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Field Mini-Bake Objectives and Motivations

5/14/96

Overall Objective: Define additional testing that might be suitable predictor that full 2km bake will be successful, e.g. beam tube will survive bakeout and meet LIGO vacuum requirements.

SPECIFIC OBJECTIVES:

Objective: Evaluate vacuum performance of LIGO beam tube

Motivation: re-establish performance baseline for fabrication process because of changes in fabrication of beam tube relative to the QT:

- ›› Fabrication equipment
- ›› Weld procedure
- ›› Installation equipment
- ›› Manpower
- ›› Cleaning methods
- ›› Field and factory environment

Objective: validation of effectiveness of field procedures and equipment.

Motivation: Changes in bakeout test relative to QT test:

- Instrumentation and its operation in a field environment are new to LIGO
- Interest in potential modification of bakeout parameters:
  - temperature (200 C?),
  - duration of bakeout
  - setup and operation of test equipment in field environment.
- Manpower (potentially)

Objective: Develop procedures and train manpower to conduct full module bakeout under LIGO guidance.

Motivation: We have only one (very high) outside estimate for the cost of baking out the beam tube as a "turn key" project.

- Can the bakeout be done more effectively (technically and cost savings) if done with substantial in-house participation?
- Develop staff experience for 2 km module bakeout and develop technical processes so that execution of 2 km bake out will be efficient.

Plan Guidelines

- Produce and test a section of beam tube as close as possible to actual configuration
- Perform test in same environment as 2 km bake out
- Minimize interference with CBI

Sequence of Activities:

Initial field makeup (6 days):

- Use portable clean rooms and field installation methods developed by CBI to build first two BT modules plus one expansion bellows (baseline plan)
- weld on either end while still mounted in portable clean room.
- seal pump out ports
- bridge expansion joint
- use spreader bar to lift assembly off slab and move it to opposite arm near corner station

Sequence (ctd):

Rough time estimates:

• place on new slab	1 day
• install BTE's, doors, ends, and weatherproof	2 days
• install thermocouples	1 day
• insulate	2 days
• install current supplies	4 days
• install pumps and RGA's - leak check system	5 days
• pump down with roughing pump	1 days
• pump down with ion pump	3 days
• measure partial pressures with RGA	5 days
• bakeout for 15 days at 150 C (measure hot?)	15 days
• cool down and measure	3 days
• bakeout 15 more days and repeat measurement	15 days
• cool down and measure	3 days
• clean up and de-mount	5 days

opportunities for repeats up to 6 months total

Support services needed on site

- liquid nitrogen for cold traps
- electrical installation:
  - convenience 110 VAC for RGA's, computers for data acquisition, etc.
  - install power for roughing and turbo pumps
- rigging services and strong back rental to move two tube sections plus baffle 2 km
- rigging service to place BTE's
- carpenters to install doors, ends and weatherproofing on BTE

Labor estimate

budget estimate for labor

Task	duration (days)	man days	LIGO man days
place on slab	1	6	2
install BTE's, doors, ends, and weatherproof	3	6	0
install baffles	1	2	0
install thermocouples	1	2	1
insulate	2	6	0
install current supplies	4	8	0
install pumps and RGA's - leak check system	5	10	2
pump down with roughing pump	1	6	6
pump down with ion pump	3	18	18
measure partial pressures with RGA	1	6	6
bakeout for 15 days at 150 C (measure hot?)	15	90	45
cool down and measure	3	18	6
bakeout 15 more days and repeat measurement	15	90	45
measure temperature sensitivity of partial pressures during c	3	18	9
clean up and de-mount	5	20	5
TOTAL labor cost (@$400/shift/person average)	***63***	***$114,400***	**140**

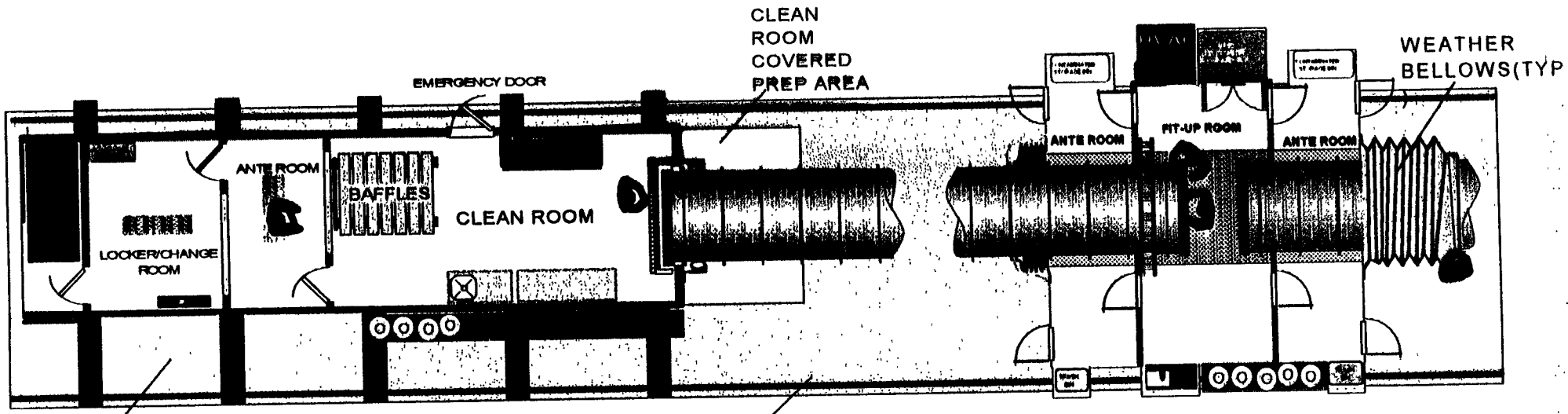
Material and Contract Labor cost estimate

Material costs	
rigger to move BT	$5,000
doors and ends for BTE	$5,000
rigger to move BTE	$1,000
Beam tube, supports, expansion joint, pump out ports	$100,000
Standing army charge from CBI (1 day schedule impact)	$5,000
Baffles (4 max)	$1,000
TOTAL material cost	***$117,000***

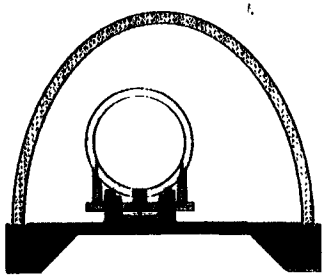
Cost Roll Up

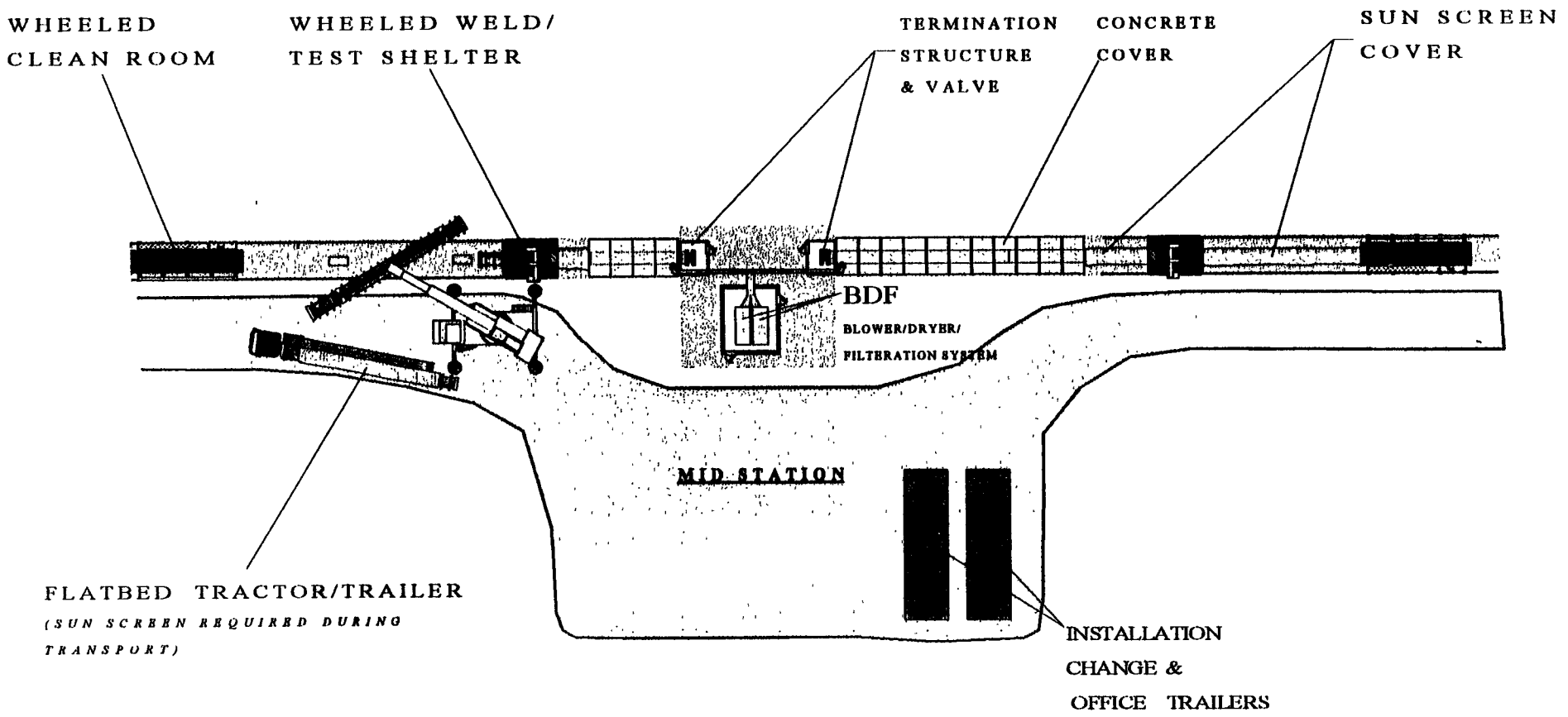
Total Labor Cost	$120 K
Total Material and Contract Cost	$120 K
Contingency, planning costs	$ 60K
TOTAL Cost	$300 K (approx)

INSTALLATION PLAN



LIGO INSTALLATION PLAN





Benefits

- re-establish performance baseline for fabrication process
- validation of effectiveness of field installation procedures and installation eqpt
- develop staff experience for 2 km module bakeout (which may be more cost effective to lead as in-house effort).
- develop procedures for 2 km bake (potentially better cost estimate even if we don't do it ourselves)
  - due to experience working in field environment, weather, etc.

Drawbacks

›› impact on CBI

- some schedule impact (approx 1 week planning time plus several days of execution time)
- some cost impact (< $100K)
- little personnel impact during setup or test

›› re-direction of key LIGO staff during initial fabrication/ installation of beam tube:

- likely staff headcount demand is approx 5 months FTE
  - 2 months for "chief baker" (under contract to LIGO as field bake project leader)
- 3 months combined from:
  - Franklin, Worden, Sibley, Jones, Riesen, Coles, Stapfer
  - Rai Weiss
- 3-4 weeks of additional planning and coordination time (primarily Larry Jones)

Risks and downside considerations

If we do find something that needs to be altered before the 2 km bake, does it cost any less to fix because of the test?

Test representative of systematic effects only, not a good statistical indicator.

Some systematic effects of 2 km bake are not represented:

- Single point control of distributed power supplies (fail safe req't)
- Leak finding technique in 2 km system
- Operational difficulties in 2 km module (material and personnel access into BTE, etc.)

Likely that any specific technical problem we anticipate can be more cheaply identified by specific narrowly defined tests (cleaning, etc.)

Positive Considerations

Test as a training ground to develop effective full bake looks promising

- potential to "earn back" savings in 2 km bake

Cheap insurance (<1% of total cost) to increase likelihood that beam tube will satisfy operational criteria following bake.