NSF Presentation -

Subcontract

for

ELECTRICAL CONTRACTOR SERVICES

for the

Beam Tube Bakeout

at

LIGO Livingston Observatory

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July 1999

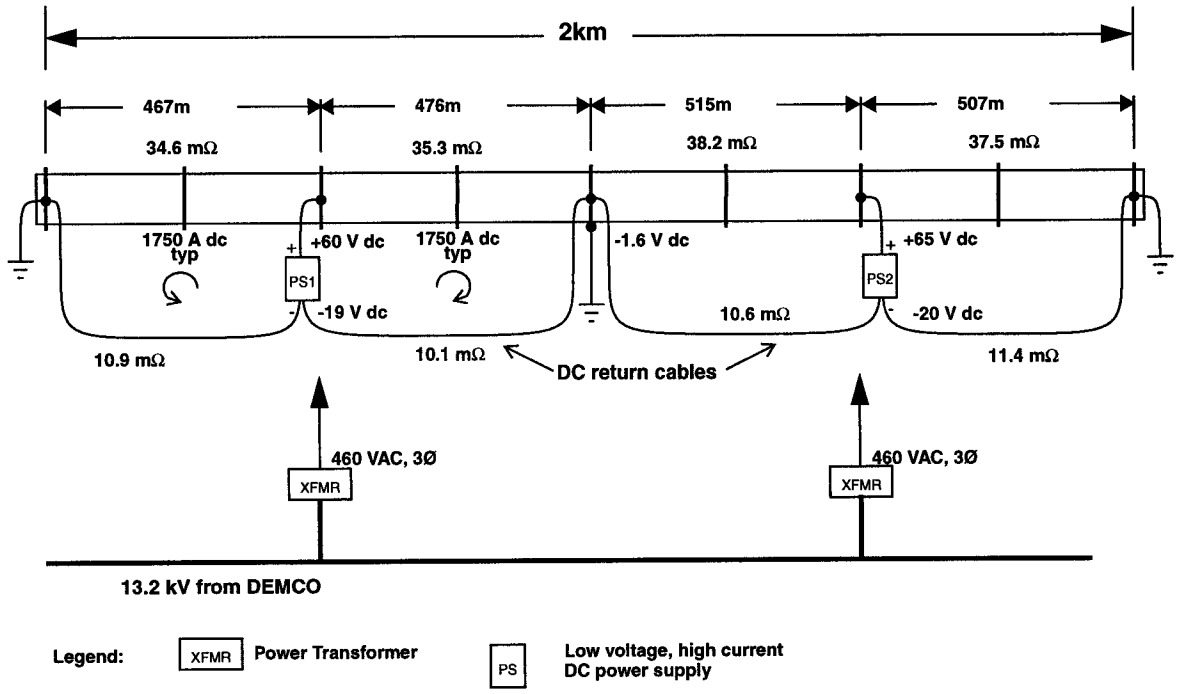
Procurement Sensitive Document -

Do Not Distribute

Background
Beam Tube Bakeout

- Technical need
  - Reduce optical noise due to gas pressure in beam tube
  - Reduce contaminants to minimize risk to optics
  - Method: 168 C, 7 days: 2000 amps through tube wall
- Completed bakeout of beam tubes at LHO
  - Results met or exceeded goals for advanced LIGO
  - Proved basic design, procedures
  - Improved measurement sensitivity, shortened time at temperature
- Hanford bakeout electrical contractor
  - Sun River Electric built/assembled portable bakeout electrical equipment
  - fine-tuned the choreography, optimized the level of effort required
- Sun River met the cost/hour targets established at the beginning of their contract

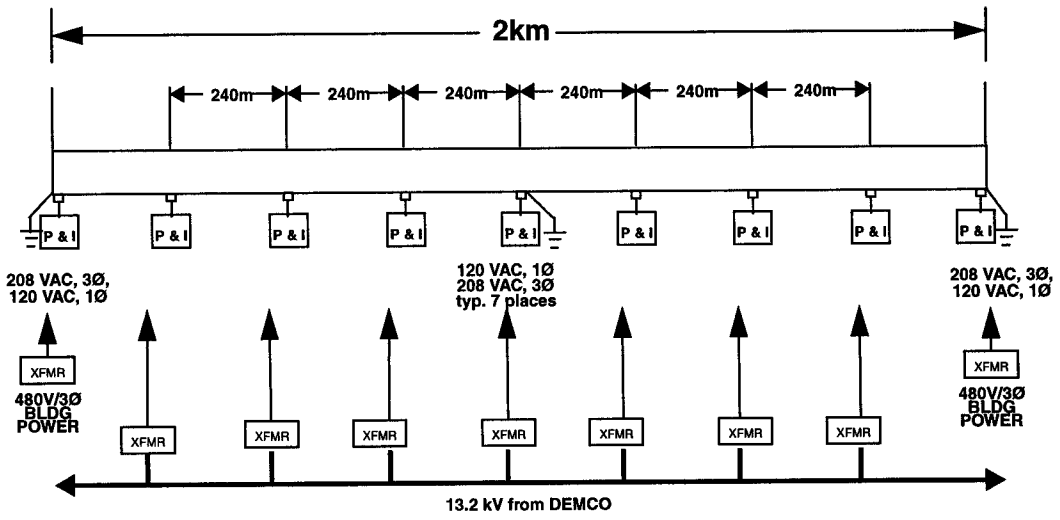
BEAM TUBE BAKEOUT DC POWER SUPPLY CONNECTIONS



Legend: XFMR Power Transformer

PS Low voltage, high current DC power supply

BEAM TUBE BAKEOUT
ELECTRICAL POWER FOR PUMPS AND INSTRUMENTATION



Legends:

Pump Port

P & I Pumps & Instrumentation

Table 1: LIGO Hanford Observatory Beam Tube Bakeout Results

	Outgassing Rates Corrected to 23 °C (all except H_2 are upper limits)					
molecule	**Goal***	**HY2**	**HY1**	**HX1**	**HX2**	**Unit**
H_2	4.7	4.8	6.3	5.2	4.6	$\times 10^{-14}$ torr•liters/sec/cm^2
CH_4	48000	< 900	< 220	< 8.8	< 95	$\times 10^{-20}$ torr•liters/sec/cm^2
H_2O	1500	< 4	< 20	< 1.8	< 0.8	$\times 10^{-18}$ torr•liters/sec/cm^2
CO	650	< 14	< 9	< 5.7	< 2	$\times 10^{-18}$ torr•liters/sec/cm^2
CO_2	2200	< 40	< 18	< 2.9	< 8.5	$\times 10^{-19}$ torr•liters/sec/cm^2
$NO+C_2H_6$	7000	< 2	< 14	< 6.6	< 1.0	$\times 10^{-19}$ torr•liters/sec/cm^2
$H_nC_pO_q$	50–2†	< 15	< 8.5	< 5.3	< 0.4	$\times 10^{-19}$ torr•liters/sec/cm^2
air leak	1000	< 20	< 10	< 3.5	< 16	$\times 10^{-11}$ torr•liter/sec

*Goal: maximum outgassing to achieve pressure equivalent to 10^{-9} torr H_2 using only pumps at stations
†Goal for hydrocarbons depends on weight of parent molecule; range given corresponds with 100–300 AMU

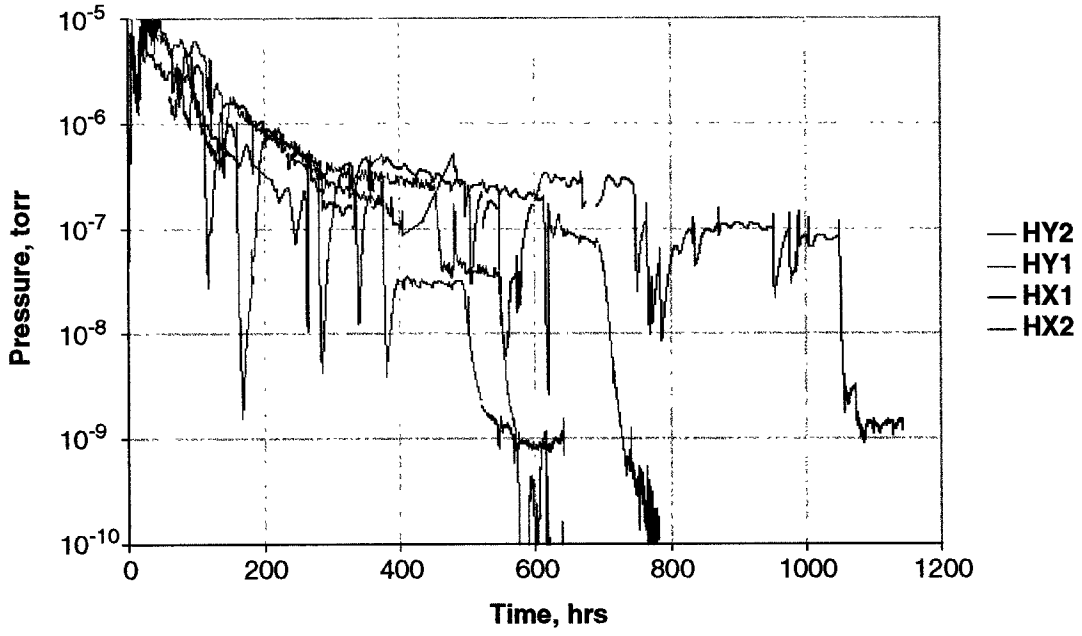
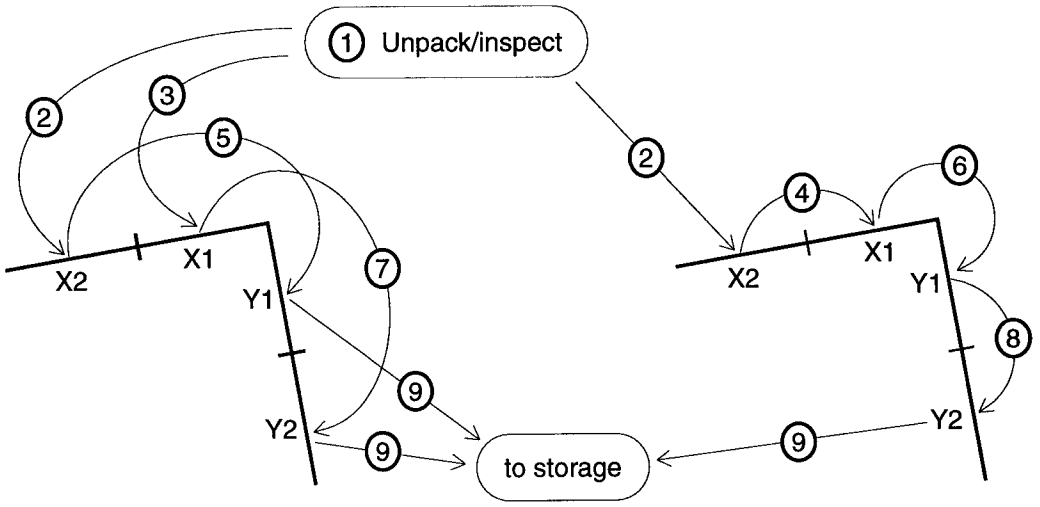


FIGURE 1: Evolution of H_2O partial pressure during the beam tube bakeouts at LHO.

Role of Electrical Contractor in Beam Tube Bakeout

- Receive fully assembled portable equipment assemblies from LHO
- Install portable equipment assemblies
  - AC transformer/panelboards (10 assemblies)
  - DC power supply trailers (4 assemblies)
  - Beam tube connections (2 sets)
  - DC cables (1 set)
  - Heater jackets and controllers (1 set)
- Assist commissioning and troubleshooting initial (X2) setup at LLO
- Move portable equipment to next modules
  - Intermittent work
- Pack equipment for shipment off of LLO site

Role of Electrical Contractor in Beam Tube Bakeout (con'd)



AC Panelboards &
DC supplies (2 sets)

DC return cables &
D-2 junction boxes

TASK NO.	TASK DESCRIPTION
1	Unpack and inspect equipment
2	Install 1st set of equipment at X2
3	Install 2nd set of AC/DC power supplies at X1
4	Move DC cables to X1
5	Move 1st set of AC/DC power supplies from X2 to Y1
6	Move DC cables to Y1
7	Move 2nd set of AC/DC power supplies from X1 to Y2
8	Move DC cables to Y2
9	Prepare equipment for shipment to storage

Why Time and Materials Subcontract?

- Bakeout equipment is not standard electrical equipment, it has been especially designed to make efficient moves from module to module
  - ›› ...but contractors have no experience with it
- Our experience at Hanford allows us to make accurate estimates of work content
- Contractor responsibilities
  - ›› Furnish suitable and adequate manpower when needed
  - ›› Provide technical supervision for electrical work
  - ›› Coordinate utility service connections/disconnections
  - ›› Obtain permits, arrange inspections

Bakeout Electrical Services Procurement

- Advertised, contacted known local contractors
- Five companies requested RFPs, 4 attended pre-proposal conference, 3 proposals received
- Estimates of work content: 8,283 hrs, 8,633 hrs, 11,562 hrs
- T&M rates (adjusted to include equipment usage): $22.81/hr, 25.69/hr, 27.63/hr
- In evaluating proposals, we judged that the three were equally capable of doing the work; MMR scored highest because of lowest T&M rate ($22.81/hr)
- During negotiation, MMR personnel agreed to work at achieving the target work hours which were attained by Sun River.

Subcontract Management

- LIGO on-site engineer will be responsible for all MMR work
- Task definitions, schedule goals and ceiling price spelled out in contract
- Daily review of progress, resolution of problems
- Weekly accounting of hours and expenditures by task
- Weekly measurement of progress
- Compare with target amounts, take corrective action if necessary
- Target hours and $ amounts listed in TDM #1

TECHNICAL DIRECTION MEMORANDUM

California Institute of Technology

TO *(Name of Contractor)* MMR Constructors, Inc.	Contract No. 1000084
(Address of Contractor) 15961 Airline Hwy, Baton Rouge LA 70817	TDM No. 1

THIS TDM IS ISSUED PURSUANT TO THE CONTRACT ARTICLE ENTITLED TECHNICAL DIRECTION

PURPOSE ☐ Approval ☐ Disapproval ☒ Clarification ☐ Recommendation

THE CONTRACTOR IS DIRECTED AS FOLLOWS:

This TDM documents target costs for each task listed in the Statement of Work pertaining to the beam tube bake-out. The unit labor hours for each activity area are provided in Table 1, while the target costs by task are provided in Table 2.

THE DIRECTIONS GIVEN HEREIN ARE WITHIN THE SCOPE OF THE ABOVE NUMBERED CONTRACT, AND SHALL NOT CONSTITUTE A BASIS FOR ANY CHANGE IN ANY OF THE CONTRACT PROVISIONS OR REQUIREMENTS RELATING TO QUANTITY, QUALITY, FIXED PRICE, DELIVERY OR PERFORMANCE SCHEDULE, OR ANY OTHER TERMS OF THE CONTRACT, NOR SHALL SUCH DIRECTIONS CONSTITUTE ANY CHANGE IN THE INSTITUTE'S OBLIGATION TO YOU UNDER ANY LIMITATION OF FUNDS PROVISION IN THE CONTRACT. BY YOUR ACCEPTANCE OF THIS TECHNICAL DIRECTION MEMORANDUM, YOU AGREE THAT NO CLAIMS FOR CHANGE OR ADJUSTMENT IN ANY OF THE TERMS OR PROVISIONS OF THE ABOVE NUMBERED CONTRACT WILL BE BASED UPON THE DIRECTIONS GIVEN HEREIN.

IF YOU TAKE EXCEPTION TO ANYTHING CONTAINED IN THIS MEMORANDUM, DO NOT PROCEED WITH DIRECTIONS, AND NOTIFY THE INSTITUTE'S AUTHORIZED REPRESENTATIVE, WHOSE SIGNATURE APPEARS BELOW, OF SUCH FACT AS SOON AS POSSIBLE, BUT IN ANY EVENT, NO LATER THAN FIVE (5) DAYS FROM THE DATE THIS MEMORANDUM IS RECEIVED.

SIGNED	THE CONTRACTOR ACCEPTS THIS TECHNICAL DIRECTON MEMORANDUM WITHOUT EXCEPTION
_____ _____	SIGNED
AUTHORIZED REPRESENTATIVE DATE	_____ _____
_____	AUTHORIZED REPRESENTATIVE DATE
PRINT NAME	_____ _____
_____	PRINT NAME
TITLE	_____
CALIFORNIA INSTITUTE OF TECHNOLOGY	TITLE
	CONTRACTOR

Table 1: Unit Assembly Move (Deinstall + Install) Labor Hours

Assembly Name	per unit[1]	Task 2 (=1/2 move)		Task 3 (=1/2 move)		Task 4,6,8		Task 5,7		Task 9 (=1/2 move)	
	Labor hrs	No. units	Labor hrs	No. units	Labor hrs	No. units	Labor hrs	No. units	Labor hrs	No. units	Labor hrs
A1/A3	16	(done)		5	40			5	80	10	80
A2	8	(done)		2	8			2	16	4	16
PS trailer	16	(done)		2	16			2	32	4	32
E	8	(done)		7	28			7	56	14	56
D-1 tube connects	2	85	85	85	85			85	170	170	170
D-2 junction boxes	32	5	80			5	160			5	80
DC Cables -	8	16	128[2]			16	128			16	128[2]
DC Cables +	8/8	16	16[2]			16	16			16	16[2]
TOTALS			309		177		304		354		578

[1] total hours to deinstall, move and install (at the next location) each unit
[2] includes provision for handling full reels

Table 2: Target Costs

	Item	Labor hrs	Labor $K	Matl $K	Equip $K	TOTAL $K
Task 1	Mobilize	40				
	Unpack & inspect	160				
	TOTAL	200	4.6	-0-	incl.	4.6
Task 2	Install	309				
	Troubleshoot/assist	40				
	TOTAL	349	8.0	-0-	incl.	8.0
Task 3	Install	177	4.0	-0-	incl.	4.0
Undistributed, Tasks 1, 2, 3	Superintendent	240	5.5	-0-	incl.	5.5
	SUBTOTAL, Tasks 1, 2, and 3:					**$22.0**

Table 2: Target Costs

	Item	Labor hrs	Labor $K	Matl $K	Equip $K	TOTAL $K
Tasks 4, 6, 8	Move	304				
	Troubleshoot/assist	40				
	TOTAL	344	7.8	-0-	incl.	7.8
Tasks 5, 7	Move	354	8.1	-0-	incl.	8.1
Task 9	Deinstall	578				
	Pack	240				
	TOTAL	818	18.7	-0-	incl.	18.7
Undistributed, Tasks 4-9	Superintendent	480	10.9	-0-	incl.	10.9
	SUBTOTAL, Tasks 4 through 10:					**$69.3**
SUMMARY	Task 1	200	4.6	-0-	incl.	4.6
	Task 2	349	7.9	-0-	incl.	8.0
	Task 3	177	4.0	-0-	incl.	4.0
	Task 1,2,3 undist.	240	5.5	-0-	incl.	5.5
	Task 4	344	7.8	-0-	incl.	7.8
	Task 5	354	8.1	-0-	incl.	8.1
	Task 6	344	7.8	-0-	incl.	7.8
	Task 7	354	8.1	-0-	incl.	8.1
	Task 8	344	7.8	-0-	incl.	7.8
	Task 9	818	18.7	-0-	incl.	18.7
	Task 4-9 undist	480	10.9	-0-	incl.	10.9
	TOTALS	4004	91.2	-0-	incl.	**$91.3**

LIGO Hardware Installation and Commissioning Summary Schedule

5/28/99

ID	Task Name	Duration	Start	Finish
1	***BEAM TUBE BAKEOUT - LIGO LIVINGSTON OBSERVATO***	***207 days***	***7/15/99***	***4/28/00***
2				
3	***Electrical Services for Bakeout***	***207 days***	***7/15/99***	***4/28/00***
4				
5	Award Electrical Services Contract	1 day	7/15/99	7/15/99
6	Mobilize	5 days	7/16/99	7/22/99
7	Install and Connect DC Power at X2	5 days	7/23/99	7/29/99
8	Checkout setup and verify all equipment ready for bakeout	20 days	7/30/99	8/26/99
9	Bakeout X2	20 days	8/27/99	9/23/99
10	Evaluate X2 bake	10 days	9/24/99	10/7/99
11	Install AC/DC Power, DC tube connections at X1	15 days	7/30/99	8/19/99
12	Move DC Cables to X1	5 days	10/1/99	10/7/99
13	Bakeout X1	20 days	11/1/99	11/26/99
14	Evaluate X1 bake	10 days	11/29/99	12/10/99
15	Move AC/DC Power set 1 to Y1	15 days	10/22/99	11/11/99
16	Move DC Cables to Y1	5 days	12/6/99	12/10/99
17	Bakeout Y1	20 days	1/10/00	2/4/00
18	Evaluate Y1 bake	10 days	2/7/00	2/18/00
19	Move AC/DC Power set 2 to Y2	15 days	12/27/99	1/14/00
20	Move DC Cables to Y2	5 days	2/14/00	2/18/00
21	Bakeout Y2	20 days	3/6/00	3/31/00
22	Evaluate Y2 bake	10 days	4/3/00	4/14/00
23	Pack AC/DC Power set 1, ship to storage	10 days	4/3/00	4/14/00
24	Pack AC/DC Power set 2 and other equip, ship to storage	10 days	4/17/00	4/28/00