ACCEPTANCE CRITERIA AND ACCEPTANCE TRAVELER FOR DFBX-G

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REVISION RECORD

Revision	Date	Subject

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1.0 PURPOSE:

This document defines the acceptance criteria for the fabrication and integration of the feedbox DFBX-G. It outlines the essential dimensional checks, pressure and leak checks, and electrical tests that must be done on the feedbox subassemblies during fabrication and assembly process. This document also specifies the required checks of the feedbox and its shipping package before shipping to CERN and after shipping is complete at the CERN's receiving dock. LBNL will accept the DFBX from the cryogenic system fabricator after the feedbox and its shipping package have successfully passed the required checks at CERN's receiving dock.

The acceptance criteria for the feedboxes are driven by LBNL-LHC feedbox functional specification [2] and the LBNL-LHC interface specifications for the feedboxes given in references [3] through [7].

The inspection processes specified in this document are to be performed in accordance to the test plans and specifications provided by the cryogenic system integrator in their response to the Request for Proposal (RFP) associated with the fabrication and assembly of the 8 feedboxes. Any exceptions to the agreed upon test procedures must submitted to LBNL for review and approval.

Section 2 of this document lists the applicable LBNL drawings used in the inspection process. Section 3 defines the acceptance criteria for the helium tank welds and the piping assemblies. The traveler table for the pipes is included in this section. Section 4 defines the essential checks and tests that must be done during the process of assembling the feedboxes and after the final assembly of the vacuum vessel. These tests include the following: (See sections 4.1 through 4.16.)

1. The position of the helium tank and chimneys with respect to the vacuum vessel top plate is measured and compared to the relevant LBNL drawings.
2. Continuity checks and hi pot tests in air are done on the leads and bus bars after they have been connected in the helium tank.
3. The cold shock, pressure test, and vacuum leak checks are done on the helium tank, bus duct assembly, and chimney assemblies.
4. A hi-pot of the leads is done in helium gas
5. The required voltage checks and continuity checks for the instrumentation leads are done in air.
6. The required pressure tests and vacuum leak checks of the instrumentation lead pipes and the feed throughs are done.
7. Hi-pot test of instrumentation conduits are done in helium gas.
8. A check is done to see that pipes are at least 12 mm apart
9. A final check of the helium tank position is done. As the vacuum vessel is welded, a distortion check of the top plate is done to make sure that the helium thank position does not change.
10. A check is done to see that the WQX, the WBX flanges are in the correct position. A check is also done on the position of the JC1 and JC2 jumper flanges. A check is done to see that the ends of the pipes are in the correct position.
11. DFBX vacuum vessel pressure test.

12. The final vacuum vessel vacuum leak check is done while the helium tank is at liquid nitrogen temperature.
13. The final helium tank and bus duct vacuum leak check is done while the helium tank is at liquid nitrogen temperature.
14. The final piping vacuum leak check is done while the helium tank is at liquid nitrogen temperature.

The minimum acceptance traveler tables for the feedbox are included in each of the sub-sections of section 4 in this report.

At the conclusion of these tests, LBNL will authorize the cryogenic system fabricator to prepare the feedbox for shipping to CERN in accordance with LBNL Shipping Specification [8]

Section 5 describes the series of tests to be performed before the package is shipped to CERN and after the package is received at CERN' dock.

2.0 APPLICABLE LBNL DRAWINGS

LBNL Drawings:

24C352	Feed Box Assembly (Sheet 1)
24C352	Feed Box Assembly (Sheet 2)
24C352	Feed Box Assembly (Sheet 3)
24C352	Feed Box Assembly (Sheet 4)
24C352	Feed Box Assembly (Sheet 5)
24C352	Feed Box Assembly (Sheet 6)
24C352	Feed Box Assembly (Sheet 7)
24C352	Feed Box Assembly (Sheet 8)
24C352	Feed Box Assembly (Sheet 9)
24C352	Feed Box Assembly (Sheet 10)
24C352	Feed Box Assembly (Sheet 11)
24C352	Feed Box Assembly (Sheet 12)
25I137	Top Plate and Tank Weldment (Sheet 1)
25I137	Top Plate and Tank Weldment (Sheet 2)
25I137	Top Plate and Tank Weldment (Sheet 3)
25I137	Top Plate and Tank Weldment (Sheet 4)
25I206	V and LD Pipe Assembly
25I890	XB and Surge Pot Assembly
25I210	CY1 Pipe Assembly
25I215	CY2 Pipe Assembly
25I218	CC'1 Pipe Assembly
25I216	CC'2 Pipe Assembly
25I217	CC'3 Pipe Assembly
25I225	DH Pipe Assembly
25I209	E1 Pipe Assembly

25I214	E2 Pipe Assembly
25I212	EX Pipe Assembly
25I213	LD1 Pipe Assembly
25I208	LD2 Pipe Assembly
25I891	LD3 Bus Duct Pipe Assembly
25I219	MBX2 Instrumentation Pipe Assembly
25I301	MQX2 Instrumentation Pipe Assembly
25I619	Wiring diagram

Note the final digit (the drawing size) has been dropped from the LBNL drawing number. See the LBNL Drawing Title block guide for information about LBNL drawing numbers [1].

3.0 ACCEPTANCE CRITERIA AND TRAVELER FOR FEEDBOX SUBASSEMBLIES

The acceptance criteria reported in this section are only the ones that must be met by the cryogenic system integrator. The acceptance criteria for the lambda plate assembly, the bus ducts, the instrumentation conduits and the LHC beam pipe assembly are fabricated at the Lawrence Berkeley National Laboratory (LBNL). LBNL will complete the acceptance tests and travelers for these assemblies

Repairs to any part of the Feedbox assembly or its subassemblies during the fabrication or assembly process must not include soft soldering, or brazing of any type. Repairs that involve the bending of prefabricated parts must be avoided. If repairs need to done to component, the repairs done and the results of tests done before and after the repairs must be included with the DFBX traveler. LBNL shall be notified with a description of the repair either by mail or electronically. The repair description includes the part or parts to be repaired, their location, the repair done, and methodology to be used for the repair.

3.1 Acceptance Criteria for the Helium Tank Welds and Box Materials

- The helium tank and lead chimneys must be fabricated in accordance to the standards of the ASME Pressure Vessel Code, Section 8.
- All welds in the helium tank assembly must be made in accordance to the ASME Pressure Vessel Code.
- All of the longitudinal welds in the helium tank except for the tank door welds must be radiographed. The radiographs and their interpretation must be included as part of the traveler.
- The welds for the tank door must be checked for cracks using a die penetration test. The results must be included as part of the traveler.
- All metallurgical tests of the tank and weld material (such as 4 K Charpy impact tests) must also be included in the acceptance traveler. LBNL's minimum acceptable absorbed energy at 4 K is 22-ft lb (144 J).

3.2 Acceptance Criteria for the Feedbox Piping

Once the piping assemblies have been fabricated to the correct dimensions shown on the LBNL piping drawings, the piping assemblies are tested using the following tests:

- ♦ Verification that the inside of the pipe assembly is free of obstructions must be made on all pipe assemblies. The large diameter pipe assemblies should be inspected using a flexible bore scope to verify that the pipe assembly is free from obstruction and gobs of weld slag. Small pipe sections should have a flexible wire or cable passed through them to verify that the pipe section is not plugged.

- ♦ A cold shock on each pipe assembly must be performed at least twice. A cold shock consists of cooling the pipe assembly to liquid nitrogen temperature (at least 80 K) and warming it back to room temperature (at least 5 C).

- ♦ The pipe must be pressure checked with dry nitrogen gas to the test pressure shown in Table 1. If leaks are detected during the pressure test, the leaks must be found and repaired. Repaired pipes must be dimension checked, cold shocked, and pressure tested.

- ♦ After completing the pressure test, the vacuum leak check should be performed by qualified vacuum leak checkers. If leaks are found and the pipe assembly is repaired, cold shock and pressure and vacuum leak checks should be repeated. The maximum allowable leak rate for a pipe assembly is 10^{-9} atm cc s-1. As a final check measure the leak rate, introduce a standard leak of about 10^{-9} atm cc s-1 and record the measured leak rate on the pipe traveler sheet. The standard leak used during the leak check process must be calibrated. If vacuum leaks are found, the pipe assembly must be repaired. Repaired pipes must be re-dimension checked, re-cold shocked, re-pressure checked and re-vacuum leak checked until no leaks are found.

- ♦ The blank-off flanges installed on the ends of the pipe assemblies are used for the pipe pressure test and vacuum leak check. The flanges must not be removed form the pipe after the tests are complete. These flanges will be used for later vacuum leak checks as specified in Sections 4.16 and 5.2.

The traveler form that follows is used for all of the pipe assemblies or sub-assemblies in the feedboxes. The pipe assembly traveler sheet is filled out for the final cold shock, pressure test and vacuum leak check. If piping sub-assemblies are welded together, the cold shock, pressure test and vacuum leak check must be repeated for the whole pipe assembly. A separate traveler sheet is required for that case. Note: the LBNL drawing for the pipe assembly or sub-assembly must be attached to the traveler sheet. The results of the earlier tests on the pipe assembly or subassembly must be attached to the pipe traveler sheet.

Table 3.2. The LBNL Drawing Number and Test Pressure for Each Pipe Assembly

Pipe Assembly Designation	LBNL Drawing Number	Minimum Test Pressure (MPa)	(psig)
V*	25I206	0.50	73
XB & surge pot	25I890	0.50	73
CY1	25I210	2.50	364
CY2	25I215	2.50	364
CC'1	25I218	2.50	364
CC'2	25I216	2.50	364
CC'3	25I217	2.50	364
DH	25I225	2.50	364
E1	25I209	2.75	400
E2	25I214	2.75	400
EX	25I212	2.75	400
LD1	25I223	2.50	364
LD2	25I208	2.50	364
LD3 + bus ducts**	25I891	2.50	364
MBX2***	25I219	2.50	364
MQX2***	25I301	2.50	364

*Note: V is the LHC beam pipe. This assembly will be fabricated and pre-tested by LBNL.

**Note: **The bus ducts assembly includes MQX1 and MBX1 that are attached the helium tank. These pipes will be fabricated and pre-tested by LBNL. The vendor will fabricate the LD3 pipe

*** MBX2 and MQX2 are the magnet instrumentation conduits. They will be fabricated by LBNL.

PIPE ASSEMBLY OR PIPE SUB-ASSEMBLY TRAVELER SHEET
Vendor Must Prepare a Separate Traveler for Each Sub-Assembly

This traveler is for pipe assembly (sub-assembly) _____________(see attached drawing) for Feedbox ____. This pipe assembly (sub assembly) was completed on ___________ (date)

Verification that the pipe assembly is clear of obstructions ______________(date)
(

Cold Shock Record for Pipe Assembly (Sub-Assembly)

Cold Shock Number	Pipe Temperature Before Cold Shock ©	LN2 Cold Shock (date)
1	___________	___________
2	___________	___________

Pressure Test Record for the Pipe Assembly (Sub-Assembly)

Min Test Pressure (psig)	Actual Test Pressure at t = 30 sec (psig)	Actual Test Pressure at t = 600 sec(psig)	Test Date (date)
__________	___________	___________	___________

Vacuum Leak Check Record for the Pipe Assembly (Sub-Assembly)

Vacuum leak _________________ atm cc s-1

Pressure __________________________ torr

Vacuum leak check date __________________________

Calibration Date for the Standard Leak __________________________

Attach chart recordings and other data as part of this traveler to show the details of the vacuum leak check of the pipe assembly (sub-assembly). If the pipe assembly vacuum leak check was done more than once, included the leak check data for all of leak checks performed on the pipe assembly (sub-assembly).

4.0 ACCEPTANCE CRITERIA AND TRAVELER FOR THE FEEDBOX ASSEMBLY

Sections 4.1 through 4.15 represent the acceptance tests that must be performed on the feedboxes during the box assembly. All of these steps represent places where the feedbox assembly traveler must be filled to verify to LBNL that the appropriate measurements of tests have been done. The vendor will do additional tests during the assembly process. The results of these tests must be given to LBNL along with the tests shown in the DFBX acceptance traveler.

4.1 Acceptance Criteria for Assembly of the Helium Tank and Top Plate Assembly

Once the helium tank, chimneys and top plate have been welded together complete Table 4.1 in accordance to the dimensions shown on LBNL drawings 24C352 (sheet 5) and 25I137 (Sheet 3).

- Check to see that the helium tank is in the correct position with respect to the top of the Feedbox top plate.
- When the tank position measurements are being made, the bellows between the lead chimneys and the helium tank should be in the neutral position with no side-to-side deflection over 0.5 mm. Record the results in Table 4.1.
- Before the assembly process can extend beyond this point, record the amount of bellows motion off axis (squirm) and photograph the position of each of the lead chimney bellows. Attach the photos of the bellows to Table 4.1 in the traveler.
- The lead chimney straightness shall be checked by passing a cylindrical gauge that is 1 mm in diameter smaller than the inside diameter of the lead chimney down the lead chimney. The results are recorded in Table 4.1.

Table 4.1. Measurements of the Critical Dimensions after the Helium Tank, and the Lead Chimneys have been Welded Together into the Top Plate Assembly continued

Confirmation that the Lead Chimneys Meet the Straightness Tolerance Specified
Use a cylindrical gauge to measure chimney straightness.

Does DFLX1 chimney meet the straightness tolerance? ___ Yes ___ No

Does DFLX2 chimney meet the straightness tolerance? ___ Yes ___ No

Does DFLX3 chimney meet the straightness tolerance? ___ Yes ___ No

Does DFLX4 chimney meet the straightness tolerance? ___ Yes ___ No

Does DFLX5 chimney meet the straightness tolerance? ___ Yes ___ No

Does DFLX6 chimney meet the straightness tolerance? ___ Yes ___ No

Does DFLY chimney, leads 1 through 6 meet the straightness tolerance? ___ Yes ___ No

Does DFLY chimney, leads 7 through 12 meet the straightness tolerance? ___ Yes ___ No

Does DFLY chimney, leads 13 and 14 meet the straightness tolerance? ___ Yes ___ No

Does DFLZ chimney, all leads, meet the straightness tolerance? ___ Yes ___ No

Measurement of Lead Chimney Bellows Offset

Is the lower bellows offset for DFLX1 chimney less than 0.5 mm? ___ Yes ___ No

Is the lower bellows offset for DFLX2 chimney less than 0.5 mm? ___ Yes ___ No

Is the lower bellows offset for DFLX3 chimney less than 0.5mm? ___ Yes ___ No

Is the lower bellows offset for DFLX4 chimney less than 0.5 mm? ___ Yes ___ No

Is the lower bellows offset for DFLX5 chimney less than 0.5 mm? ___ Yes ___ No

Is the lower bellows offset for DFLX6 chimney less than 0.5 mm? ___ Yes ___ No

Is the lower bellows offset for DFLY chimney, leads 1 to 6 less than 0.5 mm? ___ Yes ___ No

Is the lower bellows offset for DFLY chimney, leads 7 to 12 less than 0.5 mm ___ Yes ___ No

Is the lower bellows offset for DFLY chimney, leads 13 & 14 less than 0.5 mm?___ Yes ___ No

Is the lower bellows offset for DFLZ chimney, leads 1 to 10 less than 0.5 mm? ___ Yes ___ No

Photographs of the bellows offset and squirm on each of the chimneys must be attached to the traveler at this point.

4.2 Resistance and Voltage Tests for the Leads and Busses after Installation

- The resistance of each lead must be checked after it has been installed and the lead bus has been connected.
- The lead designation must be clearly marked at the end of the bus coming out of the bus duct. The position of each lead should correspond to the lead positions given in references [3], [4], and [6] and the applicable LBNL drawings.
- Once the lead resistance has been checked and the leads have been marked, insulate the end of each lead in preparation for the hi-pot voltage test.
- The leads in the bus ducts must be individually hi-potted in air. While hi-potting a lead the other leads shall be at ground potential. This statement applies to all of the leads except the temperature sensor leads on the DFLX leads. **Do not ground the wires for the temperature sensors on the HTS leads (the DFLX leads)during a hi-pot of these leads.**
- The hi-pot voltage should be held for 2 minutes. The DFLX leads and their busses must be hi-potted to 5 kV with a maximum allowable leakage current at the full hi-pot voltage of less than 50 μA to ground.
- The DFLY leads (the 600 A leads), the DFLZ leads (the 120 A leads), and their busses must be hi-potted to 2 kV with a maximum allowable leakage current at the full hi-pot voltage of less than 20 μA to ground.
- Record the resistance and voltage acceptance test results in Table 4.2-1.
- Hi-pot at 300 V and do a resistance check of the HTS temperature sensors. The maximum allowable leakage current during the hi-pot is 6 μA. The resistance of the temperature sensors should be between 50 and 70 ohms. Record the findings in Table 4.2-2. Do a continuity check of the lead voltage taps (the hi-pot was done with the lead hi-pot). Record the findings in Table 4.2-3
- Check the resistance and hi-pot to 600 V the instrumentation wires entering the helium tank and record the findings in Table 4.2-4. The temperature sensors should have a resistance between 50 and 70 ohms. The instrumentation leads must be hi-potted to 600 V in air. The maximum allowable leakage current at the full hi-pot voltage is 6 μA. The hi-pot voltage should be held for 2 minutes.

Table 4.2-1. Resistance Check and High Voltage Insulation Checks for the MQX1 and MBX1 Leads and Busses

Designation Lead	Bus	Resistance (ohms)	Lead & Bus Marked (date)	Pig Tail Length (mm)	Hi-pot Done (date)
MQX1 Leads and Busses					
7500 A HTS Leads, 5 kV, 50 µA Hi-pot (DFLX chimneys, one lead per chimney)					
DFLX 1	5L				
DFLX 2	5U				
DFLX 3	8L				
DFLX 4	8U				
600 A Leads, 2 kV, 20 µA Hi-pot (DFLY chimneys)					
DFLY1	V2A				
DFLY2	V2B				
DFLY3	V3A				
DFLY4	V3B				
DFLY5	V1B				
DFLY6	V1A				
DFLY7	H2A				
DFLY8	H2B				
DFLY9	H3A				
DFLY10	H3B				
DFLY11	H1B				
DFLY12	H1A				
DFLY13	A2B				
DFLY14	A2A				
120 A Leads, 2 kV, 20 µA Hi-pot (DFLZ Chimney)					
DFLZ1	B4B				
DFLZ2	A4A				
DFLZ3	A4B				
DFLZ4	B3A				

Table 4.2-1. Resistance Check and High Voltage Insulation Checks for the MQX1 Leads and Busses Continued

Designation Lead	Designation Bus	Resistance (ohms)	Lead & Bus Marked (date)	Pig Tail Length (mm)	Hi-pot Done (date)
DFLZ5	B3B	________	________	________	________
DFLZ6	B6A	________	________	________	________
DFLZ7	B6B	________	________	________	________
DFLZ8	A3B	________	________	________	________
DFLZ9	A3A	________	________	________	________
DFLZ10	B4A	________	________	________	________
MBX1 Leads and Busses					
7500 A HTS Leads, 5 kV, 50 µA Hi-pot					
DFLX 5	DU	________	________	________	________
DFLX 6	DL	________	________	________	________

Table 4.2-2. Resistance Check and High Voltage Insulation Checks for the HTS Lead Temperature Sensors (Hi-pot to 300 V DC, 3 µA) (R = 50 to 70 ohms)

Lead #	Temp #	Pin #	Pin #	Resistance (ohms)	Hi-pot Done (date)
DFLX1	TT891a	1	2	________	________
DFLX1	TT891a	3	4	________	NA
DFLX1	TT891b	5	6	________	________
DFLX1	TT891b	7	8	________	NA
DFLX1	TT893	9	10	________	________
DFLX1	TT893	11	12	________	NA
DFLX2	TT891a	1	2	________	________
DFLX2	TT891a	3	4	________	NA
DFLX2	TT891b	5	6	________	________
DFLX2	TT891b	7	8	________	NA

Table 4.2-2. Resistance Check and High Voltage Insulation Checks for the HTS Lead Temperature Sensors Cont. (Hi-pot to 300 V DC, 3 μA) (R = 50 to 70 ohms)

Lead #	Pin #	Pin #	Pin #	Resistance (ohms)	Hi-pot Done (date)
DFLX2	TT893	9	10	________	________
DFLX2	TT893	11	12	________	NA
DFLX3	TT891a	1	2	________	________
DFLX3	TT891a	3	4	________	NA
DFLX3	TT891b	5	6	________	________
DFLX3	TT891b	7	8	________	NA
DFLX3	TT893	9	10	________	________
DFLX3	TT893	11	12	________	NA
DFLX4	TT891a	1	2	________	________
DFLX4	TT891a	3	4	________	NA
DFLX4	TT891b	5	6	________	________
DFLX4	TT891b	7	8	________	NA
DFLX4	TT893	9	10	________	________
DFLX4	TT893	11	12	________	NA
DFLX5	TT891a	1	2	________	________
DFLX5	TT891a	3	4	________	NA
DFLX5	TT891b	5	6	________	________
DFLX5	TT891b	7	8	________	NA
DFLX5	TT893	9	10	________	________
DFLX5	TT893	11	12	________	NA
DFLX6	TT891a	1	2	________	________
DFLX6	TT891a	3	4	________	NA
DFLX6	TT891b	5	6	________	________
DFLX6	TT891b	7	8	________	NA
DFLX6	TT893	9	10	________	________
DFLX6	TT893	11	12	________	NA

Table 4.2-3. Continuity Check for the Lead Voltage Taps

Lead #	Tap #	Pin #	Continuity Check (date)
7500 A DFLX Leads with the Lower HTS Section			
DFLX1	V1a	1	________
DFLX1	V2a	2	________
DFLX1	V3a	4	________
DFLX1	V4a	5	________
DFLX1	V5a	6	________
DFLX1	V1b	1	________
DFLX1	V2b	2	________
DFLX1	V3b	4	________
DFLX1	V4b	5	________
DFLX1	V5b	6	________
DFLX2	V1a	1	________
DFLX2	V2a	2	________
DFLX2	V3a	4	________
DFLX2	V4a	5	________
DFLX2	V5a	6	________
DFLX2	V1b	1	________
DFLX2	V2b	2	________
DFLX2	V3b	4	________
DFLX2	V4b	5	________
DFLX2	V5b	6	________
DFLX3	V1a	1	________
DFLX3	V2a	2	________
DFLX3	V3a	4	________
DFLX3	V4a	5	________
DFLX3	V5a	6	________

Table 4.2-3. Continuity Check for the Lead Voltage Taps Continued

Lead #	Tap #	Pin #	Continuity Check (date)
DFLX3	V1b	1	________
DFLX3	V2b	2	________
DFLX3	V3b	4	________
DFLX3	V4b	5	________
DFLX3	V5b	6	________
DFLX4	V1a	1	________
DFLX4	V2a	2	________
DFLX4	V3a	4	________
DFLX4	V4a	5	________
DFLX4	V5a	6	________
DFLX4	V1b	1	________
DFLX4	V2b	2	________
DFLX4	V3b	4	________
DFLX4	V4b	5	________
DFLX4	V5b	6	________
DFLX5	V1a	1	________
DFLX5	V2a	2	________
DFLX5	V3a	4	________
DFLX5	V4a	5	________
DFLX5	V5a	6	________
DFLX5	V1b	1	________
DFLX5	V2b	2	________
DFLX5	V3b	4	________
DFLX5	V4b	5	________
DFLX5	V5b	6	________
DFLX6	V1a	1	________
DFLX6	V2a	2	________
DFLX6	V3a	4	________

Table 4.2-3. Continuity Check for the Lead Voltage Taps Continued

Lead #	Tap #	Pin #	Continuity Check (date)
DFLX6	V4a	5	________
DFLX6	V5a	6	________
DFLX6	V1b	1	________
DFLX6	V2b	2	________
DFLX6	V3b	4	________
DFLX6	V4b	5	________
DFLX6	V5b	6	________
600 A DFLY Gas cooled Leads			
DFLY1	V1	wire	________
DFLY1	V2	2	________
DFLY1	V3	1	________
DFLY2	V1	wire	________
DFLY2	V2	4	________
DFLY2	V3	3	________
DFLY3	V1	wire	________
DFLY3	V2	6	________
DFLY3	V3	5	________
DFLY4	V1	wire	________
DFLY4	V2	8	________
DFLY4	V3	7	________
DFLY5	V1	wire	________
DFLY5	V2	10	________
DFLY5	V3	9	________
DFLY6	V1	wire	________
DFLY6	V2	12	________
DFLY6	V3	11	________

Table 4.2-3. Continuity Check for the Lead Voltage Taps Continued

Lead #	Tap #	Pin #	Continuity Check (date)
DFLY7	V1	wire	________
DFLY7	V2	2	________
DFLY7	V3	1	________
DFLY8	V1	wire	________
DFLY8	V2	4	________
DFLY8	V3	3	________
DFLY9	V1	wire	________
DFLY9	V2	6	________
DFLY9	V3	5	________
DFLY10	V1	wire	________
DFLY10	V2	8	________
DFLY10	V3	7	________
DFLY11	V1	wire	________
DFLY11	V2	10	________
DFLY11	V3	9	________
DFLY12	V1	wire	________
DFLY12	V2	12	________
DFLY12	V3	11	________
DFLY13	V1	wire	________
DFLY13	V2	2	________
DFLY13	V3	1	________
DFLY14	V1	wire	________
DFLY14	V2	4	________
DFLY14	V3	3	________
120 A DFLZ Gas cooled Leads			
DFLZ1	V1	wire	________
DFLZ1	V2	2	________
DFLZ1	V3	1	________

Table 4.2-3. Continuity Check for the Lead Voltage Taps Continued

Lead #	**Tap #**	**Pin #**	**Continuity Check (date)**
DFLZ2	V1	wire	________
DFLZ2	V2	4	________
DFLZ2	V3	3	________
DFLZ3	V1	wire	________
DFLZ3	V2	6	________
DFLZ3	V3	5	________
DFLZ4	V1	wire	________
DFLZ4	V2	8	________
DFLZ4	V3	7	________
DFLZ5	V1	wire	________
DFLZ5	V2	10	________
DFLZ5	V3	9	________
DFLZ6	V1	wire	________
DFLZ6	V2	12	________
DFLZ6	V3	11	________
DFLZ7	V1	wire	________
DFLZ7	V2	14	________
DFLZ7	V3	13	________
DFLZ8	V1	wire	________
DFLZ8	V2	16	________
DFLZ8	V3	15	________
DFLZ9	V1	wire	________
DFLZ9	V2	18	________
DFLZ9	V3	17	________
DFLZ10	V1	wire	________
DFLZ10	V2	20	________
DFLZ10	V3	19	________

Table 4.2-4. Resistance Check and High Voltage Insulation Checks for the Helium Tank Instrumentation Leads

Sensor #	Pin #	Pin #	Resistance (ohms)	Hi-pot Done (date)
Two Liquid Level Sensors Four Leads Each, 600 V, 6 µA Hi-pot				
LT830a	1	2	________	________
LT830a	3	4	________	NA
LT830b	5	6	________	________
LT830b	7	8	________	NA
Pt RTD Temperature Sensor with Four Leads, 600 V, 6 µA Hi-pot (R = 50 to 70 ohms)				
TT830	9	10	________	________
TT830	11	12	________	NA
Two Helium Tank Heaters Two Leads Each, 600 V, 6 µA Hi-pot				
EH830a	13	14	________	________
EH830b	15	16	________	________

4.3 Cold Shock, Pressure Test and Vacuum Leak Check for the Helium Tank, Bus Duct and the Chimney Assembly

These tests are done after the lead and bust continuity and air hi-pot checks and after the helium tank cover plates have been sealed. See Figures 1a through 1c for diagrams of the tank assembly during the various tests. The cold shock, pressure test, and vacuum leak check for the helium tank, the chimneys and bus ducts are described below in steps 4.3A through 4.3D

- Before these acceptance tests are done, the bus ducts MQX1 and MBX1 must be covered with a vacuum tight cap.
- The feed pipe to the bus ducts LD3 is blanked off with a valve so that the bus ducts can be pressurized and vacuum leak checked.
- Pipe DH to the HTS lead chimneys and pipe CC'1 to the helium tank should be separated for the cold shock test. Liquid nitrogen is introduced into the helium tank for the cold shock through pipe CC'1.
- After the cold shock test, CC'1 and DH are connected to a single port for the pressure test and vacuum leak check. This port is used to pressurize and vacuum pump the helium tank.
- The helium tank relief valve must be set at of 0.6 MPa (72 psig) during the tank pressure test. The pressure relief valve on the tank must always be operable during the bus duct pressure test in the event the lambda plugs develop a leak.

4.3A Helium Vessel Cold Shock Test

The following procedure should be followed for the helium tank and bus duct assembly cold shock test. See Figure 1a.

- Make sure that the lead chimneys can be warmed to prevent frost build up in the chimney MLI.
- Thermal shock the helium vessel at least twice to liquid nitrogen temperature by filling the helium vessel with liquid nitrogen. Allow the vessel to warm up to room temperature (at least 5 C) after each cold shock. Do not fill the helium tank more than half full.
- Check the position of the chimney bellows and photograph them, when the helium tank is at liquid nitrogen temperature. Record the findings of the cold shock test in Table 4.3-1. The photographs of the cold chimneys must be in the feedbox traveler.

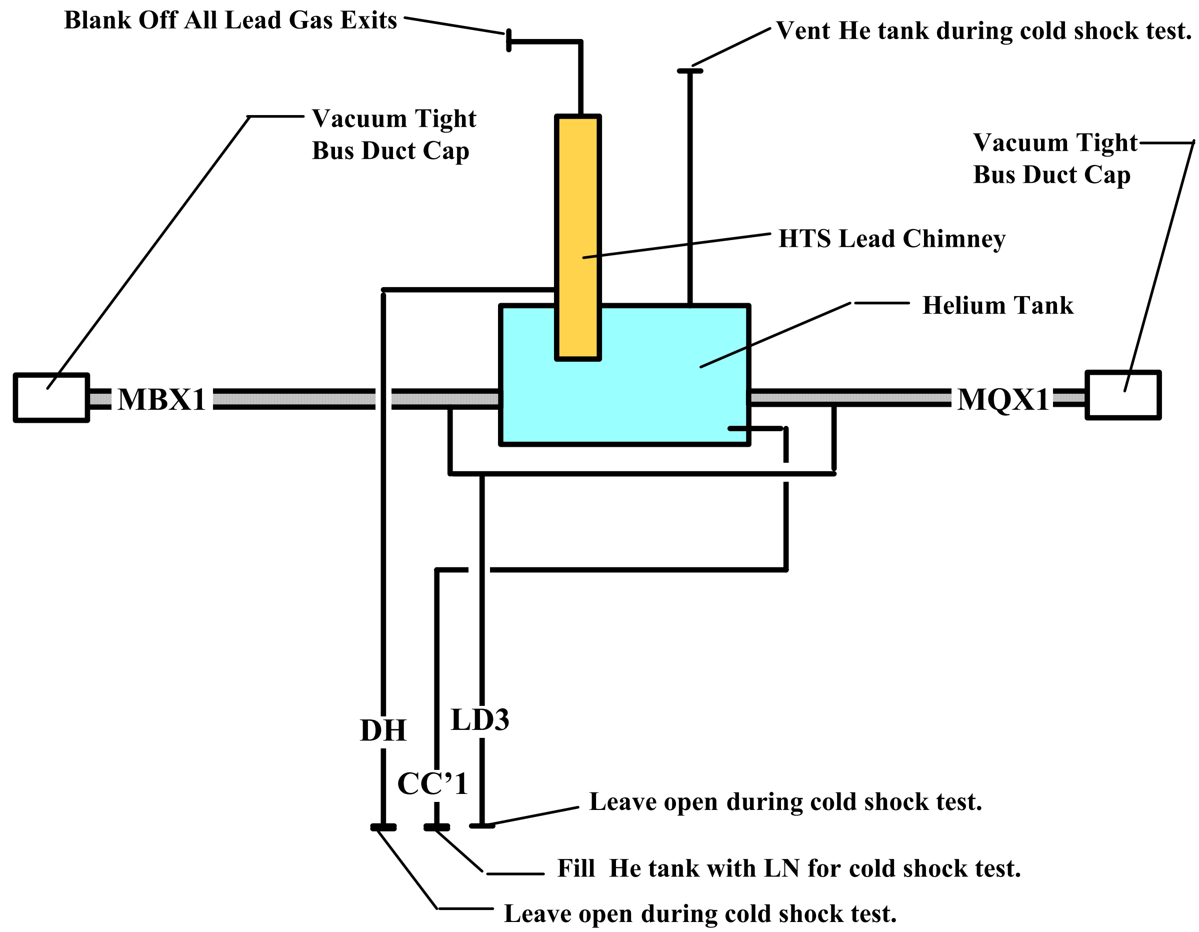

Figure 1a. A Schematic Representation of the Helium Tank, Lambda Plugs, and Bus Ducts during the Helium Tank Cold Shock Test

- The helium tank assembly must be warmed up, to eliminate the water and frost condensed on the helium tank, before going to the next step.

4.3B **Helium Vessel Pressure Test**

- Before doing the pressure test make sure that the tank piping is blanked off with a vacuum tight seal as shown in Figure 1b. The gas cooling pipes from all of the electrical leads must also be blanked off with a vacuum tight seal.

- The tank must be constrained against a movement of more than 5 mm in the downward direction, during the pressure test. The bellows should not flex more than 2 mm in any other direction but the downward direction when the tank is fully pressurized.

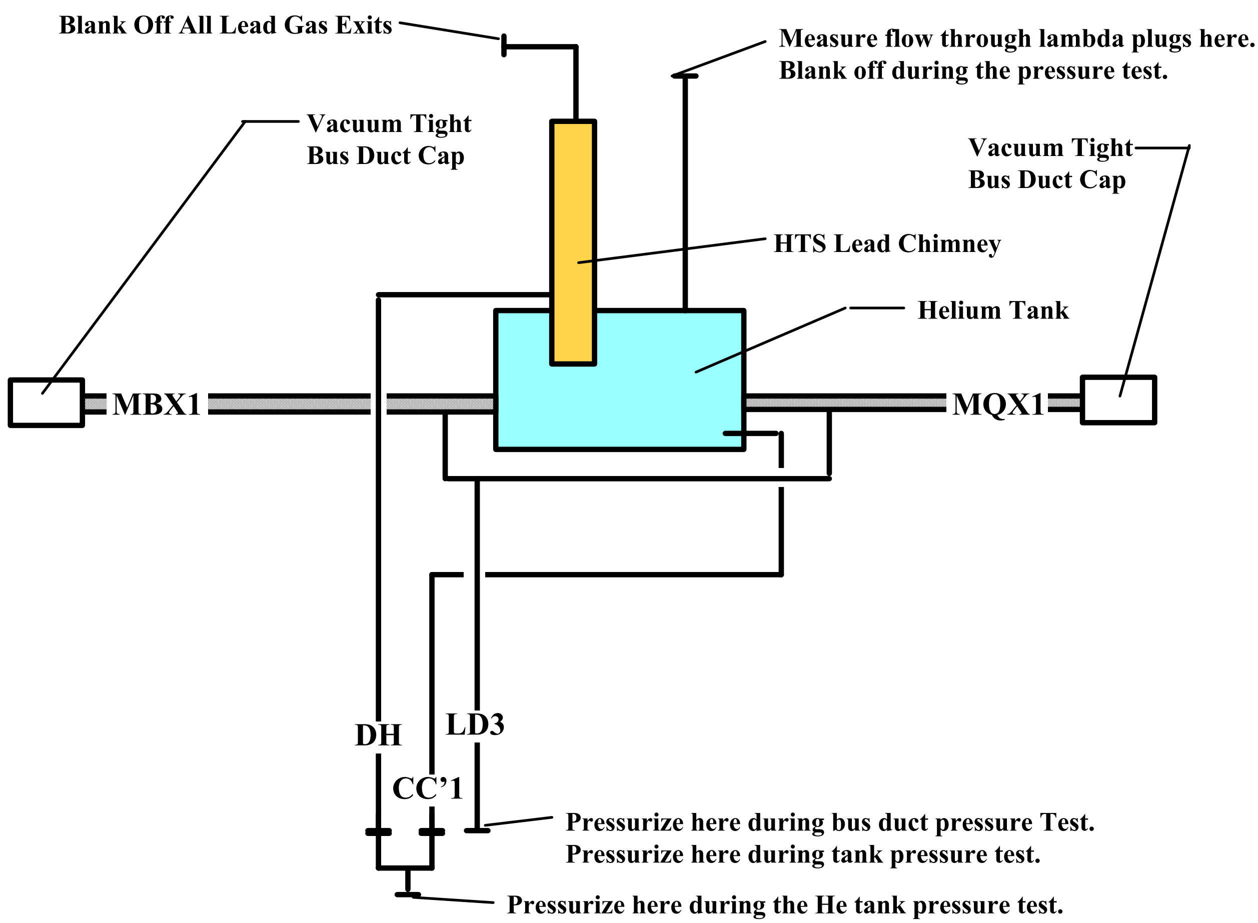

Figure 1b. A Schematic Representation of the Helium Tank, Lambda Plugs, and Bus Ducts during Bus Duct and Helium Tank Pressure Tests

- Check the bellows squirm as the helium tank is pressurized. The tank bellows should remain in proper alignment as the tank is pressurized to the test pressure.

The following 3 pressure tests should be performed:

1. Pressurize the helium tank with dry N_2 to 0.2 MPa (15 psig) while the bus duct side of the lambda plates is at 0.1 MPa (0 psig) and measure the leak rate through the installed lambda plates. The lambda plate leak rate should be the same as measured when they were assembled at LBNL. (See the results of the LBNL lambda plug tests in the LBNL bus duct traveler.) Record the lambda plug and bus duct flow findings in Table 4.3-2.
2. Pressurize the space outside of the lambda plates to 2.5 MPa (364 psig) with dry N_2 while the helium vessel must be at atmospheric pressur,0.1013 MPa (0 psig). Hold the test pressure (with the valve open) for 600 seconds. Record the pressure test findings in Table 4.3-3.

3. Pressurize the helium vessel with dry N_2 (through CC'1 and DH) and the down stream sides of the lambda plate (through pipe LD3) to 0.54 MPa (64 psig) and hold for 600 seconds. Both the tank pressure and the bus duct pressure should be measured at t = 30 seconds (with the valve closed) and t = 600 seconds. Note: the tank relief valve should be set to 0.6 MPa (72 psig) during the bus duct and tank pressure test. Record the pressure test findings in Table 4.3-3. Take photos of the bellows when the helium tank is pressurized to 0.54 MPa (64 psig).

4.3C **Helium Vessel Vacuum Leak Check**.
The helium leak check should be performed at the lowest detectable leak rate below 4×10^{-9} atm cc s^{-1}. Record the vacuum leak check findings in Table 4.3-4. Open the valve to let a standard leak of about 10^{-8} atm cc s^{-1} into the helium tank. Record the findings in Table 4.3-4.

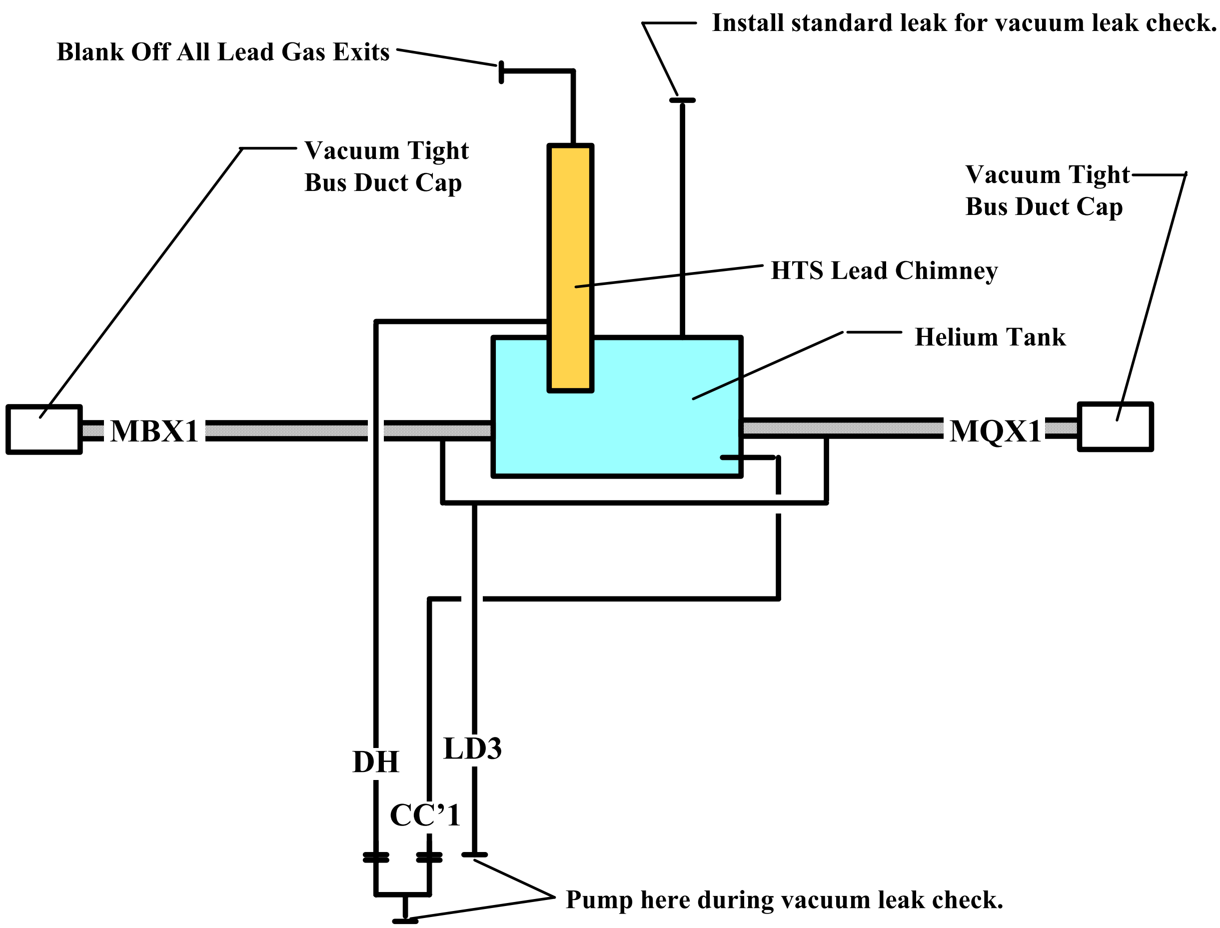

Figure 1c. A Schematic Representation of the Helium Tank, Lambda Plugs, and Bus Ducts during the Helium Tank and Bus Duct Vacuum Leak Check

4.3D **Check the Position of the Chimney Bellows**

- Take photographs of the bellows to go into the traveler. This is to ensure that the chimney bellows have not moved from their neutral position during the tests. A bellows off set of up to 1 mm is permissible
- After the bus duct and helium tank pressure tests and vacuum leak checks have been successfully completed, set the helium tank relief valve to its correct setting. Record the final helium tank relief valve setting in Table 4.3-4.

Table 4.3.1. Cold Shock Record for the DFBX Helium Tank, Tank Piping And MQX1 and MBX1 Bus Ducts

Cold Shock Number	Tank Temperature before Cold Shock (K)	LN2 Cold Shock (date)
1	____________	____________
2	____________	____________

Table 4.3.2. Flow Test Record for the DFBX Bus Ducts MQX1 and MBX1

	Helium Tank Pressure (psig)	Lambda Plug Flow Rate (cc per s)	Test Date (date)
MQX1	____________	____________	____________
MBX1	____________	____________	____________

Table 4.3-3. Pressure Test Record for the DFBX Helium Tank and Bus Ducts MQX1 and MBX1

Component Tested	**Test Pressure at t = 30 sec (psig)**	**Test Pressure at t = 600 sec (psig)**	**Test Date (date)**
Bus Duct Assembly	____________	____________	____________
Helium Tank	____________	____________	____________

Table 4.3-4. Vacuum Leak Check Record for the DFBX Helium Tank and the Bus Ducts MQX1 and MBX1 and Pipe LD3

Measured vacuum leak rate for the helium tank assembly ________________ atm cc s^{-1}

Vacuum Pressure in the helium tank __________________________________ torr

Date of the vacuum leak check __________________________________

Measured standard leak rate ________________ atm cc s^{-1}

Calibration Date for the Standard Leak ___________________________________

Final Helium Tank Relief Valve Setting after Vacuum Leak Check ____________ psig

Please include chart recording tapes and other data as part of this traveler to show the details of the vacuum leak check of the Feedbox helium tank. If the helium tank vacuum leak check was done more than once, include all of the leak check data for all of the leak checks for the helium tank, helium tank piping and bus duct assemblies.

4.4 Voltage Check (Hi-pot) of the Leads and Bus Ducts in Helium Gas

This is the step where a final voltage check of the leads and bus ducts are made with helium gas in the helium tank and the bus ducts. For this test, the helium tank, the 20 K gas space above the HTS leads and the bus ducts are connected together through a common jumper. A hi-pot test of the DFLX leads is made at 1400 V. The DFLY and DFLZ leads are hi-potted at 650 V. The temperature sensors on the DFLZ leads are hi-potted to 120 V DC and the sensors in the helium tank are hi-potted to 200 V. The arrangement of the piping for the hi-pot test is shown in Figure 1d.

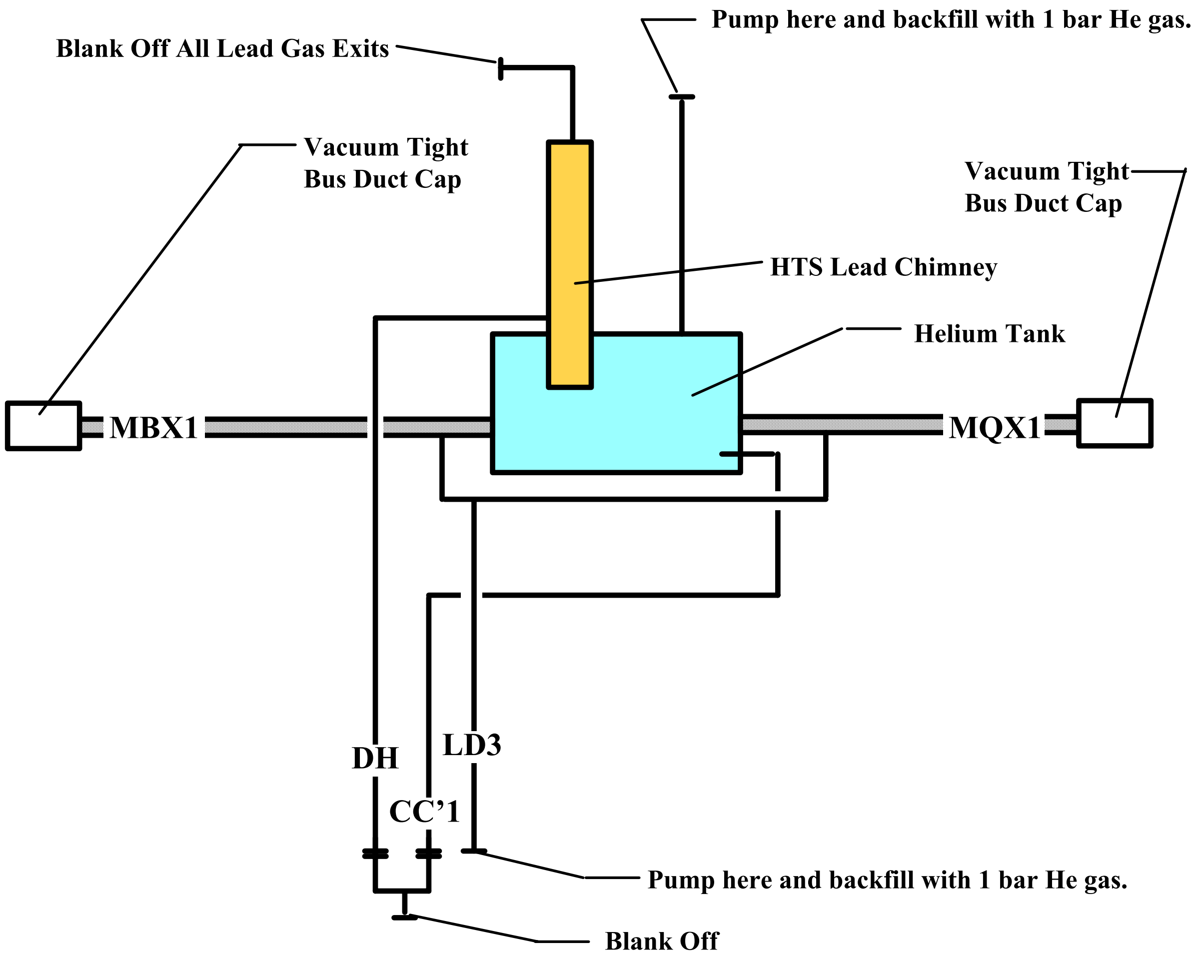

Figure 1d. A Schematic Representation of the Helium Tank, Lambda Plugs, and Bus Ducts During the Lead and Helium Tank Instrumentation Hi-pot in Helium Gas

Note: the seal arrangement for the helium tank, the pipes into the helium tank, the pipes into the 20 K gas space and the pipes into the bus ducts will be carried forward as assembly of the DFBX continues. The manifold for DH, CC'1 and LD3 will be used for filling the space with helium gas later in the DFBX assembly and acceptance test process.

The process for doing the hi-pot in helium for the leads and busses is given in the steps below. Once the helium tank leak check has been completed, one can rearrange the piping as shown in Figure 1d and perform the following steps:

- ♦ Backfill the helium tank with dry nitrogen gas to a slight positive pressure above 0.10 MPa (0 psig) and close the fill valve. This clears out any moisture that might have entered the tank when the manifold between the helium tank, bus ducts and the 20 K space is installed.

- ♦ Evacuate the dry nitrogen gas out of the helium tank and bus ducts to a pressure of 10^{-2} torr. Backfill the helium tank and bus ducts with dry grade A helium gas to a pressure of 0.10 MPa (0 psig) and close the fill valve.

- ♦ The leads in the bus ducts MQX1 and MBX1 must be individually hi-potted in from the air-side of the lead. The portion of the leads that are normally in helium shall be in helium during the hi-pot test. While hi-potting a lead, all of the other leads shall be at ground potential except for the leads to the temperature sensors that are attached to the DFLX leads. **Do not ground the temperature sensor wires on the HTS leads during a hi-pot of the DFLX leads.**

- ♦ The DFLX leads and their busses must be hi-potted to 1.4 kV with a maximum allowable leakage current at the full hi-pot voltage of less than 15 μA to ground.

- ♦ The DFLY leads (the 600 A leads), the DFLZ leads (the 120 A leads), and their busses must be hi-potted to 650 V with a maximum allowable leakage current at the full hi-pot voltage of less than 7 μA to ground.

- ♦ Record the voltage acceptance test results for the MQX1 and MBX1 leads and buses in Table 4.4-1

- ♦ The temperature sensors on the DFLX (7500 A) HTS leads must be hi-potted to 120 V DC. The maximum allowable leakage current is 1 μA. Record the results of the voltage acceptance tests in Table 4.4-2

- ♦ The sensor wires going into the helium tank should be hi-potted to the appropriate hi-pot voltage in helium gas (generally to 200 V). Record the voltage acceptance test results in Table 4.4-3.

Table 4.4-1. High Voltage Insulation Checks for the MQX1 and MBX1 Leads and Busses

Designation Lead	Bus	Hi-pot Done (date)
MQX1 Leads and Busses		
7500 A HTS Leads, 1.4 kV, 15 µA Hi-pot (DFLX chimneys, one lead per chimney)		
DFLX 1	5L	________
DFLX 2	5U	________
DFLX 3	8L	________
DFLX 4	8U	________
600 A Leads, 650 V, 7 µA Hi-pot (DFLY chimneys)		
DFLY1	V2A	________
DFLY2	V2B	________
DFLY3	V3A	________
DFLY4	V3B	________
DFLY5	V1B	________
DFLY6	V1A	________
DFLY7	H2A	________
DFLY8	H2B	________
DFLY9	H3A	________
DFLY10	H3B	________
DFLY11	H1B	________
DFLY12	H1A	________
DFLY13	A2B	________
DFLY14	A2A	________
120 A Leads, 650 V, 7 µA Hi-pot (DFLZ Chimney)		
DFLZ1	B4B	________
DFLZ2	A4A	________
DFLZ3	A4B	________
DFLZ4	B3A	________

Table 4.4-1. High Voltage Insulation Checks for the MQX1 Leads and Busses Continued

Designation Lead	Bus	Hi-pot Done (date)
DFLZ5	B3B	________
DFLZ6	B6A	________
DFLZ7	B6B	________
DFLZ8	A3B	________
DFLZ9	A3A	________
DFLZ10	B4A	________

MBX1 Leads and Busses

7500 A HTS Leads, 1.4 kV, 15 µA Hi-pot

DFLX 5	DU	________
DFLX 6	DL	________

Table 4.4-2. High Voltage Insulation Checks for the HTS Lead Temperature Sensors (Hi-pot to 120 V DC, 1 µA)

Lead #	Temp #	Pin #	Pin #	Hi-pot Done (date)
DFLX1	TT891a	1	2	________
DFLX1	TT891b	5	6	________
DFLX1	TT893	9	10	________
DFLX2	TT891a	1	2	________
DFLX2	TT891b	5	6	________
DFLX2	TT893	9	10	________
DFLX3	TT891a	1	2	________
DFLX3	TT891b	5	6	________
DFLX3	TT893	9	10	________

Table 4.4-2. High Voltage Insulation Checks for the HTS Lead Temperature Sensors Continued (Hi-pot to 120 V DC, 1 µA)

Lead #	Pin #	Pin #	Pin #	Hi-pot Done (date)
DFLX4	TT891a	1	2	________
DFLX4	TT891b	5	6	________
DFLX4	TT893	9	10	________
DFLX5	TT891a	1	2	________
DFLX5	TT891b	5	6	________
DFLX5	TT893	9	10	________
DFLX6	TT891a	1	2	________
DFLX6	TT891b	5	6	________
DFLX6	TT893	9	10	________

Table 4.4-3. High Voltage Insulation Checks for the Helium Tank Instrumentation Leads

Sensor #	Pin #	Pin #	Hi-pot Done (date)
Two Liquid Level Sensors Four Leads Each, 200 V, 2 µA Hi-pot			
LT830a	1	2	________
LT830b	5	6	________
Pt RTD Temperature Sensor with Four Leads, 200 V, 2 µA Hi-pot			
TT830	9	10	________
Two Helium Tank Heaters Two Leads Each, 200 V, 2 µA Hi-pot			
EH830a	13	14	________
EH830b	15	16	________

4.5 Continuity and Voltage Criteria for the Magnet Instrumentation Leads

This is the test of the magnet instrumentation leads that are installed in pipes MQX2 and MBX2. These conduits are fabricated at LBNL and shipped to the vendor for assembly into the feedbox.

- Do a continuity check from the pins of the feed-throughs to the Hypertronics connectors at the other end of the leads. See references [7] and LBNL drawing 25I619 for the correct pin positions and connector positions.
- Once the continuity has been checked, see that the Hypertronics connectors are insulated from one another so that a hi-pot test in air can be done. Wires that will be attached to temperature sensors are hi-potted to 600 V. All other wires must be hi-potted to 5 kV. (See reference [7].)
- Record the continuity and hi-pot test data in Table 4.5. Take photographs of the wires coming out of the MQX2 and MBX2 as they are connected to the Hypertronics connectors. These photographs must be included in the traveler.
- Take photographs of the LQX Diagnostic Assembly and LBX Diagnostic Assembly on the top of the DFBX vacuum tank. These photographs must be included in the traveler.

Table 4.5. Continuity Check and High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads

Air Side Pin #	Hypertronics Pin #	Continuity Check (date)	Hi-pot Test (date)
	MQX2 Leads		
Thirty-six Voltage Tap Leads, 5 kV, 50 µA Hi-pot			
A1	M2-1	________	________
A2	M2-2	________	________
A3	M2-3	________	________
A4	M2-4	________	________
A5	M2-5	________	________
A6	M3-1	________	________
B1	M3-2	________	________
B2	M3-3	________	________
B3	M3-4	________	________
B4	M3-5	________	________
B5	M4-1	________	________
B6	M4-2	________	________

Table 4.5. (cont.) Continuity Check and High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hypertronics Pin #	Continuity Check (date)	Hi-pot Test (date)
C1	M4-3	________	________
C2	M4-4	________	________
C3	M4-5	________	________
C4	M5-1	________	________
C5	M5-2	________	________
C6	M5-3	________	________
D1	M5-4	________	________
D2	M5-5	________	________
D3	M6-1	________	________
D4	M6-2	________	________
D5	M6-3	________	________
D6	M6-4	________	________
E1	M8-1	________	________
E2	M8-2	________	________
E3	M8-3	________	________
E4	M8-4	________	________
E5	M9-1	________	________
E6	M9-2	________	________
F1	M9-3	________	________
F2	M9-4	________	________
F3	M10-1	________	________
F4	M10-2	________	________
F5	M10-3	________	________
F6	M10-4	________	________

Table 4.5. (cont.) Continuity Check and High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hypertronicx Pin #	Continuity Check (date)	Hi-pot Test (date)
Eight Quench Protection Heaters Two Leads Each, 5 kV, 50 µA Hi-pot			
G1	M17-1	________	________
G2	M17-3	________	________
G3	M17-5	________	________
G4	M18-4	________	________
G5	M18-2	________	________
G6	M19-1	________	________
H1	M19-3	________	________
H2	M19-5	________	________
H3	M20-4	________	________
H4	M20-2	________	________
H5	M21-1	________	________
H6	M21-3	________	________
I1	M21-5	________	________
I2	M22-4	________	________
I3	M22-2	________	________
I4	M23-1	________	________
Eight Warm-up Heaters Two Leads Each, 2.0 kV, 20 µA Hi-pot			
I5	M12-1	________	________
I6	M12-2	________	________
J1	M12-3	________	________
J2	M12-4	________	________
J3	M13-1	________	________
J4	M13-2	________	________
J5	M13-3	________	________
J6	M13-4	________	________
K1	M14-1	________	________
K2	M14-2	________	________

Table 4.5. (cont.) Continuity Check and High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hypertronics Pin #	Continuity Check (date)	Hi-pot Test (date)
K3	M14-3	________	________
K4	M14-4	________	________
K5	M15-1	________	________
K6	MI15-2	________	________
L1	M15-3	________	________
L2	M15-4	________	________
Eight Temperature Sensors Four leads Each, 600 V, 7 µA Hi-Pot			
1	M25-1	________	________
2	M25-2	________	________
3	M25-3	________	________
4	M25-4	________	________
5	M25-5	________	________
6	M25-6	________	________
7	M25-11	________	________
8	M25-10	________	________
9	M25-9	________	________
10	M25-8	________	________
11	M25-7	________	________
12	M25-12	________	________
13	M25-13	________	________
14	M25-14	________	________
15	M25-15	________	________
16	M25-16	________	________
17	M26-1	________	________
18	M26-2	________	________
19	M26-3	________	________
20	M26-4	________	________

Table 4.5. (cont.) Continuity Check and High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hypertronics Pin #	Continuity Check (date)	Hi-pot Test (date)
21	M26-5	________	________
22	M26-6	________	________
23	M26-11	________	________
24	M26-10	________	________
25	M26-9	________	________
26	M26-8	________	________
27	M26-7	________	________
28	M26-12	________	________
29	M26-13	________	________
30	M26-14	________	________
31	M26-15	________	________
32	M26-16	________	________

MBX2 Leads

Air Side Pin #	Helium Side Cable Wire #	Continuity Check (date)	Hi-pot Test (date)
Six Voltage Tap Leads, 5 kV, 50 µA Hi-pot			
M1	VTAa	________	________
M2	VTCa	________	________
M3	VTBa	________	________
M5	VTAb	________	________
M6	VTCb	________	________
M7	VTBb	________	________
Four Quench Heaters Two Leads Each, 600 V, 7 µA Hi-pot.			
M4	EH1-EH825a	________	________
N1	EH1-EH825a	________	________
N2	EH2-EH825b	________	________
N3	EH2-EH825b	________	________

Table 4.5. (cont.) Continuity Check and High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Helium Side Pin #	Continuity Check (date)	Hi-pot Test (date)
N4	QH1	________	________
N5	QH1	________	________
N6	QH2	________	________
N7	QH2	________	________
Two Temperature Sensors Four Leads Each, 600 V, 7 µA Hi-pot.			
1	TT825aV+	________	________
2	TT825aV-	________	________
3	TT825aI+	________	________
4	TT825aI-	________	________
5	TT825bV+	________	________
6	TT825bV-	________	________
7	TT825bI+	________	________
8	TT825bI-	________	________

4.6 Pressure Test and Vacuum Leak Check of the Instrumentation Conduits

This section describes the acceptance test for the instrumentation lead conduits MQX2 and MBX2 and their diagnostic assemblies. The acceptance tests for the instrumentation wire conduits and diagnostic assemblies consist of a pressure test and a bleed down leak test. Since diagnostic assemblies are at room temperature, they do not have to be cold shocked.

- ♦ Before the instrumentation conduits and feed-throughs can be pressurized and leak checked, the magnet ends of the ducts must be sealed off with a pressure tight and vacuum tight seal.
- ♦ The instrument wire conduits and feed-throughs must be pressurized to 2.5 MPa (25 bar or 364 psig). The pressurization of the MQX2 conduit is done through the cap in the LQX diagnostic assembly. The pressurization of the MBX2 conduit is done through the cap in the LBX diagnostic assembly.

4.6A Pressure Test Quadrupole Instrumentation Conduit (MQX2)

- ♦ LBNL will encapsulate the magnet end of the MQX2 conduit so that all of the connectors are contained in the encapsulated end. The connectors will be wrapped with kapton so that there is no voltage break down between the connector and the encapsulation enclosure during a later hi-pot test. LBNL will provide a port at the end encapsulation enclosure to permit evacuation and vacuum leak checking of the enclosed MQX2 conduit.
- ♦ Pressurize the MQX2 conduit and LQX diagnostic assembly to 2.5 MPa (25 bar) (364 psig) with dry nitrogen gas. Shut off the valve and hold for at least 3600 seconds. Measure the pressure in the MQX2 conduit at t =100 seconds (after the valve is closed) t = 900 seconds and t = 3600 seconds LQX diagnostic assembly is sufficiently tight if it can hold pressure for the last 3500 seconds without a visible drop in pressure. Record the findings in Table 4.6 of the feedbox assembly traveler.
- ♦ If the system does not hold the pressure, bleed off the dry nitrogen and re-pressurize the conduit to 100 psig with helium gas. Find the conduit leaks with a helium leak sniffing system. When the leaks are repaired, pump out the MQX2 conduit and repeat the pressure test with dry nitrogen at 2.5 MPa (364 psig).

4.6B Vacuum Leak Check the MQX2 Instrumentation Conduit

- Pump the MQX2 conduit to a pressure of 10^{-2} torr or lower from the magnet end of the conduit. This process will take some time because of the large virtual leak through the wire bundle in the conduit.
- The helium leak check should be performed at the lowest detectable leak rate below 10^{-7} atm cc s^{-1}. Record the vacuum leak findings in Table 4.6. Open the valve to let a standard leak of about $3x10^{-7}$ atm cc s^{-1} into the vacuum leak checker manifold. Record the findings in Table 4.6.

4.6C Pressure Test Dipole Instrumentation Conduit (MBX2)

- LBNL will encapsulate the magnet end of the MBX2 conduit so that all of the cables are contained in the encapsulated end. The cable ends will be wrapped with kapton so that there is no voltage break down between the cables and the encapsulation enclosure during a later hi-pot test. LBNL will provide a port at the end encapsulation enclosure to permit evacuation and vacuum leak checking of the enclosed MBX2 conduit.
- Pressurize the MBX2 conduit and LBX diagnostic assembly to 2.5 MPa (25 bar) (364 psig) with dry nitrogen gas. Shut off the valve and hold for at least 3600 seconds. Measure the pressure in the MBX2 conduit at t =100 seconds (after the valve is closed) t = 900 seconds and t = 3600 seconds.LBX diagnostic assembly is sufficiently tight if it can hold pressure for the last 3500 seconds without a visible drop in pressure. Record the findings in Table 4.6 of the feedbox assembly traveler.
- If the system does not hold the pressure, bleed off the dry nitrogen and re-pressurize the conduit to 100 psig with helium gas. Find the conduit leaks with a helium leak sniffing system. When the leaks are repaired, pump out the MBX2 conduit and repeat the pressure test with dry nitrogen at 2.5 MPa (364 psig).

4.6D Vacuum Leak Check the MBX2 Instrumentation Conduit

- Pump the MBX2 conduit to a pressure of 10^{-2} torr or lower from the magnet end of the conduit. This process will take some time because of the large virtual leak through the wire bundle in the conduit
- The helium leak check should be performed at the lowest detectable leak rate below 10^{-7} atm cc s^{-1}. Record the vacuum leak findings in Table 4.6. Open the valve to let a standard leak of about $3x10^{-7}$ atm cc s^{-1} into the vacuum leak checker manifold. Record the findings in Table 4.6.

Table 4.6. Pressure Test and Vacuum Leak Check of the Instrumentation Conduits
MQX2 Conduit pressure Test and Vacuum Leak Check

The MQX2 Instrument lead Conduit was pressurized to ________ psig for ________ sec.

Date ________________________

Measured Pressure at t = 100 seconds ____________________________ psig

Measured Pressure at t = 900 seconds ____________________________ psig

Measured Pressure at t = 3600 seconds ____________________________ psig

Measured vacuum leak rate for the MQX2 conduit ________________ atm cc s^{-1}

Vacuum Pressure in the MQX2 conduit _______________________________ torr

Date of the MQX2 vacuum leak check __________________________________

Measured standard leak rate ________________ atm cc s^{-1}

Calibration Date for the Standard Leak ___________________________________

MBX2 Conduit pressure Test and Vacuum Leak Check

The MBX2 Instrument lead Conduit was pressurized to ________ psig for ________ sec.

Date ________________________

Measured Pressure at t = 100 seconds ____________________________ psig

Measured Pressure at t = 900 seconds ____________________________ psig

Measured Pressure at t = 3600 seconds ____________________________ psig

Measured vacuum leak rate for the MBX2 conduit ________________ atm cc s^{-1}

Vacuum Pressure in the MBX2 conduit _______________________________ torr

Date of the MBX2 vacuum leak check __________________________________

Measured standard leak rate ________________ atm cc s^{-1}

Calibration Date for the Standard Leak ___________________________________

4.7 Voltage Check (Hi-pot) of the Instrumentation Leads in Helium Gas

Steps 4.7A and 4.7 B describe the hi-potting procedure for the conductors in the MQX2 and MBX2 conduits. Step 4.7C describes pump out and the back fill of the MQX2 conduit, and the MBX2 conduit before the rest of the DFBX assembly.

4.7A Hi-pot the Instrumentation Leads in the MQX2 Conduit

- ♦ Backfill Evacuate the dry nitrogen gas out of the MQX2 conduit to a pressure of 10^{-2} torr. Backfill the MQX2 conduit with dry grade A helium gas to a pressure of 0.10 MPa (0 psig) and close the fill valve.
- ♦ The leads in the MQX2 conduit must be individual hi-potted from the air side of the lead (from the pins on the LQX diagnostic assembly). The leads inside the MQX2 conduit will be in helium gas. While hi-potting a lead, all other leads shall be at ground potential.
- ♦ The instrumentation wires in the MQX2 conduit shall be hi-potted to the appropriate in helium hi-pot voltage in leakage current called for in the interface specification. Record the test results in Table 4.7.

4.7B Hi-pot the Instrumentation Leads in the MBX2 Conduit

- ♦ Backfill Evacuate the dry nitrogen gas out of the MBX2 conduit to a pressure of 10^{-2} torr. Backfill the MBX2 conduit with dry grade A helium gas to a pressure of 0.10 MPa (0 psig) and close the fill valve.
- ♦ The leads in the MBX2 conduit must be individual hi-potted from the air side of the lead (from the pins on the LBX diagnostic assembly). The leads inside the MBX2 conduit will be in helium gas. While hi-potting a lead, all other leads shall be at ground potential.
- ♦ The instrumentation wires in the MBX2 conduit shall be hi-potted to the appropriate in helium hi-pot voltage in leakage current called for in the interface specification. Record the test results in Table 4.7.

4.7C Backfill the MQX2 Conduit, and the MBX2 Conduit with Dry Nitrogen before Crating

- ♦ Pump the helium out of the MQX2 conduit and the MBX2 conduit. Pump them down to < 10^{-2} torr, then
- ♦ back fill them with dry nitrogen gas to a pressure of 0.12 MPa (3 psig) and close the fill valve. The conduits should remain under a slight positive pressure during the rest of the DFBX assembly process.

Table 4.7. High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads

Air Side Pin #	Hi-pot Test (date)
MQX2 Leads	
Thirty-six Voltage Tap Leads, 1.4 kV, 15 µA Hi-pot	
A1	________
A2	________
A3	________
A4	________
A5	________
A6	________
B1	________
B2	________
B3	________
B4	________
B5	________
B6	________
C1	________
C2	________
C3	________
C4	________
C5	________
C6	________
D1	________
D2	________
D3	________
D4	________
D5	________
D6	________

Table 4.7. (cont.) High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hi-pot Test (date)
E1	________
E2	________
E3	________
E4	________
E5	________
E6	________
F1	________
F2	________
F3	________
F4	________
F5	________
F6	________
Eight Quench Protection Heaters Two Leads Each, 1.4 kV, 15 µA Hi-pot	
G1	________
G2	________
G3	________
G4	________
G5	________
G6	________
H1	________
H2	________
H3	________
H4	________
H5	________
H6	________

Table 4.7. (cont.) High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hi-pot Test (date)
I1	_________
I2	_________
I3	_________
I4	_________
Eight Warm-up Heaters Two Leads Each, 650 V 7μA Hi-pot	
I5	_________
I6	_________
J1	_________
J2	_________
J3	_________
J4	_________
J5	_________
J6	_________
K1	_________
K2	_________
K3	_________
K4	_________
K5	_________
K6	_________
L1	_________
L2	_________
Eight Temperature Sensors Four leads Each, 200 V, 2 μA Hi-Pot	
1	_________
2	_________
3	_________
4	_________

Table 4.7. (cont.) High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Hi-pot Test (date)
5	________
6	________
7	________
8	________
9	________
10	________
11	________
12	________
13	________
14	________
15	________
16	________
17	________
18	________
19	________
20	________
21	________
22	________
23	________
24	________
25	________
26	________
27	________
28	________
29	________
30	________

Table 4.7. (cont.) High Voltage Insulation Checks for the MQX2 and MBX2 Instrumentation Leads Continued

Air Side Pin #	Helium Side	Hi-pot Test (date)
31		________
32		________
	MBX2 Leads	
Six Voltage Tap Leads, 1.4 kV, 15 µA Hi-pot		
M1		________
M2		________
M3		________
M5		________
M6		________
M7		________
Four Quench Heaters Two Leads Each, 200 V, 2 µA Hi-pot.		
M4		________
N1		________
N2		________
N3		________
N4		________
N5		________
N6		________
N7		________
Two Temperature Sensors Four Leads Each, 600 V Hi-pot.		
1		________
2		________
3		________
4		________
5		________
6		________
7		________
8		________

4.8 Resistance and Voltage Tests on the Cryogenic Instrumentation Leads

This acceptance test is to verify that the cryogenic instrumentation leads have been connected correctly to the connector at the top of the vacuum vessel. The leads are then connected to the cryogenic sensors and heaters on the helium tank and piping. The connector also includes reading from two temperature sensors that are mounted on the LBX dipole magnet. The temperature sensor wires are hi-potted to 200 V. Fill in Table 4.8 to show that the continuity and hi-pot tests have been done.

Table 4.8. Continuity Check and High Voltage Insulation Checks for the DFBX and LBX Temperature Sensors (Hi-pot to 200 V DC, 2 μA)

Temp #	Pin #	Pin #	Continuity Check (date)	Hi-pot Done (date)
Temperature sensors from the DFBX piping (R = 50 to 70 ohms)				
TT812	1	2	________	________
TT812	3	4	________	NA
TT819a	5	6	________	________
TT819a	7	8	________	NA
TT819b	9	10	________	________
TT819b	11	12	________	NA
TT831	13	14	________	________
TT831	15	16	________	NA
TT890	17	18	________	________
TT890	19	20	________	NA
TT813	21	22	________	________
TT813	23	24	________	NA
Temperature sensors from the LBX Magnet (Sensors PS3 and PS4)				
TT818a	25	26	________	________
TT818a	27	28	________	NA
TT818b	29	30	________	________
TT818b	31	32	________	NA

Date the temperature sensor wires for sensor TT818a (PS3) correctly labeled __________

Date the temperature sensor wires for sensor TT818b (PS4) correctly labeled __________

4.9 **Inspection of Clearance Around the Pipes**
Visually inspect the pipes to see that the pipes are separated by a distance of 12 mm or more, after they have been installed. Fill in Table 4.9 below.

Table 4.9. Pipe Inspection for Minimum Spacing between Pipes

Clearance around all pipes is12 mm or more Yes ______ No ________

Pipe assembly with closest clearance Name_______ Clearance_________mm

Date of the pipe inspection ___________________________.

4.10 **Top Plate Distortion Criteria during Welding of the Vacuum Vessel End Plates**
Monitor top plate distortion at point 2 (DWG 24C352 sheet 4) on the top plate as the end plates are welded to the top plate. The maximum allowable distortion of the center of the top plate during welding to the end plates is 0.75-mm (0.030 inches) in the vertical direction. Fill in the feedbox traveler with the before and after readings in Table 4.10 to show that the top plate distortion was measured.

Table 4.10. Top Plate Distortion Check during Welding of the Vacuum Vessel End Plates (See LBNL drawing 24C352, sheet 4)

The distortion of the top plate is monitored at the top plate center during the welding of the end plates to the top plate. The final value of the top plate distortion at its center is recorded in this section. Note: other methods besides a dial indicator may used to measure the distortion.

The vertical position reading at point at the start of the weld was __________ mm

The vertical position reading at point at the end of the weld was __________ mm

4.11 Top Plate and Bottom Plate Distortion Criteria during Welding of the Vacuum Vessel Side Plates

Monitor top plate distortion as the side plates are welded to the top plate. The distortion measurements should be done at three points along the centerline of the top plate in the longitudinal direction (points 1, 2 and 3 in drawing 24C352, sheet 4) between the lead chimneys. The maximum allowable distortion of the top plate during welding is 0.50-mm (0.020 inches) in the vertical direction. Complete the feedbox traveler with the before and after readings in Table 4.12 to show that the top plate distortions were measured.

Table 4.11. Top Plate and Bottom Plate Distortion Check during Welding of the Vacuum Vessel Side Plates (See LBNL drawing 24C352, sheet 4)

The distortion of the top plate is monitored at three points along the centerline of the top plate in the longitudinal direction during the welding of the side plates to the top plate. Note: other methods besides a dial indicator may used to measure the distortion.

The dial vertical position reading at point 1 at the start of the weld was ____________ mm

The dial vertical position reading at point 2 at the start of the weld was ____________ mm

The dial vertical position reading at point 3 at the start of the weld was ____________ mm

The dial vertical position reading at point 1 at the end of the weld was ____________ mm

The dial vertical position reading at point 2 at the end of the weld was ____________ mm

The dial vertical position reading at point 3 at the end of the weld was ____________ mm

4.12 Final Position Criteria of the End Flanges, Jumper Flanges, and Pipes

4.12A Q3 End Flange (WQX) and Piping Position:

The vendor must explain to LBNL how they intend to verify that the center of the WQX flange is in the correct position with respect to the origin of the LBNL coordinate system. The origin of the LBNL coordinate system lies on the LHC beam line at the face of the WQX flange. The vendor must explain to LBNL how he intends to verify that the pipes are in the correct position in flange WQX with respect to the origin of the LBNL coordinate system. The correct pipe location and the center of the WQX flange location is specified in LBNL drawing 24C352, Sheet 8. Record the results of the measurements in Table 4.12-1 and Table 4.12-2.

4.12B D1 End Flange (WBX) and Piping Position:

The vendor must explain to LBNL how he intends to verify that the center of the WBX flange is in the correct position with respect to the origin of the LBNL coordinate system. The vendor must explain to LBNL how he intends to verify that the pipes in flange WBX are in the correct position with respect to the origin of the LBNL coordinate system. The correct pipe location and the center of the WBX flange location is specified in LBNL drawing 24C352, Sheet 8. Record the results of the measurements in Table 4.12-1 and Table 4.12-2.

4.12C QRL Flanges and Piping Position:

Measure and record the locations of the centers of the JC1 and JC2 flanges with respect to the DFBX reference coordinate system (at the beam center at WQX face). (See dimensions A, C, D, E, M, and N on LBNL drawing 24C352, sheet 5 and the tables in LBNL drawing 24C352, sheet 7. The vendor must explain to LBNL how he intends to verify that the center of the JC1 and JC2 flanges are in the correct position with respect to the origin of the LBNL coordinate system. The vendor must explain to LBNL how he intends to verify that the pipes in the JC1 and JC2 flanges are in the correct position with respect to the center of the JC1 and JC2 flanges. The pipe locations in the JC1 and JC2 flanges are specified on LBNL drawing 24C352, sheet 7. Record findings in Table 4.12-2.

4.12D Measure the position of Fiducials of the Feedbox:

Once the Taylor-Hobson tooling fixtures and the tooling flat have been installed on the vacuum vessel top plate in accordance with LBNL drawing 24C352, sheet 12, and the pipe locations have been verified, the vacuum vessel must be fiducialized. Measure the location of the tooling balls and the tooling flat and record these dimensions in Table 4.12-3. See dimensions F, G, H, I, J, K and L in LBNL drawing 24C352, Sheet 12.)

Table 4.12-1. The Basic Dimensions of the Finished DFBX Box (See LBNL Drawing 24C3626, Sheet 4)

Z Distance from datum D to the JC2 jumper center, Distance A _________ mm

Y Separation distance of the ends of the WQX and WBX flanges, Distance B _________ mm

Y Separation distance of the centers of the JC1 and JC2 flanges, Distance C _________ mm

Y Separation distance of the WQX flange to the center of JC1, Distance D _________ mm

Z Distance from datum D to the JC1 jumper center, Distance E _________ mm

X Distance from datum B to the JC1 flange face, Distance M _________ mm

X Distance from datum B to the JC2 flange face, Distance N _________ mm

Date the DFBX box dimension check was done ______________

Table 4.12-2. Piping Position in the WQX, the WBX, and the JC1 and JC2 Chimneys Using the Template Method (See LBNL Drawing 24C352, Sheets 7 and 8)

Are the pipes in the WQX flange in the correct position to within 2 mm? ___ Yes ___ No

Are the pipes in the WBX flange in the correct position to within 2 mm? ___ Yes ___ No

Are the pipes in the JC1 flange in the correct position to within 2 mm? ___ Yes ___ No

Are the pipes in the JC2 flange in the correct position to within 2 mm? ___ Yes ___ No

Date the pipe position check was done ______________

Table 4.12-3. Tooling Ball Position on the Finished Feedbox with Respect to the Zero Datum Point (See LBNL Drawing 24C352, Sheet 12) and Measured Roll Angle

Tooling Ball 1, to Beam Tube Center Z Distance F ___________ mm

Tooling Ball 1 to Beam Tube Center X Distance H ___________ mm

Tooling Ball 1 to WQX Face Y Distance K ___________ mm

Tooling Ball 2 to Beam Tube Center Z Distance G ___________ mm

Tooling Ball 2 to Beam Tube Center X Distance I ___________ mm

Tooling Ball 2 to WQX Face Y Distance J ___________ mm

Roll Angle (rotation about Y) Angle L __________ mrad

Date the tooling ball position check was done ______________

4.13 **Feedbox Preparation for Vacuum Vessel Leak Checks and Pressure Test**
This is the preparation of the DFBX for the final acceptance test for the feedbox vacuum vessel. Before the vacuum vessel can be pressure tested in step 4.13C the system must be prepared by following steps 4.13A and 4.13B

4.13A **Piping and Helium Tank Preparation for the Vacuum Leak Checks**

- ♦ The ends of the pipes that are in the WQX and WBX must be blanked off with a vacuum tight seal, except for CC'2, CC'3, EX and E1. (See Fig. 2.) Pipes CC'2 and CC'3 are connected together at both ends of the DFBX box (see Fig. 2).

- ♦ Pipes EX and E1 are connected together at the WQX of the box (See Fig. 2).

- ♦ Pipes that go through the JC1 and JC2 jumpers must be tied together through a common helium supply manifold. (See Fig. 2.)

- ♦ The helium gas manifolds must be fabricated and leaked checked to a minimum measured helium leak rate of 1×10^{-9} atm cc s^{-1}. When the manifolds are connected to the pipes in the jumpers, do a vacuum leak check of the connections between the manifold and the pipes using a halogen leak check method.

- ♦ The cryogen feed tube to the bus ducts (tube LD3) must be brought out through the JC2 hat so that a pressure check can be made of the bus ducts.

- ♦ Pipes CC'1 and DH should be interconnected so that the pressure across the HTS lead seal is balanced.

- ♦ The helium vessel and bus duct assemblies MBX1 and MQX1 should be isolated from the vacuum vessel (see Figure 2). These conduits can be pressurized with helium from the top of the box during a final piping leak vacuum leak check.

4.13B **Close the Vacuum Vessel with Temporary Hats for the Pressure Test and Vacuum Leak Checks**

- ♦ Close the ends of the vacuum vessel with hats that cover the WQX and WBX ends of the vacuum vessel. The seals for these hats must be vacuum tight.

- ♦ The ends of the bus ducts should already be covered with the bus duct close off assemblies that are vacuum tight.

- ♦ Close the JC2 and JC1 piping jumpers with hats that cover the ends of the cryogen pipes.

- ♦ The pressurization pipes to the manifolds must pass through the JC1 and JC2 hats. The points where the manifolds pass through the JC1 and JC2 hats must be vacuum tight. The seals for these hats to the flanges must also be vacuum tight.

4.13C **Pressure Test the DFBX Vacuum Vessel**

- Close down the vacuum vessel relief device. Install a temporary relief valve on the WQX hat. This valve should be set to 1.5 bar (7.5 psig). Pressurize the DFBX cryostat vacuum vessel to 0.14 MPa (1.4 bar) (6 psig) using dry nitrogen gas and hold for at least 600 seconds.

- Bubble check the vacuum vessel welds to look for gross vacuum vessel leaks. If leaks are found, repair these leaks and repeat the vacuum vessel pressure test. Record the test findings in Table 4.13. See Figure 2a.

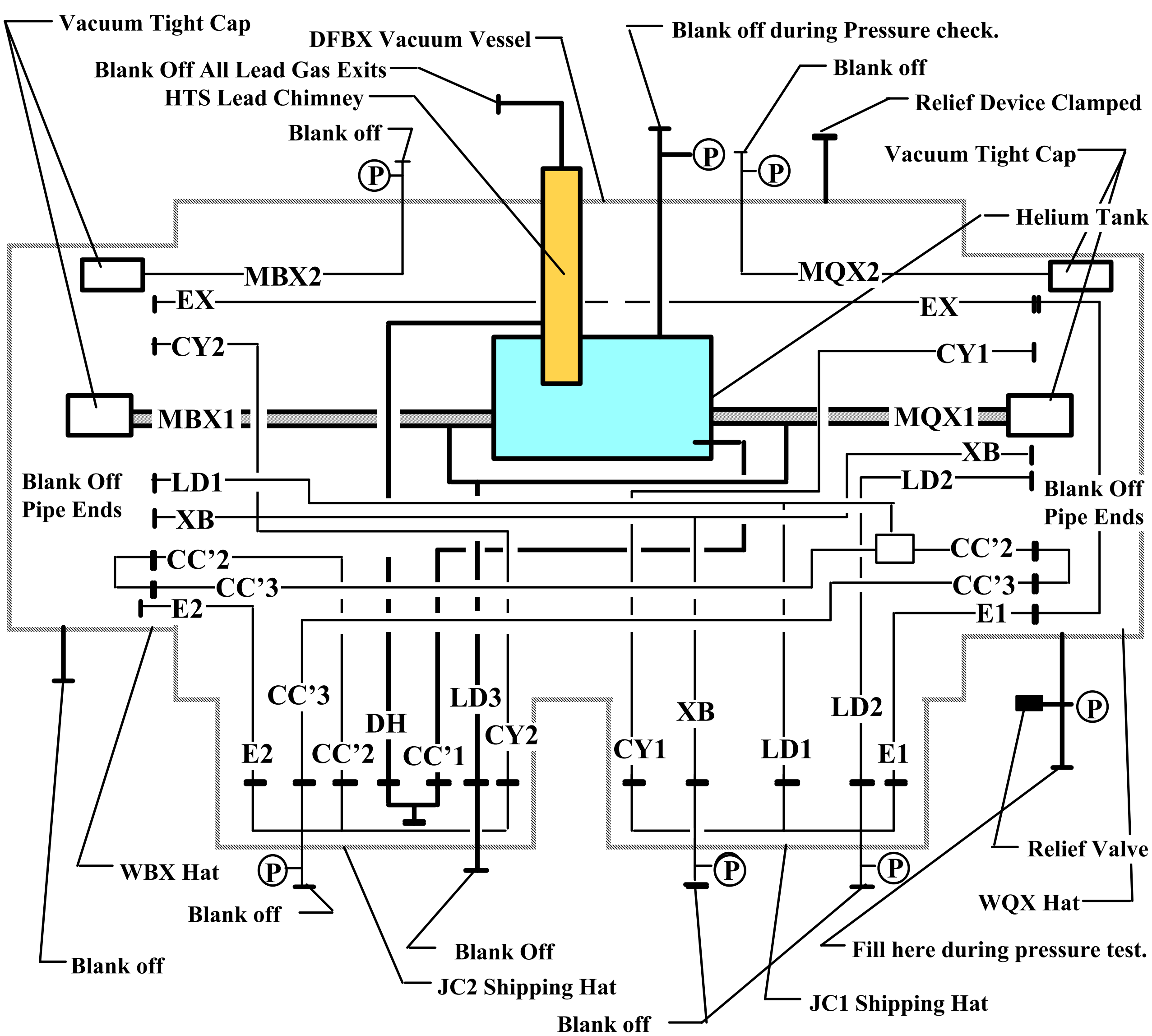

Figure 2a. A Schematic Representation of the DFBX during the Vacuum Vessel Pressure Test

4.14 **Pump Down and Vacuum Leak Test of the Vacuum Vessel**
The Vacuum vessel pump down and vacuum leak check are described in steps 4.14A and 4.14B.

4.14A **Pump and Purge the Vacuum Vessel to Remove Water from the MLI**
Pump the vacuum vessel down to the 1 torr range using roughing pump. Once the vacuum vessel pressure has reached 1 torr or lower, purge the vacuum vessel with dry nitrogen gas at 80 C. Pump the vacuum vessel down to below 10^{-2} torr with periodic purges with dry nitrogen gas at 80 C. Pump the vacuum vessel to below 10^{-3} torr (or a pressure suitable for measuring leaks rates in the 10^{-8} atm cc s^{-1} range) before starting the vacuum vessel vacuum leak check. See Figure 2b.

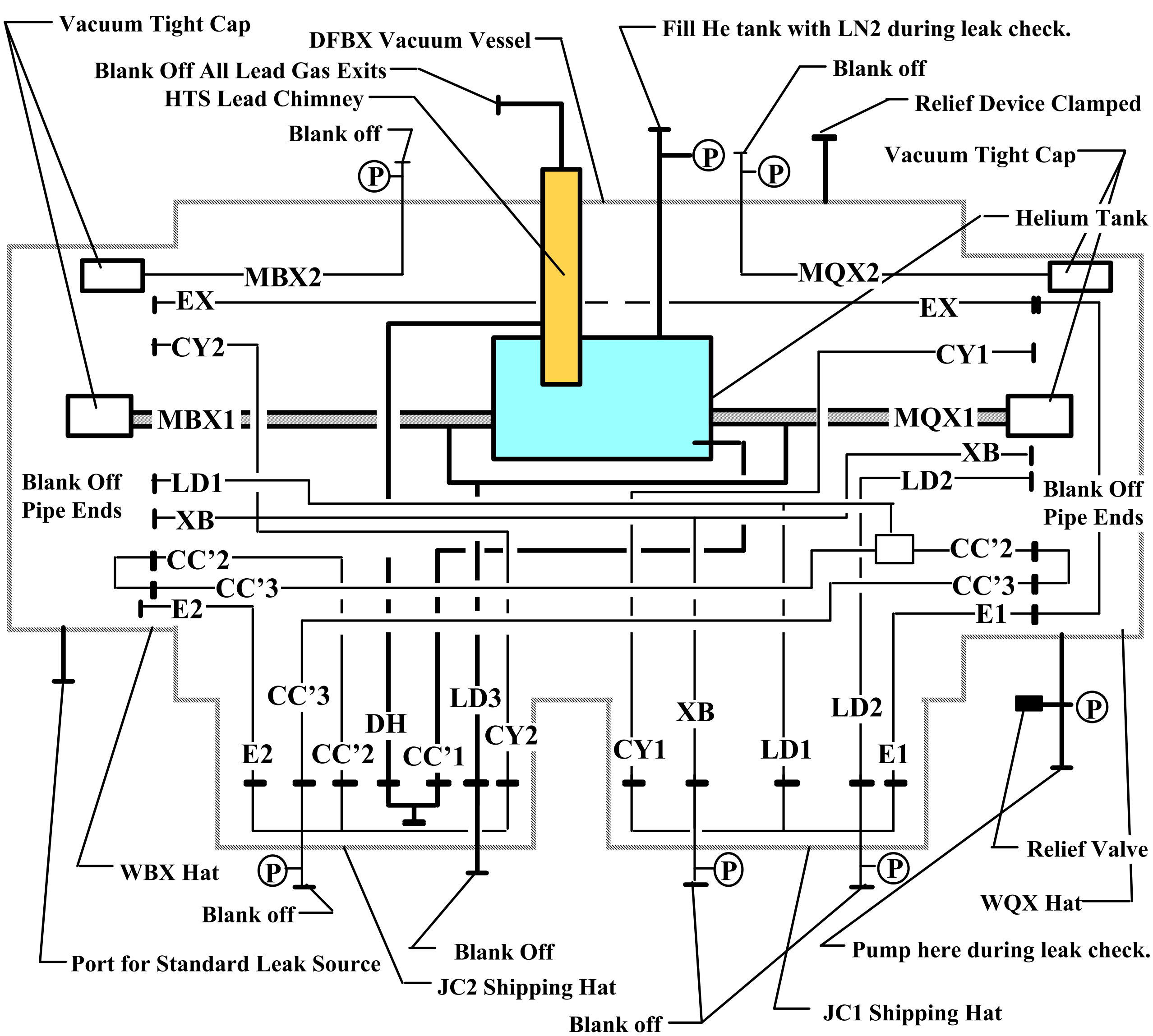

Figure 2b. A Schematic Representation of the DFBX during the Vacuum Vessel Leak Check

4.14B Vacuum Leak Check the DFBX Vacuum Vessel

- Once the pressure test has been completed pump the vacuum vessel down to proper range.
- Fill the helium vessel with a small amount of liquid nitrogen. Helium leak check the feedbox vacuum vessel at the lowest detectable leak rate less than 1×10^{-8} atm cc s^{-1}.
- Repair any leaks found in the vacuum vessel. Repeat the vacuum leak check and repairs until the vessel passes and no detectable helium leak is found at rate more than 1×10^{-8} atm cc s^{-1}.
- Compare the measured leak with a standard leak of about 10^{-8} atm cc s^{-1}. Record the test findings in Table 4.14.

Table 4.13. Pressure Test of the Vacuum Vessel

The feedbox vacuum vessel was pressurized to ___________ psig for __________ sec.

Date ________________________

Table 4.14. Vacuum Leak Check of the Vacuum Vessel

Measured vacuum leak rate for the DFBX vacuum vessel _______________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel ________________________ torr

Date of the vacuum vessel leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

Measured standard leak rate ___________________________ atm cc s^{-1}

Standard leak calibrated date ______________________________

Please include chart recording tapes and other data as part of this traveler to show the details of the vacuum leak check of the feedbox vacuum. If the vacuum vessel vacuum leak check was done more than once, include all of the leak check data for all of the leak checks for the Feedbox vacuum vessel.

4.15 Final Cold Vacuum Leak Check of the Helium Tank and Bus Ducts

4.15A Prepare for a Helium Tank and Bus Duct Final Vacuum Leak Check

With liquid nitrogen in the helium tank, continue pumping on the feedbox vacuum vessel. Pump down the helium tank to a pressure below 200 torr. See Figure 2c for a schematic representation of the DFBX during the helium tank vacuum leak check.

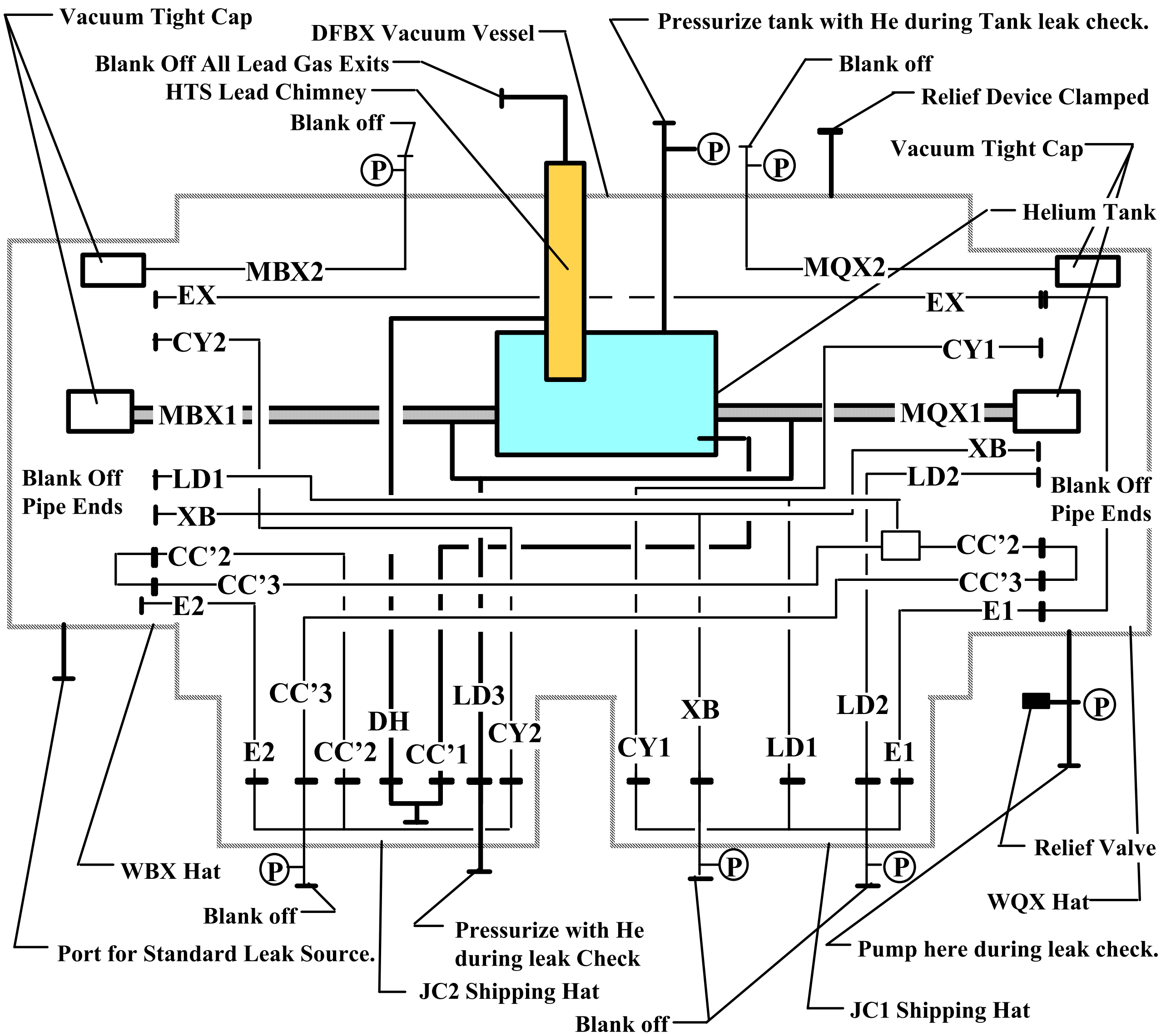

Figure 2c. A Schematic Representation of the DFBX during the Helium Tank Leak Check

4.15B **Vacuum Leak Check the Helium Tank and Bus Duct Assembly**

- Pressurize the helium tank with helium gas to 0.12 MPa (3 psig).

- Measure the vacuum leak rate from the helium tank and bus ducts to the vacuum vessel. The measured maximum helium leak rate should be less than 1×10^{-8} atm cc s^{-1}.

- Compare the measured vacuum leak with a standard helium leak of about 10^{-8} atm cc s^{-1}. Record the test findings in Table 4.15.

- After completing the vacuum leak check, pump down the helium tank and bus ducts 10^{-2} torr. Backfill the tank and bus ducts with dry nitrogen gas to 0.12 MPa (3 psig).

Table 4.15. Final Vacuum Leak Check of the Helium Tank Assembly at 80K

Measured vacuum leak rate for the helium tank assembly	________________ atm cc s^{-1}
Pressure in the DFBX vacuum vessel?	_________________________ torr
Helium pressure in the helium tank?	________________________psig
Date of the helium tank assembly leak check	_________________________________
Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}?	_____ Yes _____ No
If no, what standard leak rate could be measured?	___________________________ atm cc s^{-1}
When was the Standard Leak Calibrated?	_______________________________

Please include any chart recording tapes and other data as part of this traveler to show the details of the final vacuum leak check of the Feedbox helium tank assembly.

4.16 **Final Warm Pressure Test and Vacuum Leak Check of the Piping**

During steps 4.16A, 4.16B, 4.16C and 4.16D, fill the helium tank with a small amount of liquid nitrogen. Keep the vacuum vessel under vacuum. After steps 4.16 A through 4.16D are complete, back fill the vacuum vessel with dry nitrogen and warm up the helium tank. See Figure 2d. Then proceed with step 4.16E.

4.16A **Pressure Test and Helium Leak Check the Feedbox Piping from the JC1 Jumper**

- Pressurize the XB pipe assembly in the JC1 hat with dry nitrogen gas to 0.44 MPa (50 psig) and hold for 600 seconds. Record the pressure in Table 4.16-1.

- Pump down the XB pipe assembly through its manifold in JC1 hat to a pressure of 1 torr.

- Pressurize the XB pipe assembly with helium gas to 0.3 MPa (30 psig). Measure the helium leak rate from the XB pipe assembly to the vacuum vessel. The measured leak rate should be less than 3×10^{-9} atm cc s^{-1}.

- Compare the measured leak with a standard leak of about 10^{-8} atm cc s^{-1}. Record the findings in Table 4.16-1.
- After the test is complete, pump down the XB pipe assembly to 10^{-1} torr, backfill with dry nitrogen to 0.12 MPa (3 psig), and seal.
- Pressurize the rest of the JC1 hat piping with dry nitrogen to 2.42 MPa (338 psig) and hold for 600 seconds. . Record the test in Table 4.16-2.
- Pump down the rest of DFBX piping that is manifolded together in the JC1 hat to a pressure of 1 torr.
- Pressurize the piping with helium gas to 0.3 MPa (30 psig). Measure the helium leak rate from the piping to the vacuum vessel. The measured leak rate should be less than $3x10^{-9}$ atm cc s^{-1}.
- Compare the measured leak with a standard leak of about 10^{-8} atm cc s^{-1}. Record the findings in Table 4.16-2.
- After the test is complete, pump down the manifold in the JC1 hat to 10^{-1} torr, backfill with dry nitrogen to 0.12 MPa (3 psig), and seal.

4.16B Pressure Test and Helium Leak Check the Feedbox Piping from the QC2 Jumper

- Pressurize the rest of the JC1 hat piping with dry nitrogen to 2.42 MPa (338 psig). Hold for 600 seconds; record the pressure in Table 4.16-3.
- Pump down the Feedbox piping through the manifolds that pass through the JC2 hat to 1 torr.
- Pressurize the piping with helium gas to 0.3 MPa (30 psig). Measure the helium leak rate from the piping to the vacuum vessel. The measured leak rate should be less than $3x10^{-9}$ atm cc s^{-1}.
- Compare the measured leak with a standard leak of about 10^{-8} atm cc s^{-1}. Record the leak check findings in Table 4.16-3.
- After the test is complete, pump down the manifold in the JC2 hat to 10^{-1} torr, backfill with dry nitrogen to 0.12 MPa (3 psig), and seal.

4.16C Helium Leak Check the Feedbox MQX2 Conduit

- Pressurize the MQX2 conduit with dry nitrogen to 2.20 MPa (306 psig). Hold for 600 seconds; record the pressure in Table 4.17-4.
- Pump down the feedbox MQX2 manifold that passes through the LQX diagnostic assembly feed through to 1 torr.

- Pressurize the MQX2 manifold with helium gas to 0.3 MPa (30 psig). Measure the helium leak rate from the piping to the vacuum vessel. The measured leak rate should be less than 3×10^{-9} atm cc s^{-1}.

- Compare the measured leak with a standard leak of about 10^{-8} atm cc s^{-1}. Record the leak check findings in Table 4.16-4.

- Pump down the MQX2 manifold 10^{-1} torr, backfill with dry nitrogen to 0.12 MPa (3 psig) and seal.

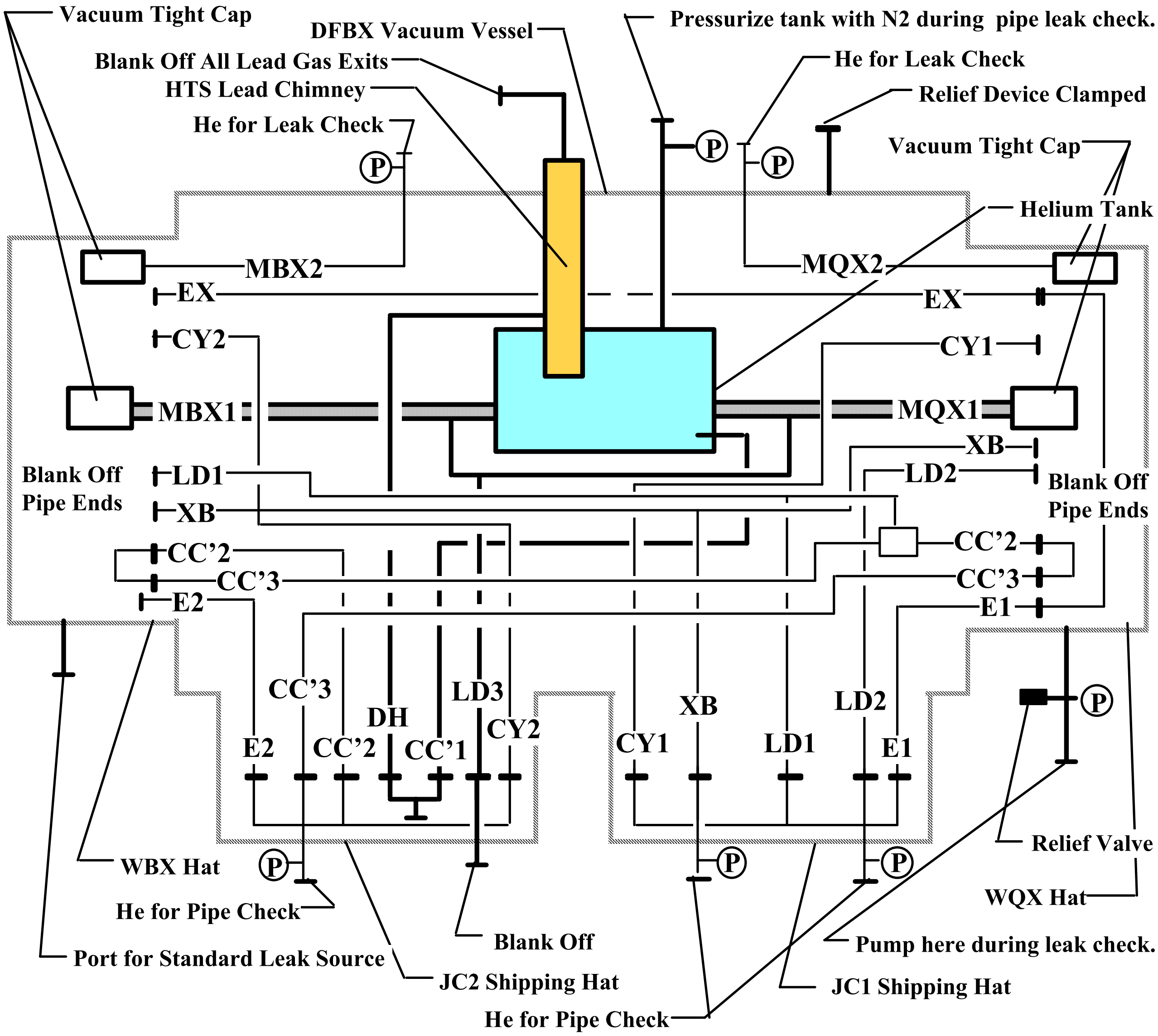

Figure 2d. A Schematic Representation of the DFBX during Final Piping Pressure Tests and Vacuum Leak Checks

4.16D **Helium Leak Check the Feedbox MBX2 Conduit**

- Pressurize the MBX2 conduit with dry nitrogen to 2.20 MPa (306 psig). Hold for 600 seconds; record the pressure in Table 4.16-5.
- Pump down the Feedbox MBX2 manifold that passes through the LBX diagnostic assembly feed through to 1 torr.
- Pressurize the MBX2 manifold with helium gas to 0.3 MPa (30 psig). Measure the helium leak rate from the piping to the vacuum vessel. The measured leak rate should be less than 3×10^{-9} atm cc s^{-1}.
- Compare the measured leak with a standard leak of about 10^{-8} atm cc s^{-1}. Record the leak check findings in Table 4.16-5.
- Pump down the MBX2 manifold 10^{-1} torr, backfill with dry nitrogen to 0.12 MPa (3 psig) and seal.

Table 4.16-1. Pressure Check and Final Vacuum Leak Check of the XB Pipe from the JC1 Jumper

XB pipe Pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the JC1 helium piping ________________________psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Table 4.16-2. Final Pressure Test and Vacuum Leak Check of the Rest of the Piping from the JC1 Jumper

JC1 pipe Pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the JC2 helium piping ________________________psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Please include chart recording tapes and other data as part of this traveler to show the details of the final vacuum leak check of the Feedbox piping assembly. If the helium piping leak check was done more than once, include all of the leak check data for all of the leak checks for the piping.

Table 4.16-3. Final Pressure Check and Vacuum Leak Check of the Piping from the JC2 Jumper

JC2 pipe Pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the JC2 helium piping ________________________psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Table 4.16-4. Final Pressure Test and Vacuum Leak Check of the MQX2 Conduit

MQX2 Pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the DFBX MQX2 conduit ________________________psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Table 4.16-5. Final Pressure Test and Vacuum Leak Check of the MBX2 Conduit

MBX2 Pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the DFBX MBX2 conduit ________________________ psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Please include chart recording tapes and other data as part of this traveler to show the details of the final vacuum leak check of the piping, and the MQX2 and MBX2 manifolds done above.

4.16E Backfill the Feedbox with Dry Nitrogen before Crating

- Backfill the feedbox vacuum vessel with dry nitrogen gas to 0.12 MPa (3 psig) and close the fill valve. The vacuum vessel relief device should still be clamped down and the relief valve on the LBX hat should still be installed. The vacuum vessel relief device should be tagged to inform CERN that the relief device must be unclamped before the feedbox can be installed in the LHC.

- Warm the helium tank to room temperature, pump it to < 10^{-2} torr, and back fill with dry nitrogen gas to 0.12 MPa (3 psig) and close the valve.

- Record the pressure in the vacuum vessel (about 3 psig) and in the helium tank (about 3 psig) in Table 4.16-6, and on tags attached to the box.

- Record the pressure in the piping manifolds and instrumentation conduits (about 3 psig) in Table 4.16.6 and on the tags attached to the box.

- The schematic of the DFBX during preparation for shipping and shipping is shown in Figure 2e.

Table 4.16-6. Pressure Measurements in the Vacuum Vessel, the Helium Tank, The Piping and the MQX2 and MBX2 Conduits before Packing in the Shipping Crate

Ambient Temperature when the Box is Pressurized	____________________ C
Barometric Pressure	___________________ m-bar
Pressure in the Vacuum Vessel	_______________________ psig
Pressure in the Helium Tank and Bus Ducts	________________________ psig
Pressure in the XB Pipe Manifold	________________________ psig
Pressure in the JC1 Hat Pipe Manifold	________________________ psig
Pressure in the JC2 Hat Pipe Manifold	________________________ psig
Pressure in the MQX2 Manifold	_______________________ psig
Pressure in the MQX2 Manifold	_______________________ psig
Date the pressure measurements above were made.	_______________________

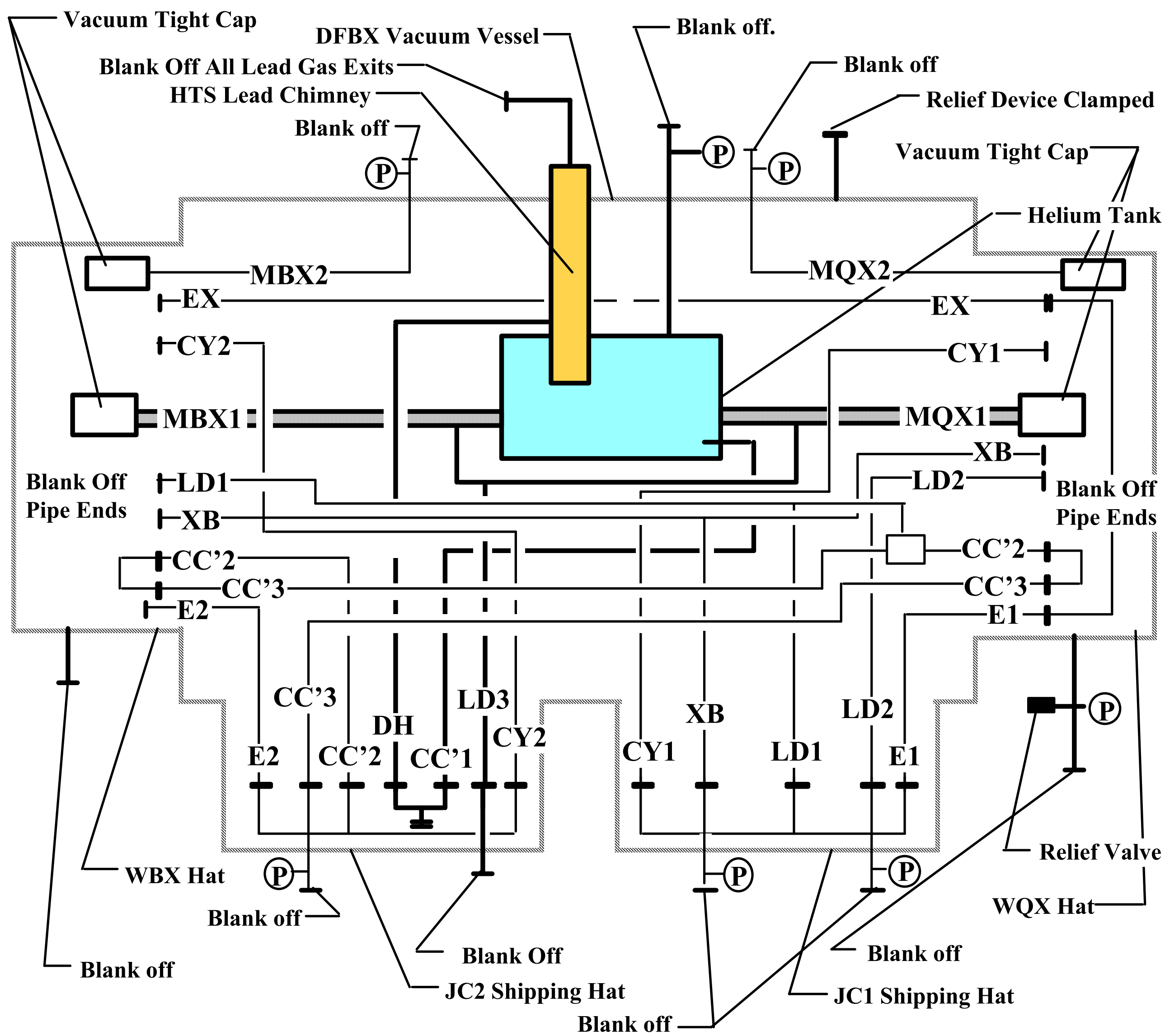

Figure 2e. A Schematic Representation of the DFBX during Shipment

5.0 INSPECTIONS BEFORE SHIPPING AND FOR ACCEPTANCE AFTER SHIPPING

After completing the in-process inspection operations stated above, the cryogenic system fabricator will be authorized to pack the feedbox in preparation for shipping to CERN. Sections 5.1 and 5.2 show the required inspections on the DFBX, which will be in its shipping crate, before and after it is shipped to CERN. The two shipping travelers are the final travelers that are to be completed before LBNL can accept the DFBX on the CERN loading dock.

5.1 Final DFBX Inspection in its Shipping Container before Shipment to CERN

The DFBX will be shipped to CERN from the vendor sealed and pressurized with dry nitrogen gas, suitable for a prolonged storage period at CERN. Crating and shipping of the feedbox should be performed in accordance to the Crating and Shipping Specification [8]. The LBNL shipping acceptance checks at the vendor loading dock are as follows:

5.1A Inspect the DFBX crating container before it is loaded into the shipping container. Note any significant pre-existing damage or corrosion in the traveler and attached photographs of the package

5.1B Record the readings on the shock indicators mounted on the DFBX and the DFBX shipping crate to determine whether they have been properly zeroed. The shock indictors are then covered with a protective cover to prevent tampering.

5.1C Record the pressure in the DFBX vacuum vessel and the helium tank and bus duct assembly. The temperature of the DFBX vacuum vessel will also be read. The pressures temperature and approximate altitude are listed in the traveler in Table 4.16

5.1D Verify that all auxiliary hardware had been adequately restrained, and that all protuberances on the DFBX are adequately protected.

DFBX SHIPPING INSPECTION TRAVELER BEFORE SHIPMENT TO CERN

Pre-shipment inspection for DFBX ______ performed on (date) ______________________ at (the location of the vendor's plant) _______________________ by _____________________.

Section 5.1.1 Visual Inspection of the DFBX and its Shipping Crate after the DFBX in Packed

Note a pre-existing corrosion or damage to the outer surface of the DFBX and its shipping crate. If more space is needed, attach additional pages. Attach photos of the DFBX in its shipping crate taken from all fours sides and from the top.

Has all DFBX auxiliary hardware had been adequately restrained? _______Yes _______No

Have all DFBX protuberances been adequately protected? _______Yes _______No

Section 5.1.2 Inspection of the Shock Indicators before Loading on the Truck

Are all of the shock indicators (accelerometers) properly zeroed? _______Yes _______No
If the answer to the above question is no, all shock indicators must be zeroed in all directions for which they can be used. Repeat the measurement.
Are all of the shock indicators (accelerometers) properly zeroed? _______Yes _______No

Are all of the shock indicators covered to prevent tampering? _______Yes _______No

Section 5.1.3 Inspection of the DFBX Pressure Gauges Before Shipping

Ambient Temperature _____________________ C

Barometric Pressure when the pressure is measured ____________________ m-bar

Pressure in the Vacuum Vessel ________________________ psig

Pressure in the Helium Tank and Bus Ducts _________________________ psig

Pressure in the XB Pipe Manifold _________________________ psig

Pressure in the JC1 Hat Pipe Manifold _________________________ psig

Pressure in the JC2 Hat Pipe Manifold _________________________ psig

Pressure in the MQX2 Manifold ________________________ psig

Pressure in the MQX2 Manifold ________________________ psig

5.2 Final DFBX Inspection in its Shipping Container after Shipment to CERN

The LBNL acceptance checks at the CERN loading dock are as follows:

5.2A LBNL personnel or a LBNL designee will inspect the DFBX shipping container before it is unloaded by CERN riggers from the truck at the CERN loading dock. If there is no visible damage to the DFBX shipping-container, the DFBX shipping crate will be unloaded from the shipping container. If there is apparent damage, the inspectors shall document the damages and notify the cryogenic system fabricator.

5.2B If the shipping container passes the visual inspection, the DFBX shipping crate is unloaded from the container and transported to the location where the final acceptance inspection of the feedbox takes place. The results of the visual inspection will be recorded in Table 5.2-1. Extra pages may be attached if necessary

5.2C The LBNL representative will read the accelerometers mounted on the DFBX shipping container and the DFBX shipping crate to determine the maximum acceleration experienced by the DFBX container during shipment. Maximum acceleration should be less than the value stated in the Shipping Specification document. The recorded acceleration will be entered into Table 5.2-2 of the traveler any record of acceleration measured over time will become part of the traveler record.

5.2D LBNL representative or a LBNL designee will read the pressure in the DFBX vacuum vessel, helium tank and piping. This test does not have to be recorded in the traveler because pressure checks and vacuum leak checks will be done later.

After the DFBX meets all the above preliminary acceptance checks, the box shall be pressure tested and vacuum leak checked to see if leaks have been developed during shipment. The vacuum leak check steps include the following:

5.2E The DFBX vacuum vessel will be evacuated using the same procedure that is given in Section 4.14 of this document. The results of the vacuum vessel leak check shall be recorded in Table 5.2.3 of the traveler.

5.2F The DFBX helium tank, bus ducts and chimneys will be vacuum leak checked using the same procedure that is given in Section 4.15 of this document. The results of the helium tank and bus-duct vacuum leak-check shall be reported in Table 5.2-4 of the traveler.

5.2G Pressurize the DFBX bus ducts to 2.2 MPa (306 psig) as in pressure test 2 in section 4.3B. Pressurize the DFBX helium tank to 0.39 MPa (42 psig) as in pressure test 2 in section 4.3B. Enter results in Table 5.2-5 of the traveler.

5.2H The DFBX piping, shall be pressure tested and vacuum leak checked using the same procedure that is given in Section 4.16 of this document. The results of the pressure test piping vacuum leak check shall be reported in Tables 5.2-6, 5.2-7, and 5.2-8 of the traveler.

5.2I The DFBX instrumentation conduits shall be pressure tested vacuum leak checked using the same procedure that is given in Section 4.16 of this document. The results of the conduit vacuum leak checks shall be reported in Tables 5.2-9 and 5.2-10 of the traveler.

Once the DFBX has been pressure tested and vacuum leak checked, the vacuum vessel will be opened by removing the WQX hats, the WBX hat, the JC1 hat, and the JC2 hat. This allows for a complete inspection of the piping at the interfaces with magnets and the CERN QRL. The following steps are undertaken to inspect the pipe and flange positions:

5.2I The position of the piping with respect to the WQX flange will be done in accordance to the procedure in Section 4.12A. A template should be used to determine the piping position in the WQX flange. The results of the measurements will be recorded in Table 5.2-11.

5.2J The position of the piping with respect to the WBX flange will be done in accordance to the procedure in Section 4.12B. A template should be used to determine the piping position in the WBX flange. The results of the measurements will be recorded in Table 5.2-11.

5.2K The position of the piping with respect to the JC1 and JC2 flanges will be done in accordance to the procedure in Section 4.12C. A template should be used to determine the piping position in the JC1 and JC2 flanges. The results of the measurements will be recorded in Table 5.2-11.

If the DFBX passes the tests outlined in this section, it is considered accepted by LBNL from the cryogenic system fabricator. LBNL will sign the shipping inspection traveler to indicate DFBX formal acceptance of the box provided that all of the required documents have also been received and found to be in order.

DFBX INSPECTION TRAVELER AFTER SHIPMENT TO CERN

The shipping inspection for DFBX ______ performed on (date) ______________________ at (the location on the CERN site) ___________________________ by _____________________.

Signature ___________________ Date ____________________

Was the DFBX crate removed for the truck before inspection? _______Yes _______No

Table 5.2-1 Visual Inspection of the DFBX and its Shipping Crate after the DFBX has been Shipped and before it is Unpacked

Note a pre-existing corrosion or damage to the outer surface of the DFBX and its shipping crate. If more space is needed, attach additional pages. Attach photos of the DFBX in its shipping crate taken from all fours sides and from the top.

Has all DFBX auxiliary hardware had been adequately restrained? _______Yes _______No

Have all DFBX protuberances been adequately protected? _______Yes _______No

Are all of the shock indicators covered to prevent tampering? _______Yes _______No

Table 5.2-2 Inspection of the Shock Indicators after Shipment to CERN

Shock Indicator Set Number	#1	#2	#3
Longitudinal Shock Reading (g)	________	________	________
Transverse Shock Reading (g)	________	________	________
Vertical Shock Reading (g)	________	________	________

Shock Indicator Set Number	#4	#5	#6
Longitudinal Shock Reading (g)	________	________	________
Transverse Shock Reading (g)	________	________	________
Vertical Shock Reading (g)	________	________	________

Are the shock indicator readings consistent with one another? _______Yes _______No

Table 5.2-3. Vacuum Leak Check of the DFBX Vacuum Vessel

Measured vacuum leak rate for the DFBX vacuum vessel _______________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Date of the vacuum vessel leak check ____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

Measured standard leak rate __________________________ atm cc s^{-1}

Standard leak calibrated date _____________________________

Table 5.2-4. Leak Check of the Helium Tank and Bus Duct Assembly at 80K

Measured vacuum leak rate for the helium tank assembly _______________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel? _______________________ torr

Helium pressure in the helium tank? ______________________psig

Date of the helium tank assembly leak check _______________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

When was the Standard Leak Calibrated? _____________________________

Please include any chart recording tapes and other data as part of this traveler to show the details of the final vacuum leak check of the DFBX helium tank and bus duct assembly.

Table 5.2-5. Pressure Test Record for the DFBX Helium Tank and Bus Ducts MQX1 and MBX1

Component Tested	Test Pressure at t = 30 sec (psig)	Test Pressure at t = 600 sec (psig)	Test Date (date)
Bus Duct Assembly	____________	____________	____________
Helium Tank	____________	____________	____________

Table 5.2-6. Pressure Test and Vacuum Leak Check of the XB Pipe from the JC1 End

XB pipe pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly _____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel ________________________ torr

Helium pressure in the JC1 helium piping _________________________psig

Date of the DFBX piping assembly leak check ______________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? __________________________ atm cc s^{-1}

Standard leak calibration date _________________________________

Table 5.2-7. Pressure Test and Vacuum Leak Check of the Piping from the JC1 End

JC1 pipe pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly _____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel ________________________ torr

Helium pressure in the JC1 helium piping _________________________psig

Date of the DFBX piping assembly leak check ______________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? __________________________ atm cc s^{-1}

Standard leak calibration date _________________________________

Table 5.2-8. Pressure Test and Vacuum Leak Check of the Piping from the JC2 End

JC2 pipe pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the JC2 helium piping ________________________psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Table 5.2-9. Pressure Test and Vacuum Leak Check of the MQX2 Conduit

MQX2 pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the DFBX MQX2 conduit ________________________psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Table 5.2-10. Pressure Test and Vacuum Leak Check of the MBX2 Conduit

MBX2 pressure at 30 seconds _______, at 600 seconds ________, on __________(date)

Measured vacuum leak rate for the piping assembly ____________________ atm cc s^{-1}

Pressure in the DFBX vacuum vessel _______________________ torr

Helium pressure in the DFBX MBX2 conduit ________________________ psig

Date of the DFBX piping assembly leak check _____________________________

Could one measure a standard leak rate of 10^{-8} atm cc s^{-1}? _____ Yes _____ No

If no, what standard leak rate could be measured? _________________________ atm cc s^{-1}

Standard leak calibration date ________________________________

Please include chart recording tapes and other data as part of this traveler to show the details of the final vacuum leak check of the DFBX MQX2 instrumentation conduit.

Table 5.2-11. Piping Position in the WQX, the WBX, and the JC1 and JC2 Chimneys Using the Template Method (See LBNL Drawing 24C352, Sheets 7 and 8)

Does the WQX pipe template fit over the pipes and flange pins? ____ Yes ____ No

Does the WDX pipe template fit over the pipes and flange pins? ____ Yes ____ No

Does the JC1 pipe template fit over the pipes and flange pins? ____ Yes ____ No

Does the JC2 pipe template fit over the pipes and flange pins? ____ Yes ____ No

Date the pipe position check was done _______________

6.0 REFERENCES

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[3] J. Zbasnik, et al "Interface Specification Inner Triplet Feedboxes DFBX to LQXC," LHC-DFBX_-ES-210.00, 7 June 2001

[4] J. Zbasnik, et al, "Interface Specification DFBX to LBX," LHC-DFBX_-ES-230.00, 6 July 2001

[5] Jon Zbasnik, "Interface Specification DFBX to QRL," LHC-DFBX_-ES-240.00, 7 February 2001

[6] J. Zbasnik, et al "Interface Specification Inner Triplet Feedboxes DFBX – Power Converters," LHC-DFBX_-ES-250.00, 1 May 2001

[7] J. Zbasnik, et al "Interface Specification Inner Triplet Feedboxes Electrical Signals," LHC-DFBX_-ES-270.00, 22 February 2001

[8] S. Virostek, "DFBX Shipping Specification," LBNL Specification 986, October 2002