such States during the performance of this contract.

B. It is required that the Institute personnel having technical cognizance over this contract effort be appraised by the Contractor on a continuing basis of all technical aspects of work being performed. This includes, but is not limited to, immediate notification of any significant problems which arise and making available, upon request, Contractor information such as data relating to analyses and other technical matters directly relating to the technical aspects of the effort.

C. The Contractor shall arrange non-escort privileges for Government and LIGO representatives to all areas of the Contractor's and subcontractor's facilities where the work is being performed under this contract. This shall include access to fabrication, assembly, cleaning, and test areas for the purpose of monitoring activities.

D. The Contractor shall provide at the Contractor's and subcontractor's facilities, as appropriate, any reasonable office space and equipment for use by the Institute's representatives in monitoring contract activities.

E. The Contractor shall furnish to the Institute, prior to commencement of work at any Institute or Government controlled facilities, all insurance certificates required by the General Provisions, Article 32 Insurance and Idemnification.

F. The below named Contractor personnel shall be considered Key Personnel under this contract. Prior to removing, replacing, or diverting any of the named individuals, the Contractor shall notify the Institute reasonably in advance and shall submit justification, including proposed substitutions, in sufficient detail to permit evaluation of the impact on this contract.

Name	% of Time TBD	Applicable Performance Period
TBD	TBD	From TBD to TBD

G. The Contractor agrees that all information released by the Contractor for publicity or promotional purposes which is directly related to the contract work will be submitted to the Institute for review of technical accuracy prior to issuance.

H. The Contractor shall provide the Institute copies, for information purposes, of any notification of invention and/or request for intangible property rights resulting from this contract. The same information will be provided for all subcontractors.

I. It is agreed that as a condition of the award of this contract, the Government and the Institute shall have the right to use, duplicate and disclose, and have others do so, for any purpose whatsoever, the technical data contained in the proposal upon which this contract is based.

ARTICLE 5, ALTERATIONS IN THIS CONTRACT

The following alterations have been made in the General and Additional Provisions of this contract:

A. The terms "Institute" and "Caltech" are used interchangeably throughout this Contract. All references to "the Institute" shall be deemed to refer to "Caltech" and vice versa.

B. General Provisions Article 4, Changes, is modified by the addition of the following paragraph:

The parties hereto agree that no adjustment will be made to the contract Total Fixed Price where a claim by either party for an adjustment under this Article would result in a decrease or increase in the Total Fixed Price of less than TBD dollars. A claim, as used in this paragraph, shall be deemed to refer to a claim based on a separately identifiable contract change.

IN WITNESS WHEREOF, the parties hereto have executed this Contract as of the day and year first above written.

CALIFORNIA INSTITUTE OF TECHNOLOGY

By _____

_____

_____

CHICAGO BRIDGE & IRON

By _____

(Typed Name) _____

_____

(Title)

Instructions to Contractor:

Do not insert date on Preamble page.

EXHIBIT I

DELIVERABLE DOCUMENTATION

ELECTRONIC FILE IDENTIFICATION:

(A) ARTS I-5
(B) EXHIBITS
(C) CONTR DATA REQ LIST
(D) DRD

EXHIBIT I

DELIVERABLE DOCUMENTATION
LIGO BEAM TUBE MODULES

A. The deliverable documentation under this contract is summarized in the following Contract Data Requirements List (CDRL), which identifies the items to be delivered and when delivery is required, the quantity and type of each item, and the frequency of issue. Documentation shall be delivered as early as available but no later than the date specified in the CDRL. The Data Requirement Description (DRD) forms referenced in the CDRL describe the specific requirements for the item(s) to be delivered.

B. The Contractor shall display on the cover or title page of all deliverable non-design documentation (i.e., all documents except drawings and specifications) the following minimum information:

- Document Title
- Contractor's Name
- Contract Number
- Document Number (Institute and/or Contractor assigned)
- Approval Signatures - Contractor and Institute
- program Identification - LIGO
- Date of Issue
- CDRL Line Item Number
- Approval Status

C. The approval code on the CDRL is defined as follows:

A = Submitted for Institute's approval
X = Institute approval not required

D. The following requirements apply to all data submitted for Institute's approval:

1. The Contractor shall submit the approval draft, with the Contractor-signed original cover or title page, on or before the date indicated.

2. If the draft is approved, the Contractor will be notified in writing by the LIGO Contract Technical Manager. The Contractor shall then prepare and deliver final copies as indicated in the CDRL.

3. If the submitted approval draft requires significant Contractor modifications before approval will be granted, the following steps shall be taken:

a. The required modifications will be discussed between the cognizant parties and a letter itemizing said changes will be sent by the LIGO Contract Technical Manager to the Contractor.

b. The Contractor shall submit an updated draft, containing the required modifications.

c. If the updated draft is approved, the Contractor will be notified in writing by the LIGO Contract Technical Manager. The Contractor shall then prepare and deliver final copies as indicated in the CDRL.

The requirements and approvals for data item revisions shall be the same as applied to the original data item submittal unless otherwise specified.

4. All documentation is to be delivered to the Document Control Center (DCC) in care of Ms. Linda Turner, LIGO Project, Mail Stop 102-33, California Institute of Technology, 391 So. Holliston Ave., Pasadena, CA 91125. The Document Control Center will be the point of official receipt and distribution.

CONTRACT DATA REQUIREMENTS LIST

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. ORIG.	QTY. COPIES	REMARKS
	01	Project Management Plan			10 working days prior to			
01		Draft	A	Once	Design Review	0	4	
02		Final	X	Once	15 working days ARC[1]	0	4	[1]After receipt of comments to "Draft" (ARC)
		(Revisions)		As required	15 working days ACC[2]			[2]After major contract change (ACC)
03		Draft	A			0	4	
04		Final	X	Once	15 working days ARC	0	4	
	02	Project Implementation Plan		Once	10 working days prior to			
05		Draft	A		Design Review	0	4	
06		Final	X	Once	15 working days ARC	0	4	
	03	Design			10 working days prior to			
07		Draft	A	Once	Design Review	0	4	
08		Final	X	Once	15 working days ARC	1 (EF[3])	4	[3]Electronic file via modem or floppy disk
09	04	Project Review Data Package	X	Once for each review	At the review	0	4	
10	05	Design Review Data Package	X	Once	10 working days prior to review	0	24	
11	06	Fabrication Readiness Review Data Package	X	Once for each location	5 working days prior to review	0	10	

(c)

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. ORIG.	QTY. COPIES	REMARKS
12	07	Installation Readiness Review Data Package	X	Once for each site	5 working days prior to review	0	10	
13	08	Mill Test Report	X	Once for each heat	1st working day of WFR[4]	1 (FAX)	0	[4]Week following receipt at contractor (WFR)
14	09	Coupon Screening Outgassing Test Data	X	Once for each coil	1st working day of WFM[5]	1 (FAX)	0	[5]Week following measurement (WFM)
15	10	Tube Section Dimensional Test Data	X	Once for each section	1st working day of WFM	1 (FAX)	0	
16	11	Expansion Joint Test Data	X	Once for each joint	1st working day of WFR	1 (FAX)	0	
17	12	Tube Section Leak Test Data	X	Once for each section	1st working day of WFM	1 (FAX)	0	
18	13	Tube Section Rinse FTIR Data	X	Once for each of 1st 10 sections; subsequently, 1 of every 10	1st working day of WFR	1 (FAX)	0	
19	14	Girth Joint Leak Test Data	X	Once for each joint	1st working day of WFM	1 (FAX)	0	

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. ORIG.	QTY. COPIES	REMARKS
20	15	Module Alignment Data	X	Once for each support	1st working day of WFM	1 (FAX)	0	
21	16	Module Pumpdown Pressure/Time Data	X	Once for each module	1st working day following measurement	1 (EF)	0	
22	17	Module Pre-Bake Leak Test Data	X	Once for each module	1st working day following measurement	1 (EF)	0	
23	18	Module Bake Data	X	Once for each module	1st working day following cooldown	1 (EF)	0	
24	19	Module Post-Bake Leak Test Data	X	Once for each module	1st working day following measurement	1 (EF)	0	
25	20	Completion Review Data Package	X	Once for each site	5 working days prior to review	0	4	
26	21	Minutes	X	Once for each revision	10 working days after review	0	4	
27	22	On Site Daily Log	X	N/A	To be made available for review if required	N/A	N/A	
28	23	Nonconformance Report	X	Each report	1st working day of week following report	1 (FAX)	0	

Data Requirement Description (DRD)
Project Management Plan, DRD No. 01

Purpose: To provide the basis for detailed scheduling, work progress reporting, and tracking of termination liability.

Preparation Instructions: Prepare a Project Management Plan identifying the planned implementation of the effort in Article I, Statement of Work. The Plan shall serve as a baseline document for project scheduling, for work progress monitoring and reporting and for tracking the termination liability. The Plan shall include:

a. Work Breakdown Structure (WBS) per Article 1, C.1.
Work Breakdown Dictionary narratively defining the scope of each element in the WBS

b. A Summary Schedule containing schedules for implementation of all major WBS items, showing pertinent milestones.

c. Configuration Management Plan, including documentation control.

d. Quality Assurance Plan.

e. Cost Schedule by quarter.

f. Procurement Plan.

Project Implementation Plans, DRD No. 02

Purpose: To determine resolutions on open items as to how the project shall be implemented.

Preparation Instructions: Prepare the following plans for implementation of the fabrication and installation of the LIGO Beam Tube Modules, as described in Article I (SOW), C.2.:

a. Subcontract Plan

b. Fabrication Plan

c. Installation Plan

d. Insulate and Bake Plan

e. Acceptance Test Plan

Design, DRD No. 03

Purpose: To provide drawings, specifications, and procedures on open items needed for the project.

Preparation Instructions: Prepare the following designs for implementation of the fabrication and installation of the LIGO Beam Tube Modules, as described in Article 1 (SOW), D.:

1. Terminations.
2. Modified drawings from revised module length.
3. Pump port hardware, including pump flange interface, spares list, and modified leak check procedures.
4. Modified spiral weld procedure, weld quality monitoring procedure.
5. Modified leak check hoods.
6. Cleaning equipment.
7. Cleanliness monitoring procedure.
8. Field shelters for tube installation.
9. Modified vacuum box for girth seams.
10. Module bake, including check of support design.
11. Leak localization procedure.
12. Post-bake leak test procedure.
13. Alternative GPS alignment check.
14. Corrosion mitigation recommendations.

Data Requirement Description (DRD)
Project Review Data Package, DRD No. 04

Purpose: To assess project progress and status.

Preparation Instructions: The Data Packages to be provided in support of the project reviews shall contain all data and information on all topics to be discussed and presented at a review, and shall include, but not be limited to, the following:

a. All current technical contract activities.

b. Updated schedules including milestones and other events accomplished or missed, reasons for delay and corrective measures taken.

c. Problem areas, including those concerns requiring actions(s), decisions(s) or assistance on the part of the LIGO Project.

d. Action items closed during the review period, progress of open action items, and identification of new action items.

e. Response to technical direction received.

f. Cost status showing expenditures and obligations made at the WBS report item level, including in-house costs, vendor costs, open commitments, actuals verses budget, percent complete at the WBS element level and calculated termination liability.

Data Requirement Description (DRD)
Design Review Data Package, DRD No. 05

Purpose: To present and substantiate design of open items.

Preparation Instructions: Prepare the following information:

1. Layouts, concepts and analysis to describe the design concepts utilized in the Design (DRD No. 03).

2. Explanation of rationales for making the design decisions.

3. Copies of view graphs to be presented at the Design Review.

Data Requirement Description (DRD)
Fabrication Readiness Review Data Package, DRD No. 06

Purpose: To demonstrate readiness for starting fabrication.

Preparation Instructions: Prepare the following information regarding preparations for fabricating components of Beam Tube Modules. Include all problem areas (past, present and potential) with actions taken and planned for mitigation.

Fabrication Plan (see Article 1 (SOW), C.2.b.) Development:

1. Significant decisions and contracts.
2. Coil processing and coupon outgassing results.
3. Qualification of fixtures and equipment.
4. Transportation.

Data Requirement Description (DRD)
Installation Readiness Review Package, DRD No. 07

Purpose: To demonstrate readiness for starting field installation.

Preparation Instructions: Prepare the following information regarding preparations for installing components of Beam Tube Module. Include all problem areas (past, present and potential) with actions taken and plans for mitigation.

Installation Plan (see Article 1 (SOW), C.2.c.) Developments:

1. Significant decisions and contracts.

2. Qualification of fixtures and equipment.

3. Staged start of installation/practice working with equipment.

Data Requirements Description (DRD)
Mill Test Report, DRD No. 08

Purpose: To communicate the composition and mechanical properties of each heat of stainless steel used for fabrication.

Preparation Instructions: Photocopy the supplying steel mill's report.

Data Requirements Description (DRD)
Coupon Screening Outgassing Test Data, DRD No. 09

Purpose: To communicate the hydrogen outgassing results of coupon screening tests.

Preparation Instructions: Prepare form with test measurements and outgassing calculations.

Data Requirements Description (DRD)
Tube Section Dimensional Test Data, DRD No. 10

Purpose: To communicate dimensional test data from tube section measurements.

Preparation Instructions: Prepare form with measurement data.

Data Requirements Description (DRD)
Expansion Joint Test Data, DRD No. 11

Purpose: To communicate expansion joint properties and data.

Preparation Instructions: Photocopy the expansion joint manufacturer's data sheets for each unit.

Data Requirements Description (DRD)
Tube Section Leak Test Data, DRD No. 12

Purpose: To communicate leak test data from tube section measurements.

Preparation Instructions: Prepare form with measurement data.

Data Requirements Description (DRD)
Tube Section Rinse FTIR Data, DRD No. 13

Purpose: To communicate contamination levels in final rinse of beam tube cleaning, as a measurement of cleaning process controls.

Preparation Instructions: Photocopy the measurement laboratory's report and data plot for each unit.

Data Requirements Description (DRD)
Girth Joint Leak Test Data, DRD No. 14

Purpose: To communicate girth joint leakage results.

Preparation Instructions: Prepare form with measurement data for each girth seam made -- both fabrication and installation joints, including calibration data.

Data Requirements Description (DRD)
Module Alignment Data, DRD No. 15

Purpose: To communicate alignment data from field measurements.

Preparation Instructions: Prepare form with GPS measurement data for measurements at each support.

Data Requirements Description (DRD)
Module Pumpdown Pressure/Time Data, DRD No. 16

Purpose: To communicate pumpdown performance for each module.

Preparation Instructions: Make an electronic file copy of the spreadsheet time-pressure-temperature record of each module pumpdown.

Data Requirements Description (DRD)
Module Pre-Bake Leak Test Data, DRD No. 17

Purpose: To communicate pre-bake leak test data for each module.

Preparation Instructions: Make an electronic file copy of the spreadsheet time-RGA-temperature record of each pre-bake leak test, including calibrations. Make a file copy of calculated maximum N_2 partial pressure in the module and resultant maximum leak rate for air. If HMS readings are performed, prepare a (hard copy) form with measurement data, including calibrations.

Data Requirements Description (DRD)
Module Bake Data, DRD No. 18

Purpose: To communicate bake data for each module.

Preparation Instructions: Make an electronic file copy of the spreadsheet time-RGA-temperature record for module bake, starting and ending at ambient temperature.

Data Requirements Description (DRD)
Module Post-Bake Leak Test Data, DRD No. 19

Purpose: To communicate post-bake leak test data for each module.

Preparation Instructions: Make an electronic file copy of the spreadsheet time-RGA-temperature record of each post-bake leak test, including calibrations. Make a file copy of calculated maximum N_2 partial pressure in the module and resultant maximum leak rate for air. If HMS readings are performed, prepare a (hard copy) form with measurement data, including calibrations.

Data Requirements Description (DRD)
Completion Review Data Package, DRD No. 20

Purpose: To present all aspects of as-built design and associated fabrication, installation and testing of LIGO Beam Tube Modules, and to provide a permanent record of presented material and subsequent closeout of resultant action items.

Preparation Instructions: The Data Package to be provided in support of the Completion Review shall contain all data and information on all topics to be discussed and presented at the Review and shall include, but not be limited to, the following (for each beam tube module):

a. Test report documenting the results of screening and acceptance tests.

b. Tube alignment verification.

c. As-built drawings.

d. Status of cleanup.

e. Disposition of property procured under the contract or made available as Institute furnished property.

f. Remaining issues and open action items.

Data Requirements Description (DRD)
Minutes, DRD No. 21

Purpose: To document proceedings of all formal Institute/Contractor LIGO project meetings.

Preparation Instructions: The Minutes shall document proceedings of all formal LIGO Project/ Contractor project meetings. The Minutes shall include:

a. A summary of all business transactions between the Contractor and the Institute, including any alterations and/or clarifications to the Review Data Package generated during the Review.

b. Contractor action items and planned completion dates.

c. LIGO Project action items and planned completion dates.

Data Requirements Description (DRD)
On-Site Daily Log, DRD No. 22

Purpose: To track activity, and to record significant events and problems encountered.

Preparation Instructions: The On-Site Daily Log is not a deliverable item; however, it should be made available to the Institute upon request. The Log shall be kept in accordance with established engineering/business practice and should as a minimum contain the following:

a. Identification of Contractor and subcontractors teams at the site.

b. Weather conditions, temperature, wind, rain, etc.

c. Brief description of work performed, site activities.

d. Heavy equipment utilized.

e. Any problems impacting work progress.

f. Foreseeable problems which may impact the progress of site activities.

Data Requirements Description (DRD)
Nonconformance Report, DRD No. 23

Purpose: To communicate nonconformances.

Preparation Instructions: Photocopy standard form(s).

EXHIBIT II

LIGO DOCUMENTS

NOTE:
THE PAGES THAT FOLLO.
INCLUDE ALL OF THOSE
LISTED IN ARTICLE 1, B.1.
EXCEPT FOR THE LAST 3,
FROM PARSONS & J-U-B.
PLEASE SEE L. JONES IF YOU
LIKE TO SEE THESE.
THEY WILL BE SENT TO
CBI WITH TO THE RFP.

EXHIBIT III

BEAM TUBE DELIVERABLES

A. The Beam Tube Deliverables consist of pump carts and gate valves which are required for the beam tube pump down (a separate contract). These components are defined in Exhibit I Vacuum Equipment Specification. There are three types of pump carts and one type of gate valve. The required equipment is listed below:

WASHINGTON SITE - Required date: 6/19/96

LOUISIANA SITE - Required date: 8/10/97

	Item	Quantity Hanford	Quantity Louisiana
1.	Main Roughing Pump (per Exhibit I, paragraph 5.2.1.1)	3	3
2.	Turbo Molecular Pump Set (per Exhibit I, paragraph 5.2.1.2)	5	5
3.	Auxiliary Turbo Cart (per Exhibit I, paragraph 5.2.5)	2	2
4.	122 cm Gate Valve (per Exhibit I, paragraph 5.3.1)	8	6

Note: Quantities above are those required for the beam tube pump down only and may not be the same as the total quantity call[illegible] Equipment Specification.

NOTE:
THIS PAGE, PLUS THE 4 PAGES FOLLOWING, ARE COPIED FROM THE VACUUM EQUIPMENT CONTRACT.
WE PLAN TO SEND A COMPLETE COPY OF THE VACUUM EQUIPMENT WITH THE BEAM TUBE RFP.

L. JONES

ion pumps, getter pumps, and 80K pumps are used for vibration-free pumping during normal operation.

The main pumping phases include:

1. Initial Pumpdown (from 760 torr to less than 1 torr): Roots roughing pump sets are to be used. The duration of this phase is limited to 4 hours per vacuum section. See Section 4.2.
2. Intermediate Pumpdown (from 1 torr to less than 10^{-6} torr): Turbo molecular pump sets are to be used. The duration of this phase is expected to be of order 24 hours. Low noise and vibration are required.
3. Final Pumpdown and normal operation (below 10^{-6} torr): No mechanical pumps may be used. Ion, getter and cryogenic pumps are to provide continuous pumping without vibration.

5.2.1 Roughing Pumps The roughing pumps shall consist of two types of portable pump stations, the main roughing pump set and the turbo molecular pump sets. The main roughing pump set shall be used for pumping from atmosphere to less than 1 torr while the turbo molecular pump set shall be used for pumping from 1 torr to less than 10^{-6} torr. The main roughing pump sets are exempt from the vibration and acoustic noise limits. The turbo molecular pump sets, however, shall be designed to operate for extended periods of time without contributing to vibration and noise levels beyond those described in Section 4.6.

The design of the roughing pumps shall preclude contaminating the beam tubes and chambers during the life of the equipment, even with equipment failures and operator mistakes.

5.2.1.1 Main Roughing Pump Sets Each main roughing pump set shall consist of a roots blower backed by one or more roughing pumps. Five sets are required at each site. The minimum pumping speed at 1 torr at the pump inlet shall be 500 CFM and at 0.1 torr, 1000 CFM. There shall be no oil in the pumping path. The roots blower shall incorporate a "canned" motor. The pump set shall be self contained so that under power failure or pump failure, interlocks shall prevent the pumped chambers from being vented or exposed to a non-operating pump. The pump set shall be capable of roughing volumes as large as the 2 km beam tube module (volume >2000 m^3) without overheating. Provisions for connection to the control system shall be provided. Provision for sealed connection to a ducted facility exhaust system shall be provided.

There shall be vacuum gauges located at each pump inlet (both the roots pump and the backing pump) and there shall be auxiliary valved (manual) ports to allow connection of a leak detector. All unused connections shall be fitted with blankoff flanges.

5.2.1.2 Turbo Molecular Pump Sets Each turbo molecular pump set shall consist of a "wide range" magnetically levitated turbo molecular pump backed by an oil free pump (diaphragm, piston, or scroll pump). Five sets are required at each site. The minimum pumping speed at the roughing port shall be 1400 liters/sec for nitrogen at 10^{-3} torr. Throughput at a backing pressure of 1 torr shall be at least 5 torr liters/second. The pump set shall be capable of pumping large volumes (>2000 m^3) without overheating. The pump set shall be self contained so that under power failure or pump failure, interlocks shall prevent the pumped chambers from being vented or exposed to a non-operating pump. Provisions for connection to the control system shall be provided.

There shall be vacuum gauges located at each pump inlet (both the turbo pump and the backing pump) and there shall be auxiliary valved (manual) ports to allow connection of a leak detector or auxiliary backing turbo. All unused connections shall be fitted with blankoff flanges.

5.2.2 Main Ion Pumps The main ion pumps, positioned as shown in Figures 2 and 3, have nominal pumping speeds of 2500 liter/sec minimum for nitrogen. Other configurations using ion pumps or combined ion pump/getter pump assemblies are allowed. The minimum life of the pumps shall be 40,000 hours or more at an operating pressure of 10^{-6} torr. Noble gas diode-type ion pumps shall be used. If required for starting purposes, or to avoid the use of custom power supplies, multiple power supplies and feedthroughs may be employed to operate each pump. Maximum allowable ion pump starting pressure shall be at least 1×10^{-5} torr. Ion pump and getter controllers shall be mountable in standard 19 inch racks.

5.2.3 80K Pumps There are two types of 80K pumps: long and short. The long 80K pumps shall have a cylindrical cold surface 3.7 m long by a nominal 1.2 m diameter and the short 80K pumps shall have a cold surface 1.2 m long by a nominal 1.2 m diameter. All other features of the 80K pumps shall be identical. The pumping surface shall be coaxial with the beam tube axis, and provide a clear aperture of $\geq$ 1.05 m, warm or cold. The 80K pumps may be of the liquid nitrogen, continuous flow, or refrigerated design. In any case the vibration requirements of section 4.6 shall be met.

Certain parts of the 80K pumps may have large thermal gradients which may give rise to local, intermittent release of gas. The design shall preclude the sudden and direct release of this gas into the optical path.

Each 80K pump shall have a removable beam tube section at one end to allow insertion of optics components. The minimum length required for this section is 60 cm.

5.2.4 Getter Pumps LIGO plans to install getter pumps of a nominal 2000 liters/sec pump speed (hydrogen) on the beam tube at each 250 meter pump port. This will be done after one year of operation to ensure that the beam tube gas loads are understood. These pumps are not to be provided by this contract.

5.2.5 Annulus Pumps Auxiliary turbo molecular pump sets (auxiliary turbo carts) shall be provided for roughing of the annular spaces. Five pump sets are required for each site. The pump sets shall be self contained so that under power failure or pump failure, interlocks shall prevent the pumped chambers from being vented. Provisions for connection to the control system shall be provided. These pump sets shall use an oil free backing pump to minimize the risk of contamination of the annuli.

Each chamber shall have a 200l/s (maximum) ion pump to maintain the annular vacuum. The ion pump shall be isolatable from the annuli with a hand valve. Noble gas diode pumps shall be used. The ion pump controllers shall be mountable in standard 19 inch racks.

5.3 Valve Subsystem

5.3.1 Gate Valves All gate valves shall be stainless steel with metal sealed flanges or weld fittings where appropriate, and metal bellows stem feedthroughs. Only non-contaminating and non-migratory lubrication shall be used on the internal mechanisms. Valve body and flange leakage shall be measured to be less than 10^{-10} torr•liter/sec of helium before installation. 122 cm and larger gate valves shall have double viton gate seals. Annular spaces between gate valve seals shall be isolatable and pumped with an ion pump when the valve is closed. All gate seals shall be leak free to a level of 10^{-9} torr•liter/sec of helium.

Valves of the same size and type shall be identical to minimize the number of required spare parts. All valves shall be rated for 10000 cycles before service is required.

All valves, regardless of operation (electric, pneumatic, or manual), shall be protected from accidental operation. Such protection may be provided by mechanical, electrical, or procedural means. In instances where accidental venting is possible, redundant means shall be employed.

5.3.2 Small Valves Small valves (less than 15cm aperture), such as right angle manual valves, shall be all metal and bakeable.. Exceptions are those valves which are used on the o-ring annuli and those which are mounted on the portable pump stations. These may be viton sealed. All metal sealed valves shall be rated for 10000 cycles before service is required.

5.4 Vent and Purge Subsystem Components inside each of the chambers shall be protected against particulate contamination at all times: when chambers are open, while venting to air, during opening and closing, and when closed, including pumpdown. This protection shall be equivalent to exposure within a Fed. Std. 209 Class 100 clean room. The vacuum enclosure area of each station will be designed as a Fed. Std. 209 Class 50,000 clean room. Vent and purge systems shall be provided with valved and pressure limited, Class 100 air with a water vapor dew point of less than −60 degrees Celsius. There shall be two 100 CFM systems available in the corner stations and 50 CFM systems elsewhere. The air compressors shall be mounted outside the buildings in designated areas. The purge system shall allow for the connection of air shower manifolds in the chambers, used to distribute purge gas over the optical components inside the chambers. Additionally, portable soft-wall cleanrooms shall be provided to allow coverage of open chamber ports. A total of 13 portable units are required (8 for the Washington site).

5.5 Bakeout Subsystem Insulation and heating equipment shall be modular so as to allow efficient removal and placement. There need only be enough equipment to bake the largest contiguous vacuum section at one time; however, the equipment shall be capable of baking any of the vacuum sections. Temperature sensors shall be installed at positions representing minimum and maximum temperatures. Bakeout controls shall be sufficient to insure that the performance requirements are met.

5.6 Monitor and Control Subsystem Vacuum monitoring and control equipment includes Pirani gauges, ion gauges (cold cathode), process controllers

BEAM TUBE CONTRACT
WORK BREAKDOWN STRUCTURE

1.1.2.1 Beam Tube Design

1.1.2.1.1 Reserved

1.1.2.1.2 Beam Tube Design

1.1.2.2 Washington Beam Tube Construction

1.1.2.2.1 Reserved

1.1.2.2.2 Washington Beam Tube Factory Fabrication

1.1.2.2.3 Washington Beam Tube Field Installation

1.1.2.2.4 Washington Beam Tube Insulate and Bake

1.1.2.2.5 Washington Tube Acceptance Test

1.1.2.3 Louisiana Beam Tube Construction

1.1.2.3.1 Reserved

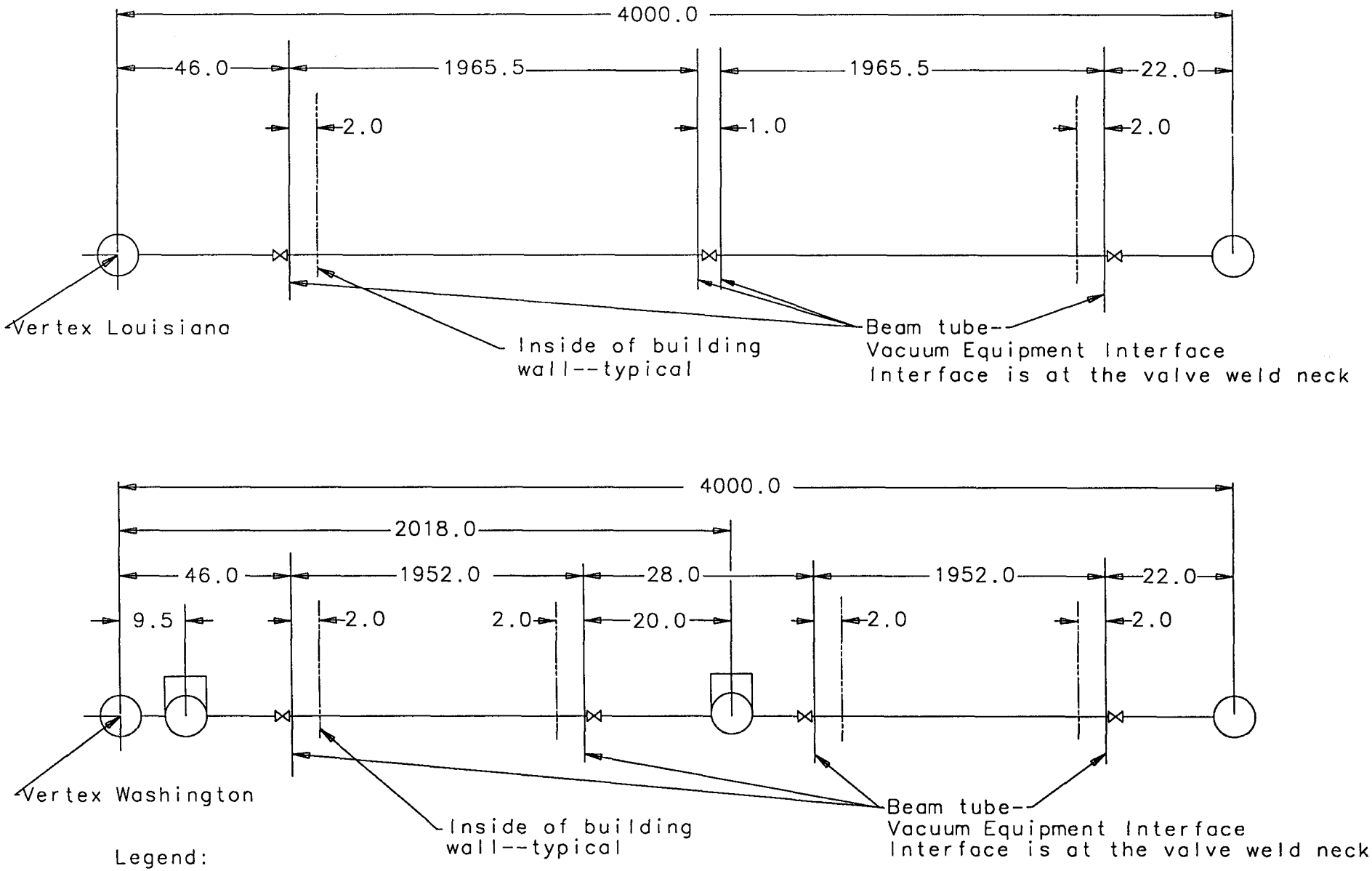
1.1.2.3.2 Louisiana Beam Tube Factory Fabrication

1.1.2.3.3 Louisiana Beam Tube Field Installation

1.1.2.3.4 Louisiana Beam Tube Insulate and Bake

1.1.2.3.5 Louisiana Tube Acceptance Test

REV	DATE	DRWN	APVD	DESCRIPTION
0				3/24/95 Original



Legend:

⋈ Gate Valve

BSC

TMC

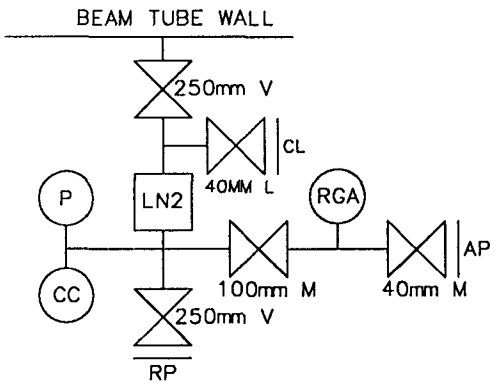
LIGO ARM LAYOUTS

Dimensions in meters; not to scale

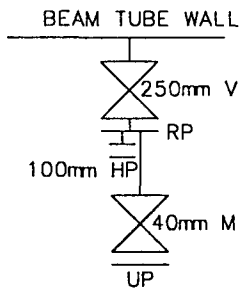
	LIGO PROJECT
Drawn	
Check	
Engr	
APPD J Worden	LIGO ARM LAYOUTS
APPD L Jones	
SCALE:	TYPE D950021 SHEET 1 of 1 REV

PUMP PORT HARDWARE

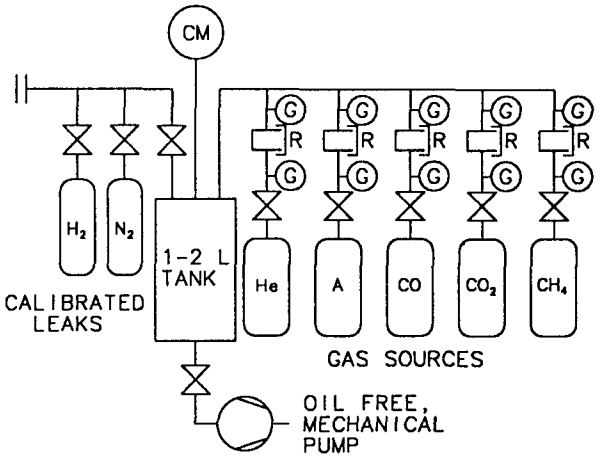
TYPE B: FOR PORTS DURING BAKE & LEAK CHECK



TYPE H: FOR PORTS DURING HOLD (AFTER ACCEPTANCE, BEFORE OPERATION)



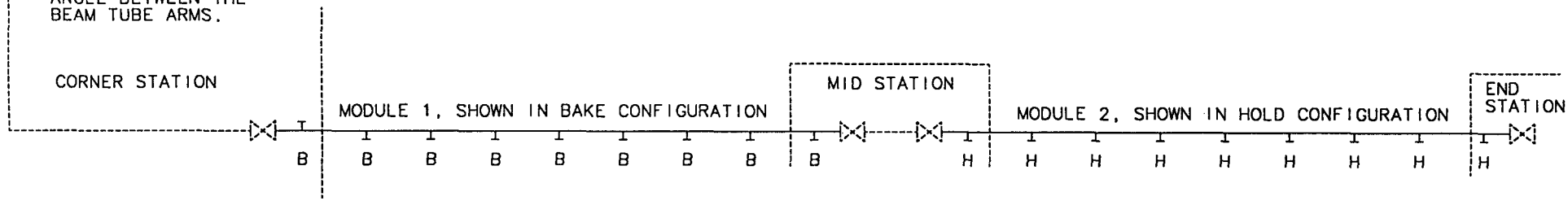
PORTABLE CALIBRATION MODULE



LEGEND FOR PUMP PORT HARDWARE:

AP: BLANKED PORT FOR AUXILIARY TURBO PUMP
CC: COLD CATHODE GAUGE
CL: BLANKED PORT FOR CALIBRATED LEAKS
CM: CAPACITANCE MANOMETER GAUGE (ABSOLUTE)
G: BOURDON GAUGE
HP: BLANKED PORT FOR RGA HEAD INSTALLATION
LN2: LIQUID NITROGEN TRAP, 4 M COLD SURFACE
L: VARIABLE LEAK VALVE
M: METAL SEALED VALVE
P: PIRANI GAUGE
R: REGULATOR
RGA: BALZERS QMG 421 OR EQUIVALENT
RP: BLANKED PORT FOR ROOTS AND TURBO PUMPS
TP: BLANKED PORT FOR TURBO PUMP
UP: BLANKED PORT FOR UTILITY PURPOSES
V: VITON SEALED VALVE

NOTE THAT PUMP PORTS AT MODULE ENDS AT THE CORNER STATION ARE POSITIONED ON THE INBOARD SIDE OF THE ANGLE BETWEEN THE BEAM TUBE ARMS.



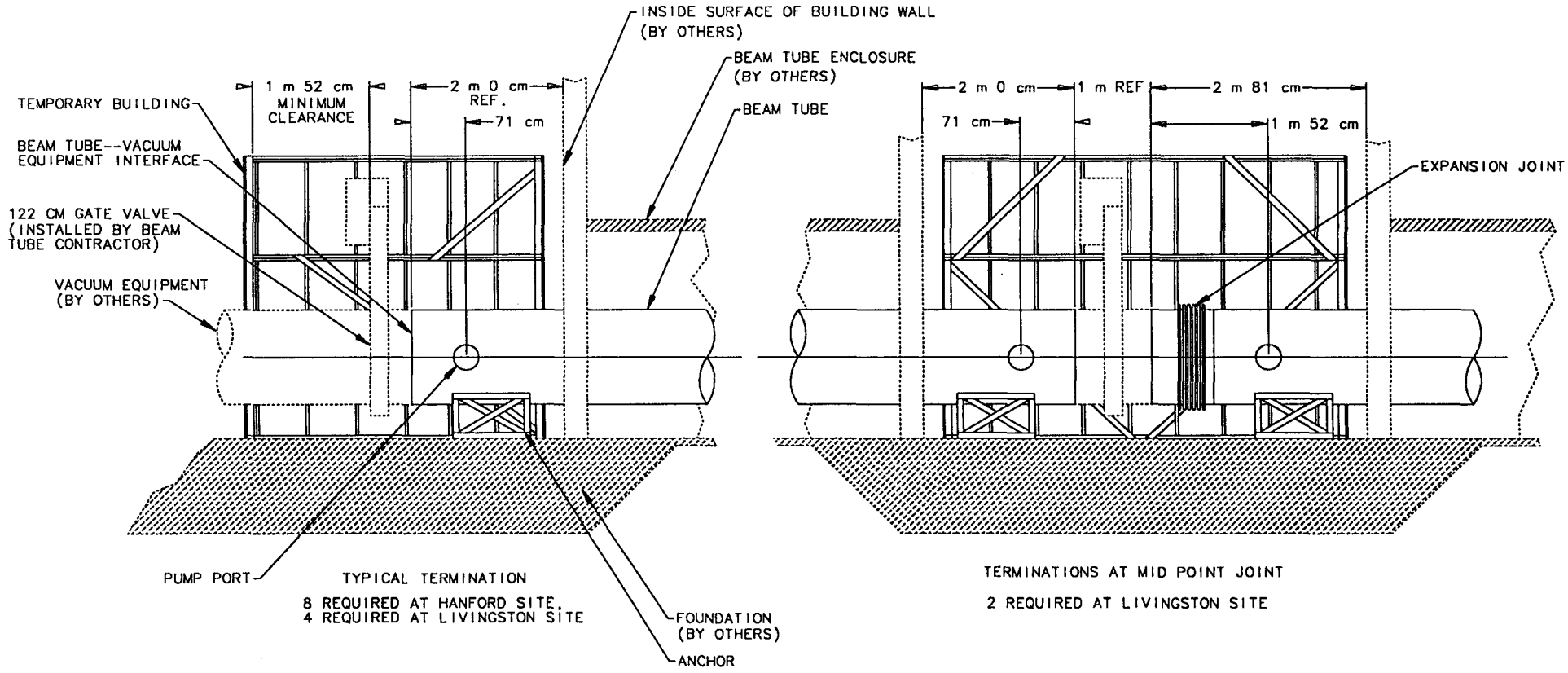
PLAN VIEW OF ARM AT HANFORD SITE, SHOWING TYPES OF HARDWARE AT EACH PUMP PORT

LIGO PROJECT

DRAWN	L. JONES
CHKD	
ENGR	
APPD	
APPD	
SCALE: NTS	

BEAM TUBE PUMP PORT HARDWARE

TYPE D950027 REV -1



TYPICAL TERMINATION

8 REQUIRED AT HANFORD SITE,
4 REQUIRED AT LIVINGSTON SITE

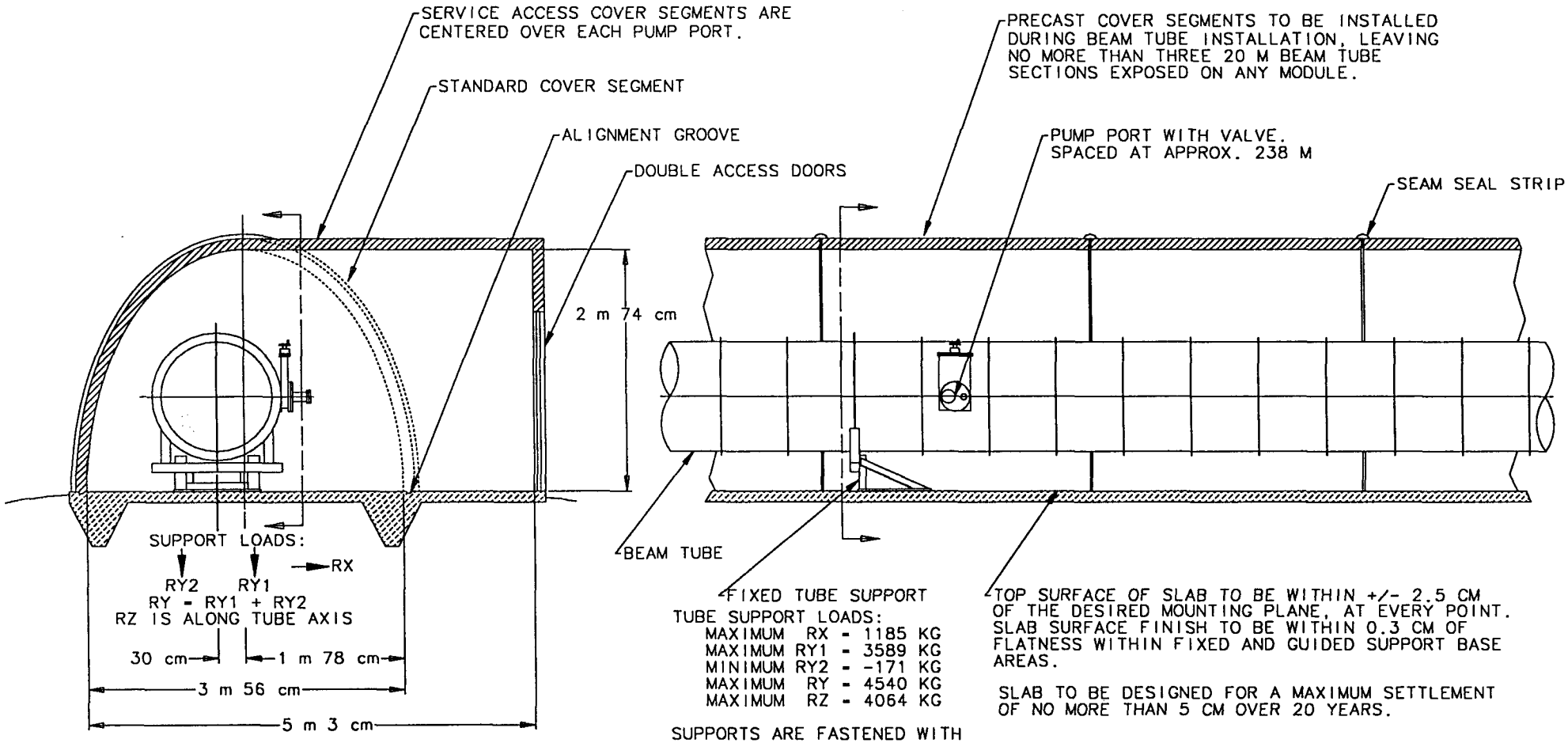
TERMINATIONS AT MID POINT JOINT

2 REQUIRED AT LIVINGSTON SITE

LIGO PROJECT

BEAM TUBE
TERMINATIONS

D950028



TUBE SUPPORT LOADS:
- MAXIMUM RX - 1185 KG
- MAXIMUM RY1 - 3589 KG
- MINIMUM RY2 - -171 KG
- MAXIMUM RY - 4540 KG
- MAXIMUM RZ - 4064 KG

SUPPORTS ARE FASTENED WITH 15 MM EXPANSION ANCHORS

FIXED SUPPORTS ARE EQUALLY SPACED AT 39 M 62 CM ALONG TUBE AXIS

TOP SURFACE OF SLAB TO BE WITHIN +/- 2.5 CM OF THE DESIRED MOUNTING PLANE, AT EVERY POINT. SLAB SURFACE FINISH TO BE WITHIN 0.3 CM OF FLATNESS WITHIN FIXED AND GUIDED SUPPORT BASE AREAS.

SLAB TO BE DESIGNED FOR A MAXIMUM SETTLEMENT OF NO MORE THAN 5 CM OVER 20 YEARS.

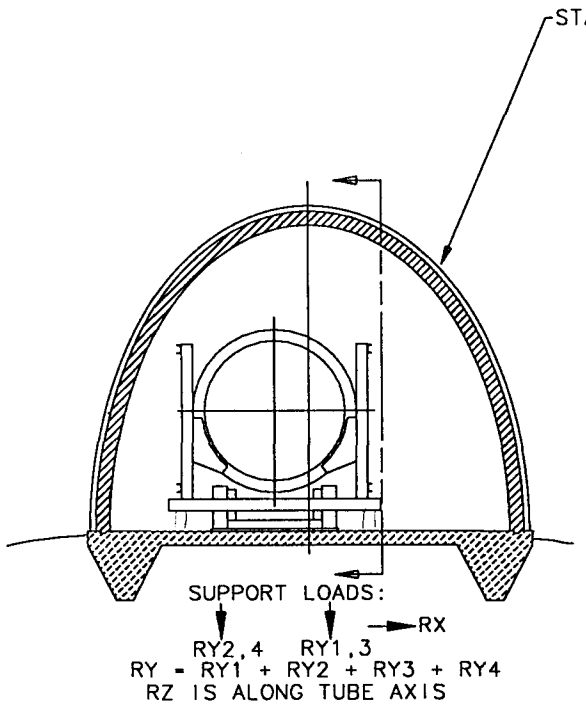
SLAB LOADS DURING CONSTRUCTION:
SLAB OVER FOOTINGS WILL SUPPORT 9800 KG/M²

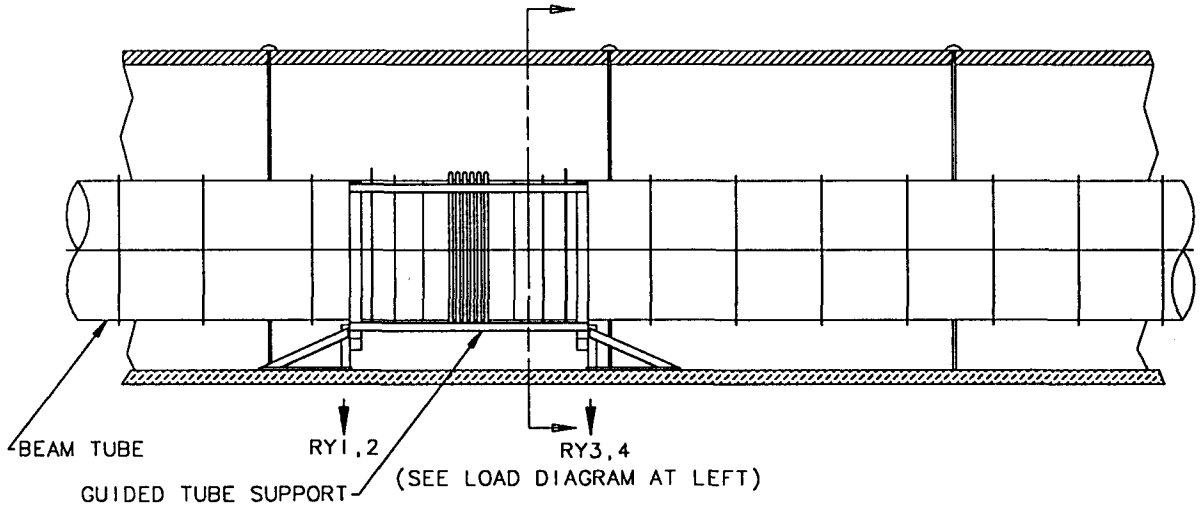
GENERAL DETAILS AND FIXED SUPPORT DETAILS

LIGO PROJECT

BEAM TUBE/ ENCLOSURE INTERFACE

D950029 | 1-2





TUBE SUPPORT LOADS:

MAXIMUM	RX =	737 KG
MAXIMUM	RY1 =	1616 KG
MINIMUM	RY2 =	-154 KG
MAXIMUM	RY3 =	1457 KG
MINIMUM	RY4 =	-5 KG
MAXIMUM	RY =	3549 KG
MAXIMUM	RZ =	0 KG

SUPPORTS ARE FASTENED WITH 15 MM EXPANSION ANCHORS

GUIDED SUPPORTS ARE SPACED MIDWAY BETWEEN FIXED SUPPORTS.

GUIDED SUPPORT DETAILS

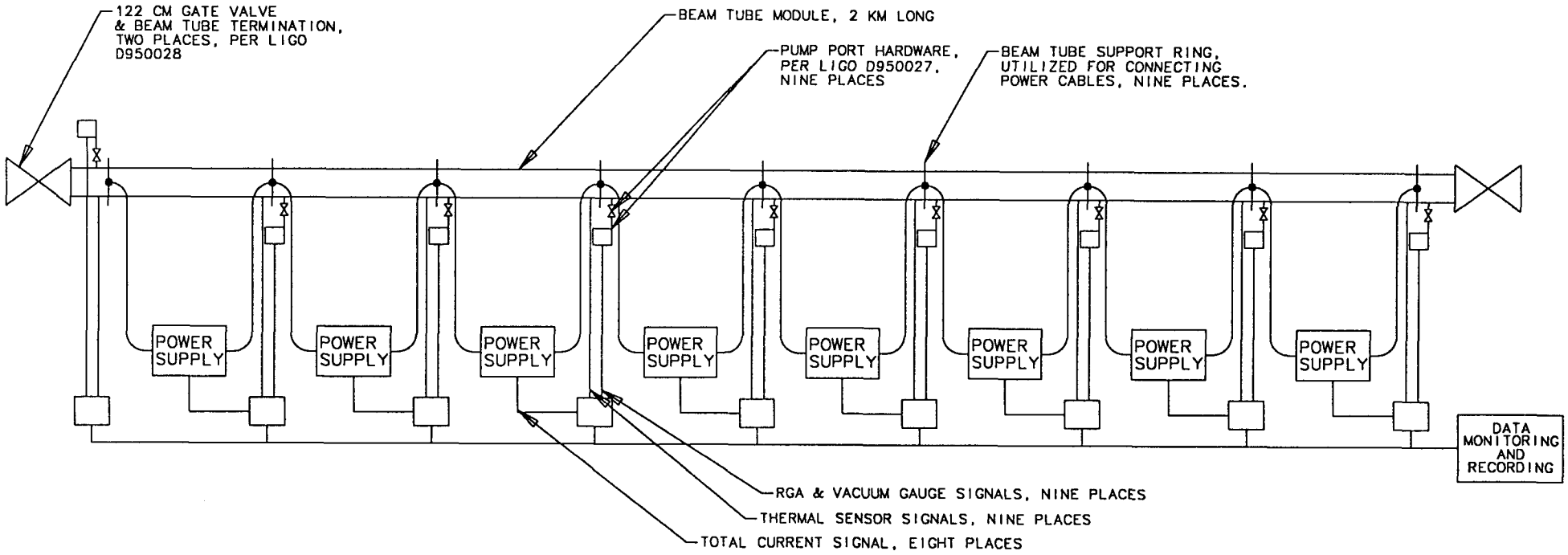
LIGO PROJECT

L. JONES

BEAM TUBE/ ENCLOSURE INTERFACE

SCALE: NTS

D950029 2-2



INSULATION:

A. GENERAL: TWO 5 CM THICK LAYERS OF FIBERGLASS BLANKET, 12 KG/M³ MINIMUM DENSITY, EACH WITH FOIL-SKRIM-KRAFT FACING. THERMAL CONDUCTIVITY TO BE 0.061 W/M·C OR LOWER AT A MEAN TEMPERATURE OF 80C. INSULATION SHALL NOT ACCELERATE CORROSION OF A STEEL TEST PANEL COMPARED TO STERILE COTTON (ASTM C665) AND SHALL NOT PROMOTE THE GROWTH OF FUNGI OR BACTERIA (UL 181).
B. CIRCUMFERENTIAL JOINTS OF OUTER LAYER TO BE STAGGERED WITH RESPECT TO JOINTS OF INNER LAYER.
C. ALL JOINTS OF OUTER LAYER TO BE TAPED.
D. SPECIAL: SUPPORT RINGS, SUPPORT CONNECTIONS, TUBE WALL NEAR SUPPORTS, EXPANSION JOINTS, POWER CABLE CONNECTIONS, PUMP PORT HARDWARE, 122 CM GATE VALVES, AND TERMINATIONS TO HAVE INSULATION COVERAGE TO ASSURE THAT VACUUM SURFACES ARE MAINTAINED WITHIN TEMPERATURE LIMITS (SEE BAKE TEMPERATURE).

BAKE IMPLEMENTATION:

A. TUBE WALL: BAKE IS EFFECTED BY PASSING CURRENT THROUGH THE BEAM TUBE WALL, HEATING THE TUBE BY ITS OWN RESISTANCE.
B. ALL OTHER VACUUM SURFACES TO BE HEATED BY AUXILIARY MEANS.

BAKE TEMPERATURE:

A. ALL VACUUM SURFACES TO BE HELD WITHIN THE RANGE OF 140-170C FOR THE DURATION OF THE MODULE BAKE, INCLUDING PUMP PORT HARDWARE AND 122 CM GATE VALVES.

BAKE DURATION:

A. MODULE BAKE TO EXTEND TO 30 DAYS AT BAKE TEMPERATURE, OR UNTIL THE WATER OUTGASSING RATE AT BAKE TEMPERATURE DECREASES TO < 1E-11 T·L/S·CM², WHICHEVER OCCURS FIRST.
B. IF A PROBLEM OCCURS THAT CAUSES THE TEMPERATURE OF A VACUUM SURFACE TO FALL BELOW THE MINIMUM BAKE TEMPERATURE, THE BAKE TIME SHALL BE INCREASED, IF NEEDED, TO ASSURE THAT THE ABOVE REQUIREMENT IS MET.

BAKE MONITORING & RECORDING:

A. ALL DATA (POWER SUPPLY CORRENTS, TEMPERATURES, VACUUM PRESSURES, AND RGA READINGS) SHALL BE WIRED TO A SINGLE STATION AS INDICATED ABOVE, FOR THE PURPOSES OF MONITORING AND RECORDING.
B. A SUFFICIENT QUANTITY OF THERMAL SENSORS SHALL BE USED TO INDICATE TEMPERATURES OF TYPICAL WALL POSITIONS, AS WELL AS TYPICAL SUSPECT HOT OR COLD SPOTS AND TYPICAL PUMP PORT HARDWARE, 122 CM GATE VALVE AND TERMINATION POSITIONS. THERMAL SENSORS SHALL BE INCLUDED FOR MONITORING THE STATUS OF EACH LN2 TRAP.
C. ALL MONITORED DATA SHALL BE RECORDED WITH TIME TAG ON A FIFTEEN MINUTE CYCLE DURING BAKE AND THE ACCUMULATED FILE SHALL BE SAVED DAILY TO FLOPPY DISK OR TAPE.

LIGO PROJECT

DRWN L JONES

BEAM TUBE MODULE BAKE

SCALE: NTS

D950030

(8)

EXHIBIT III

DETAILED DESIGN

THIS PAGE WILL BE FOLLOWED BY AN INDEX PAGE, OR "ZERO BILL" LISTING ALL OF THE CBI DRAWINGS, PROCEDURES AND SPECIFICATIONS, AND TITLED "BEAM TUBE MODULE, LIGO-D95xxx".

THE ACTUAL STACK OF THESE LISTED DOCUMENTS WILL ACCOMPANY THE RFP.