CBI	IDENTIFICATION HMST1N LIGO-E950066-07-B			
TITLE HELIUM MASS SPECTROMETER HOOD TEST OF BEAM TUBE SECTIONS	REFERENCE NO. 953570 (930212)		SHT 1 OF 9	
	OFFICE RSE		REVISION 7D	
PRODUCT LIGO BEAM TUBE MODULES CALIFORNIA INSTITUTE OF TECHNOLOGY	MADE BY CNS	CHKD BY EEB	MADE BY PBS	CHKD BY WAC
	DATE 3/15/94	DATE 5/1/94	DATE 1/30/97	DATE 2/4/97

1.0 SCOPE:

1.1 This procedure covers the helium mass spectrometer hood leak test of each completed beam tube can section at the fabrication plant.

1.2 Perform the leak testing outlined in this procedure after the:

1.2.1 Stiffeners, bellows assembly and, when applicable, the pump port nozzles have been welded to the beam tube can section.

1.2.2 The beam tube section has been visually inspected and any weld repairs have been made to correct excess undercut, lack of penetration and pinholes in either the can spiral welds or the stiffeners to can welds.

2.0 LEAK TESTING EQUIPMENT TO BE USED IN THIS PROCEDURE:

2.1 Helium mass spectrometers used to perform the leak testing in this procedure shall be the Varian 960 turbo, or instrument of comparable capability. The HMS vent valve must be disabled.

APPROVED	
CBI: M. Tellalian	DATE: 2-7-97
CALTECH:	DATE:

2.2 Hood test enclosure stands. Each enclosure as shown in drawings ER-200 through ER-208. shall consist of two halves, a moveable bottom and a top. The hood shall be able to structurally withstand being fully evacuated. The test enclosure stands shall contain the following:

2.2.1 A capacitance manometer a 1/2" NPT connection threaded into a 1/2"Ø NPT coupling welded into the test enclosure cover.

2.2.2 A 3"Ø coupling installed in the bottom portion of the test enclosure to which is connected a tee. On one leg of the tee is a vacuum valve with piping leading to a Leybold RV5000 pumping system or unit of comparable or greater capacity. This pump for shall be used for evacuating the test before backfilling the enclosure with helium, and for the evacuation of helium from the test enclosure following the completion of testing. On the second leg of the tee there is piping leading to the helium supply system.

2.3 One end double seal assembly includes the following test equipment as shown on drawings ER-200, ER-210 through ER-215, ER-231 and described below.

2.3.1 A 160 K (6") Ø nozzle with a 6"Ø ASA flanged vacuum valve to which is connected a mechanical vacuum pump for roughing and forepumping such as a Leybold WAU2001 Roots booster backed by a rotary vane pump or unit of comparable capacity. The pump unit connection line shall contain a valved 100 mm (4"Ø) crossover line to a diffusion pump foreline. It shall also contain a tee with a 40 KF (1 1/2"∅) long flange valved for connecting the helium mass spectrometer.

2.3.2 A 500 K (20"∅) flanged port with a 20"∅ ASA flanged vacuum valve to which is mounted a liquid nitrogen cold trap and a flanged 20"∅ Varian HS-20 or equivalent diffusion pump. The 100 K (4"∅) foreline to this pump shall be connected through the valved crossover line to the mechanical vacuum pump unit in item 2.3.1.

NOTE: The diffusion pumps used in this procedure shall be new units and shall never have been operated with silicone oil. Diffusion pumps will be filled with Santovac 5 pump oil. DO NOT USE SILICONE OIL FOR THIS PROCEDURE.

2.3.3 A 25 KF (1 1/2"∅) long flange connection for a cold cathode gauge head connected to an HPS Model 937 or similar control unit.

2.3.4 A 25 KF (1"∅) UHV valve and a 25 KF (1"∅) long flange connection with an adapter for a convection gauge tube connected to the control unit listed in item 2.3.4.

2.3.5 Two KF short flange valved connections leading from the interspace between the end assembly double seals to a mechanical vacuum pump, a nitrogen or clean air supply.

2.3.6 Leybold Trivac D16 or similar rotary vane pump.

2.4 A second end double seal assembly includes the following test equipment as shown on drawings ER-200, ER-210 through ER-215, ER-231, and described below.

2.4.1 A KF flange connection for a 1 to 5 $\times 10^{-10}$ atm cc/sec helium standard leak.

2.4.2 Two KF flange valved connections leading from the interspace between the end assembly double seals to a mechanical vacuum pump, nitrogen or clean compressed air supply.

2.4.3 A KF flange with a vent valve for backfilling the tube section with air.

2.5 All vacuum valves 2" (50mm)∅ and smaller shall be bellows stem sealed and have KF style flange connections. Any such valves facing the evacuated space of the can section shall be stainless steel.

2.6 All UHV valves larger than 2" (50mm)∅ shall be stainless steel UHV gate valves.

2.7 All "O" rings in test equipment shall be elastomer or metal vacuum seal rings.

2.8 A Gowmac model 20-160 thermal conductivity gas chromatograph with helium reference, or other instrument of similar capability. Alternatively, an oxygen analyzer capable of detecting oxygen levels down to 2.0%.

2.9 An optional control and data acquisition system including Labtech Notebook ™ software, an IBM compatible PC, DAS 1402 data acquisition card, PIOSSR I/O card, PB-24 relay boards, or similar equipment.

2.10 An optional external cold trap in the test line to provide additional protection for the HMS.

3.0 PROCEDURE:

3.1 Install the beam tube can section in the test enclosure stand. Do not place the top cover of the enclosure at this time. Confirm that the expansion joint (if present) is restrained by an installed leak test fixture.

3.2. Engage the end double seal assemblies at each end of the beam tube can section.

3.3 Inflate the head seals and either evacuate the interspace, or purge the interspace with nitrogen or bottled air.

3.4 Rough pump the tube section with the roughing pump..

3.5 Energize the diffusion pump and fill the cold trap with LN_2 if the pump is not already energized, and if the cold trap is not already filled.

3.6 When the absolute pressure in the tube section (P_1) is below 50 millitorr:

3.6.1 Close the 6" ∅ roughing valve (V_2) at the nozzle in the end head assembly.

3.6.2 Open the 6" ∅ foreline valve (V_3).

3.6.3 Close the 2" ∅ foreline valve (V_4) leading to the auxiliary vane pump.

3.6.4 Initiate opening of the 20" ∅ gate valve (V_1) that connects the tube section to the cold trap and diffusion pump. (The actuator on this valve is damped to produce a reduced opening rate.)

3.7 With the HMS isolated from the test system, perform the following operations:

3.7.1 Zero the instrument.

3.7.2 Verify the instrument calibration against the internal standard leak. The instrument helium leak rate indication must come within one scale increment of the standard leak value.

3.7.3 If the helium leak rate indication of step 3.7.2 above is not within one scale increment (0.2×10^{-8}) of the HMS internal standard leak value, perform an autocalibration operation. Upon completion of the autocalibration operation, repeat step 3.7.2.

3.8 When the absolute pressure in the tube section is 3×10^{-5} torr or less and is descending slowly:

3.8.1 Open the 2" ∅ foreline valve ((V_5) to the helium mass spectrometer (HMS).

3.8.2 Initiate the HMS "Test" cycle, which will begin the HMS pumping sequence.

3.8.3 Allow the HMS to pump to a steady state condition.

3.8.4 While monitoring the foreline pressure (P_2), the HMS test port and spectrometer tube pressures, and the tube section pressure (P1), close the valves to the mechanical fore pumps backing the 20"∅ diffusion pump (V_3 and V_4). With the HMS solely backing the diffusion pump, monitor the foreline pressure (P_2) to ensure that it does not rise appreciably above 0.1 torr. Should the foreline pressure begin to increase, indicating the throughput is too large for the HMS effective pump speed, reverse the valve arrangement and continue pumping the can section with the mechanical vacuum pump unit backing the diffusion pump. When the absolute pressure in the can section has reached a lower level, try again to solely back the diffusion pump with the HMS. When this is accomplished, proceed to step 3.10.

3.9 Should the tube section absolute pressure fail to reach a level where the HMS can solely back the diffusion pump and leakage is suspected, helium tracer probe the end assembly seals for leaks.

3.9.1 If either one or both of these seals indicate inleakage, isolate and vent the test system and visually inspect the seal or seals to determine the cause of the leak or leaks. Replace or repair the seals as necessary and repeat steps 3.2 through 3.7 as necessary until the HMS is solely backing the diffusion pump.

3.9.2 If neither of the end seals indicate inleakage, place the top cover of the test enclosure. Evacuate the enclosure. Monitor the tube section absolute pressure (P_1). A significant drop in tube section absolute pressure during enclosure evacuation would indicate inleakage. To verify the existence of inleakage, vent the enclosure with helium to atmospheric pressure by closing the valve to the enclosure vacuum pump and opening the valve to the helium gas supply. It is not necessary to pressurize the hood with helium to a full atmosphere if a helium leakage signal is received prior to ful repressurization.

3.9.3 If leakage in the tube section is verified, proceed to section 5.0 of this procedure, LEAK LOCATION.

3.9.4 If there is no indication of leakage through the tube section under test, nor the tube test station end seals, helium tracer probe test the test station including the tube vent valve, the calibrated leak valve and flange connections, and the pumping system valves and fittings. Continue until the source of the difficulty has been identified and repaired.

3.10 After the tube section absolute pressure has gone below 3×10^{-5} torr and the HMS is solely backing the diffusion pump and the tube section absolute pressure stabilizes or reaches a slow rate of decrease, calibrate the test system as follows:

3.10.1 With the HMS test valve in the fully open position, zero the system background. Allow the HMS to continue to pump the system until the system background is stable to the point that the HMS can pump for one minute without a substantial automatic zero adjustment.

3.10.2 Open the valve to the helium standard leak mounted on the far end head assembly, and allow the helium signal to stabilize. Record the time required for the helium leak rate indication to reach a peak (not saturated) which is the response time.

3.10.3 Record the helium signal value (M_1) as a number of divisions on the instrument. A division shall be based on the smallest increment on the most sensitive scale of the leak rate indicator meter.

3.10.4 Close the standard leak valve and record the clean up time required for the helium leak signal to diminish to less than 33% of the M_1 signal value.

3.10.5 Record the background signal (M_2) as a number of divisions on the instrument after the background signal has stabilized. A division shall be based on the smallest increment on the most sensitive scale of the leak rate indicator meter.

3.10.6 Calculate the preliminary system sensitivity (S_1) in atm. cc/ sec/ div.

$$S_1 = (\text{Std helium calibrated leak value}) \div (M_1 - M_2)$$

3.10.7 If $S_1 \leq 1 \times 10^{-10}$ atm. cc / sec / div, proceed with the test. If $S_1 > 1 \times 10^{-10}$ atm. cc / sec / div, perform the necessary maintenance and corrective action to bring the system to the required sensitivity, and begin the test sequence again.

3.11 Place the test hood enclosure top half if it has not previously been placed, and inflate and seat the enclosure seals.

3.12 Evacuate the hood using the Leybold RV5000 (or equivalent) pump system.

3.13 Backfill the hood enclosure with helium by opening valve V_{11} to the helium gas supply.

3.14 Calculate the helium concentration sensitivity correction factor (C_{hc}).

$$C_{hc} = (P_{hood} \div 760 \text{ torr}) \times (100 \div \% \text{ Helium in hood}).$$

3.15 After the hood has filled with helium, observe the HMS leak rate indicator for the larger of one (1) minute or three times the measured response time recorded in step 3.10.2.

3.16 Upon completion of the observation time, record the leak rate indicator signal (M_3) as a number of divisions on the instrument.

3.17 If the test leak rate indicator signal (M_3), less the background signal (M_2), multiplied by the system sensitivity (S_1), corrected for *helium concentration* is equal to or greater than 1×10^{-10} atm cc / sec, go directly to section 5.0 , LEAK LOCATION.

If: $(M_3 - M_2) \times S_1 \times C_{hc} \geq 1 \times 10^{-10}$ atm cc / sec, go to section 5.0, Leak Location, below.

3.18 If the test leak rate indicator signal (M_3), less the background signal (M_2), multiplied by the system sensitivity (S_1) is less than 1×10^{-10} atm cc / sec, proceed with step 3.19 below.

If: $(M_3 - M_2) \times S_1 \times C_{hc} < 1 \times 10^{-10}$ atm cc / sec, proceed with step 3.19 below.

3.19 Open the valve to the helium permeation standard leak mounted on the far end head assembly and allow the helium signal to stabilize. Record the leak rate indication signal (M_4) as a number of divisions on the instrument.

3.20 Calculate the final system sensitivity (S_2) in atm cc/sec/div.

$$S_2 = (\text{Std helium calibrated leak value}) \div (M_4 - M_3)$$

3.21 There must be an agreement of 65% or more between S_1 and S_2. If there is not 65% or greater agreement, perform the necessary maintenance and corrective action to bring the system to the required sensitivity, and begin the test sequence again at step 3.10 above. Percent agreement is equal to the lesser of S_1 or S_2 divided by the greater of S_1 or S_2.

$$\% \text{ Agreement} = (\text{Lesser of } S_1, S_2 \div \text{Greater of } S_1, S_2) \times 100$$

3.22 Calculate the final test sensitivity (S_F) corrected for tracer gas concentration .

$$S_F = S_2 \times C_{hc}$$

3.23 If $S_F \geq 1 \times 10^{-10}$ atm cc / sec / div, perform the necessary maintenance and corrective action to bring the system to the required sensitivity, and begin the test sequence again at step 3.11 above.

3.24 Calculate the final observed leak rate (Q_F) corrected for helium concentration .

$$Q_F = (M_3 - M_2) \times S_F = \qquad \text{atm cc / sec}$$

3.25 If $Q_F \geq 1 \times 10^{-10}$ atm cc / sec, go to section 5.0 LEAK LOCATION, below.

3.26 If $Q_F < 1 \times 10^{-10}$ atm cc / sec, the leak test of the tube section is acceptable. Complete all documentation required in Section 4.0 following.

3.27 Evacuate the helium from the test hood enclosure with the Leybold RV5000 or similar pumping system, back fill the hood enclosure with room air, and vent the inflatable enclosure seals.

3.28 Backfill the tube section with room air through vent valve V_7.

4.0 <u>DOCUMENTATION</u>:

4.1 Complete a Form WL233A, CBI LIGO TUBE SECTION LEAK TEST REPORT, or a similar report generated by computer including all of the information required for Form WL233A. A copy of Form WL233A is Figure 1 on page 9 of this procedure.

4.2 Check for accuracy, sign and date the Form WL233A or the computer generated report.

4.3 Sign-off and date the beam tube section Quality Plan for the leak test after it has been successfully completed.

4.4 Assure that any repairs made to the beam tube have been recorded on the tube section record drawing.

4.5 In the Comments section of the tube section Quality Plan, make entries of all noteworthy leak testing events, such as leaks repaired, or unusual difficulties in completing a leak test.

5.0 LEAK LOCATION

5.1 Evacuate the helium from the test enclosure and backfill it with air.

5.2 Deflate all hood enclosure seals and remove the top half of the test enclosure and lower the bottom half to permit access to the tube for leak location.

5.3 Locate the source of the leakage by conventional helium tracer probe, and bagging techniques.

5.4 Repair any leaks found in accordance with an approved welding procedure.

5.5 Document any repairs and details of repair on the tube section Record Drawing, and the Quality Plan.

5.6 Leak test the tube section in accordance with this procedure.

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TITLE HELIUM MASS SPECTROMETER HOOD TEST OF BEAM TUBE SECTIONS	REFERENCE NO. 953570 (930212)		SHT 9 OF 9	
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PRODUCT LIGO BEAM TUBE MODULES CALIFORNIA INSTITUTE OF TECHNOLOGY	MADE BY CNS	CHKD BY EEB	MADE BY PBS	CHKD BY WAC
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CBI LIGO TUBE SECTION LEAK TEST REPORT

TUBE SECTION I.D. NO.	953571 CONTRACT	Hanford/Livingston LOCATION (Circle One)

Procedure and Rev. HMST1N Rev. ____	HMS Leak Detector (Mfg., Model and Serial Number)
System Standard Helium Leak ID	System Standard Leak Helium Leakage Rate ______ $\times 10^{-10}$ atm. cc/sec.
Basis for HMS Leak Indicator Division Unit of 2 on 10^{-11} Scale (50 divisions to a scale)	HMS Element Pressure During Test Torr
Tube Section Absolute Pressure (P_1) During Test Torr	D.P. Foreline Absolute Pressure (P_2) During Test Torr
Observed response time: __________	Observed Clean up time: __________

M_1 (Initial Helium Signal) [_____ div on 10^{-10} scale, x 10] = _____ divisions on 10^{-11} scale

M_2 (Background Signal) [_____ div on 10^{-10} scale, x 10] = _____ divisions on 10^{-11} scale

Preliminary system sensitivity (S_1) = $\frac{\text{Leakage Rate of Std. Leak}}{M_1 - M_2}$ = _______ x 10^{-} — atm cc / sec / division

Hood Pressure (P_{hood}) = _______ torr. Helium concentration = _______ %

Helium concentration correction factor (C_{he}) = $\frac{760 \text{ torr} \times 100}{P_{hood} \times \% \text{ Helium}}$ = _______

M_3 (Test Helium Signal) [_____ div on 10^{-10} scale, x 10] = _____ divisions on 10^{-11} scale

M_4 (Final Calibration Signal) [_____ div on 10^{-10} scale, x 10] = _____ divisions on 10^{-11} scale

Final system sensitivity (S_2) = $\frac{\text{Leakage Rate of Std. Leak}}{M_4 - M_3}$ = _______ x 10^{-} — atm cc / sec / division

Final Test Sensitivity (S_F)

$S_F = S_2 \times C_{he}$ = ________ x 10^{-} — atm cc / sec / division

Final Observed Leakage Rate (Q_F) = $(M_3 - M_2) \times S_F$ = ________ x 10^{-} — atm cc / sec.

Check Applicable Box(es):

☐ Weld repairs were made during leak testing and have been visually inspected and re-tested and found acceptable. See VT Report No.

☐ No welded repairs made during leak testing.

Tests were performed and all leakage was evaluated in accordance with the referenced procedure.
Defects not repaired and retested during testing are recorded above as to location and disposition.
All other tested areas included in this report were found acceptable.

COMMENTS: ____

____

____

______________________________ ______________
OPERATOR/EVALUATOR DATE

Results reviewed by: ______________________ ______________
DATE

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