* * * FACSIMILE MESSAGE * * *

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FAX NUMBER IS: 815 439 6010
VERIFY NUMBER IS: 815 439 6000

PAGE: 1 **OF:** ~~2~~ 27

DATE: April 22, 1994

TO: Larry Jones

FAX NO.: 818/304-9834

FROM: Paula Morgan
Structural Research Dept.
CBI Technical Services Co.

RE: Qualification Test
FDR Viewgraphs
930212 File 2.2.2

Attached are e[illegible]ided viewgraphs, as will be presented at FDR, for the Qualification Test. We r[illegible]hat the viewgraphs previously sent did not clearly present areas of the Qualificati[illegible]specially the "test items versus calculation items".

Paula

Paula

QUALIFICATION TEST OBJECTIVES

- DEMONSTRATE FULL CONFORMANCE OF DETAILED DESIGN
  - Physical Configuration Representation
  - Dimensional Verification
  - Welding Procedures and Apparatus
  - Cleaning Procedures and Execution
  - Structural Demonstration
  - Leak Rate Requirements < 10×10^{-11} ATM CC/S into Beam Tube
  - Outgas Rate Measurement

- IDENTIFY ANALYSIS FEATURES VS TESTED FEATURES

- FULL SCALE CONFIGURATION

- QT TEST EXECUTION IN ACCORDANCE WITH APPROVED PLAN

QUALIFICATION TEST PLAN

1. LISTING OF TEST ITEMS AND CALCULATION ITEMS

2. TEST CONFIGURATION AND PROCEDURES

3. DESIGN QT REPORT

TEST ITEMS AND CALCULATION ITEMS

- DESIGN

  - Structural Performance of Beam Tube Sections

    1. Dimensions and Material: Thoroughly and realistically tested; identical beam tube material and thickness; identical stiffener material, sizes, spacing and attachments; different tube section length = 60' but identical support spacing (65').

    2. Loadings: Demonstrated by test, external pressure to design vacuum and maximum axial compression load application during bakeout.

    3. Calculations: To demonstrate structural adequacy and code conformance.

  - Structural and Mechanical Performance of Expansion Joints - Thoroughly and realistically tested, same vacuum load and maximum axial deflection as the complete module. Fatigue performance is addressed by calculation.

TEST ITEMS AND CALCULATION ITEMS

- DESIGN

  - Structural, Mechanical and Thermal Performance of Beam Tube Supports - The most critical aspects of the supports are tested. Support configuration identical. Guided support range of movement is tested. Some non-critical design elements such as full gravity load and horizontal transverse loads rely on calculations. Fixed support longitudinal load adequacy relies on calculation. Alignment mechanical performance is tested as well as thermal performance to limit local cool spots.

  - Baffle Mechanical Performance - Demonstrated by test. Identical to complete module. Installation, fit and stability are verifed by test.

TEST ITEMS AND CALCULATION ITEMS

- MATERIALS SUPPLIED TO CBI

  - Coil Manufacture + Bakeout - Fully demonstrated by test. QT processes same as planned by Option

  - Coupon Outgas Testing - Fully demonstrated by test. Equipment and methods same as planned for Option. All material within the beam outgas tube tested with the exception of pump port.

  - Beam Tube Manufacturing - Spiral welded tube manufacturing process is demonstrated by test.

  - Beam Tube Transportation - Transportation methods fully demonstrated by test. Method acceptability for fatigue concerns verified by calculation.

  - Expansion Joint Manufacturing - Manufacturing process demonstrated by test. Exceptions: QT uses flat sheets of cold rolled plats vs HRAP coil form for Option. QT uses mechanical forming vs possible hydroforming for Option.

  - Stiffener Manufacturing - Fully demonstrated by test.

  - Baffle Manufacturing - Fully demonstrated by test.

TEST ITEMS AND CALCULATION ITEMS

- CBI FABRICATION

  - Beam Tube Handling - For Option is verified by calculation. QT will use conventional handling methods and equipment.

  - Stiffener Attachment - Fully demonstrated by test. Same welding procedures and same type of equipment.

  - Pumping Port Reinforcement Pad - Fully demonstrated by test. Same welding procedures and same type of equipment.

  - Beam Tube End Final Prep Manufacture - Demonstrated by test. Evaluation made during QT of when to machine to achieve necessary end flatness.

  - Pumping Port - Demonstrated by test. Boring, fitting, purging and welding for QT is same as for Option.

  - Attach Expansion Joint - Fully demonstrated by test.

  - Work Conditions - Realistic work conditions where the QT environment will be similar to the planned Option fabrication facility environment.

TEST ITEMS AND CALCULATION ITEMS

- ASSEMBLY OF BEAM TUBE MODULES

  - Use of Clean Room and Weld Enclosures - Environment will be emulated, actual equipment and its operation will not be tested. Past experience precludes the necessity to test.

  - Preliminary Alignment of Beam Tubes - Demonstrated by test. Exception: Similar procedure with conventional surveying methods vs GPS.

  - Circumferential Welds - Fully demonstrated by test.

  - Beam Tube Personnel Entrance - Sequence of personnel entrance fully demonstrated by test.

  - Installation of Structural Supports - Fully demonstrated by test.

TEST ITEMS AND CALCULATION ITEMS

- LEAK TESTING

  - Can Assemblies - Demonstrated by test. Instead of high production Option method equipment, the QT can section is bagged for the helium surround; leaks will be localized by fine spray helium or helium bagging to isolate an area.

  - Circumferential Beam Tube Welds - Demonstrated by test. QT procedure identical to Option.

  - 10" Valve and Blind Flange Seals - Leak tightness of the 10" valve and its pump port attachment is demonstrated by test. The valve will be bagged and a Helium Mass Spectrometer Test performed.

  - Beam Tube Module - Demonstrated by test. Leak test of QT Beam Tube Module, before and after bake, uses RGA to determine air signature. If air signature indicates any leak, helium fine spray or isolation bagging will be used for location. QT uses similar procedures and the same decision process as the Option. Equipment is somewhat different.

TEST ITEMS AND CALCULATION ITEMS

- DIMENSIONAL CONTROL

  - Control of Materials and Assemblies - Fully demonstrated by test

  - Final and Maintenance Alignment - GPS adequacy for alignment is established and will not be tested. Also significant GPS improvements are anticipated.

  - Clear Aperture - Verified by calculation based on stack up of component tolerances (test measured) and GPS alignment capabilities. Clear aperture is not verified by measurement.

TEST ITEMS AND CALCULATION ITEMS

- CLEANING/OUTGAS PERFORMANCE

  - Can Assembly Cleaning - Demonstrated by test. Essential parameters - temperature, pressure and flow rate of the steam, and the type of spray nozzle - are replicated. Differences: steam cleaning unit instead of a specially prepared skid, manual jet cleaning pull, versus Option power winch, no high flow fans, and QT uses softened water.

  - Final Cleaning - Done when can is in place in Beam Tube Module is demonstrated by test.

  - Bakeout - If I^2R performed - electrical current, insulation, current injection, and bakeout outgas effects are the sam as the Option. Differences: voltage, % of tube which will have auxilliary heating due to end effects, control system. If electric resistance method performed - insulation, temperature variations at supports, and effect of bakeout on outgassing rates are the same as the Option.

  - Outgas Performance - Outgassing rates of QT Beam Tube Module measured during all phases. Rates used by Caltech to confirm full scale facility pumping requirements.

OUT OF PAGE

TEST ITEMS AND CALCULATION ITEMS

- List of items requiring verification testing and items verified by calculation.

- List represents most important issues affecting design and production of complete Beam Tube Modules

  - Operation Sequence
    1. Design
    2. Material Procurement
    3. Fabrication
    4. Assembly

  - Key Issues
    1. Leak Testing
    2. Cleaning
    3. Dimensional Control

  - Discussion of tested items as well as significant differences (including significance) between QT and a Complete Module

QT CONFIGURATION AND PROCEDURES FOR FABRICATION/INSTALLATION/ TESTING

- QT Beam Tube Physical Configuration
- QT Pumping and Outgas System
- QT Procedures

QUALIFICATION TEST PUMPING AND OUTGASSING TEST SYSTEMS

Requirements

- Test the qualification test beam tube for hydrogen and water vapor outgassing rates.
- Provide a system to evacuate the beam tube and measure the above outgassing rates.
- The desired material outgassing rates are 1×10^{-13} T L/sec cm^2 for hydrogen and 1×10^{-16} T L/sec cm^2 for water vapor.
- Net water vapor pumping speed to be less than 600 L/sec in order to simulate the water pumping speed of the option phase pumping system.

Critical issues

- Background outgassing rate for water is critical due to low outgassing rate.
- High quality RGA is required to provide maximum measurement sensitivity.

QUALIFICATION TEST PUMPING AND OUTGASSING TEST SYSTEMS

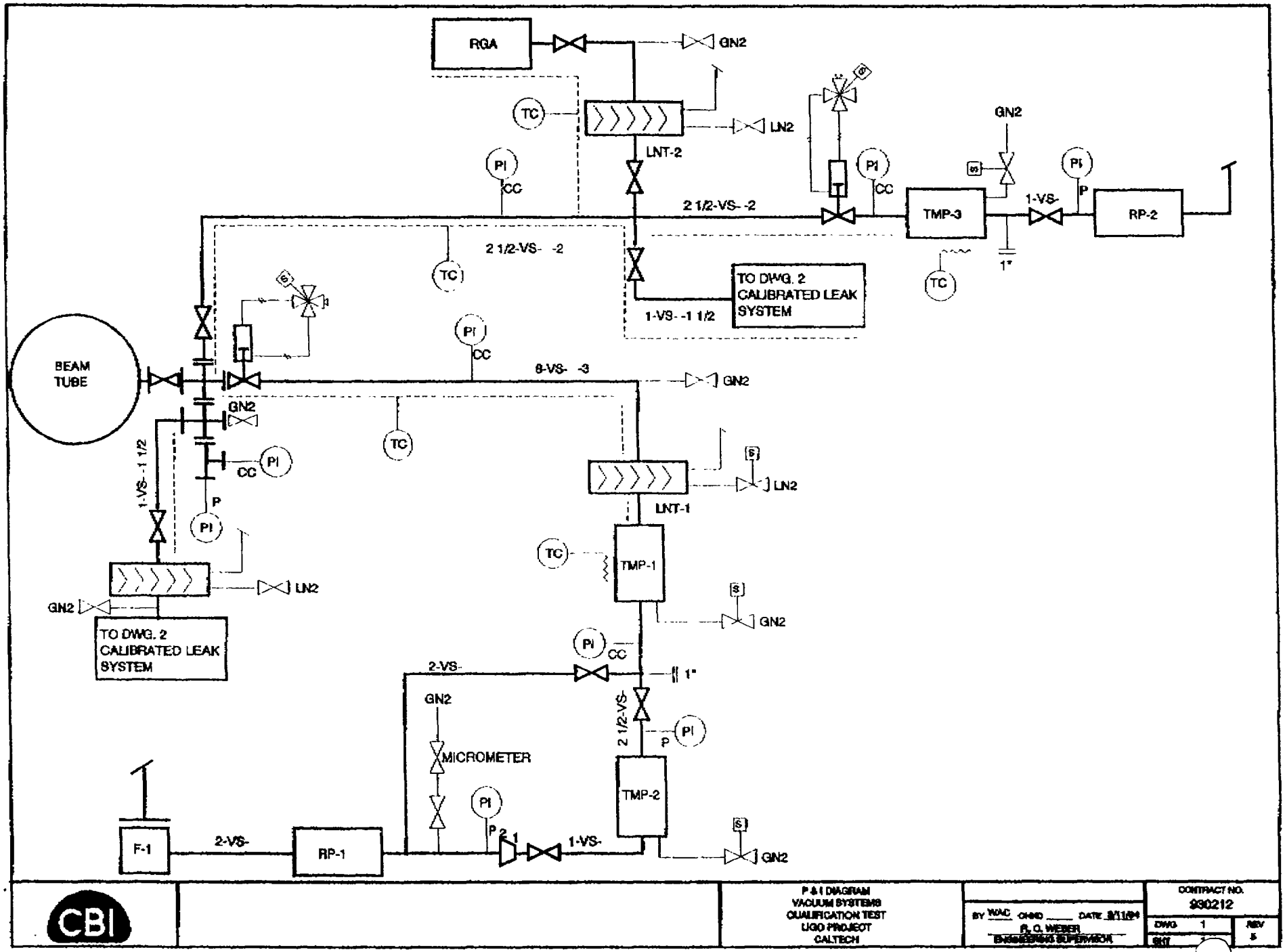
- Minimize contamination from hydrocarbons and water vapor.

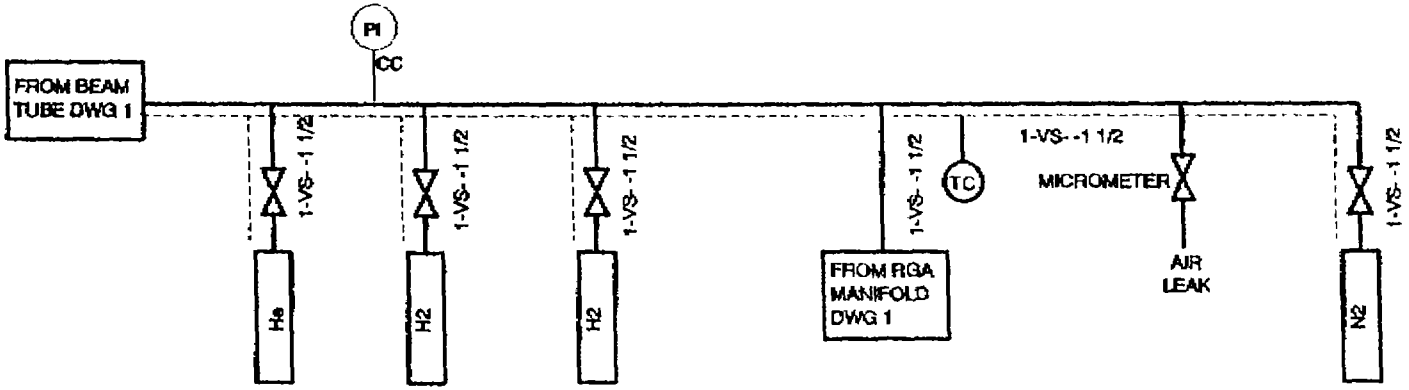
Selected Configuration

- Minimize surface area to reduce background outgassing rates.
- Cold trap the RGA to reduce false hydrogen signals.
- Cold trap the pumping system to minimize contamination and as pump for H2O outgassing test.
- Ensure that the water pumping speed is less than 600 L/sec. This trap flow rate must be accurately known for the water outgassing test. Trap pumping speed limited to 600 L/S by use of orifice in the piping.
- Bake out the entire system to reduce the background outgassing rates.

QUALIFICATION TEST PUMPING AND OUTGASSING TEST SYSTEMS

- Select calibrated leaks which are dry to eliminate a source of water vapor contamination.
- Use auxiliary pumping system to evacuate the RGA and calibrated leak systems to prevent contamination.
- Use two turbomolecular pumps in series to provide sufficient hydrogen compression ratio for low background outgassing rate.
- The system is capable of use for the leak test of the qualification test beam tube including the air signature test of the beam tube leak rates.


RGA
GN2
TC
LN2
LNT-2
PI
CC
2 1/2-VS- -2
TMP-3
1-VS-
RP-2
1"
TO DWG. 2
CALIBRATED LEAK
SYSTEM
1-VS- -1 1/2
BEAM
TUBE
8-VS- -3
1-VS- 1 1/2
LNT-1
TMP-1
2-VS-
MICROMETER
TMP-2
F-1
RP-1
P & I DIAGRAM
VACUUM SYSTEMS
QUALIFICATION TEST
LIGO PROJECT
CALTECH
CONTRACT NO.
930212
DWG 1
REV 5



CBI

P & I DIAGRAM
CALIBRATED LEAK SYSTEM
QUALIFICATION TEST
LIGO PROJECT
CALTECH

BY WAC CHKD _____ DATE 1/6/99
R. G. WEBER
ENGINEERING SUPERVISOR

CONTRACT NO.
990212

DWG 2 REV 3

SHT 1

P & I SYMBOLS

COLD CATHODE VACUUM GAGE

PIRANI VACUUM GAGE

MANUAL VALVE

ELECTROPNEUMATEC VALVE

TWO WAY SOLENOID VALVE

FOUR WAY SOLENOID VALVE WITH PNEUMATIC SUPPLY

TWO WAY SOLENOID VALVE WITH PNEUMATIC SUPPLY

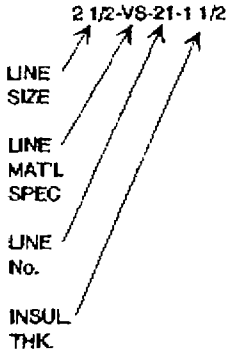
TEMPERATURE CONTROL

HEAT TRACED PIPING

PRELIMINARY EQUIPMENT SIZING

TMP -1	1100 L/S
TMP-2	60 L/S
TMP-3	60 L/S
TMP-4	60 L/S
TMP-5	60 L/S
RP-1	50 CFM
RP-2	1 CFM
RP-3	1 CFM
RP-4	1 CFM
LNT-1	6" TRAP
LNT-2	2 1/2" TRAP
LNT-3	2 1/2" TRAP

LINE DESIGNATION



CBI		P & I DIAGRAM P & I SYMBOLS QUALIFICATION TEST LIGO PROJECT CALTECH	BY WAC CHKD ___ DATE 3/30/94 R. D. WEBER ENGINEERING SUPERVISOR	CONTRACT NO. 930212 DWG 3 REV 0 SHT

LIGO QUAL. TEST OUTGASSING CALCULATION

VACUUM VESSEL SHELL(QUAL TEST PIPE)

AREA = 1.65E+06 sq cm (140 ft long)

K-1 = 4.00E-08	T L/sq cm - s	Q-1 = 6.60E-02	T L/S
K-50 = 8.00E-10	T L/sq cm - s	Q-50 = 1.32E-03	T L/S
K-AB= 1.00E-13	T L/sq cm - s	Q-AB= 1.65E-07	TL/S

TEST HEADS

AREA = 2.50E+04 sq cm

K-1 = 4.00E-08	T L/sq cm - s	Q-1 = 1.00E-03	T L/S
K-50 = 8.00E-10	T L/sq cm - s	Q-50 = 2.00E-05	T L/S
K-AB= 1.00E-13	T L/sq cm - s	Q-AB= 2.50E-09	TL/S

STAINLESS STEEL VALVES, FITTINGS AND PIPE

AREA = 1.00E+04 sq cm

K-1 = 4.00E-08	T L/sq cm - s	Q-1 = 4.00E-04	T L/S
K-50 = 8.00E-10	T L/sq cm - s	Q-50 = 8.00E-06	T L/S
K-AB= 1.00E-12	T L/sq cm - s	Q-AB= 1.00E-08	TL/S

ALUMINUM

AREA = 0.00E+00 sq cm

K-1 = 0.00E+00	T L/sq cm - s	Q-1 = 0.00E+00	T L/S
K-50 = 0.00E+00	T L/sq cm - s	Q-50 = 0.00E+00	T L/S
K-AB= 0.00E+00	T L/sq cm - s	Q-AB= 0.00E+00	TL/S

ELASTOMER

AREA = 0.00E+00 sq cm

K-1 = 0.00E+00	T L/sq cm - s	Q-1 = 0.00E+00	T L/S
K-50 = 0.00E+00	T L/sq cm - s	Q-50 = 0.00E+00	T L/S
K-AB= 0.00E+00	T L/sq cm - s	Q-AB= 0.00E+00	TL/S

notes: 1. K-1, Q-1 & P-1 signify properties after one hour at vacuum
2. K-50, Q-50 & P-50 signify properties after fifty hours at vacuum
3. K-AB, Q-AB & P-AB signify properties after the vacuum bake-out

TOTAL OUTGASSING FLOW

Q-1 = 6.74E-02	T L/S
Q-50 = 1.35E-03	T L/S
Q-AB = 1.78E-07	T L/S

Notes
AB subscript denotes "after bake"
and is for hydrogen only
outgassing rates for 1 and 50 hours
represent total pressure rates (water)
shading denotes input data required

PUMPING SYSTEM EVALUATION

PUMPING SPEED (PER PUMP) = 6.00E+02 L/sec
CALCULATED PARTIAL PRESSURE P-1 = 1.12E-04 TORR
P-50 = 2.25E-06 TORR
P-AB = 2.96E-10 TORR

PUMPING SPEED (PER PUMP) = 9.00E+02 L/sec
CALCULATED PARTIAL PRESSURE P-1 = 7.49E-05 TORR
P-50 = 1.50E-06 TORR
P-AB = 1.97E-10 TORR

Qualification Test Procedures

ID	Title	Directly from Detailed Design	QT Addenda to Detailed Design	QT Specific
Material Specifications				
C-240-0186	Coil Material Specification	X		
C-CMBS1	Coil Material Bake Specification	X		
WMS-ER308L	Cleaning and Bakeout Procedure of ER 308L Weld Wire	X		
C-240-0187	Baffle Material Specification	X		
C-CMBS1	Baffle Material Bake Specification	X		
C-240-0194	Expansion Joint Material Specification	X		
Purchasing Specifications				
C-BT-QT	Qualification Test Beam Tube Sections			X
C-EJ-QT	LIGO Beam tube Expansion Joints Qualification Test			X
C-SUPT-1	Beam Tube Support Specification	X		
CBAF-1	Baffle Fabrication Specification	X		
C-PORT-QT	Pump Port Specification			X
C-PORTPAD-1	Pump Port Reinforcing Pad Specification	X		
C-VAC-1	Vacuum Stiffener Specification	X		
C-SUPSTF-1	Support Ring/Baffle Ring Fabrication Specification	X		
Fabrication/Installation Procedures				
FSQT	Beam Tube Can Section Fabrication Sequence for LIGO Qualification Test Addenda		X	
ISQT	Beam Tube Can Section Installation Sequence for LIGO Qualification Test Addenda		X	
FPCircumferential	Fitting/Purge Procedure for Circumferential Butt Welds for LIGO	X		
FPStiffener	Fitting/Purge Procedure for Stiffener Attachment Welds for LIGO	X		
FPPumpPort	Fitting/Purge Procedure for Pump Port Attachment Welds for LIGO	X		
MI	Material Traceability	X		
IR	Receiving Inspection	X		
DCQT	Dimensional Control		X	
Welding Procedures				
WPS-INDEX	Weld Procedure Index	X		
WPS-ER308S/GMA (w/PQR 4858)	Weld Procedure, GMA Welding for 304L Materials	X		
WPS-ER308L/Repair (w/PQRs 10029 & 4858)	Weld procedure, GMA for Repair Welding for 304L Materials	X		

CONSTRUCTION PLAN

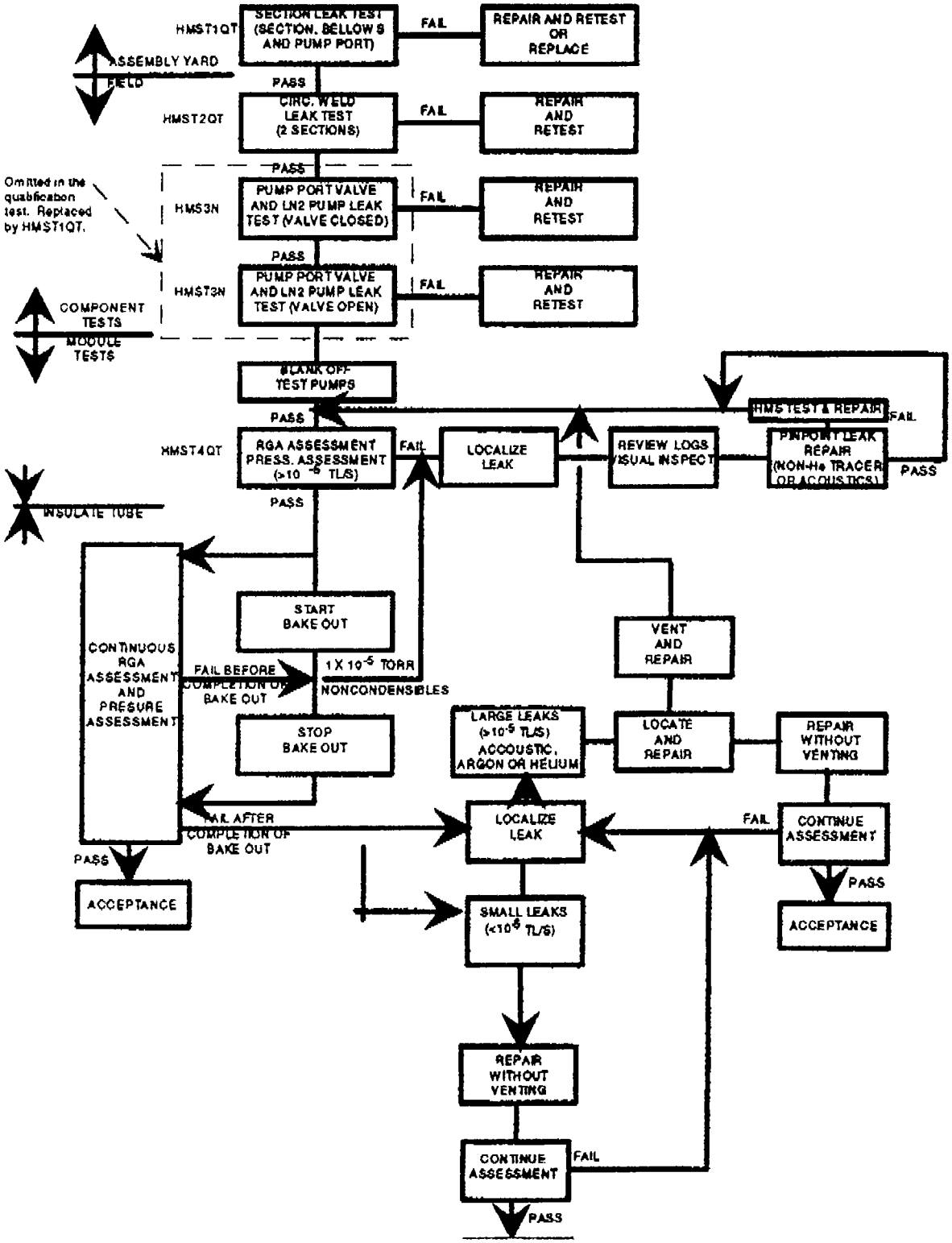
- FSQT - Fabrication Sequence
- ISQT - Installation Sequence
- LIGOCPQT
- LIGOTPQT

QUALIFICATION TEST PUMP DOWN AND OUTGASSING TEST PROCEDURE

- Evacuate to $<10^{-5}$ torr
- Evaluate air signature and outgassing rates
- Insulate tube
- Bake out tube and monitor outgassing rates during bake out
- Monitor outgassing rates during cooldown
- Evaluate air signature and outgassing rates at ambient temperature

LEAK TEST PROCEDURES

LEAK DETECTION DECISION TREE QUALIFICATION TEST



BAKEOUT PROCEDURE

SPECIFIES EQUIPMENT AND PROCEDURE TO EMULATE CRITICAL BAKEOUT PARAMETERS

- Insulation
- Temperatures
- Duration

THE PROCEDURE SPECIFIES ELECTRIC RESISTANCE HEAT CABLE TO HEAT UP AND MAINTAIN TEMPERATURE

I^2R METHOD

CBI prepared basic module bakeout design and submitted RFQ for QT bakeout by I^2R. Proposal will be prepared for design of Beam Tube Module I^2R bakeout and Option performance of same.

DATA ACQUISITION PROCEDURE

- Written Documentation is recorded in laboratory notebooks.
- Computerized Data Acquisition for temperatures, pressures, and other analog signals, RGA data and reports, and "logbook files".
- Format - Written documentation is per procedure or recorder. Computerized data per custom analog data software, RGA software and for logbook files, which record instrument state vectors keyed to time and date, Microsoft Word document format.
- Transmission - Daily transmittal of compressed archive LIGO files via modem to Caltech designated host computer.

QUALIFICATION TEST REPORT

- Outline/Index - Report will follow outline which will incorporate all aspects of the QT Test Plan.
- Data Reporting - in same format as specified in QT procedures including Data Acquisition Procedure.
    - Test Documentation
    - Instrument Output