1.0 SCOPE:

1.1 This procedure covers the helium mass spectrometer hood test of the closing weld joint between beam tube can sections.

1.2 Perform the leak testing outlined in this procedure after the closing weld joint between two adjacent beam tube can sections has been visually inspected and any weld repairs have been made to correct excess undercut, lack of penetration and pinholes in that weld.

2.0 LEAK TESTING EQUIPMENT TO BE USED IN THIS PROCEDURE:

2.1 The helium mass spectrometer (HMS) used to perform the leak testing outlined in this procedure shall be the Varian Model 960 or equivalent with an optimum high sensitivity in the range of 10^{-11} atm cc/sec. of helium. All leak detectors must be turbo pumped. Diffusion pumped units are not acceptable.

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CALTECH		DATE

2.2 A circumferential leak test box constructed of an aluminum channel section. The box shall completely surround the outside circumference of the closing weld joint between beam tube can sections. The box shall KF fittings for the attachment of a calibrated leak and vacuum lines. The box may also have an 100 ISO fitting for the attachment of an optional turbomolecular pump (TMP). See drawings ER-600 through ER-604.

2.3 Flexible stainless steel hose with KF connector ends for connecting the HMS to the box or the TMP.

2.4 Combination weld purge dam/helium hood enclosure consisting of two (2) inflatable rubber seals containing two (2) hose connections. The seals are interconnected with a fiber reinforced rubber ring also containing two (2) hose connections 180° apart. The inflatable seal connections are for pressurizing and venting the seals. One connection in the fiber reinforced rubber ring is for injecting both argon and helium gas and the second is for venting or evacuating the enclosure. See the figure at the end of this procedure.

2.5 Two (2) hoses for attaching to the fiber reinforced rubber ring and the inflatable rubber seals.

2.5.1 The hose attached to one of the reinforced rubber ring connectors is for helium supply, and the hose attached to the second reinforced rubber ring connector is for venting and sampling the gas in the enclosure.

2.5.2 A gas line adapter is provided for inflation of the two inflatable seals.

2.6 Mechanical vacuum pump such as a Leybold Trivac D16 or equivalent.
2.7 Clamping rings, centering rings, seals, and vacuum valves.

2.8 One standard helium calibrated leak, 1 to 5 X 10^{-10} atm. cc/sec. of helium

2.9 Nashua Ductseal™ no. 102 , or an equivalent sealing putty.

2.10 Turbomolecular pump station (optional, if required to reduce pumpdown time or pump speed).

2.11 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%.

2.12 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.

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

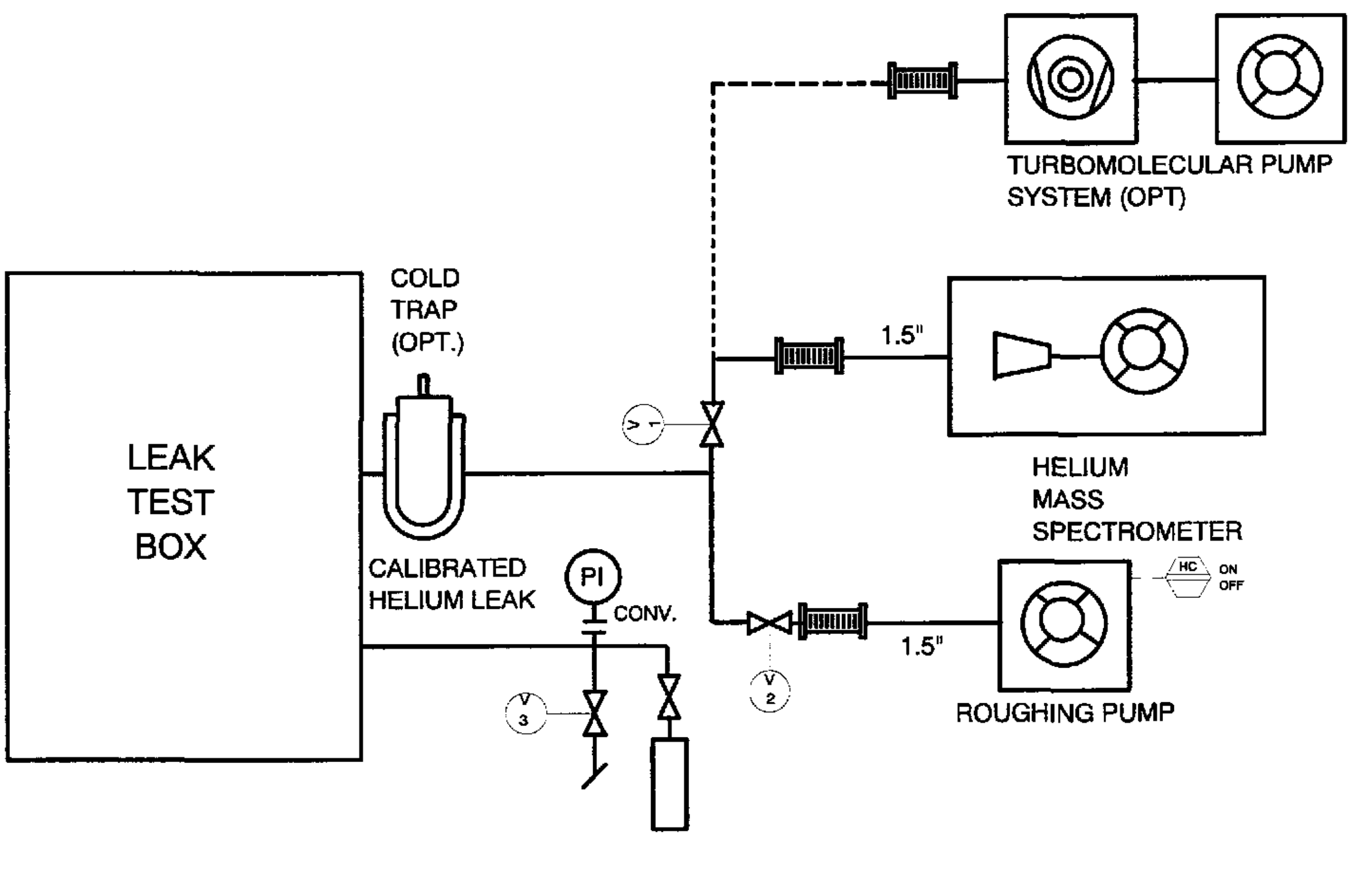

Figure 1

3.0 PROCEDURE:

3.1 Remove any rough areas adjacent to the weld in the vicinity of where the metal box seals will contact the outside surface of the tube in order to effect the necessary temporary seal. Remove purge ring and inspect weld per procedure "VI8X", making any required chipping, grinding, or repairs per procedures "GR8X" and "INSTALLSEQ". Replace purge ring for leak testing.

3.2 Install the circumferential leak test box over the outside of the closing weld joint between the beam tube can sections.

3.3 Center the circumferential leak test box over the weld caulk the joints with Ductseal ™ no. 102 putty or equal. **Do not place sealing putty in contact with any tube surface not previously tested.**

[Previous Paragraph 3.4 deleted]

3.4 Evacuate the circumferential leak test box with the roughing pump (roughing pump on, roughing valve V1 open.) Should the vacuum in the box stabilize at a high pressure indicating potential putty seal leakage, tracer probe the perimeter of the box to detect and pinpoint the area of leakage. Patch the putty seal to eliminate detected leakage.

3.5 Install the internal helium hood enclosure if it is not already in place. The fill line shall be placed near the top (12 o'clock), and the vent/monitor line shall be near the bottom (6 o'clock).

3.6 If a turbomolecular pump (TMP) is used, begin pumping the circumferential leak test box with the turbomolecular pump backed by the auxiliary roughing pump after the box has been rough pumped to below 0.1 torr ($P_{RP} < 0.1$ torr). In sequence:

3.6.1 Close roughing valve V1,

3.6.2 Move the roughing line from the large roughing pump inlet to the turbomolecular pump stand inlet.

3.6.3 Start the turbomolecular pump system.

3.6.4 Open valve V1.

3.7 Fill the cold trap with LN_2 after the test system pressure is evacuated to below 30 millitorr.

3.8 With the HMS isolated from the test system (V2 closed), perform the following operations:

3.8.1 Zero the instrument.

3.8.2 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.

3.8.3 If the helium leak rate indication of step 3.8.2 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 3.8.2.

3.9 When the test system has been evacuated to below 5 millitorr:

3.9.1 Open valve V2 while pumping the HMS test port.

3.9.2 Close valve V1.

[Previous paragraph 3.9 (Opt) deleted]

3.10 When the HMS test port and UHV pressures stabilize, close the calibrated leak valve and allow the background level to stabilize.

3.10.1 With the HMS test valve V2 in the fully open position, zero the system background.

3.10.2 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.

3.11 Open the valve to the helium permeation standard leak mounted on the vacuum box 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.

3.12 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.

3.13 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.

3.14 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.

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

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

3.16 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 at step 3.7 above.

3.17 Fill the hood enclosure with helium by opening the regulated helium gas supply.

3.18 Calculate the helium concentration sensitivity correction factor (C_{hc}) = 100 ÷ % Helium in hood.

3.19 Observe the HMS leak rate indicator meter for the larger of one (1) minute or three times the measured response time recorded in step 3.11.

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

3.21 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 Signal Verification and 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 Signal Verification and Leak Location, below.

3.22 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 3.23 below.

If: $(M_3 - M_2) \times S_1 \times C_{hc} < 1 \times 10^{-10}$ atm cc/sec, proceed with step 3.23 below.

3.23 Open the valve to the helium standard leak mounted on the circumferential leak test box. Wait until the leak rate indication has stabilized, and record the leak rate indication signal (M_4) as a number of divisions on the instrument.

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

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

3.25 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 3.7 above. Percent agreement is equal to the lesser of S_1 or S_2 divided by the greater of S_1 or S_2.

% Agreement = (Lesser of S_1, S_2 ÷ Greater of S_1, S_2) x 100

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

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

3.27 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, remove the helium from the hood and begin the test sequence again at step 3.7 above.

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

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

3.29 If $Q_F \geq 1 \times 10^{-10}$ atm cc/sec, go to section 5.0 Signal Verification and Leak Location, below.

3.30 If $Q_F < 1 \times 10^{-10}$ atm cc/sec, the leak test of the closing joint and the adjacent area is acceptable. Complete all documentation required in Section 4.0 following. Remove the circumferential leak test box and associated putty seals from the beam tube.

4.0 DOCUMENTATION:

4.1 Complete a Form WL233B, CBI LIGO CIRCUMFERENTIAL WELD LEAK TEST REPORT, or a similar report generated by computer including all of the information required for Form WL233B. A copy of Form WL233B is Figure 2 on page 9 of this procedure.

4.2 Check for accuracy, sign and date the Form WL233B or the computer generated report.

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

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

4.5 In the comments section of the checklist, make entries of all note worthy leak testing events, such as leaks repaired, or unusual difficulties in completing a leak test.

5.0 SIGNAL VERIFICATION AND LEAK LOCATION

When necessary, leak signals shall be verified, and the location of leaks identified by applying one or more of the following techniques:

5.1 To distinguish a signal indication as due to a source associated with the HMS, isolate the HMS from the circumferential leak test box while monitoring the leak detector.

5.1.1 If the signal remains constant, then the source of the signal is attributable to the HMS. After further diagnosis, and repair of the cause of the signal, repeat the leak test procedure from the beginning.

5.1.2 If the signal diminishes rapidly to the previously observed background level, then the source of the signal is in the system upstream of the HMS. Re-open the HMS to the test system, and investigate further.

5.2 To distinguish a signal as due to a source in the test system in contrast to a signal due to a leak through the boundary under test, remove the helium from the hood while observing the signal indication.

5.2.1 If the signal remains steady or is increasing, the predominant source of the signal is in the test system. Investigate the test system further to identify and repair the cause of the signal, and repeat the leak test procedure from the beginning.

5.2.2 If the signal diminishes substantially after removal of the helium from the hood, a leak through the boundary under test is indicated. Proceed with leak location techniques.

5.3 Leak location by tracer probe technique. Perform the following while maintaining the vacuum in the circumferential leak test box, and while monitoring the leak rate indicator of the HMS:

5.3.1 Remove the purge dam/helium hood.

5.3.2 Visually examine the tube interior surface for any indication of a probable leak location.

5.3.3 Tracer probe the interior surface of the test area. Us either a small diameter, nonconforming, low flow helium probe, or a conforming helium probe end.

5.3.4 The tracer probing should proceed from the highest location in the tube (12 o'clock) downward.

5.3.5 When the leak has been located on the interior surface, proceed as follows:

5.3.5.1 Document the location of the leak,

5.3.5.2 Place punch marks straddling the location of the leak,

5.3.5.3 Re-install the purge dam/helium hood, and fill with helium,

5.3.5.4 Proceed with locating the leak location on the exterior surface.

5.3.6 Repair weld the leak in accordance with an approved CBI-LIGO repair welding procedure, and re-test the entire weld in accordance with this Procedure.

5.4 Leak location by detector probe technique (typically utilized to locate leaks greater than 10^{-7} atm cc/ sec.) Perform the following while maintaining a helium pressure in the hood:

5.4.1 Remove the circumferential leak test box from the area of the tube being tested.

5.4.2 Perform a detailed visual examination of the test area exterior surface, noting any locations where a leak might be probable. If the leak has been previously located on the interior surface, particular attention should be paid to the corresponding exterior surface.

5.4.3 With the helium detector probe unit attached to the helium mass spectrometer, perform a detector probe examination from the tube exterior. The sensitivity of the instrument, and the scan rate shall be verified by scanning a calibrated capillary leak. Typical detector stand-off is 0.12", with a scan speed of 2 ft/min. This examination should usually proceed from the lowest area of interest (6 o'clock) to the highest area.

5.4.4 If the leak can be repaired solely from the exterior surface, or the interior surface location of the leak has been determined, proceed with the weld repair of the leak in accordance with an approved CBI-LIGO repair welding procedure.

5.4.5 Assure that all documentation has been completed for the repair.

5.4.6 Leak test the entire test area again in accordance with this Procedure.

5.5 Leak location by the HMS vacuum box technique. Perform the following while maintaining a helium pressure in the hood:

5.5.1 Isolate the HMS from the test system. Replace the circumferential leak test box with a small HMS vacuum box.

5.5.2 Visually inspect the weld joint that contains the unacceptable leakage. If any area or areas are observed that appear to contain potential leaks, locally leak test that area or areas first.

5.5.3 Place the small HMS vacuum box over the selected area of the closing weld joint.

5.5.4 Evacuate the small HMS vacuum box with the HMS auxiliary vacuum pump. After it has evacuated to approximately 100 millitorr, throttle open the high vacuum system to the metal box. Should the pressure in the small HMS vacuum box stabilize at a higher pressure indicating potential seal leakage, tracer probe the perimeter of the seal to detect and pinpoint the area of leakage. If seal leakage is detected and pinpointed, increase the seating force to obtain a sufficient seal.

5.5.5 Observe the HMS leak indicator signal in divisions as the high vacuum absolute pressure meter stabilizes (reaches a plateau). If the indicator signal shows an increase over the normal background, isolate the box. If the signal decreases, leakage is indicated in the area being tested. If the indicator signal shows no increase over normal background and/or does not change when the box is isolated, no leakage is indicated in that area.

5.5.6 When a leak(s) is pinpointed, vent the vacuum box and vent the helium hood enclosure.

5.5.7 Repair the pinpointed leak or leaks and retest the entire closing weld joint.

CBI

TITLE HELIUM MASS SPECTROMETER HOOD TEST OF CLOSING WELD JOINTS BETWEEN BEAM TUBE SECTIONS PRODUCT LIGO BEAM TUBE MODULES CALIFORNIA INSTITUTE OF TECHNOLOGY	IDENTIFICATION HMST2N			
	REFERENCE NO. 953570(930212)		SHT 9OF 9	
	OFFICE RSE		REVISION 6D	
	MADE BY CNS	CHKD BY EEB	MADE BY PBS	CHKD BY WAC
	DATE 3/15/94	DATE 5/1/94	DATE 1/29/97	DATE 2/4/97

CBI **LIGO CIRCUMFERENTIAL WELD LEAK TEST REPORT**

WELD I.D. NO. ________ ________ 953571 CONTRACT Hanford/Livingston MODULE LOCATION (Circle One)

Procedure and Rev. HMST2N Rev. ____	HMS Leak Detector (Mfg., Model and Serial Number)
System Standard Helium Leak ID	System Standard Leak Helium Leakage Rate ______ x 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
HMS Test Port Pressure 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 (S1) = Leakage Rate of Std. Leak / $M_1 - M_2$ = _______ x 10^{-} — atm cc / sec / division

Helium concentration = _______ %

Helium concentration correction factor (Che) = 100 / % 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 (S2) = 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) = ($M_3 - M_2$) x 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 ______________

Printed in USA WL 233B 5/94

Figure 2. CBI LIGO CIRCUMFERENTIAL WELD LEAK TEST REPORT (WL233B)