 BERKELEY LAB	Lawrence Berkeley National Laboratory Engineering Specification	<u>Cat Code</u> SU3300	<u>LBL Document #</u> SU-1008-8067	<u>Rev</u> C	<u>Page</u> 1 of 21
<u>Author(s)</u> Mike Solis		<u>Collaborating Institution</u> N/A			
<u>Reviewed By</u> KLRAY		<u>Reviewed Date</u> May 28 2020 12:15:25 PM PDT			
<u>Approved / Concurred By</u> DWCHENG		<u>DCC Release Date</u> May 28 2020 12:55:10 PM PDT			
<u>Title</u> SUPERCONDUCTING MAGNET PROGRAM / LARP QXF GENERAL SPLICE BOX WORK INSTRUCTIONS					

Splice Box Work Instructions (WI)

Windchill Unique ID: SU-1008-8067C

Issued May 28 2020 12:55:10 PM PDT

Prepared by

Checked by

Mike Solis

KLRAY

Work Instructions Originator

Approved by

DWCHENG

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 2 of 21
---	--	---	--	------------------------	------------------------

Table of Contents

REVISION HISTORY	3
PURPOSE	3
SCOPE	3
DEFINITIONS.....	3
REFERENCE DOCUMENTS.....	4
TOOLS REQUIRED	4
HARDWARE REQUIRED	5
WORK INSTRUCTIONS.....	6
MAGNET IDENTIFICATION.	6
COIL IDENTIFICATION.	6
OVERVIEW	6
SPLICE BOX BASE PLATES ASSEMBLY	7
VOLTAGE TAP PREPARATION (IF IN CONFIGURATION)	9
FIRST LAYER SOLDERING	10
SOLDER VOLTAGE TAPS (IF IN CONFIGURATION)	13
SECOND LAYER PREPARATION.....	14
SECOND LAYER SOLDERING.....	15
SECOND LAYER VOLTAGE TAPS (IF IN CONFIGURATION).....	18
FINAL SPLICE BOX STEPS	18
MAGNET BORE MEASUREMENT	19
COMPLETION	19
VERIFICATION SIGNOFF SHEET	20

 LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 3 of 21
---	---	---	------------------------	------------------------

Revision History

Revision	Issued	Changes
A	10-24-2018	Original issue.
B	1-30-2020	Remove electrical testing (covered in SU-1010-1903), update images
C	5-26-2020	Add Magnet Bore Measurement, integrate soldering instructions into main instruction, add info about cleaning after soldering, make lengths boldface, change which bolt holes used in fig. 5 & 13, remove "finish wiring" section (replaced with SU-1012-5517)

Purpose

The purpose of this working Instruction is to describe the process of making the coil lead solder splices, and installation of the Splice Box. The MQXFA magnet that is being built for the HL-LHC project is approximately 15 feet long (4.5m) and 2 feet in diameter. The "Integration and Loading" and "Connectors and Finishing" work instructions are prerequisites to the installation of the Splice Box.

Scope

This document covers the installation of the MQXFA Splice Box to the Axial End Loaded MQXFA structure, and the bore clearance measurement verification. It does not cover the final electrical tests, which will be performed subsequently.

Definitions

N/A

 LBNL Engineering Specification	Splice Box Work Instructions	<u>LBNL Document #</u> SU-1008-8067	<u>Rev</u> C	<u>Page</u> 4 of 21
---	---	---	------------------------	------------------------

Reference Documents

- SU-1010-1903 - MQXFA Electrical Test Procedures
- SU-1008-8074 - MQXFA Coil Pack Subassembly
- SU-1011-5637 - MQXFA Integration and Loading Work Instructions
- SU-1012-5517 - MQXFA Connectors and Finishing Work Instructions
- 27L108 - MQXFA Splice box
- SU-1012-5537 - Bore Gauge Assy
- SU-1011-2020 - MQXFA Connector Layout Assy, LE
- SU-1011-1876 - MQXFA Connector Layout Assy, RE
- SU-1010-3108 - MQXFA Series VT Schematic, Whole Magnet
- SU-1011-1677 - MQXFA Pre-Series VT Schematic, Whole Magnet
- SU-1010-7805 - MQXFA Series PH Schematic, Whole Magnet
- SU-1010-7806 - MQXFA Series SG Schematic

Tools Required

Calibrated Tools:

- DMM Digital Multi-meter
- ~~LCR Meter~~
- ~~Hipot Tester~~
- ~~Impulse Tester~~

Non Calibrated Tools:

- Cable Cutters
- C Clamps - Various sizes
- G10 Clamp Blocks
- Large tip soldering iron.
- Rheostat
- Cartridge heater
- Metric Hex Drivers (2.5mm, 3mm, 4mm & 5mm)
- Bore Gauge Assy (SU-1012-5537)

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 5 of 21
---	--	---	--	------------------------	------------------------

Hardware Required

Fabricated Parts & Hardware:

Part Description	Part No.	Qty
SPLICE CONNECTION BOX, QXFA, BASE PLATE	27L096	1
SPLICE CONNECTION BOX, QXFA, CORNERPLATE 2	27L097	1
SPLICE CONNECTION BOX, QXFA, CORNER PLATE 1	27L098	1
SPLICE CONNECTION BOX, QXFA, CORNER PLATE 4	27L099	1
SPLICE CONNECTION BOX, QXFA, CORNER PLATE 3	27L100	1
SPLICE CONNECTION BOX, QXFA, SEPARATION PLATE 2	27L134	1
SPLICE CONNECTION BOX, QXFA, SEPARATION PLATE 1	27L135	1
SPLICE CONNECTION BOX, QXFA, SEPARATION PLATE 4	27L136	1
SPLICE CONNECTION BOX, QXFA, SEPARATION PLATE 3	27L137	1
SPLICE CONNECTION BOX, QXFA, SECOND LAYER PLATE	27L101	1
SPLICE CONNECTION BOX, QXFA, TOP PLATE 1	27L102	1
SPLICE CONNECTION BOX, QXFA, TOP PLATE 2	27L113	1
SPLICE CONNECTION BOX, QXFA, RAMP 4	27L103	1
SPLICE CONNECTION BOX, QXFA, RAMP 1	27L104	1
SPLICE CONNECTION BOX, QXFA, RAMP 2	27L105	1
SPLICE CONNECTION BOX, QXFA, RAMP 3	27L106	1
SPLICE CONNECTION BOX, QXFA, STANDOFF	27L151	8
SOLDER BLOCK, QXFA	27L146	3
SPLICE CONNECTION BOX, QXFA, CLIQ LEAD GUIDE	27L145	1
FHSCS FT M8X20X1.25 SS A2 DIN7991	N/A	8
18-8 SS Hex FH, M5 x 0.8 mm x 25 mm	92125A216	8
18-8 SS Hex FH, M4 x 0.7 x 25 mm	92125A202	20
18-8 SS SH, M6 x 1 mm x 35 mm	91292A141	8
18-8 SS Hex FH, M5 x 0.8 mm x 14 mm	92125A211	8
BHSCS FT M4X16X0.7 SS A2 ISO7380	94500A282	21
PIN, DOWEL, 3/16 DIA X 1/2 LG	90145A505	4
SHCS FT M5X16X0.8 SS A2 DIN912	91292A126	4
18-8 SS SH, M5 x 0.8 mm x 30 mm	91292A192	2

 LBL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 6 of 21
--	---	--	-----------------	-----------------

Work Instructions

Magnet Identification.

1. Identify the structure serial ID. Note the ID and complete the remaining fields in the Verification point 1 of the Verification signoff sheet.

Verification Point 1

Coil Identification.

2. Identify the coils installed within the assembly. You may have to reference to the Coil Pack Assembly work instructions to determine the Coil serial number and position within the coil pack. Document the coil serial information in the verification signoff sheet.

Verification point 2

Overview

3. Magnet Assembly and Splice Box Orientation

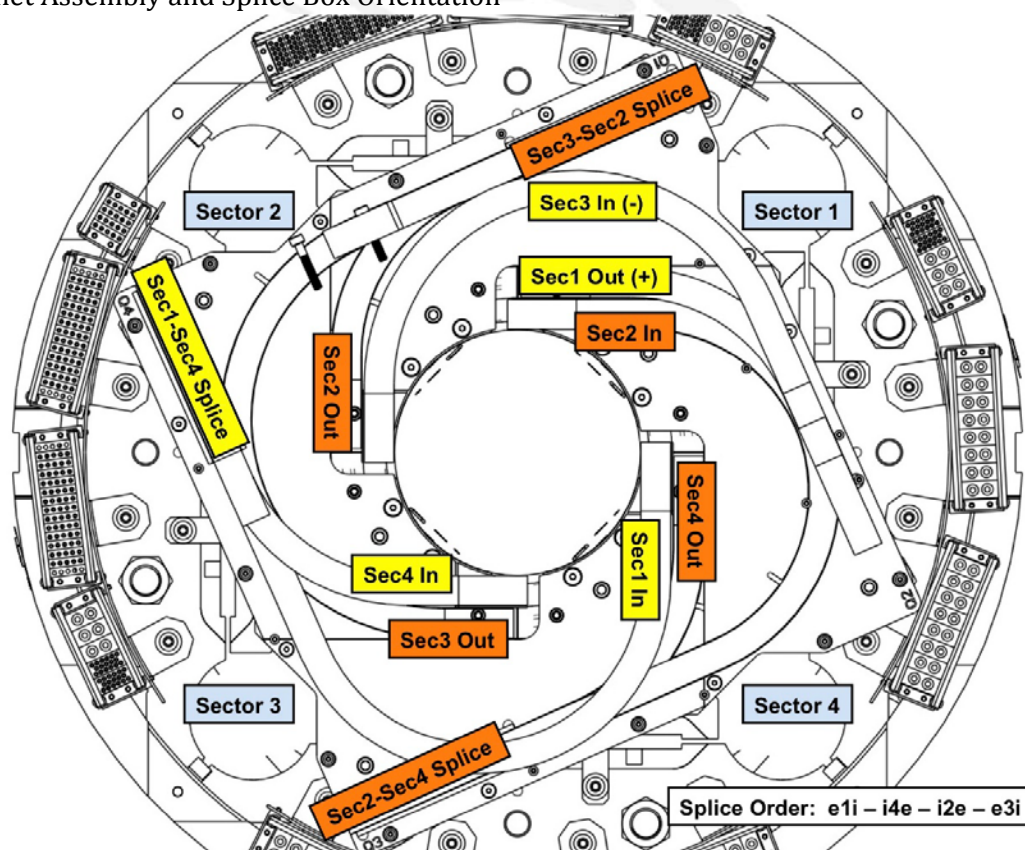


Figure 1: Splice box orientation; both layers visible. (Bot) Splice joint identification. Refer to Table 2 for color coding.

	LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 7 of 21
---	---	---	--	-----------------	-----------------

Item/Quad.	Lead Location	Info
Quadrant 1 Coil	Inner	Spliced to Quadrant 4 In
Quadrant 1 Coil	Outer	Positive (A) current lead
Quadrant 2 Coil	Inner	Spliced to Quadrant 4 Out
Quadrant 2 Coil	Outer	Spliced to Quadrant 3 Out
Quadrant 3 Coil	Inner	Negative (B) current lead
Quadrant 3 Coil	Outer	Spliced to Quadrant 2 Out
Quadrant 4 Coil	Inner	Spliced to Quadrant 1 In
Quadrant 4 Coil	Outer	Spliced to Quadrant 2 In

Table 1: Coil leads list for magnet splices. Orange leads indicate 1st layer splice connections. Yellow leads refer to 2nd layer leads.

Splice Box Base Plates Assembly

- Obtain MQXFA schematic (SU-1010-3108 series, SU-1011-1677 pre-series) of the splice arrangement for the magnet from the cognizant electrical engineer. Attach the schematic to the back of this traveler.
- Attach the splice box standoffs (27L151) to the axial end plate.

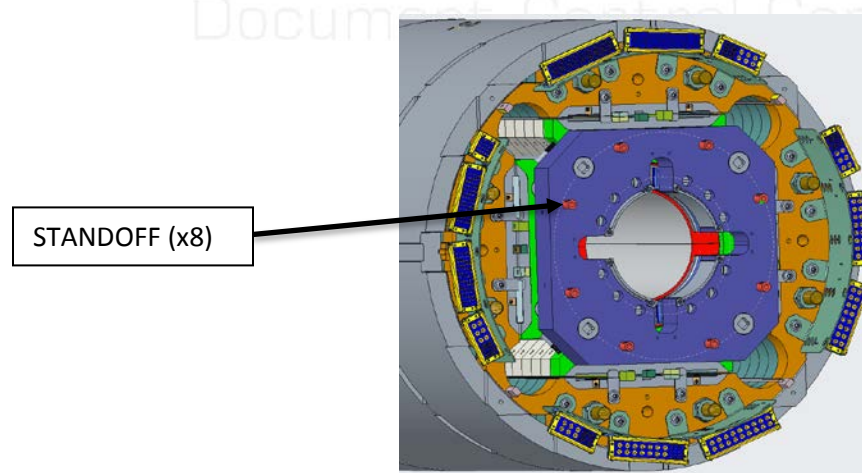


Figure 2: Standoff Locations

	LBLN Engineering Specification	Splice Box Work Instructions	<u>LBLN Document #</u> SU-1008-8067	<u>Rev</u> C	<u>Page</u> 8 of 21
---	---	---	---	------------------------	------------------------

6. Mount the splice box base plate (27L096) onto the standoffs using the flathead screws. Ensure that it is oriented correctly. Take care to not damage the cable leads and instrumentation wires already installed.

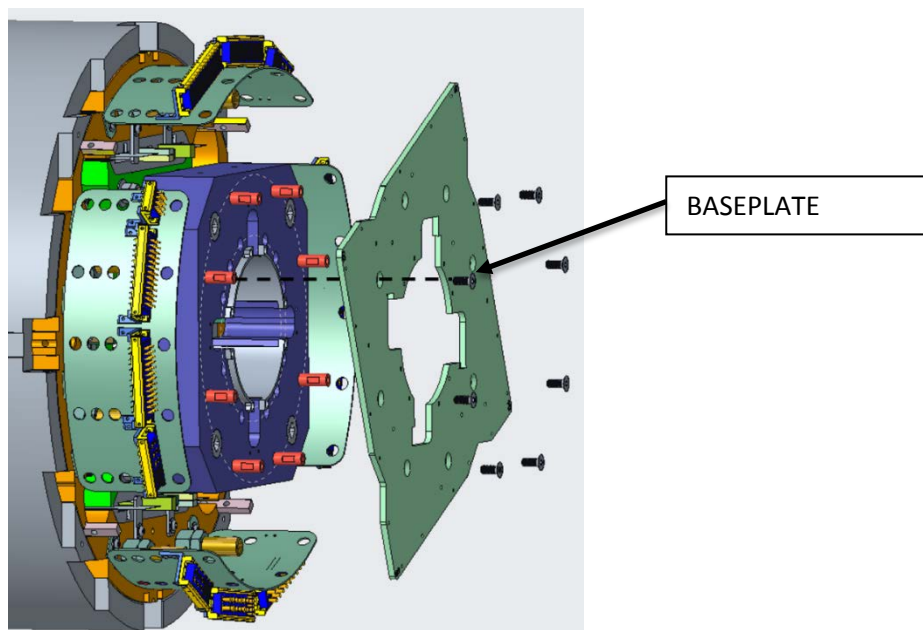


Figure 3: *Splice box base plate installation*

7. For each 1st layer corner plate of the splice box (Qty 4), attach the corresponding cable QXFA ramp. Align and fasten with Dowel Pin (0.1875 X 0.50) and screw (M5 X 16 SHCS SS).

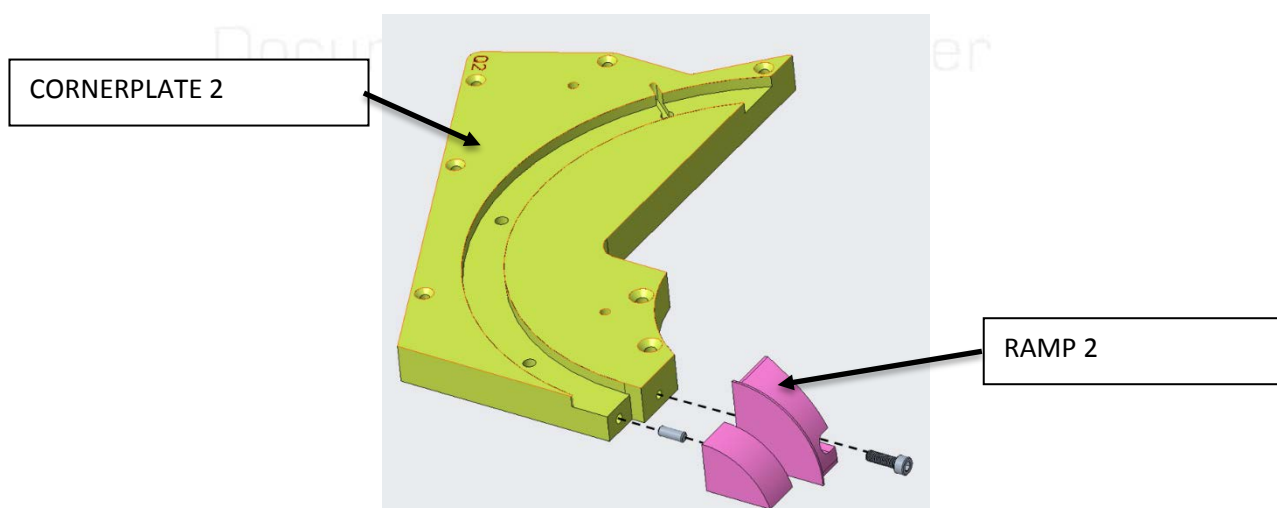


Figure 4: *MQXF ramp installation*

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 9 of 21
---	--	---	--	------------------------	------------------------

8. Attach each of these quadrants to the mounted base plate with M4 x 25mm screws, Qty 3 per quadrant. Refer to Figure 5 for screw locations.

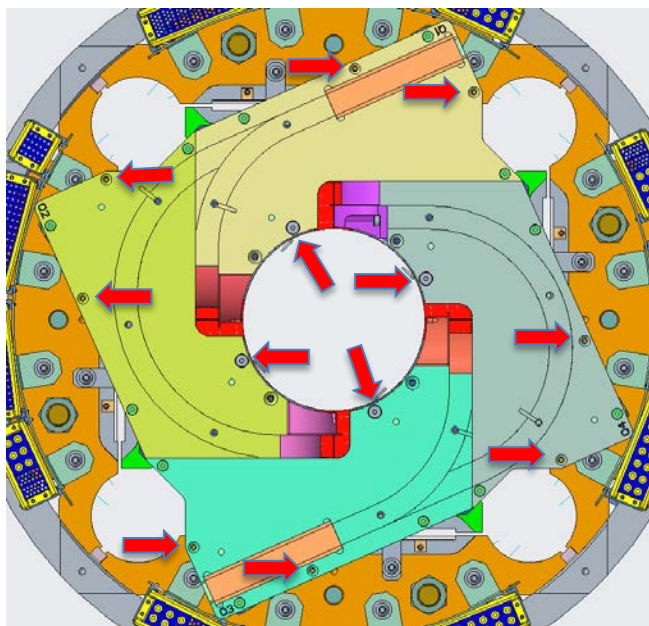


Figure 5: 1st Layer Quadrant Fastener Locations

Voltage Tap Preparation (If in Configuration)

9. Verify with Cognizant Engineer if Voltage Taps will be soldered in the splice box. (If yes, follow steps 10-12, 32, 53-55, if not skip).

Verification point 3

10. Cut two pairs of voltage tap (VT) wiring (28 AWG, Kapton/Tefzel insulated) to **5m (16 ft 5 in)** in length.
11. Insert the two pairs of VT wires from the back side of the splice box at the indicated holes, and temporarily hold them in place with tape. Label the flying lead of each of these wires with its respective coil/cable information per **Figure 6**.

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 10 of 21
---	--	---	--	------------------------	-------------------------

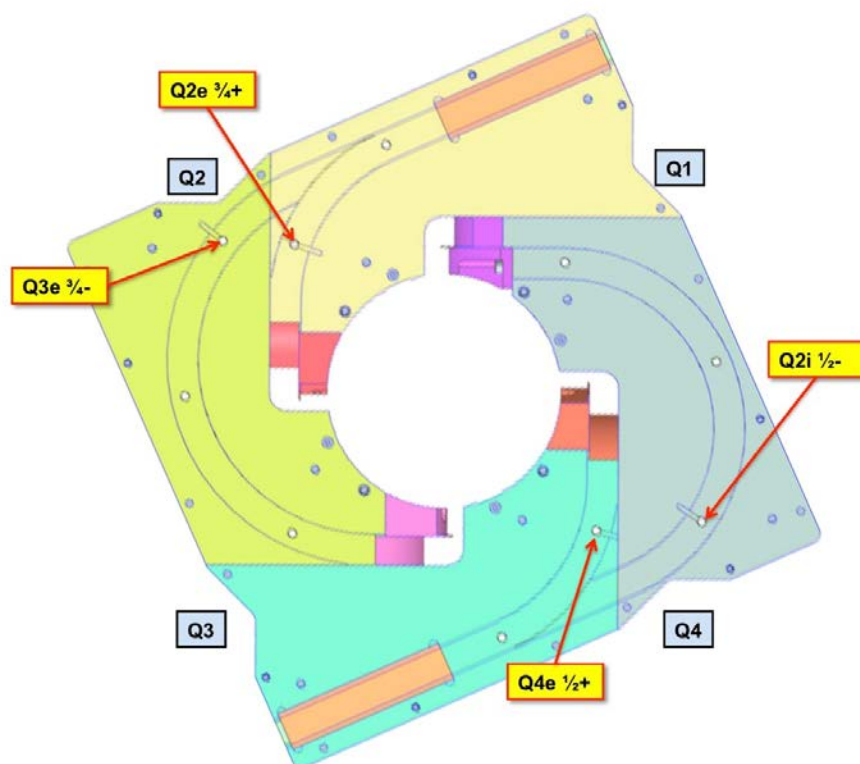


Figure 6: Layer 1 Voltage Tap Feedthrough Locations (FVT signals shown in yellow)

12. The VT Wires are now ready for solder.

First Layer Soldering



CAUTION: Soldering involves temperatures in the range of 250C/430F. Don't touch leads while they're hot. Post reminders if necessary.

13. Route each 1st layer coil leads individually in its designated slot, and temporarily clamp in place with C-clamps and G-10 clamp blocks as needed to hold them in place.
14. Lay a drop cloth in the bore to protect the leads from any potential solder drips.
15. Prepare the copper splice blocks (27L146), clean any discolored/oxidized surfaces with a wire brush, and pre-tin the groove surfaces using MOB-39-FLUX and 96Sn4Ag solder.
16. Place two copper splice blocks (27L146) in their respective locations in the first layer.

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 11 of 21
---	--	---	--	------------------------	-------------------------

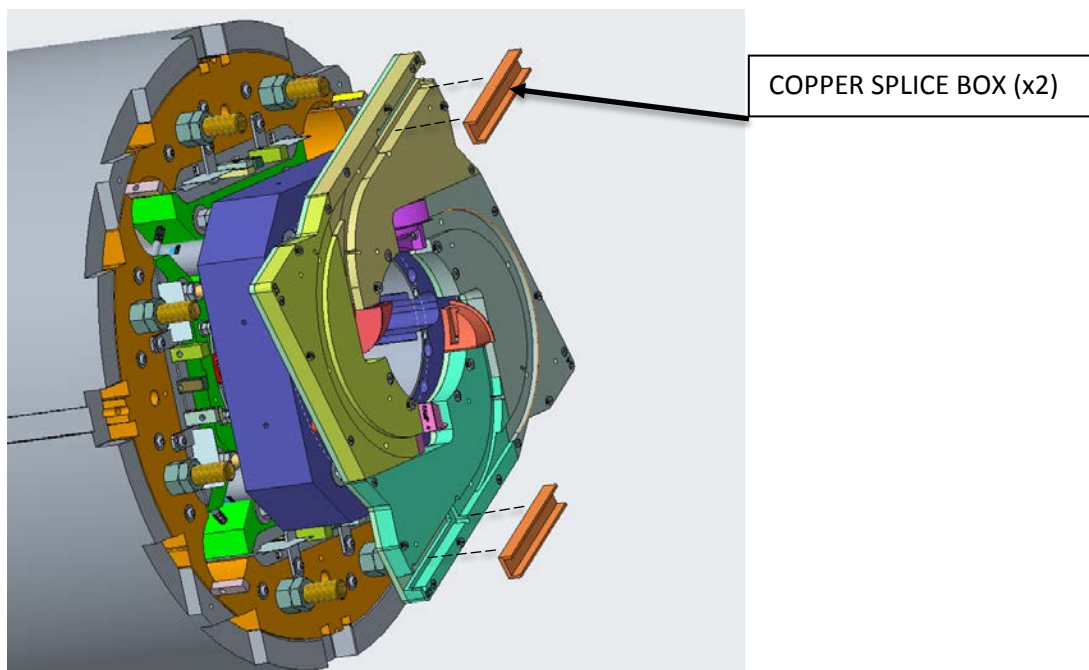


Figure 7: Layer 1 Copper Splice box placement

17. With coil leads tightly routed through the channels of the splice box mark each lead with a sharpie. Mark a line flush with the outer edge of the copper splice box.

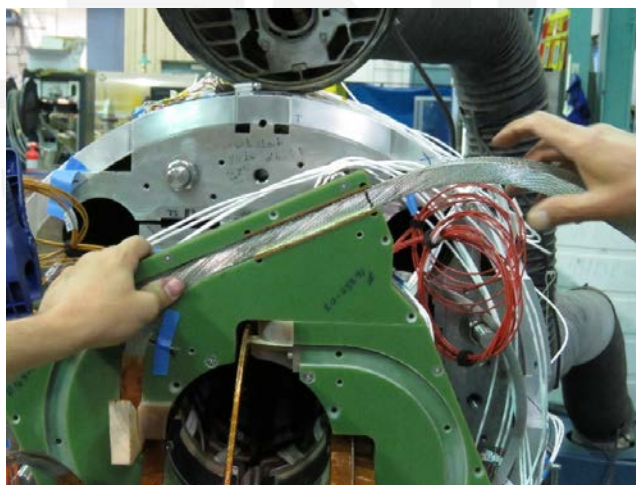


Figure 8: Coil leads marked for cutting

18. Coat the lead area around the sharpie mark with MOB-39-FLUX (2" in both directions of the line and both sides of the lead).
19. Use solder 96Sn4Ag flat ribbon solder to pre-tin the ends with the large soldering iron with a rheostat to control heat (2" in both directions of the line and both sides of the lead). Use an aluminum block to hold the leads flat & straight; (may require two technicians).
20. **When cool** clean off flux with damp rag/Alcohol.

 LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 12 of 21
---	---	--	-----------------	------------------

21. Cut the excess leads flush with the end of the splice box.



Figure 9: *Cutting coil leads*

22. Cut two **2.2m (87")** lengths of cable for the CLIQ leads. For both cables, strip a **4.5" long** segment at one end of the cable, and compress the stripped cable to approximately 2mm in diameter. Then pre-tin the stripped cable. Set one cable aside for the second layer.

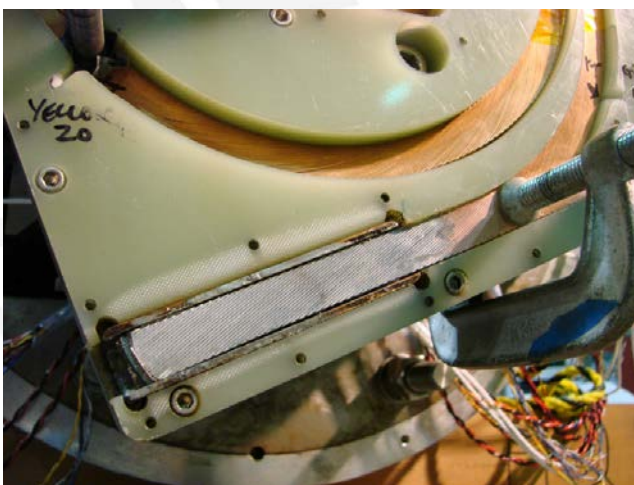


Figure 10: *Tinned & Cut Leads Ready for Solder*

23. Coat each coil lead with flux. Coat the leads 2 inches beyond the length of the copper splice box, front and back.
24. Tin the coil leads 2 inches beyond the length of the copper splice box, front and back.
25. Alternate layering the lead pairs with 4.5" length ribbon solder between each layer.
26. Add the CLIQ lead to the top of the stack in Quadrant 1.
27. Clamp everything using aluminum clamping block.

 LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 13 of 21
---	---	--	-----------------	------------------

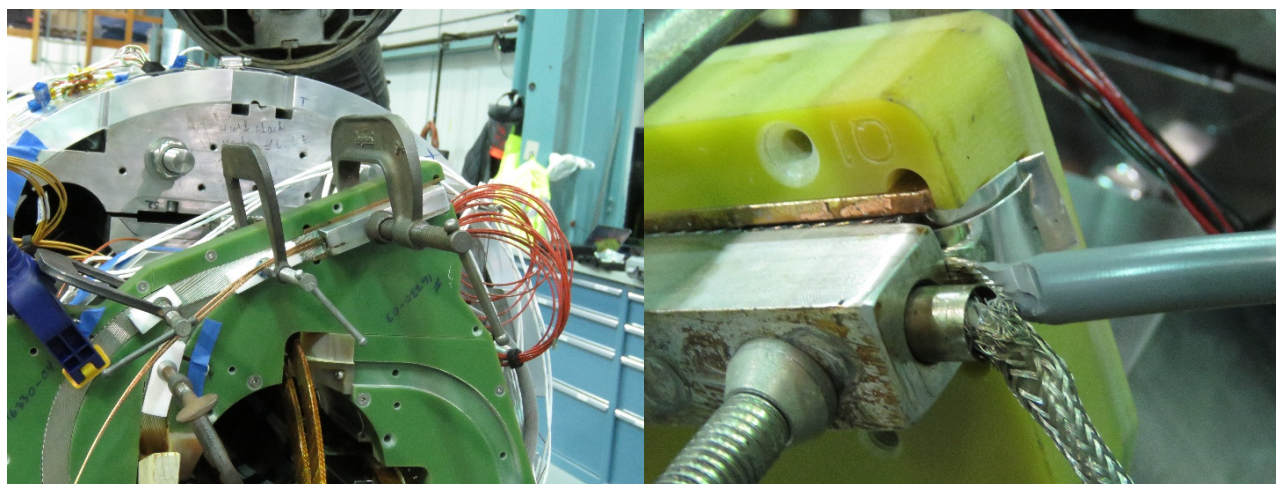


Figure 11: Splice solder setup

28. Install cartridge heater into the aluminum block; plug it into a rheostat and a GFI. As the solder melts, tighten clamps on the aluminum block. Wipe away excess melting solder with a bristle brush.
29. After soldering the leads is complete, turn off / remove cartridge heaters, C-Clamp and aluminum block & place in a safe spot as it cools.
30. **When cool**, clean splices with alcohol / wipes, remove copper block to also wipe the back side. Clean as much flux from between the soldered leads and the G11 parts as possible. Reinsert the copper block and ensure it is reseated properly.

Verification point 4

31. Ensure both Q1 and Q3 are complete.

Solder Voltage Taps (If in Configuration)

32. Use MOB-39-FLUX and 96Sn4Ag flat ribbon solder to solder the VT wires to the coil leads.

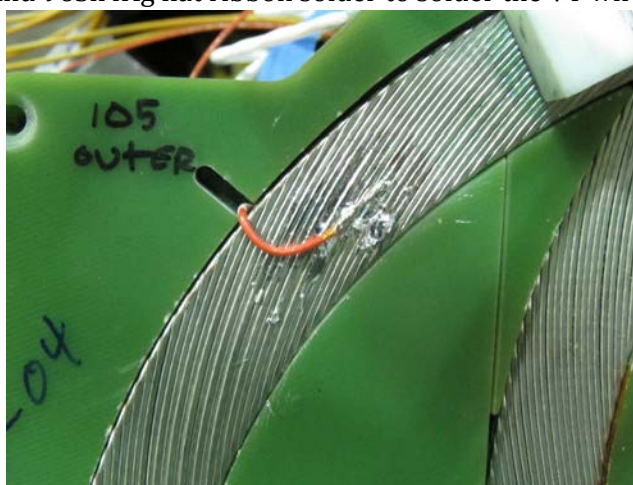


Figure 12: VT Soldered to coil lead

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 14 of 21
---	--	---	--	------------------------	-------------------------

Second Layer Preparation

33. Cut and insert the G10 blocks into each groove to fill the space around the cable as well as the splice joints. Cut the G10 filler pieces from sheets with the appropriate thickness to mechanically restrain the leads in place when the intermediate covers are installed.
34. Attach the four 1/8"-thick Separation Plates (27L134 - 27L137) on to the first layer, covering the coil leads. Fasten the Plates with M4, 25mm Long screws Qty 3 per quadrant.

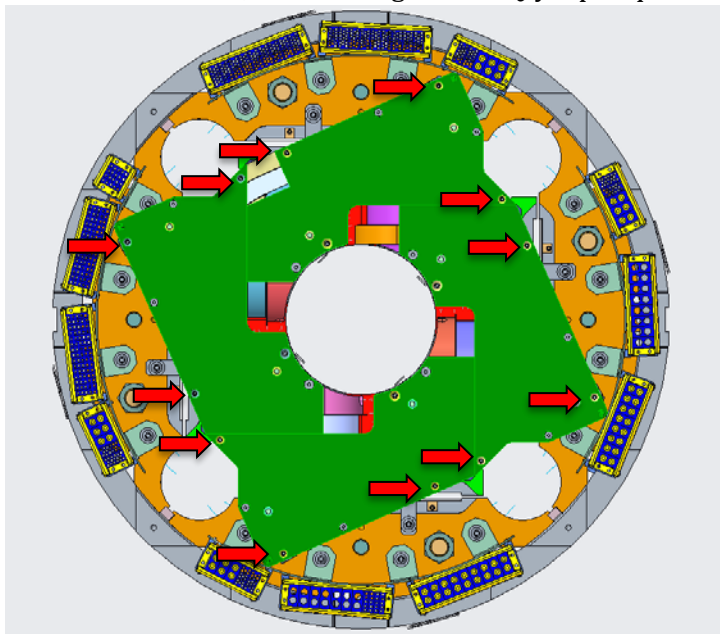


Figure 13: Separation plate screw locations

35. Attach the Second Layer Plate (27L101) to the top of the first layer covers. Fasten with M6, 35mm long socket head screw (Qty 8).

Document Control Center

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 15 of 21
---	--	---	--	------------------------	-------------------------

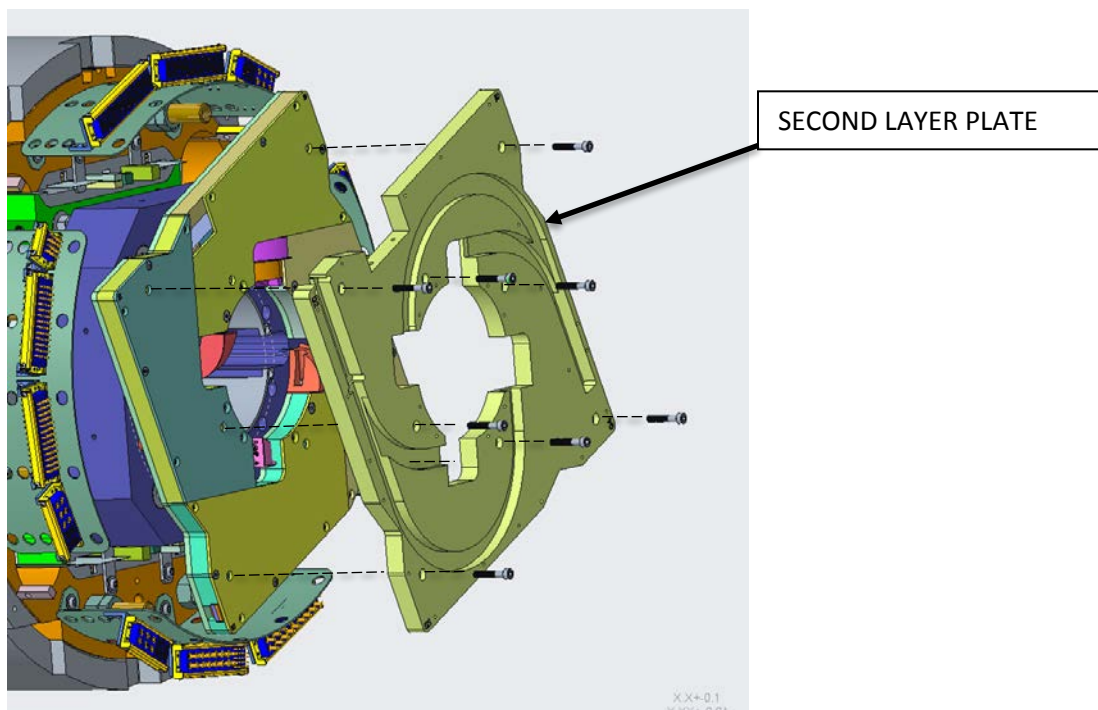


Figure 14: *Second Layer Plate Placement & Screw Locations*

Second Layer Soldering



CAUTION: Soldering involves temperatures in the range of 250C/430F. Don't touch leads while they're hot. Post reminders if necessary.

36. Route each 2nd layer cable individually in its designated channel, and temporarily clamp in place with C-clamps and G-10 clamp blocks as needed to hold them in place.
37. Ensure there is a drop cloth in the bore to protect the leads from any potential solder drips.
38. Prepare the copper splice blocks (27L146), clean any discolored/oxidized surfaces with a wire brush, and pre-tin the groove surfaces using MOB-39-FLUX and 96Sn4Ag solder.
39. Place copper splice block (27L146) in quadrant 2.

 LBL Engineering Specification	Splice Box Work Instructions	<u>LBL Document #</u> SU-1008-8067	<u>Rev</u> C	<u>Page</u> 16 of 21
--	---	--	------------------------	-------------------------

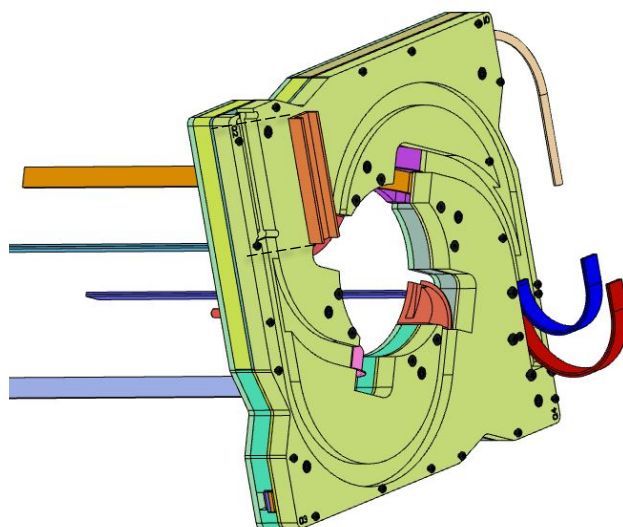


Figure 15: *Copper Splice box on second layer*

40. With coil leads tightly routed through the channels of the splice box mark each lead with a sharpie. Mark a line flush with the outer edge of the copper splice box.



Figure 16: *Coil leads marked for cutting*

41. Coat the lead area around the sharpie mark with MOB-39-FLUX (2" in both directions of the line and both sides of the lead).
42. Use solder 96Sn4Ag flat ribbon solder to pre-tin the ends with the large soldering iron with a rheostat to control heat (2" in both directions of the line and both sides of the lead). Use an aluminum block to hold the leads flat & straight; (may require two technicians).
43. **When cool** clean off flux with damp rag/Alcohol.
44. After cable has cooled, cut the excess leads flush with the end of the splice box.
45. Locate the second **2.2m (87")** long CLIQ lead. Ensure that a **4.5" long** segment at one end of the cable has been pre-tinned.
46. Coat each coil lead with flux. Coat the leads 2 inches beyond the length of the copper splice box, front and back.

 LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 17 of 21
---	---	--	-----------------	------------------

47. Tin the coil leads 2 inches beyond the length of the copper splice box, front and back.
48. Alternate layering the lead pairs with 4.5" length ribbon solder between each layer.
49. With the tinned end of the CLIQ leads seated under the aluminum clamping block, clamp in place. Make sure the leads remain flat, tight and in place.

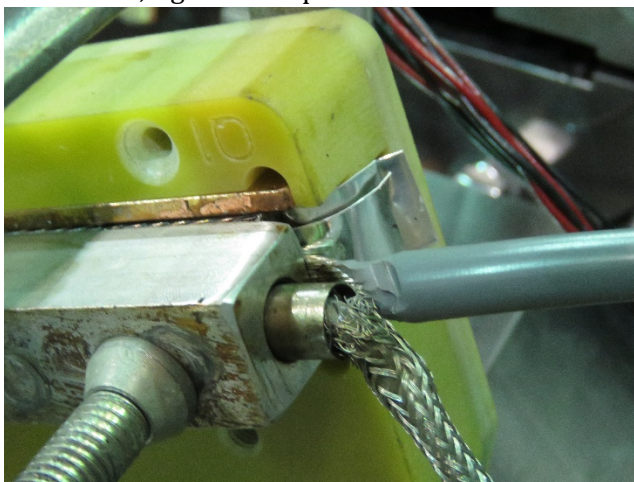


Figure 17: Splice solder setup

50. Install cartridge heater into the aluminum block; plug it into a rheostat and a GFI. As the solder melts, tighten clamps on the aluminum block. Wipe away excess melting solder with a bristle brush.
51. After soldering the leads is complete, turn off / remove cartridge heaters, C-Clamp and aluminum block & place in a safe spot as it cools.
52. **When cool**, clean splices with alcohol / wipes, remove copper block to also wipe the back side. Clean as much flux from between the soldered leads and the G11 parts as possible. Reinsert the copper block and ensure it is resealed properly.

Verification point 5

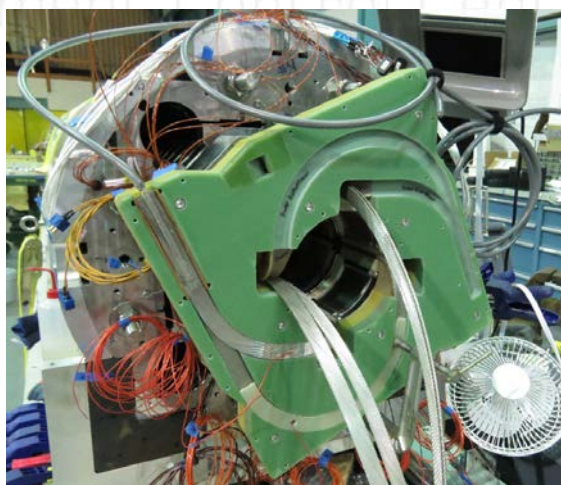


Figure 18: 2nd layer CLIQ lead installed (1st layer CLIQ lead visible)

	LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 18 of 21
---	---	---	--	-----------------	------------------

Second Layer Voltage Taps (If in Configuration)

53. Cut two more pairs of voltage tap (VT) wiring (28 AWG, Kapton/Tefzel insulated) to **5m (16 ft 5 in)** in length for the 2nd layer.
54. The positioning of the two pairs of VT wires is determined by the VT holes of the Top Plates. Refer to **Figure 11** for approximate locations. 1.

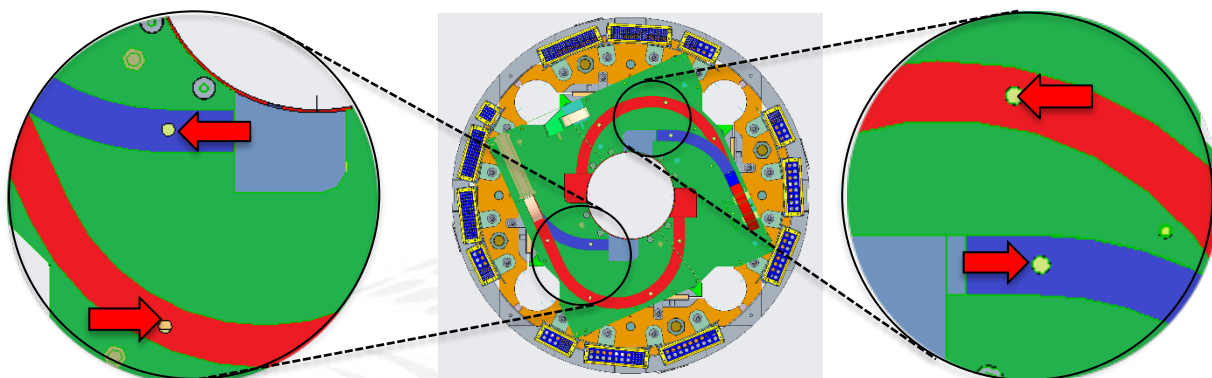


Figure 19: *Second layer VT feedthrough locations*

55. Label the flying lead of each of the VT wires with its respective coil/cable information per sheet 3 of drawing 27L108 (MQXFA Splice box).
56. Place the G10 filler pieces into each groove to fill the space around the cable as well as the splice joints.
57. Attach the 2nd layer covers (27L102 & 27L113), and route voltage tap wires through the holes of the top plates. Fasten in place with BHSCS FT M4x16 SS screws.
58. Ensure that the labels remain intact for each wire.
59. Secure & strain relieve the VT wires that are coming out of the cover.

Final Splice Box Steps

60. **(If not done in VT Section)** Place the G10 filler pieces into each groove to fill the space around the cable as well as the splice joints.
61. **(If not done in VT Section)** Attach the 2nd layer covers (27L102 & 27L113). Fasten in place with BHSCS FT M4x16 SS screws.
62. Record the lengths of the two current leads coming out of the pizza box [Magnet (A) & Magnet (B)]

Verification Point 6

	LBL Engineering Specification	Splice Box Work Instructions	LBL Document # SU-1008-8067	Rev C	Page 19 of 21
---	--	---	--	------------------------	-------------------------

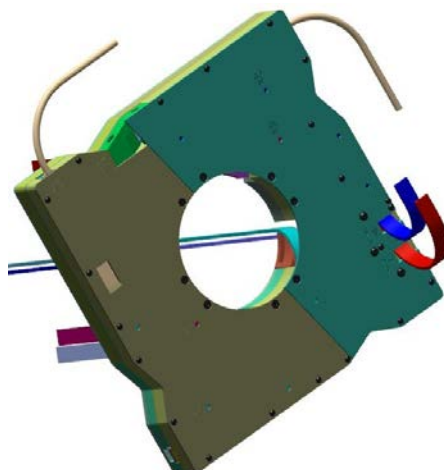


Figure 20: *Complete Splice Box Assembly*

63. Record the lengths of the protection heater leads, the voltage tap leads (if in configuration), and the CLIQ leads in the Verification Sign-Off Sheet

Verification Point 7

Magnet Bore Measurement

64. Insert the Bore Gauge into the magnet bore. "Top" and "RE" will be identified. Take care to not damage the Kapton with the insertion of the bore gauge.
65. Carefully insert bore gauge until the "STOP 1" position is reached
66. Rotate Bore Gauge to "Top 2"
67. Push Bore Gauge in further until the "STOP 2" position is reached. The tube should now be resting on the pions with clearance
68. If the gauge fits, then we have verified the minimum free coil aperture is 146.7 mm. Sign off in VP10.

Verification Point 8

69. Extract tube to "STOP 1." Take care not to damage the Kapton with the extraction of the bore gauge.
70. Rotate the bore to "Top 1"
71. Fully extract the bore gauge, again taking care to not damage the Kapton during the extraction

Completion

72. Completion shall be performed by a cognizant or QA Engineer.
73. Verify all fields of the verification signoff sheet are filled out and comply with MQXFA specifications.
74. With all fields populated, the cognizant or QA Engineer is to sign and date the Verification Signoff Sheet attesting to its completion.

Verification Point 9

 LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 20 of 21
---	---	---	------------------------	-------------------------

Verification Signoff Sheet

EACH MECHANICAL SYSTEM IS REQUIRED TO HAVE A COMPLETED VERIFICATION SHEET.
VERIFICATION MUST BE DONE BY AN ENTITY OTHER THAN THE ASSEMBLY TECHNICIAN.

VERIFICATION POINT 1

Assembly Initiation
Structure Serial ID:
ASSEMBLY START DATE:
Assembly Technician (List all involved)

VERIFICATION POINT 9

Assembly & Verification Signoff Sheet Completion	
Date Completed	Quality Assurance Engineer

Document Control Center

 LBNL Engineering Specification	Splice Box Work Instructions	LBNL Document # SU-1008-8067	Rev C	Page 21 of 21
---	---	---	------------------------	-------------------------

VERIFICATION POINT	ASSEMBLY TECHNICIAN (Sign & Date)	RECORDED INFORMATION				CAL INFO	VERIFICATION BY (Sign & Date)
2		Q1 Coil S/N:	Q2 Coil S/N:	Q3 Coil S/N:	Q4 Coil S/N:	N/A	
3		Voltage Taps soldered in Splice Box?				N/A	
4		Flux cleaned when solder process complete? (Layer 1)				N/A	
		Q1		Q3			
5		Flux cleaned when solder process complete? (Layer 2, Q2)				N/A	
6		Lead Lengths				N/A	
		Magnet (A) (0.5m min)					
		Magnet (B) (2.1m min)					
7		Lead Lengths (shortest)				N/A	
		Protection heater (4.5m min)					
		Voltage Tap (4.5m min)					
		CLIQ lead (2m min)					
8		Bore measurement passes?				N/A	