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
- DRD Number
- CDRL Line Item Number
- Approval Status

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

A = Requires 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 draft version on or before the date indicated.

2. If the draft is acceptable, the Contractor will be notified in writing (TDM) by the LIGO Contract Technical Manager. The Contractor shall then arrange for signatures and deliver final copies as indicated in the CDRL.

3. If the 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 documented by TDM.

b. The Contractor shall submit a revised draft for approval.

c. If the revised draft is approved, the Contractor will be notified by TDM. The Contractor shall then arrange for signatures and deliver final copies as indicated in the CDRL.

The requirements and approvals for revisions shall be the same as for the original 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 51-33, California Institute of Technology, 391 So. Holliston Ave., Pasadena, CA 91125. The Document Control Center shall be the point of official receipt for all documentation.

CONTRACT DATA REQUIREMENTS LIST

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. CR[1]	QTY. COPIES
	01	Project Management Plan[2]					
01		a. Schedule	DX/FA[3]	One draft, one final	D10/F15[4] (Design Review)	01	02
02		b. Configuration Management Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
03		c. QA Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
04		d. Resource Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
05		e. Safety Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
	02	Project Implementation Plan					
06		a. Subcontract Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
07		b. Fabrication Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
08		c. Installation Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02
09		d. Acceptance Test Plan	DX/FA	One draft, one final	D10/F15 (Design Review)	01	02

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. CR[1]	QTY. COPIES
	03	Design					
10		a1. Terminations	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF[3]), 4
11		a2. Terminations ICDs	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
12		b. Module Length	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
13		c1. Pump Port Hardware	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
14		c2. Pump Port Hardware ICD	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
15		d. Spiral Weld Quality	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
16		e. Cleaning Equipment	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
17		f. Cleanliness Monitoring	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
18		g. Field Enclosures	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
19		h. Vacuum Box	DX/FA	One draft, one finall	D10/F15 (Design Review)	1	1(EF), 4
20		i. Baffles	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
21		j. Leak Localization	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
22		k. Acceptance Test	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
23		l. Alignment Alternate	DX/FA	One draft, one final	D10/F15 (Design Review)	1	1(EF), 4
24		Design Document Revisions	DX/FA	As required	To suit production schedule	1	1(EF), 4 1(EF), 2
25	04	Project Status Review Data Package	X	Once for each review	At the review	0	5
26	05	Design Review Data Package	X	Once	10 working days prior to review	1	2
27	06	Fabrication Readiness Review Data Package	X	Once for each location	5 working days prior to review	1	2
28	07	Installation Readiness Review Data Package	X	Once for each site	5 working days prior to review	1	2

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. CR[1]	QTY. COPIES
29	08	Mill Test Report	X	Once for each heat	FAX, 1st working day of WFR[4], CWL[5]	0	1 (FAX)
30	09	Coupon Screening Outgassing Test Data	X	Once for each coil	FAX, 1st working day of WFM[8], CWL	0	1 (FAX)
31	10	Tube Section Dimensional Test Data	X	Once for each section	FAX, 1st working day of WFM, CWL	0	1 (FAX)
32	11	Expansion Joint Test Data	X	Once for each joint	FAX, 1st working day of WFR, CWL	0	1 (FAX)
33	12	Tube Section Leak Test Data	X	Once for each section	FAX, 1st working day of WFM, CWL	0	1 (FAX)
34	13	Tube Section Rinse FTIR Data	X	Once for each of 1st 10 sections; subsequently, 1 of every 10	FAX, 1st working day of WFR, CWL	0	1 (FAX)
35	14	Girth Joint Leak Test Data	X	Once for each joint	FAX, 1st working day of WFM, CWL	0	1 (FAX)
36	15	Module Alignment Data	X	Once for each support	FAX, 1st working day of WFM, CWL	0	1,1 (FAX)
37	16	Module Pumpdown Pressure/Time Data	X	Once for each module	1st working day following measurement	0	1 (EF)

CDRL NO	DRD NO	TITLE OR DESCRIPTION OF DATA	APPROVAL CODE	FREQUENCY OF ISSUE	DATE DUE TO USER	QTY. CR[1]	QTY. COPIES
38	17	Module Leak Test Data	X	Once for each module	1st working day following measurement	0	1 (EF)
39	18	Completion Review Data Package	DX/FA	Once for each site	D10/F15	1	1(EF), 2
40	19	Minutes	X	Once for each review	10 working days after review	0	4
41	20	On Site Daily Log	X	N/A	To be made available for review if required	N/A	N/A
42	21	Nonconformance Report	X	Each report	FAX, 1st working day of week following report, CWL	0	1, 1 (FAX)

[1]Camera Ready: Stacked, one-sided, no holes.

[2]Revisions due within 15 days after major contract change.

[3]Draft = X; Final = A (DX/FA) Caltech to provide comments to draft within 22 working days after receipt of draft.

[4]Draft = 10 working days prior to review; Final = 15 working days after receipt of comments to draft (D10/F15).

[5]Electronic file (Final only) via modem or floppy disk.

[6]Week following receipt of contractor (WFR)

[7]Copy 1 week later (CWL)

[8]Week following measurement (WFM)

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, for Caltech approval.

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. A detailed, Integrated Schedule that shows all activities that cover the total contract work scope. Top level contract milestones shall be identified and shall include the milestones identified in Article 3, A as a minimum. All activities and milestones shall show their relationships to each other. The critical path for the contract schedule shall be identified.

b. Configuration Management Plan, including documentation control. The plan shall reflect the requirement for LIGO Project approval of all changes to drawings, specifications, and procedures where applicable.

c. Quality Assurance Plan identifying what features and processes are critical, and how consistent conformance with the identified critical features is achieved. Identify project person responsible for QA and the specific QA procedures to be followed.

d. A Resource Plan that assigns material and labor resources against the Integrated Schedule.

e. A Safety Plan identifying the policies and responsibility for the overall safety of the project. The plan shall show how safety is maintained and include specific safety manuals as applicable.

Data Requirement Description (DRD)
Project Implementation Plans, DRD No. 02

Purpose: To document and provide a basis for the implementation of the project, for Caltech approval.

Preparation Instructions: Prepare the following plans for implementation of the fabrication and installation of the LIGO Beam Tube Modules:

a. Subcontracting plan: Develop make or buy decisions for all items, and indicate method(s) of subcontracting and subcontract management.

b. Fabrication plan: Develop and document how the fabrication of the beam tube modules will be accomplished, including the following items:

- Fabrication mobilization/demobilization
- Fabrication locations
- Coil purchase and process sequence schedule, including coupon testing
- Spiral mill size, procurement, training, location and operation
- Material Handling: fragility, cleanliness
- Qualification of all fabrication equipment
- Preparation and assembly of tube sections
- Leak testing
- Cleaning
- Shipping and storage plans for tube sections
- Fabrication Readiness Review

c. Installation plan: Develop and document how the installation of the beam tube modules will be accomplished, including the following items:

- Qualification of all installation equipment
- Installation Readiness Reviews
- Installation mobilization/demobilization
- Installation sequencing and time phasing, including terminations (see DRD No. 03, a.) and baffles.

d. Acceptance Test and Outgassing Rate Measurements plan: In accordance with LIGO-E950020, develop and document how the Acceptance Test and outgassing rate measurements will be performed, including the following items:

- Module Acceptance Test (air signature leak assay)
- Partial pressure measurements
- Leak localization (see LIGO-E950021)
- Repair techniques
- Pump port hardware replacement and leak check

Data Requirement Description (DRD)
Design, DRD No. 03

Purpose: To provide all necessary drawings, specifications, and procedures for the fabrication, installation and testing of the beam tube modules which were not included in Exhibit III (Detailed Design), for Caltech approval.

Preparation Instructions: Develop and document the design of the LIGO Beam Tube Modules in the following areas:

a. Design module terminations in accordance with LIGO-D950028, including interface control documents for gate valve weld neck details and anchor foundation requirements. This task includes the design/specifying of temporary buildings to protect valves and pumps from the elements, and revises the installation procedures to include the terminations. Termination anchors shall be adjustable in position, with the same adjustment range as the beam tube supports.
b. Revise module length in accordance with Drawing LIGO-D950021, Rev. B., LIGO Arm Layouts.
c. Design pump port hardware in accordance with LIGO-D950027, including an interface control document for pump connections.
d. Revise the spiral weld procedure to ensure adequate penetration; develop procedures to effectively monitor weld quality.
e. Design fixtures and equipment for cleaning beam tube sections in accordance with the Beam Tube Module Detailed Design (Exhibit III).
f. Generate a procedure for QA monitoring of the beam tube section cleanliness by making FTIR measurements of the solvent rinse effluent. Specify measurements for the first ten tube sections and every tenth tube section thereafter.
g. 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.
h. Revise design of the vacuum box for leak checking module girth seams for more efficient application. Sealing the vacuum box with "Duct Seal" putty is acceptable as long as the putty is not applied to any weld area that has not previously passed a leak test. (Refer to LIGO-D950079, LIGO-D950080, LIGO-D950081, LIGO-D950085, and LIGO-D950086 in Master Document List, Detailed Design, LIGO-C950496.)
i. Generate a procedure and fixture design to install 1000 baffle "A" units per Drawing LIGO-D950094C and Caltech furnished location data. These will be spaced irregularly, requiring individual measurement. The procedure will specify that baffles are to be located to a tolerance of plus or minus 1/2 inch measured from the clean room end of the tube, except that baffles will not be located within six (6) inches of the girth seams or in expansion joints.
j. Generate a procedure for leak localization of a beam tube module based on the equipment shown in LIGO-D950027 and the plan developed in DRD No. 02, d.
k. Generate a Beam Tube Module Acceptance Test procedure for the air signature leak test of a module using the plan developed in DRD No. 02, d.

1. Design an alternative GPS alignment check procedure for use during installation and observatory operation, which does not require holes in the enclosure cover segments. The support slab outside of the enclosure will be accepted as a reference surface. Refer to LIGO-E950073 and LIGO-E950074 in Master Document List, Detailed Design, LIGO-C950496. The scope of the alternate design development will be as described in Volume I, section 2.1.1.9 of CBI's proposal dated July 28, 1995, except that:

    1. Alternate method #1 will not be investigated.
    2. Alternate methods requiring reference equipment will not be investigated.

    Budgetary pricing for the difference in cost between the original method and for the alternate methods investigated will be presented. If an alternate procedure is chosen, firm pricing for the chosen alternate will be provided and the contract will be revised accordingly, if the alternate procedure is adopted.

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

Purpose: To periodically assess the progress and status of the project.

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. Total float against top level contract milestones must be identified and reported as well as the critical path for the contract. Percent complete against all schedule activities and milestones shall be shown.

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. Monthly progress reports showing percent complete at one level below the milestone payment level.

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

Purpose: To present and substantiate design of items listed in DRD No. 03.

Preparation Instructions: Prepare the following information:

1. Layouts, concepts and analysis which describe the designs utilized in DRD No. 03

2. Solutions and 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 the readiness for starting fabrication.

Preparation Instructions: Provide information describing the preparations for fabricating the components for the Beam Tube Modules. Include a discussion of all problem areas (past, present and potential) indicating actions taken and planned for mitigation.

1. Significant procurements and contracts and their rationale
2. Coil processing and coupon outgassing results
3. Qualification of fixtures and equipment
4. Transportation/Storage of tube sections
5. Mobilization

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

Purpose: To demonstrate readiness for starting field installation.

Preparation Instructions: Provide information describing the preparations for installing the Beam Tube Modules. Include a discussion of all problem areas (past, present and potential) indicating actions taken and plans for mitigation.

1. Significant procurements and contracts
2. Qualification of fixtures and equipment
3. Staged start of installation
4. Mobilization

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 electronic file copies of the spreadsheet time-pressure-temperature record of each module pumpdown, including the following:

a. Log data at a maximum sampling period of 15 minutes.

b. Record apparatus state vectors: valve positions, pump states, LN_2 trap states, etc.

c. Provide an "electronic notebook," or test log file of activities.

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

Purpose: To communicate leak test data for each module.

Preparation Instructions: Provide test data as listed below.

a. RGA calibration with CO, CO_2, CH_4, Kr, Air

b. Absolute outgassing rates for H_2, CO, CO_2, CH_4

c. Air signature leakage calculations results using N_2 and A by means of either the χ^2 algorithm provided which measures 42 amu in a 21 gas model or the Balzers QAM gas analysis software if found appropriate

d. An "electronic notebook," or test log file, of activities

e. Leak localization data, if required, including: solution of simultaneous equations for the leak positions and sizes, instrument offsets determined from valve closures, the error matrix

f. The full history of leak measurements done by HMS including the exact location of leaks found and the method of repair

Data Requirements Description (DRD)
Completion Review Data Package, DRD No. 18

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 certification.

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. 19

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. 20

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. 21

Purpose: To communicate nonconformances.

Preparation Instructions: Photocopy standard form(s).