Doc

CALIFORNIA INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project

To: Distribution
From: L. Jones *L Jones*
Phone: 2970
Refer to: LIGO-E960105-00-B
Date: July 5, 1996

Subject: Beam Tube Alignment

A meeting will be held in the ECR at 1:00 pm on Wednesday, July 10 to determine significant elements of beam tube alignment. Please plan to attend. The results of this meeting will be communicated to CBI at a meeting at Hanford on July 15. Issues are listed below, with background information and proposed actions.

Issue #1: determine the optimum height of the beam tube axis:

Now that the slabs have been constructed we should review the possibility of applying a slight bias to the vertical location of the beam tube axis, referenced to nominal. We will have 150 mm total vertical adjustment available at each beam tube support after tube installation, less slab height variations. This can be centered, for equal range, upward and downward (this is our base plan, assuming a perfect slab installation).

Depending upon the as-built height of the beam tube slabs, we may wish to bias the axis height to account for slab installation errors. The initial survey data taken by RSI is attached, along with a plot for visualization. Slab installation height (measured at the slab centerline) was well within tolerances; of +/- 25 mm allowable, variance ranged from +18 mm to -12 mm, with an average of 4.5 mm on Arm #1 and 6.5 mm on Arm #2.

Proposal #1: We should have the beam tube installed at the currently planned height, relative to nominal. Since the slabs average 5.5 mm above nominal, this will provide (on average) for 5.5 mm additional settlement and 5.5 mm less adjustment for upwards displacement, than previously planned. Putting it another way, our "worst case" adjustments will be limited to 63 mm upward and 57 mm downward. This will not change the grouting plans for the vacuum equipment.

Issue #2: one GPS measurement vs. two:

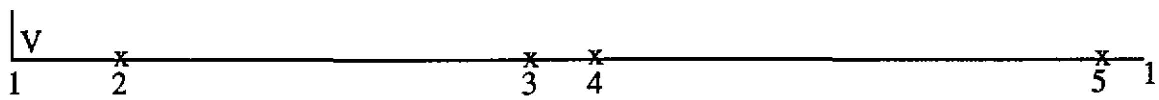
An open issue with CBI on their tube alignment procedure has to do with how many GPS readings they should take at each tube support. CBI appeared to be arguing for two measurements of a given hardware setup (for increased confidence) at the 5/16 status meeting. Since then, it was determined that CBI's plan is to install the tube to crude tolerances, take a GPS reading to determine required adjustments, make those adjustments, and take a final GPS "as-built" reading to confirm proper adjustment. This second GPS reading thus serves the purpose of verifying that the tube was adjusted properly.

Proposal #2: We should approve CBI's plan to take the two GPS readings as described. This will be followed by negotiations to determine the appropriate cost change for the alignment task.

Issue #3: specifying vs. marking the BT/VE interface locations:

We are contractually required to provide CBI with "Beam tube module termination interface locations on the slab for each module; ....." At the time of the updated design review, CBI indicated that they planned to use GPS coordinates supplied by LIGO to define and locate the eight interface locations, instead of marks on the slabs, and most of us felt that was preferable. Then PSI submitted their requested tolerances on the interface locations (attached) which are tighter than can be expected from GPS measurements. Assuming the requested tolerances are necessary, means other than GPS would need to be employed to define the interface locations.

Proposal #3: We should stick with our contractual plans and provide CBI with slab reference marks at each BT/VE interface. The outline of steps for providing these four slab marks per arm at Hanford would be as outlined below (see also LIGO-D950021, attached). These tolerances meet PSI's requested axial tolerance and perpendicularity tolerance but do not meet their requested transverse tolerance, which is believed to be overly constrained. This will be checked prior to the July 10 meeting.



1. Using LIGO-provided coordinates and the reference monument system, establish/confirm alignment points on stakes at the vertex (1) and near the end of each beam tube axis (1).
2. Establish BT/VE interface mark #2 on the termination foundation (marker details TBD--typical) located 46.000 m +/- 0.003 m from the vertex and on the beam tube axis +/- 0.005 m, projected to the foundation surface.
3. Establish BT/VE interface mark #3 on the termination foundation on the vertex side of the mid station, 1961.500 m +/- 0.012 m from mark #2 and on the beam tube axis +/- 0.005 m, projected to the foundation surface.
4. Establish BT/VE interface mark #4 on the termination foundations on the side away from the vertex of the mid station, 19.500 m +/- 0.003 m from mark #3 and on the beam tube axis +/- 0.005 m, projected to the foundation surface.
5. Establish BT/VE interface mark on the termination foundation at the end station, 1961.500 m +/- 0.012 m from mark #4 and on the beam tube axis, +/- 0.005 m, projected to the foundation surface.

These steps will likely call for a combination of GPS and optical/tape measurements to accomplish.

Issue #4: LIGO's QC checks of CBI's alignment:

What is the best way for LIGO to gain confidence in CBI's alignment of the beam tube?

Proposal #4: We should follow the following principles:

1. Checks should be made using GPS rather than alternative methods (this will probably be the least expensive means of satisfying our precision requirements).
2. Checks should be made prior to the installation of beam tube enclosure covers (this is the last time a GPS measurement can be efficiently be made directly on the beam tube support).
3. Checks should be made independently of CBI's personnel and equipment (this is a more confident overall check). To effect this, the fixture that positions a GPS antenna on a support will need to be procured.
4. Checks should be made between the time that CBI has finished with a support and the time that enclosure covers are close enough to disturb the reading (this follows from item 2).
5. Checks should be made according to the following schedule, per module:

Tube Section Sequence Number	Alignment Check Schedule
Sections 001-005	Every tube section
Sections 006-050	Every fifth tube section
Sections 051-100	Every tenth tube section

6. Additional measurements: approximately one month after the enclosure covers have been installed, measurements should be taken of the "slab nails," that were installed (and measured) by CBI, at every support. These readings are not quality checks on CBI, but will provide "as-built" measurements which will include the effect of initial slab settlement under the weight of the enclosure covers. This measurement will require design and procurement of a special fixture to securely hold the GPS antenna over the slab nail and high enough above the enclosure to eliminate multipath problems.

Issue #5: GPS training opportunity:

CBI is planning on having the GPS equipment supplier to provide GPS training at Hanford, and has invited LIGO personnel to be included in this training.

Proposal #5: we should take advantage of this opportunity and have at least one member of the operations staff from each site participate, assuming schedule permits.

Distribution:

Mark Coles	Dennis Coyne	*Cecil Franklin	Albert Lazzarini
*Otto Matherny	Allen Sibley	Bill Tyler	Bill Althouse
*Rai Weiss	*John Worden		

*via teleconference; Jones will initiate calls

cc:
F. Asiri
B. Barish
G. Sanders
G. Stapfer
Chronological File
Document Control Center

FILE 3.2.3.3

RECEIVED 6-17-96

PARSON'S INFRASTRUCTURE & TECHNOLOGY

CC: FRED ASIRI
OTTO MATHER
TIM MELOTT
3.2.1.7

SURVEYING DATA
FIELD NOTES

LIGO HANFORD, WASHINGTON SITE

CONTRACT NO.: PC194932
LIGO-C960516-00-0

WORK RELEASE NO.: RSI-007

RSI JOB NO. 17096

BY: ROGER'S SURVEYING, INC. 1996

ROGERS SURVEYING, INC.
RSI Project No.: 17096

Work Order No.: RSI-007
June 13, 1996

PARSON'S INFRASTRUCTURE & TECHNOLOGY

AS-BUILT TOP OF SLAB - SOUTHWEST ARM
LIGO HANFORD PROJECT

Station	Description	Top of Concrete Elevation	Plan Elevation	Variance
1+65.5				
	5' LT	533.78	533.78	0.00
	C/L	533.78	533.78	0.00
	5' RT	533.79	533.78	0.01
5+50	C/L	533.79	533.77	0.02
8+96.37				
	5' LT	533.78	533.78	0.00
	C/L	533.79	533.78	0.01
	5'RT	533.79	533.78	0.01
11+00	C/L	533.80	533.80	0.00
16+76.37				
	5' LT	533.85	533.86	-0.01
	C/L	533.85	533.86	-0.01
	5' RT	533.85	533.86	-0.01
23+50	C/L	533.93	533.93	0.00
24+56.37				
	5' LT	533.94	533.94	0.00
	C/L	533.95	533.94	0.01
	5' RT	533.94	533.94	0.00
29+00	C/L	533.99	533.98	0.01
32+36.37				
	5' LT	534.03	534.02	0.01
	C/L	534.03	534.02	0.01
	5' RT	534.02	534.02	0.00
38+50	C/L	534.11	534.12	-0.01
40+16.37				
	5' LT	534.15	534.15	0.00
	C/L	534.15	534.15	0.00
	5' RT	534.14	534.15	-0.01
44+00	C/L	534.24	534.25	-0.01
47+96.37				
	5' LT	534.35	534.35	0.00
	C/L	534.35	534.35	0.00
	5' RT	534.35	534.35	0.00

ROGERS SURVEYING, INC.
RSI Project No.: 17096

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PARSON'S INFRASTRUCTURE & TECHNOLOGY

AS-BUILT TOP OF SLAB - SOUTHWEST ARM
LIGO PROJECT

Station	Description	Top of Concrete Elevation	Plan Elevation	Variance
55+76.37				
	5' LT	534.56	534.54	0.02
	C/L	534.57	534.54	0.03
	5' RT	534.57	534.54	0.03
61+50	C/L	534.74	534.68	0.06
65+78.20				
	5' LT	534.83	534.80	0.03
	C/L	534.81	534.80	0.01
	5'RT	534.82	534.80	0.02
66+57.30				
	5' LT	534.84	534.81	0.03
	C/L	534.84	534.81	0.03
	5' RT	534.84	534.81	0.03
73+50	C/L	535.09	535.09	0.00
76+63.16				
	5' LT	535.19	535.17	0.02
	C/L	535.20	535.17	0.03
	5' RT	535.20	535.17	0.03
79+00	C/L	535.28	535.26	0.02
84+43.16				
	5' LT	535.50	535.47	0.03
	C/L	535.51	535.47	0.04
	5' RT	535.50	535.47	0.03
90+00	C/L	535.70	535.70	0.00
92+23.16				
	5' LT	535.79	535.79	0.00
	C/L	535.80	535.79	0.01
	5' RT	535.81	535.79	0.02
95+50	C/L	535.94	535.93	0.01
100+03.16				
	5' LT	536.14	536.14	0.00
	C/L	536.15	536.14	0.01
	5' RT	536.15	536.14	0.01

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PARSON'S INFRASTRUCTURE & TECHNOLOGY

AS-BUILT TOP OF SALB - SOUTHWEST ARM

LIGO PROJECT

Station	Description	Top of Concrete Elevation	Plan Elevation	Variance
106+00	C/L	536.48	536.43	0.05
107+83.16				
	5' LT	536.58	536.54	0.04
	C/L	536.59	536.54	0.05
	5' RT	536.60	536.54	0.06
111+00	C/L	536.72	536.70	0.02
115+63.16				
	5' LT	536.95	536.95	0.00
	C/L	536.96	536.95	0.01
	5'RT	536.96	536.95	0.01
117+50	C/L	537.07	537.06	0.01
123+43.16				
	5' LT	537.41	537.39	0.02
	C/L	537.41	537.39	0.02
	5' RT	537.42	537.39	0.03
130+77.50				
	5' LT	537.88	537.84	0.04
	C/L	537.88	537.84	0.04
	5' RT	537.88	537.84	0.04

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PARSON'S INFRASTRUCTURE & TECHNOLOGY

AS-BUILT TOP OF SLAB - NORTHWEST ARM

LIGO HANFORD PROJECT

Station	Description	Top of Concrete Elevation	Plan Elevation	Variance
130+77.50				
	5' LT	529.67	529.63	0.04
	C/L	529.68	529.63	0.05
	5' RT	529.67	529.63	0.04
127+00	C/L	529.68	529.64	0.04
123+40.16				
	5' LT	529.68	529.65	0.03
	C/L	529.68	529.65	0.03
	5'RT	529.69	529.65	0.04
121+00	C/L	529.66	529.66	0.00
115+60.16				
	5' LT	529.68	529.70	-0.02
	C/L	529.67	529.70	-0.03
	5' RT	529.68	529.70	-0.02
110+50	C/L	529.72	529.74	-0.02
107+80.16				
	5' LT	529.75	529.77	-0.02
	C/L	529.75	529.77	-0.02
	5' RT	529.75	529.77	-0.02
104+50	C/L	529.78	529.80	-0.02
100+06.16				
	5' LT	529.82	529.87	-0.05
	C/L	529.83	529.87	-0.04
	5' RT	529.84	529.87	-0.03
94+50	C/L	529.97	529.96	0.01
92+20.16				
	5' LT	530.03	530.01	0.02
	C/L	530.02	530.01	0.01
	5' RT	530.02	530.01	0.01
88+50	C/L	530.10	530.08	0.02
84+40.16				
	5' LT	530.17	530.16	0.01
	C/L	530.18	530.16	0.02
	5' RT	530.18	530.16	0.02

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PARSON'S INFRASTRUCTURE & TECHNOLOGY

AS-BUILT TOP OF SLAB - NORTHWEST ARM

LIGO PROJECT

Station	Description	Top of Concrete Elevation	Plan Elevation	Variance
76+60.16				
	5' LT	530.36	530.36	0.00
	C/L	530.35	530.36	-0.01
	5' RT	530.35	530.36	-0.01
71+50	C/L	530.51	530.49	0.02
66+57.30				
	5' LT	530.67	530.65	0.02
	C/L	530.67	530.65	0.02
	5'RT	530.69	530.65	0.04
65+78.20				
	5' LT	530.70	530.66	0.04
	C/L	530.69	530.66	0.03
	5' RT	530.70	530.66	0.04
59+50	C/L	530.91	530.87	0.04
55+73.37				
	5' LT	531.02	531.01	0.01
	C/L	531.03	531.01	0.02
	5' RT	531.03	531.01	0.02
54+50	C/L	531.07	531.05	0.02
47+93.37				
	5' LT	531.34	531.29	0.05
	C/L	531.35	531.29	0.06
	5' RT	531.35	531.29	0.06
44+00	C/L	531.49	531.45	0.04
40+13.37				
	5' LT	531.67	531.62	0.05
	C/L	531.67	531.62	0.05
	5' RT	531.67	531.62	0.05
39+00	C/L	531.71	531.67	0.04
34+00	C/L	531.94	531.90	0.04

ROGERS SURVEYING, INC.
RSI Project No.: 17096

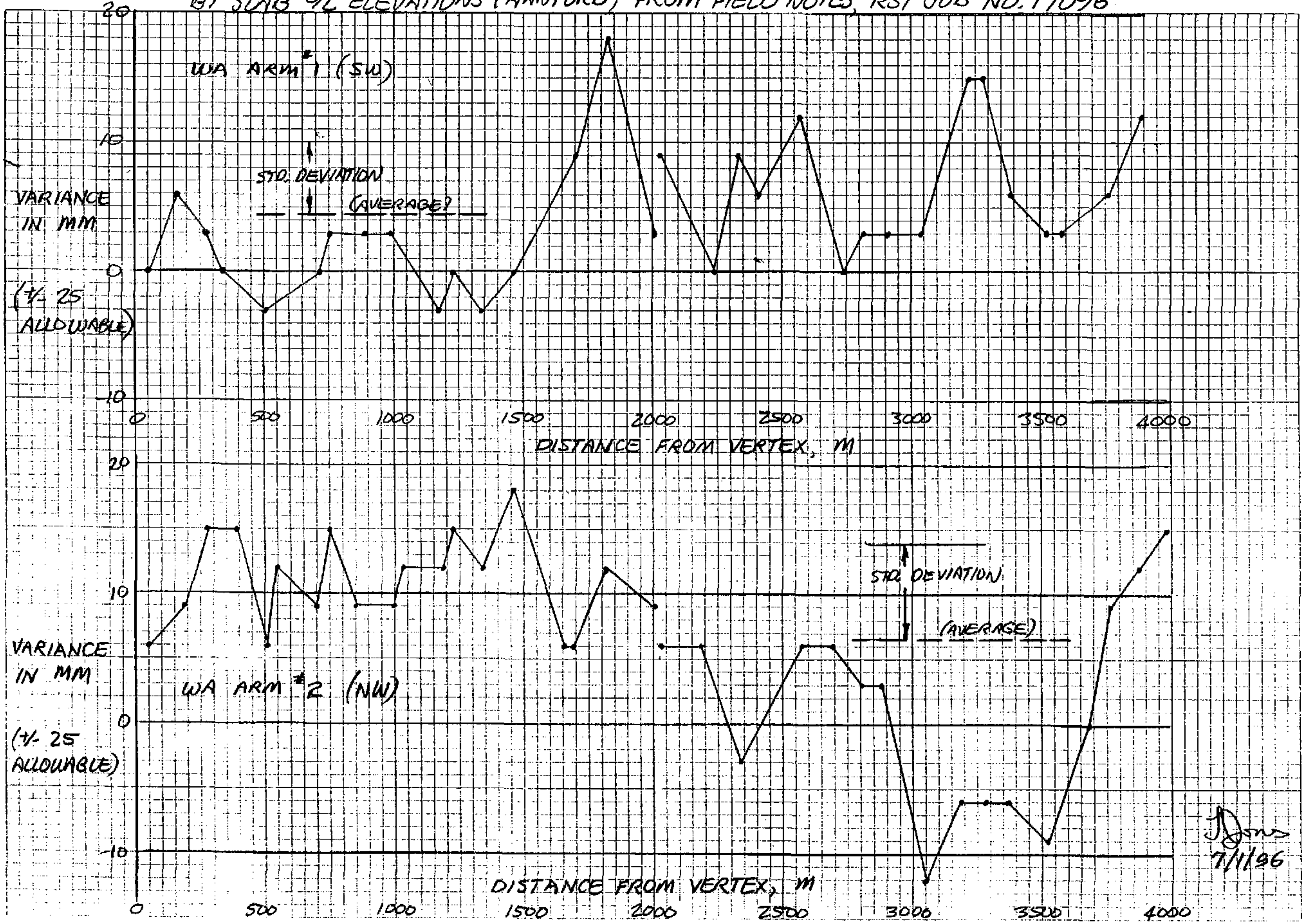
Work Order No.: RSI-007
June 13, 1996

PARSON'S INFRASTRUCTURE & TECHNOLOGY

AS-BUILT TOP OF SLAB - NORTHWEST ARM
LIGO PROJECT

Station	Description	Top of Concrete Elevation	Plan Elevation	Variance
32+33.37				
	5' LT	532.01	531.98	0.03
	C/L	532.01	531.98	0.03
	5' RT	532.02	531.98	0.04
28+00	C/L	532.22	532.19	0.03
24+53.37				
	5' LT	532.42	532.37	0.05
	C/L	532.42	532.37	0.05
	5' RT	532.42	532.37	0.05
23+00	C/L	532.48	532.45	0.03
18+00	C/L	532.76	532.72	0.04
16+73.37				
	5' LT	532.83	532.81	0.02
	C/L	532.83	532.81	0.02
	5'RT	532.83	532.81	0.02
13+00	C/L	533.05	533.00	0.05
8+93.37				
	5' LT	533.28	533.23	0.05
	C/L	533.28	533.23	0.05
	5' RT	533.27	533.23	0.04
6+00	C/L	533.44	533.41	0.03
1+65.50				
	5' LT	533.70	533.68	0.02
	C/L	533.70	533.68	0.02
	5' RT	533.70	533.68	0.02

BT SLAB C/L ELEVATIONS (HANFORD) FROM FIELD NOTES, RSI JOB NO. 17096



LIGO-C960854-00-V

PROCESS SYSTEMS INTERNATIONAL, INC.
20 Walkup Drive, Westborough, MA 01581

LIGO PROJECT FAX COVER SHEET

V049-PL-150

TO: John Worden

SENDING FAX NO.: (508) 898-0322

SENDER: D. McWilliams

TELEPHONE NO.: (508) 898-0382

c/o Ms. Linda Turner
M/S 51-33
Fax: (818) 304-9834

DATE: April 19, 1996

SUBJECT: **Beam Tube Gate Valves Alignment Criteria**

Project Needs List Item V049-NL-LP- 49

PSI requires the Beam Tube Gate Valves to be aligned to meet the following criteria. All dimensions refer the gate valve body flange face.

Axial: +/- 1/8" referenced to the nominal offset from the VE/ BT interface.

Transverse: +/- 0.080" referenced to the Design Optical Axis.

Angularity: +/- .125 degrees maximum at the flange bolt circle referenced to the vertical plane along the Design Optical Axis.

Perpendicularity: +/-0.030" at the flange bolt circle referenced to the Design Optical Axis

cc: **Project File** V049-PL-150

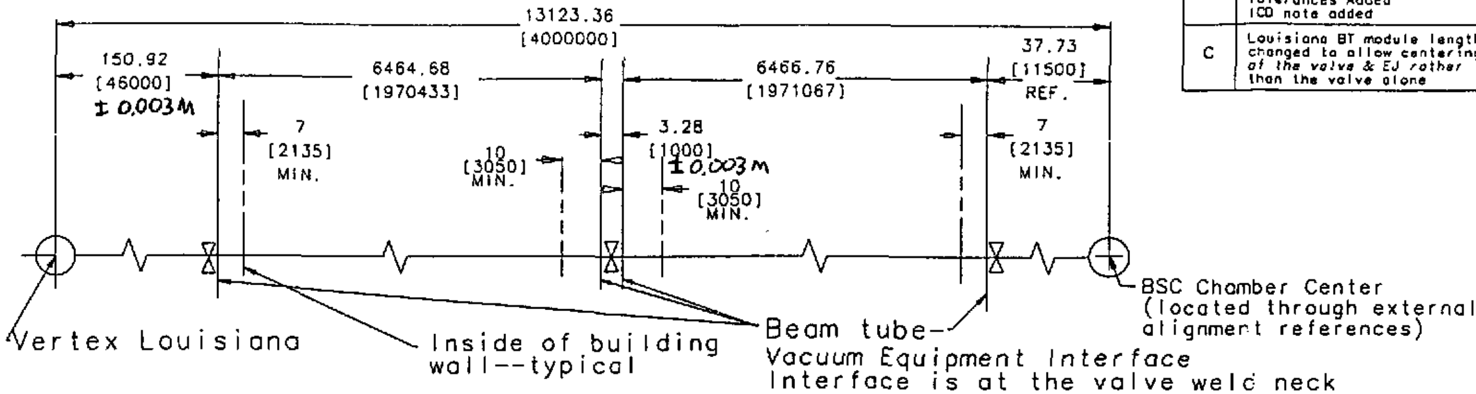
SHT 1 of 1

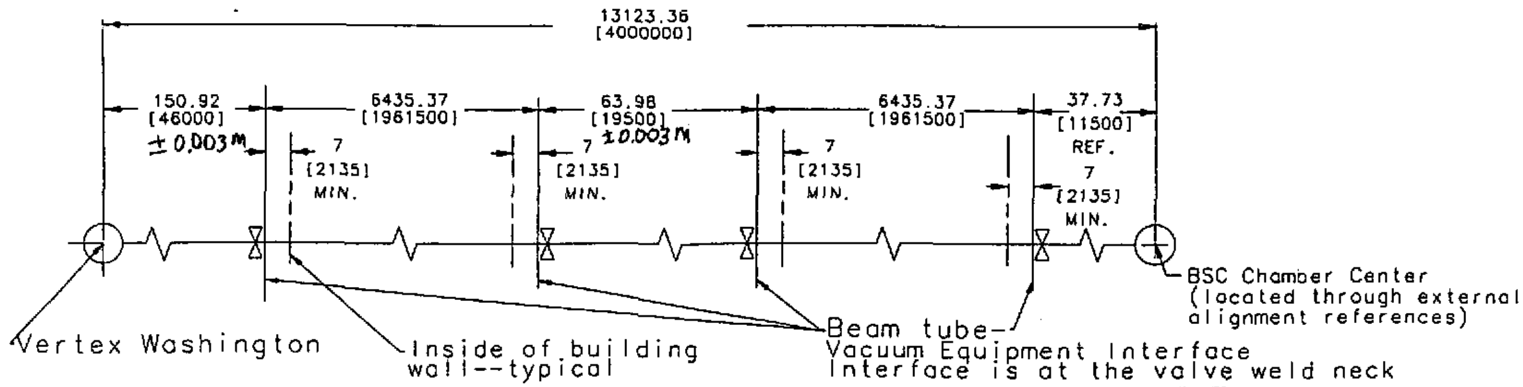
R. Bagley
D. McWilliams

NOTES: (UNLESS OTHERWISE SPECIFIED)

(1) ICD INFORMATION: This drawing contains interface information.

REV	DESCRIPTION OF CHANGE	APPROVAL	DATE
A	Original		3/24/95
B	Lengths changed English units added TMCs eliminated Tolerances Added ICD note added		10/6/95
C	Louisiana BT module lengths changed to allow centering of the valve & EJ rather than the valve alone	DCN C960023	2/26/96





DRAFT OF CHANGES FOR REV. D:
CLOSER TOLERANCES SPECIFIED AS SHOWN FOR CORNER & MID POSITIONS
[signature] 7/4/96

Legend:
Gate Valve
BSC

QTY REQD	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN ft [mm] TOLERANCES ARE: ft ± 0.5 in; mm ± 12 mm; DO NOT SCALE DRAWING	APPROVALS	DATE	LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY
	DRAWN D. Coyne DCC	2/26/96	TITLE LIGO ARM LAYOUTS
	CHECKED L. Jones LKJ	2/26/96	
	F. Asiri	2/26/96	
	J. Worden	2/?/96	SIZE A3 DWG NO. D950021 REV ~~B~~ C
MATERIAL NA	M. Coles	2/28/96	
FINISH NA	A. Lazzarini	2-26-96	SCALE NTS SHEET 1 of 1

FAX COVER PAGE

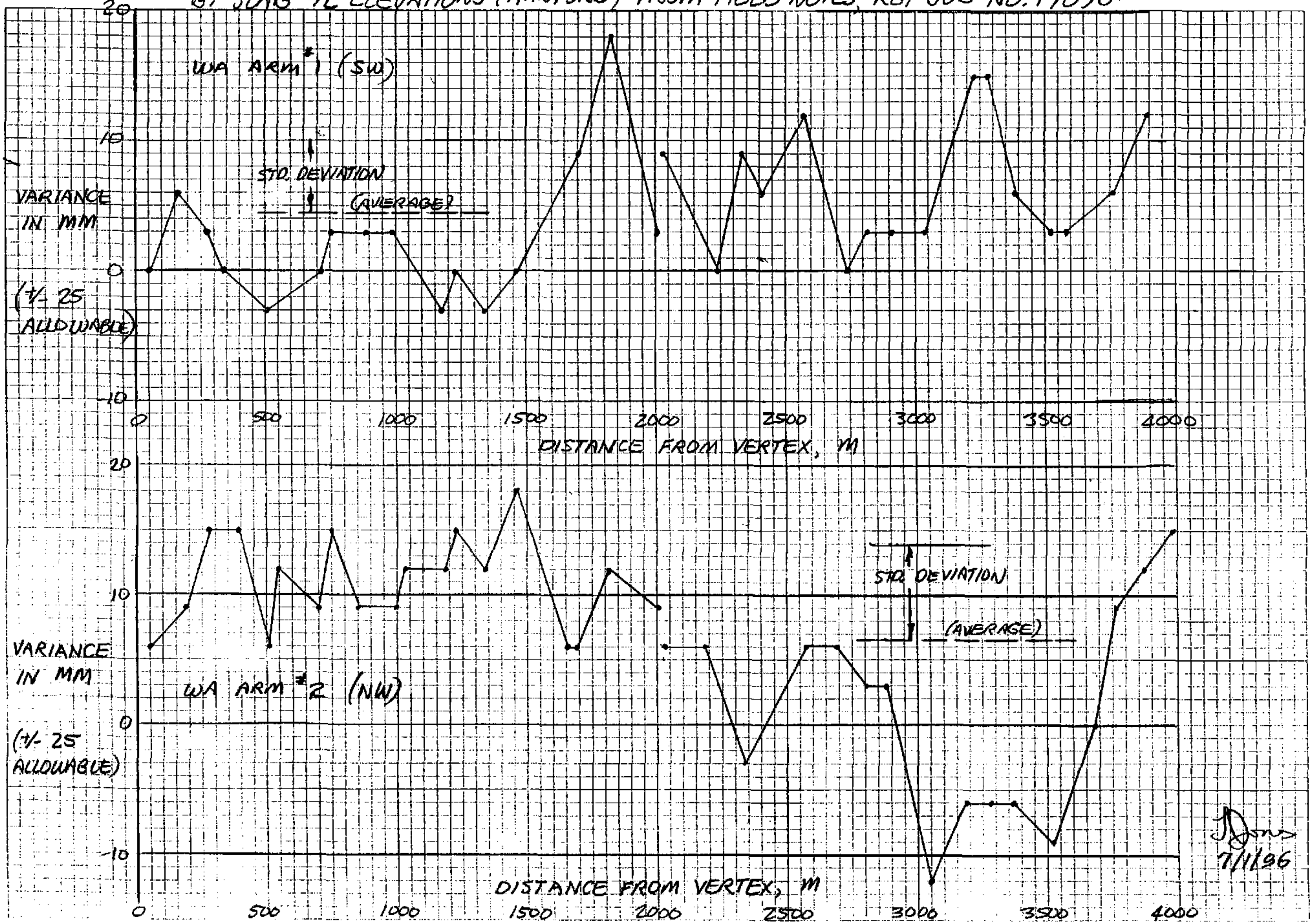
CALIFORNIA INSTITUTE OF TECHNOLOGY

LIGO Project, 51-33 East Bridge Laboratory, Pasadena, California 91125
818-395-2970, Fax 818-304-9834

TO:	Rai Weiss
ORGANIZATION:	LIGO/MIT
FAX NUMBER:	(617) 253-7014
VOICE NUMBER:	(617) 253-3527
DATE:	7/8/96

FROM:	Larry Jones
ORGANIZATION:	LIGO Project
FAX NUMBER:	(818) 304-9834
VOICE NUMBER:	(818) 395-2970
REFER TO:	LIGO-E960105-00-B
SUBJECT:	missing pages
NUMBER OF PAGES FAXED INCLUDING THIS COVER SHEET:	4

BT SLAB C/L ELEVATIONS (HANFORD) FROM FIELD NOTES, RSI JOB NO. 17096



L160-C960854-00-V

PROCESS SYSTEMS INTERNATIONAL, INC.
20 Walkup Drive, Westborough, MA 01581

LIGO PROJECT FAX COVER SHEET

V049-PL-150

TO: John Worden

c/o Ms. Linda Turner
M/S 51-33
Fax: (818) 304-9834

SENDING FAX NO.: (508) 898-0322

SENDER: D. McWilliams

TELEPHONE NO.: (508) 898-0382

DATE: April 19, 1996

SUBJECT: **Beam Tube Gate Valves Alignment Criteria**

Project Needs List Item V049-NL-LP-49

PSI requires the Beam Tube Gate Valves to be aligned to meet the following criteria. All dimensions refer the gate valve body flange face.

Axial: +/- 1/8" referenced to the nominal offset from the VE/ BT interface.

Transverse: +/- 0.080" referenced to the Design Optical Axis.

Angularity: +/- .125 degrees maximum at the flange bolt circle referenced to the vertical plane along the Design Optical Axis.

Perpendicularity: +/-0.030" at the flange bolt circle referenced to the Design Optical Axis

cc: Project File V049-PL-150

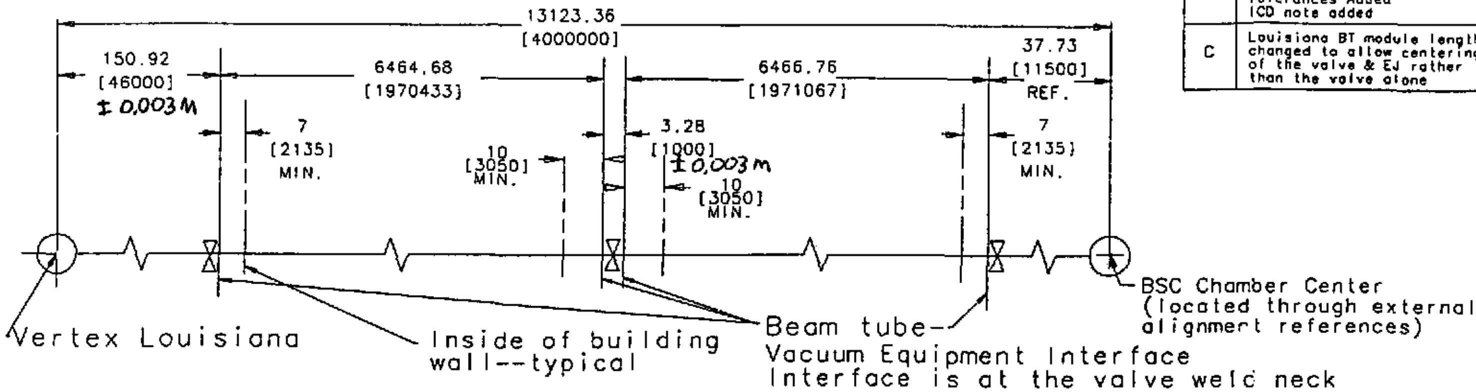
R. Bagley
D. McWilliams

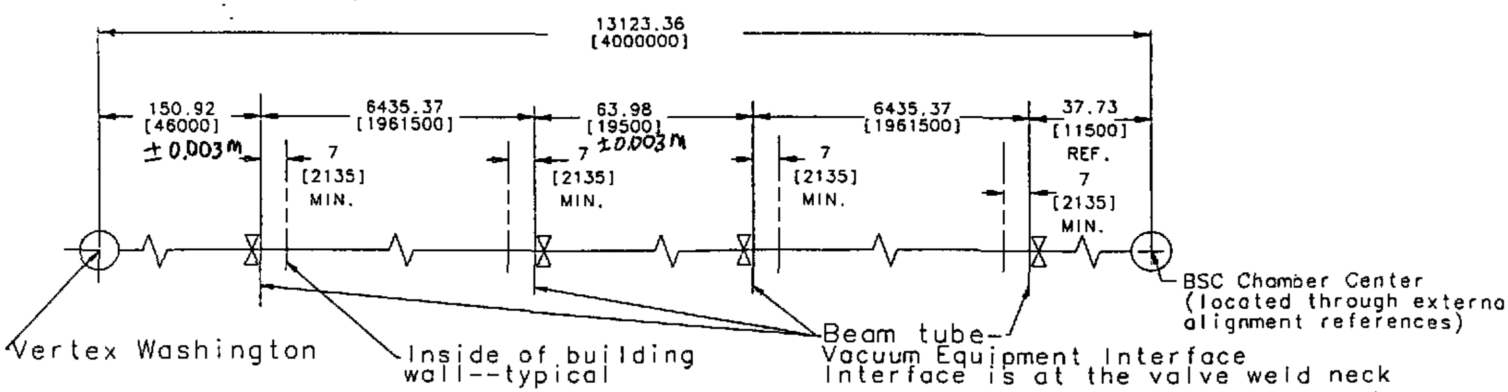
SHT 1 of 1

NOTES: (UNLESS OTHERWISE SPECIFIED)

(1) ICD INFORMATION: This drawing contains interface information.

REV	DESCRIPTION OF CHANGE	APPROVAL	DATE
A	Original		3/24/95
B	Lengths changed English units added TMCs eliminated Tolerances Added ICD note added		10/6/95
C	Louisiana BT module lengths changed to allow centering of the valve & EJ rather than the valve alone	DCN C960024	2/26/96





DRAFT OF CHANGES FOR REV. D:

CLOSER TOLERANCES SPECIFIED AS SHOWN FOR CORNER & MID POSITIONS

[signature] 7/4/96

Legend:

⧖ Gate Valve

◯ BSC

QTY REQD	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN ft [mm] TOLERANCES ARE: ft ± 0.5 in; mm ± 12 mm; DO NOT SCALE DRAWING	APPROVALS	DATE	LIGO	CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY
	DRAWN D. Coyne	DCC 2/26/96	TITLE	LIGO ARM LAYOUTS
	CHECKED L. Jones	LKJ 2/26/96		
	F. Asiri	FBA 2/26/96		
MATERIAL NA	J. Worden	JW 2/26/96	SIZE A3	DWG NO. D950021 REV ~~B~~ C
FINISH NA	M. Coles	MC 2/28/96	SCALE NTS	SHEET 1 of 1
	A. Lazzarini	AL 2/26/96		