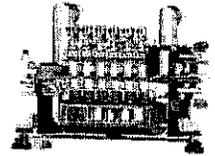




MQX1 FABRICATION TRAVELER



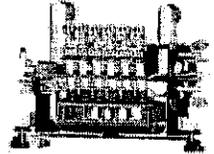
Housing S/N 252448-7 Plug S/N MA-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
10	46	Record I.D. Number of Superconducting Cable: <u>LHC-3A-N0012</u> Include copy of certs in Appendix A		P. Bueh	12/10/02	
20	46	Cut 4 S/C cable pieces to length, tinning ends with Stay-Bright Solder. Punch I.d. hole in both ends, mark thin edge with Red marker	J. Zbasnik sketch, "Rutherford Cable for MQX1"	P. Bueh	2/20/03	
30	46	Record I.D. Number of Copper Cable: <u>LHC-NSC37-0318</u> Include copy of certs in Appendix A		P. Bueh	12/10/02	
40	46	Cut 4 Cu cable pieces to length, tinning ends with Stay-Bright Solder. Mark thick edge with Blue marker	J. Zbasnik sketch, "Rutherford Cable for MQX1"	P. Bueh	2/21/03	
50	46	Separately tin areas with 60/40 Sn Pb solder as required. Check that proper solder is used <u>P.B.</u> ; check that proper flux is used <u>P.B.</u>	J. Zbasnik sketch, "Rutherford Cable for MQX1"	P. Bueh	2/28/03	
60	46	Solder fill area for lambda plug seal with 60/40 Sn Pb solder, check that blue and red marks are together <u>P.B.</u> ; check that proper solder is used <u>P.B.</u> ; check that proper flux is used <u>P.B.</u>	J. Zbasnik sketch, "Rutherford Cable for MQX1"	P. Bueh	3/4/03	
70	46	Join pretinned areas as required.		P. Bueh	3/4/03	
80	46	Send cables to plating shop for flux removal and cleaning		P. Bueh	3/6/03	
90	46	Bakeout cables at 80 C to remove water		P. Bueh	3/7/03	
100	46	Grit blast lambda plug seal area, acetone and alcohol rinse		P. Bueh	3/12/03	
110	46	Apply Kapton wrap on each side of plug seal area; check that Kapton film is .002 " thk x 0.315" wide <u>P.B.</u> . Apply two layers, each with 50% overlap.	J. Zbasnik sketch, "Rutherford Cable for MQX1"	C. Lee	3/13/03	
120	46	Hold in clean, dry storage for potting		C. Lee	3/13/03	
130	46	Record I.D. Number of Corrector Bus: LHC-NSC37-0318 Include copy of certs in Appendix A *** ?		P. Bueh	12/10/02	



MQX1 FABRICATION TRAVELER



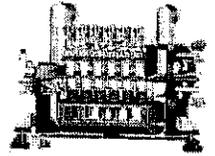
Housing S/N 25I448-7 Plug S/N MR-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
140	46	Cut 24 corrector bus pieces to length	J. Zbasnik sketch, "Corrector Bus for MQX1"	P. Bueh	4/16/03	
150	46	Remove baked-on Kapton insulation	J. Zbasnik sketch, "Corrector Bus for MQX1"	C. Z...	4/22/03	
160	46	Grit blast lambda plug seal area, acetone and alcohol rinse		P. Bueh	4/22/03	
170	46	Prepare G-10 CR Plug for potting. <i>Include copy of certs in Appendix A</i>	Procedure Needed	P. Bueh	4/22/03	
180	46	Insert Conductors in G-10 Plug		P. Bueh	4/22/03	
190	46	Verify Proper Orientation of Conductors, <i>witnessed by: J. Z.</i>	S/C cables face corrector bus array	P. Bueh	4/23/03	
200	46	Mix 200 g of Stycast 2850MT(blue), 10 g of 24 LV Hardener, 6 drops of Antifoam 88 <i>witnessed by: R. H.</i> <i>Include copy of certs in Appendix A</i>		P. Bueh	4/25/03	
210	46	Seal conductors per procedure	Procedure Needed	P. Bueh	4/25/03	
220	46	Reserve excess epoxy for archival sample. When cured, measure durometer hardness; Durometer = <u>89-</u>	Procedure Needed	P. Bueh	4/28/03	
230	46	Prepare for injection in vacuum chamber	Procedure Needed	P. Bueh	4/29/03	
240	46	Mix 500 g of Stycast 2850MT(blue), 25 g of 24 LV Hardener, 15 drops of Antifoam 88 <i>witnessed by: M. G.</i> <i>Include copy of certs in Appendix A</i>		P. Bueh	4/29/03	
250	46	Perform injection per procedure	Procedure Needed	P. Bueh	4/29/03	



MQX1 FABRICATION TRAVELER



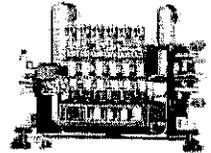
Housing S/N 252448-7 Plug S/N M0-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
260	46	Reserve excess epoxy for archival sample. When cured, measure durometer hardness; Durometer = <u>89</u>	Procedure Needed	P. Bueh	4/30/03	
270	46	Dunk plug in LN 3 times	Procedure Needed	P. Bueh	5/14/03	
280	46	Vacuum leak test after warm up and drying; Before shock ^{5 x 10⁻⁵ Torr} Leak rate = <u>5 x 10⁻⁷</u> atm cc/s	Procedure Needed	P. Bueh	5/12/03	
290	46	Hipot cond to cond to 5 kV, Passed Hipot? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> ^{1477, 7210, 2516} Include data sheet in Appendix B	Procedure Needed	P. Bueh	5/24/03	
295	46	Hold for Engineer Approval to proceed <u>Joe Granich</u>				
300	46	Prepare SS Housing for potting Make sure S/N of housing matches S/N in this Traveler Include copy of certs in Appendix A	Procedure Needed	P. Bueh	6/13/03	
310	46	Prepare G-10CR plug/bus assembly for potting	Procedure Needed	P. Bueh	6/12/03	
320	46	Insert Plug into housing in vacuum chamber to allow magnet side (pipe end) potting		P. Bueh	6/13/03	
330	46	Mix 200 g of Stycast 2850MT(blue), 10 g of 24 LV Hardener, 6 drops of Antifoam 88 witnessed by: <u>M.G.</u> Include copy of certs in Appendix A		P. Bueh	6/13/03	
340	46	Pot per procedure	Procedure Needed	P. Bueh	6/13/03	
350	46	Reserve excess epoxy for archival sample. When cured, measure durometer hardness; Durometer = <u>85</u>		P. Bueh	6/17/03	
360	46	Position assembly in vacuum chamber for potting the DFBX side (flange end)		P. Bueh	6/17/03	



MQX1 FABRICATION TRAVELER



Housing S/N <u>25Z448-7</u>	Plug S/N <u>MA-1</u>
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Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
370	46	Mix 300 g of Stycast 2850MT(blue), 15 g of 24 LV Hardener, 9 drops of Antifoam 88 witnessed by: <u>M.G.</u> <i>Include copy of certs in Appendix A</i>		P. Bish	6/17/03	
380	46	Pot per procedure		P. Bish	6/17/03	
390	46	Reserve excess epoxy for archival sample. When cured, measure durometer hardness; Durometer = <u>88</u>		P. Bish	6/18/03	
400	46	Dunk plug in LN 3 times	Procedure Needed	P. Bish	6/23/03	
410	46	Vacuum leak test after warming and drying, using Test Assembly 25M905 Leak rate = <u>2.1×10^{-5}</u> atm cc/s	Procedure Needed	P. Bish	6/24/03	
420	46	Package and ship to B77, include traveler for work completed thus far				

Note: Perform rate of rise test upon receipt in B77.
Jon Zisman

Author
Jon Zbasnik

Department
Mechanical Engineering

Date
6 June 2003

Date: 7/17/03 Helium Leak Rate: 4.5×10^{-10} Signed: A. Phedris
cc/sec He

Parallel Pumping on Conductor Protection Tube? Yes X No

Witnessed: JR D...

g. ~~CP 460 (MBX1), CP 461 (MOX1): Lambda Plug Leak Check after LN Temperature Pressure Test~~

The maximum acceptable helium leak rate for the lambda plug is 0.1 atm cc/sec (helium), which exceeds the maximum leak rate that can be measured with a conventional helium mass-spectrometer type leak detector. Follow the steps in g.1 if the leak rate can be measured with a conventional leak detector. If the leak rate cannot be measured with a mass spectrometer, perform a rate of rise measurement in g.2.

g.1 Leak Detector Method

Remove the Conductor Protection Tube and connect a helium mass spectrometer leak detector to the assembly as in part IV-a above. Apply a spray of Helium gas to the exposed conductors. Measure and record the room temperature leak rate.

Date: 7/17/03 Helium Leak Rate: 1.4×10^{-7} Signed: A. Phedris

Witnessed: JR D...

MAX - 25I448-7.

g.2 Rate of Pressure Rise Method

Install a "Rad-Lab" Tee to the Helicoflex Seal Flange. Connect one leg of the Tee to a pumping station through a Veeco-style vacuum valve and install a Convectron vacuum gauge on the other leg. Make sure the Conductor Protection Tube is opened to the atmosphere.

Evacuate the piping to about 20 mTorr.
Close the Veeco valve and record the reading of the convectron gage every 60 sec.
Allow the pressure to rise to about 10 Torr.

Note: The trapped volume is 7.2 liter, so the rate of pressure rise must be less than 3.8 mTorr/sec.

Date: 8/5/03

Time: <u>11:30</u>	Pressure: <u>26 MT</u>
Time: <u>11:31</u>	Pressure: <u>160 MT</u>
Time: <u>11:32</u>	Pressure: <u>280 MT</u>
Time: <u>11:33</u>	Pressure: <u>400 MT</u>
Time: <u>11:34</u>	Pressure: <u>512 MT</u>

ENGINEERING NOTE

Author

Doyle Byford and Jon Zbasnik

Department

Mechanical Engineering

Date

29 Aug, 2003

X. DATA SHEETS FOR OPERATION 800 AND 810 TESTS

Data sheet for operation 800 test

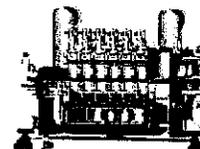
Housing S/N 254448-7

Conductor	Leakage, micro amps or Trip Voltage	Conductor	Leakage, micro amps or Trip Voltage	Conductor	Leakage, micro amps or Trip Voltage		
5U	0.0 mA	V3B	0.0 mA	A3B	0.0 mA		
5L		V3A		A3A			
8U		A4B		A2B			
8L		A4A		A2A			
B6B		B4B		H1B			
B6A		B4A		H1A			
B3B		H2B		V1B			
B3A		H2A		V1A		✓ 9 mA	
H3B		V2B					
H3A		✓ 9 mA		V2A		✓ 9 mA	

Signed Doyle Byford Date 9-18-03



MQX1 FABRICATION TRAVELER



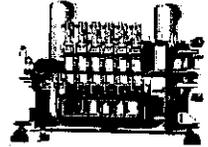
Housing S/N 25Z448-7 Plug S/N MQ-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
430	77	Remove Protective Assembly 25M951 from conductors and install the lambda plate housing in the assembly fixture		P. Brieb	8/5/03	
440	77	Rotate lambda plug to proper orientation		P. Brieb	8/5/03	
450	77	<i>OK ganize corrector handles remove strips</i>		P. Brieb	8/6/03	
460	77	Make Bend 1 of the 28-conductor bundle		P. Brieb	8/6/03	
470	77					
480	77					
490	77	Make the 5-inch-long solder joints for current transfer in the inner and outer cables. Verify that 60/40 Sn/Pb solder is used. <u>PO</u> Verify that rosin-type flux is used. <u>PO</u> Clean any flux residue after soldering.		P. Brieb	8/6/03	
500	77	Apply Kapton wrap on cable bus #1, overlapping existing Kapton wrap by at least 1.5 inch; check that Kapton film is .002 " thk x 0.315" wide <u>PO</u> . Apply two layers, each with 50% overlap.		P. Brieb	8/6/03	
505	77	Apply Kapton wrap on cable bus #2, overlapping existing Kapton wrap by at least 1.5 inch; check that Kapton film is .002 " thk x 0.315" wide <u>PO</u> . Apply two layers, each with 50% overlap.		P. Brieb	8/6/03	
510	77	Apply Kapton wrap on cable bus #3, overlapping existing Kapton wrap by at least 1.5 inch; check that Kapton film is .002 " thk x 0.315" wide <u>PO</u> . Apply two layers, each with 50% overlap.		P. Brieb	8/6/03	
515	77	Apply Kapton wrap on cable bus #4, overlapping existing Kapton wrap by at least 1.5 inch; check that Kapton film is .002 " thk x 0.315" wide <u>PO</u> . Apply two layers, each with 50% overlap.		P. Brieb	8/6/03	
520	77	Install fishbone G-10 spacers between cable conductors in the straight section. Use 14 inch long pieces.		P. Brieb	8/7/03	
530	77	Install strip insulators between corrector busses in the straight section. Use 14 inch long pieces.		P. Brieb	8/7/03	



MQX1 FABRICATION TRAVELER



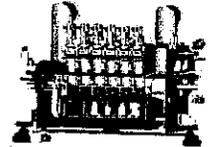
Housing S/N 251146-7 Plug S/N 119-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
540	77	Apply Kapton ground wrap over the bus assembly straight section; check that Kapton film is .002 " thk x 0.315" wide <u>PB</u> . Apply two layers, each with 50% overlap.		P. B. Bish	8/7/03	
550	77	Apply spiral wrap of Kevlar tape over the Kapton ground wrap. 1/4 inch pitch. Epoxy the starting and stopping knots.		P. B. Bish	8/7/03	
555	77	Slip the large radius elbow, with backing rings attached, into position. Clamp into position. Include a copy of the certs in Appendix A.	3/4" x 10" Rings 2 ea.			
560	77	Install 2 G-10 spiders, 25M937, in the straight section as shown on 25M857. Apply a wrapping of fiberglass tape, soaked with epoxy, on both sides of the spiders to keep them in position.		P. B. Bish	8/7/03	
570	77	Install Vertical Pipe assembly 25M908. Note: this subassembly must have previously been thermally shocked and leak checked. Include a copy of the testing report in Appendix B.		P. B. Bish	8/8/03	
580	77	Bend the conductors to form the second bend and clamp in position. Insert strip and fishbone insulators between conductors and extend 1.5 inch past the horizontal elbow weld.		P. B. Bish	8/8/03	
590	77					
600	77					
610	77	Apply Kapton ground wrap to the end of the 1.5 inch-long section with G-10 insulators; check that Kapton film is .002 " thk x 0.315" wide <u>PB</u> . Apply two layers, each with 50% overlap.		P. B. Bish	8/8/03	
620	77	Apply spiral wrap of Kevlar tape over the Kapton ground wrap. 1/4 inch pitch. Epoxy the starting and stopping knots.		P. B. Bish	8/8/03	
625	77	Slip the small radius elbow, with backing rings attached, into position. Clamp into position		P. B. Bish	8/18/03	



MQX1 FABRICATION TRAVELER



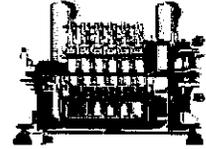
Housing S/N 25M857-7 Plug S/N m9-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
630	77	Install 1 G-10 spider as shown on 25M857. Apply a wrapping of fiberglass tape, soaked with epoxy, on both sides of the spider to keep it in position.		P. Bush	8/8/03	
640	77	Install Horizontal Assembly 25M907. Note: the bellows in this subassembly must have previously been thermally shocked and leak checked. Include a copy of the testing report in Appendix B.		P. Bush	8/18/03	
645	77	Perform closeout welding. Use GTAW process, with a skipping technique and intermediate cooling with "cool gun" to minimize heat input. Fill out weld log and include in Appendix C.				
647	77	Dimensional Check of Bus Duct Piping within tolerance? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>				
650	77	Adjust bellows to the proper length. Trim conductors to a 5.75 inch overhang out of 25M907. Make sure the cable end is tinned with Stay Bright solder before cutting to prevent the cable from unravelling.		A.P.		
655	77	Ring out conductors and attach labels to conductors. <i>Include data sheet in Appendix B</i>	MQX1 Electrical Test Procedure			
660	77	Place teflon tubes over the individual conductors to prevent end flashover during hipot testing. Teflon tubes to extend from the section with G-10 insulators 1.5 inch past the end. Wrap with mylar tape to hold the tubes in place.		A.P.		
665	77	Install Spacer 25M956 as shown on 25M857.		A.P.		
670	77	Install Test Cap 25M950. Note: this subassembly must have previously been thermally shocked and leak checked. Include a copy of the testing report in Appendix B.		A.P.		
680	77					
690	77					



MQX1 FABRICATION TRAVELER



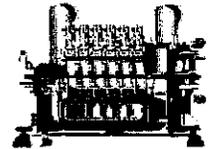
Housing S/N 251448-7 Plug S/N M9-1

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
700	77	Leak check closeout welds. Connect to ISO flange on 25M908. Leak rate less than 1×10^{-9} atm cc/s (helium) ? Yes <input checked="" type="checkbox"/>		A.P.	9/4/03	
710	77	Dunk assembly in LN 2 times to thermally shock closeout welds. Use dry Ne gas inside piping.		A.P.	9/8/03	
720	77	Pressure test closeout welds & lambda plug at room temperature to 370 psig with dry N ₂ . <i>Include data sheet in Appendix B.</i>	Procedure needed	A.P.	9/9/03	
730	77	Leak check closeout welds. Leak rate less than 1×10^{-9} atm cc/s (helium) ? Yes <input checked="" type="checkbox"/>		A.P.	9/9/03	
740	77	Pressure test closeout welds and lambda plug at LN temperature to 370 psig with dry N ₂ . <i>Include data sheet in Appendix B.</i>	Procedure needed	A.P.	9/9/03	
750	77	Leak check closeout welds. Leak rate less than 1×10^{-9} atm cc/s (helium) ? Yes <input checked="" type="checkbox"/>		A.P.	9/10/03	
760	77	Determine leak rate or rate of rise across lambda plug from flange side to pipe side. Leak rate less than 0.1 atm cc/s? Yes <input checked="" type="checkbox"/>		A.P.	9/10/03	
770	77	Determine leak rate or rate of rise across lambda plug from pipe side to flange side. Leak rate less than 0.1 atm cc/s? Yes <input type="checkbox"/>				
780	77	Attach "pressure-tested" label to magnet end of the assembly		A.P.	11/24/03	
790	77					
800	77	Hipot cond to cond to 5 kV in air, Passed Hipot? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> <i>Include data sheet in Appendix B</i>	Test Done by Eric Henson		9/18/03	
810	77	Hipot cond to cond to 2 kV in He, Passed Hipot? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> <i>Include data sheet in Appendix B</i>	Not done yet			
820	77					



MQX1 FABRICATION TRAVELER



Housing S/N _____	Plug S/N _____
-------------------	----------------

Note: Add S/N at OP 300
See last page for signoffs

OP	AREA	OPERATION DESCRIPTION	REFERENCE PROCEDURE OR DRAWING	NAME	DATE	DR #
830	77	Cover the conductor bundle with a close-fitting teflon tube. Attach spacers 25M955 on the bundle as shown on 25M857 to prevent the bundle from movement inside the tube.		A.P.		
840	77	Install protective tube assembly 25M951. Flush both sides of lambda plug with dry N ₂ gas and cap for shipment to DFBX vendor.		A.P.	11/24/03	
850	77	Package for shipment to DFBX vendor. Include a copy of the assembly's traveler in the shipping container.		A.P.	11/26/03	

Traveler Entries Reviewed by: Jon Zbasnik

Date 11/26/03

Traveler Approved by: Joseph Ranson

Date 12/02/03

Author

Jon Zbasnik

Department

Mechanical Engineering

Date

6 June 2003Project:

LHC I.R. Feedboxes

Title:

Pressure and Leak Testing of MBX1 and MQX1 Bus Ducts

Part Serial Number 25I448-7**I. Description**

We present the thermal cycling and subsequent pressure and leak test of MBX1 and MQX1 Bus Ducts fabricated at LBNL. These assemblies contain superconducting busses that allow the superconducting inner triplet magnets and corrector magnets to be supplied with current. A barrier between the 1.8K, 1 bar superfluid helium magnet bath and the 4.3K, 1.3 bar liquid helium bath in the DFBX (lambda plug) is integral to the bus duct assembly.

Isometric views of MBX1 and MQX1 are shown in Figures 1 and 2, respectively.

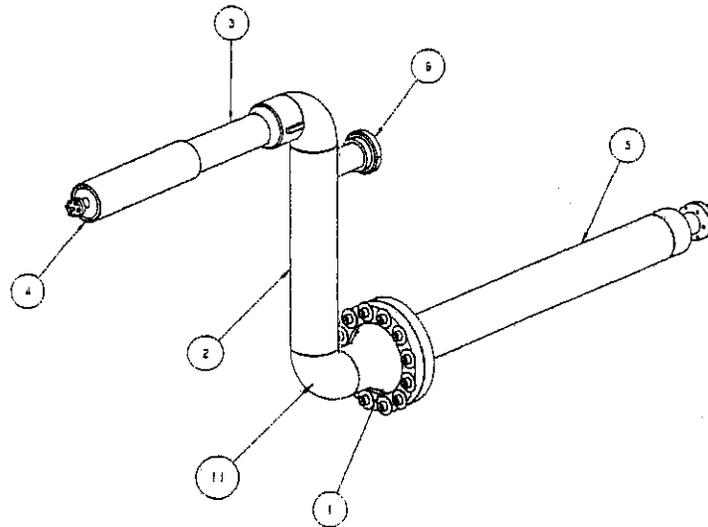


Figure 1. Isometric view of MBX1. 1-Housing with Lambda Plug; 2-Vertical Pipe Section; 3-Horizontal Section (this connects to magnet); 4-test Cap (this is removed for tunnel installation); 5-Conductor Protection Tube (this is removed for attachment to DFBX); 6-Helicoflex Sealing system; 11-Short Radius 3 IPS Weld Elbow.

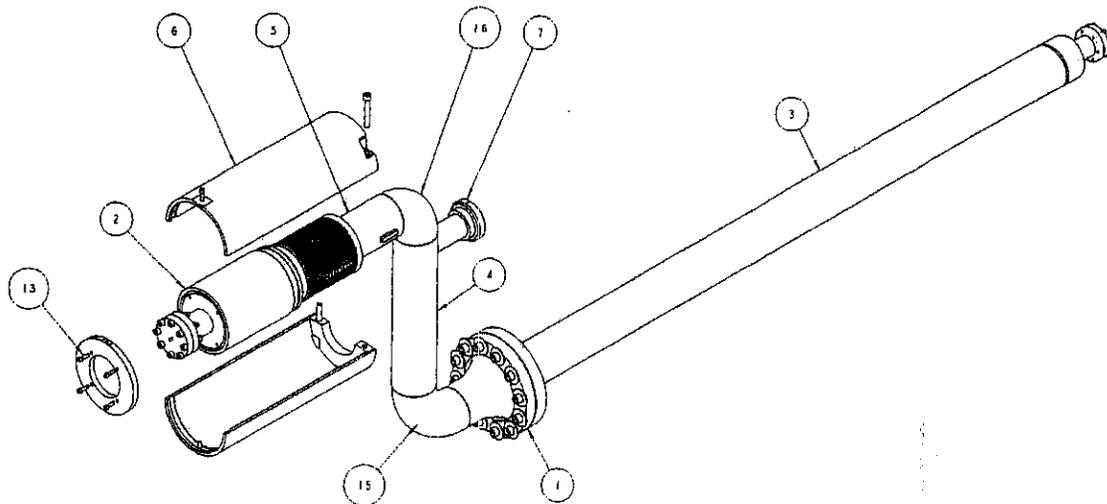
Author
Jon ZbasnikDepartment
Mechanical EngineeringDate
6 June 2003

Figure 2. Isometric View of MQX1. 1 - Housing with Lambda Plug; 2 - Test Cap (this is removed for tunnel installation); 3 - Conductor Protection Tube (this is removed for attachment to DFBX); 4 - Vertical Pipe Section; 5 - Horizontal Section (this connects to magnet); 6 & 13 - Bellows Restraint (this is removed for tunnel installation); 7 - Helicoflex Sealing System; 15 - Long Radius 3 IPS Weld Elbow; 16 - Short Radius 3 IPS Weld Elbow.

The bus duct design pressure is 20 bar applied to the magnet side and 3.5 bar applied to the DFBX side. The duct would probably be damaged with hydrostatic testing using water since the electrical insulation would be compromised, so it will be tested pneumatically with dry nitrogen or helium. In accordance with Pub 3000, the magnet-side piping will be pressure tested to 25 bar (370 psig).

The magnet-side piping is 3 IPS (3.5 inch outer diameter) schedule 10, type 304L stainless steel pipe and weld elbows. The Lambda Plug housing is machined from a forged 304L stainless steel special weldneck flange. Welding was performed by LBNL welders using the GTAW process with ER316L filler wire. The assembly of NEMA G-10CR and conductors potted into the housing completes the pressure boundary of the magnet-side piping.

Author

Jon Zbasnik

Department

Mechanical Engineering

Date

6 June 2003

II. Pressure Test Hazards

The chief hazard in this test is the stored energy in the pressurized gas providing a driving force that could eject the potted plug out of the housing.

The stored energy is given by:

$$U = \frac{P_h V_h}{\gamma - 1} \left[1 - \left(\frac{P_l}{P_h} \right)^{\frac{\gamma - 1}{\gamma}} \right],$$

where U = stored energy in N-m (J)

P_h = Initial Vessel Pressure (absolute) in N/m² (Pa) = 25 bar = 2.5 MPa

P_l = Final Vessel Pressure (absolute) in N/m² (Pa) = 0.1 MPa

V_h = Vessel Volume in m³ = 442 in³ = 7.2 x 10⁻³ m³

γ = specific heat ratio, C_p/C_v , = 1.67 for helium and 1.4 for nitrogen.

If we test with dry nitrogen,

$$U = \frac{3.0 \times 10^6 * 7.2 \times 10^{-3}}{1.4 - 1} \left[1 - \left(\frac{.1}{2.5} \right)^{\frac{1.4 - 1}{1.4}} \right]$$

$$U = 5.4 \times 10^4 [1 - (.04)^{.286}]$$

$$U = 3.25 \times 10^4 \text{ N-m or } 32 \text{ kJ}$$

The stored energy is quite low, and is equivalent to about 7.9 g of TNT.

If we test with helium,

$$U = \frac{3.0 \times 10^6 * 7.2 \times 10^{-3}}{1.67 - 1} \left[1 - \left(\frac{.1}{2.5} \right)^{\frac{1.67 - 1}{1.67}} \right]$$

$$U = 3.22 \times 10^4 [1 - (.04)^{.401}]$$

$$U = 2.3 \times 10^4 \text{ N-m or } 23 \text{ kJ}$$

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The stored energy is quite low, and is equivalent to about 5.8 g of TNT.

In spite of the rather low stored energies, the part should be tested behind a protective barricade such as inside a 1-inch-thick plywood box. The box should be large enough to accommodate the styrofoam dewar for cold pressure testing. The corners should be reinforced with 2 inch Al angle. The top should be easily removable to allow the part to be placed inside. The high pressure line and LN fill tube can also penetrate through the top.

III. Calculations

Allowable pressure in 3 inch pipe, fittings, and welds.

Assume full penetration welds, without Radiographic Testing. The allowable pressure in psi is given by:

$$P = \frac{SEt}{R + .6t},$$

where S = allowable stress (psi) = 16,500 psi
 E = Joint Efficiency = .65 because of the welds
 R = inner radius = 1.63
 t = wall thickness (inch) = .12 inch

$$P_{\text{allowable}} = 756 \text{ psig}$$

The test pressure of 370 psig is considerably below the allowable pressure of 756 psig.

Shear Stress in Stycast 2850MT bond between 304 Stainless Steel and the G-10CR Insulator block.

We take the limiting case that the entire pressure load is carried by the Stycast epoxy bond between the stainless housing and the G-10CR insulator block,

$$\tau_{\text{shear}} = \frac{PA_{\text{pipe}}}{A_{\text{shear}}}$$

$$\tau_{\text{epoxy}} = P \frac{\pi r_i^2}{2\pi r_{G-10} l_{\text{epoxy}}},$$

where P = test pressure = 370 psig
 r_i = inner radius of piping = 1.63 inch
 r_{G-10} = outer radius of G-10CR insulator = 1.35 inch
 l_{epoxy} = length of epoxy bond = 1.75 inch

$$\tau_{\text{epoxy}} = 370x \frac{1.63^2}{2 * 1.35 * 1.75}$$

$$\tau_{\text{epoxy}} = 208 \text{ psi}$$

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Shear Stress in NEMA G-10CR Plug

In this case we have the limiting case in which the pressure load is carried by a shear load in the end of the G-10 insulator block.

$$\tau_{G-10} = P \frac{\pi r_i^2}{2\pi r_{G-10} * l_{G-10}}$$

where P = test pressure = 370 psig

r_i = inner radius of piping = 1.63 inch

r_{G-10} = outer radius of G-10CR insulator joint = 1.1 inch

l_{G-10} = shear length of G-10CR = .25 inch

$$\tau_{G-10} = 370 \frac{1.63^2}{2 * 1.1 * .25}$$

$$\tau_{G-10} = 1787 \text{ psi}$$

These shears are very low and are well within the materials' capability.

IV. Pressure & Leak Testing**a. OP 700 (MBX1), OP xxx (MQX1): Post-Weld Leak Check**

Connect a calibrated helium mass spectrometer leak detector to Item 6, Figure 1 for the MBX1 or to Item 7, Figure 2 for the MQX1 and leak check the closeout welds using a tracer probe method in which helium is sprayed over the weld joints. The leak rate should be less than 1×10^{-9} atm cc/sec (helium).

The maximum acceptable room temperature helium leak rate for the lambda plug is 0.1 atm cc/sec (helium), which exceeds the maximum leak rate that can be measured with a conventional helium mass-spectrometer type leak detector. If the lambda plug leak rate is too high for the leak detector, pump in parallel on the Conductor Protection Tube to allow the leak detector to be used.

Background 4.2×10^{-10}

Date: 9/4/03 Helium Leak Rate: no response Signed: Amnet Redels

Parallel Pumping on Conductor Protection Tube? Yes X No _____

Witnessed: _____

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b. OP 710 (MBX1), OP xxx (MQX1): Thermal Shock to LN Temperature

Make sure a teflon Oring is used to seal the Protection tube to the Lambda Plug Housing.

Pressurize both sides of the assembly shown in Figure 1 or Figure 2 to 20 psig with pure neon gas, valve the gas supply off and submerge the assembly in a bath of Liquid Nitrogen.

Hold in the LN bath for at least 1 hour to allow the part to reach LN temperature.

Remove from Liquid Nitrogen bath and allow the part to reach room temperature. Set up a fan to circulate a flow of air over the part and speed the warmup. Allow sufficient time for the part to defrost and become dry.

Repeat the process to obtain 2 thermal cycles.

Signed: Amot Lekedis 9/8/03

Witnessed: _____

c. OP 720 (MBX1), OP xxx (MQX1): Room Temperature Pressure Test

The pressure test is to be performed using dry nitrogen gas.

Hook up dry nitrogen gas source to the magnet side piping as indicated in Figure 3.

Use pressure safety manifold M8104-6 with a relief valve set to 500 psig.

Allow any leakage across the lambda plate to be vented out the Conductor Protection Tube.

Place the part in the protective barrier described above.

Raise the pressure to 370 psig in steps of about 50 psi. Pause at each step for 60 sec. When 370 psig is attained, close the shutoff valve and record the test gauge reading for 10 minutes at 1 minute intervals.

Reduce pressure to 0 psig.

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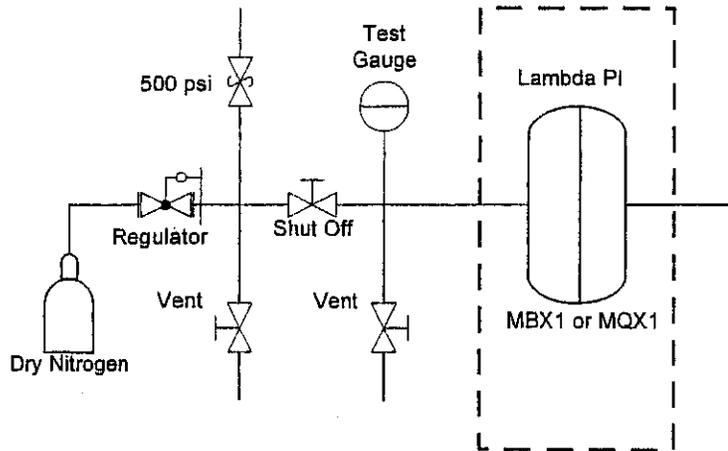


Figure 3. Pressure Test Setup.

Date: 9/9/03

Time: <u>8:27</u>	Pressure: <u>370 PSI</u>
Time: <u>8:28</u>	Pressure: <u>370</u>
Time: <u>8:29</u>	Pressure: <u>370</u>
Time: <u>8:30</u>	Pressure: <u>370</u>
Time: <u>8:31</u>	Pressure: <u>365</u>
Time: <u>8:32</u>	Pressure: <u>365</u>
Time: <u>8:33</u>	Pressure: <u>360</u>
Time: <u>8:34</u>	Pressure: <u>355</u>
Time: <u>8:35</u>	Pressure: <u>355</u>
Time: <u>8:36</u>	Pressure: <u>350</u>
Time: <u>8:37</u>	Pressure: <u>350</u>
Time: _____	Pressure: _____

Signed: Matthew Rhodes

Witnessed: Jon R. Dyer 9/9/03

d. OP 730 (MBX1), OP xxx (MQX1): Leak Check after Room Temperature Pressure Test

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Connect a calibrated helium mass spectrometer leak detector to Item 6, Figure 1 for the MBX1 or to Item 7, Figure 2 for the MQX1 and leak check the closeout welds using a tracer probe method in which helium is sprayed over the weld joints. The leak rate should be less than 1×10^{-9} atm cc/sec (helium).

The maximum acceptable room temperature helium leak rate for the lambda plug is 0.1 atm cc/sec (helium), which exceeds the maximum leak rate that can be measured with a conventional helium mass-spectrometer type leak detector. If the lambda plug leak rate is too high for the leak detector, pump in parallel on the Conductor Protection Tube to allow the leak detector to be used.

Background 3.2×10^{-10}

Date: 9/9/03 Helium Leak Rate: 0 No Response Signed: Amurth Reddy

Parallel Pumping on Conductor Protection Tube? Yes No

Witnessed: J. D. [Signature] 9/9/03

e. OP 740 (MBX1), OP xxx (MQX1): Pressure Test at LN Temperature

The pressure test is to be performed using neon gas.

Hook up the neon gas source to the Assembly as indicated in Figure 4.

Use pressure safety manifold M8104-6 with a relief valve set to 500 psig.

Allow any leakage across the lambda plate to be vented out the Conductor Protection Tube through a relief valve set to 30 psig. The relief valve is at room temperature.

Place the part in the protective barrier described above.

Raise the pressure to 370 psig in steps of about 50 psi. Pause at each step for 60 sec. Maintain at 370 psig for 10 minutes.

Reduce pressure to 0 psig.

Allow the assembly to reach room temperature

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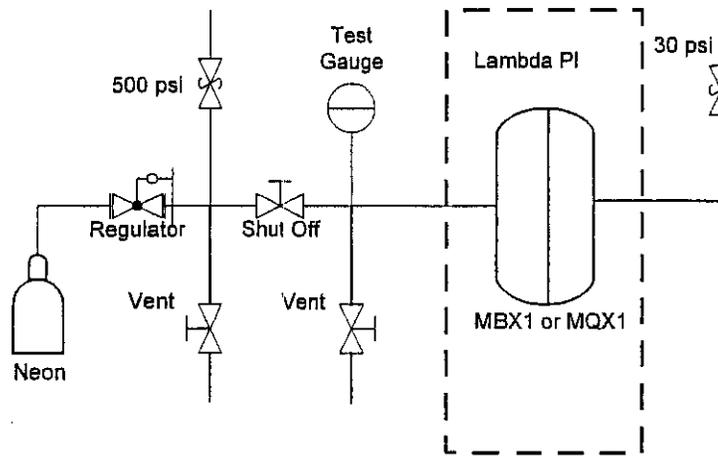


Figure 4. LN Temperature Pressure Test Setup.

Date: 9/9/03

Time: 2:30 PM Pressure at 370 psig
Time: 2:40 PM Pressure released to 0 psig

Signed: Annal Redis

Witnessed: _____

f. OP 750 (MBX1), OP xxx (MQX1): Leak Check after LN Temperature Pressure Test

Connect a calibrated helium mass spectrometer leak detector to Item 6, Figure 1 for the MBX1 or to Item 7, Figure 2 for the MQX1 and leak check the closeout welds using a tracer probe method in which helium is sprayed over the weld joints. The leak rate should be less than 1×10^{-9} atm cc/sec (helium).

The maximum acceptable room temperature helium leak rate for the lambda plug is 0.1 atm cc/sec (helium), which exceeds the maximum leak rate that can be measured with a conventional helium mass-spectrometer type leak detector. If the lambda plug leak rate is too high for the leak detector, pump in parallel on the Conductor Protection Tube to allow the leak detector to be used.

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*Background 5.2 x 10⁻¹⁰*Date: 9/10/03 Helium Leak Rate: ∅ No Response Signed: Ammet PedalisParallel Pumping on Conductor Protection Tube? Yes 4 No _____

Witnessed: _____

g. OP 760 (MBX1), OP xxx (MQX1): Lambda Plug Leak Check after LN Temperature Pressure Test

The maximum acceptable helium leak rate for the lambda plug is 0.1 atm cc/sec (helium), which exceeds the maximum leak rate that can be measured with a conventional helium mass-spectrometer type leak detector. Follow the steps in g.1 if the leak rate can be measured with a conventional leak detector. If the leak rate cannot be measured with a mass spectrometer, perform a rate of rise measurement in g.2.

g.1 Leak Detector Method

Remove the Conductor Protection Tube and connect a helium mass spectrometer leak detector to the assembly as in part IV-a above. Apply a spray of Helium gas to the exposed conductors. Measure and record the room temperature leak rate.

Date: _____ Helium Leak Rate: _____ Signed: _____

Witnessed: _____

g.2 Rate of Pressure Rise Method

Install a "Rad-Lab" Tee to the Helicoflex Seal Flange. Connect one leg of the Tee to a pumping station through a Veeco-style vacuum valve and install a Convectron vacuum gauge on the other leg.

Make sure the Conductor Protection Tube is opened to the atmosphere.

Evacuate the piping to about 20 mTorr.

Close the Veeco valve and record the reading of the convectron gage every 60 sec.

Allow the pressure to rise to about 10 Torr.

Note: The trapped volume is 7.2 liter, so the rate of pressure rise must be less than 3.8 mTorr/sec.

Date: 9/10/03

Time: <u>2:09 PM</u>	Pressure: <u>30 mTorr</u>
Time: <u>2:10</u>	Pressure: <u>148 mTorr</u>
Time: <u>2:11</u>	Pressure: <u>300 m.T.</u>
Time: <u>2:12</u>	Pressure: <u>448 m.T.</u>
Time: <u>2:13</u>	Pressure: <u>608 m.T.</u>

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Time: _____	Pressure: _____

Signed: _____

Witnessed: _____

Date	Time	Test Type	Memory	Step	Pass/Fail	Test Result	Timer	Parameter 1	Parameter 2	Serial Number	Test Model #	Test Serial #	Calibration Due Date	Model Number
9/17/2003	10:00:18 AM	DC Withstand	9	1	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	2	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	3	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	4	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	5	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	6	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	7	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:00:18 AM	DC Withstand	9	8	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(86B-V3A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	1	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	2	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	3	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	4	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	5	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	6	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	7	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	10:48:30 AM	DC Withstand	9	8	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A4B-V2A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	1	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	2	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	3	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	4	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	5	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	6	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	7	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:11:18 AM	DC Withstand	9	8	Pass	Pass	60.0s	2.50KV	0.0microamps	2514487(A3B-V1A)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:26:43 AM	DC Withstand	10	1	Pass	Pass	60.0s	5.00KV	0.0microamps	2514487(5L-8U)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:26:43 AM	DC Withstand	10	2	Pass	Pass	60.0s	5.00KV	0.0microamps	2514487(5L-8U)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:26:43 AM	DC Withstand	10	3	Pass	Pass	60.0s	5.00KV	0.0microamps	2514487(5L-8U)	7550DT	9111100	1/31/2004	MQ
9/17/2003	11:26:43 AM	DC Withstand	10	4	Pass	Pass	60.0s	5.00KV	0.0microamps	2514487(5L-8U)	7550DT	9111100	1/31/2004	MQ

Eric Henson noted in logbook that continuity was verified.
 Note: some entries here are entered manually by Eric to
 save time.