Lawrence Berkeley National Laboratory **Nonconformance Report (NCR)** LBNL Windchill Document Template	LBNL Document # Assigned in Windchill	Rev A	Page 1 of 1

Date: 11/8/23 QA Doc #: **MQXFA-NCR-0429**

Originator: J. Doyle Company: LBNL

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Part Name: MQXFA Test Assy Quantity Impacted: 1

Part Number: SU-1011-0518G Serial No. (if applicable): MQXFA12

Additional Notes:

ITEM NO.	NONCONFORMING CHARACTERISTIC	DISPOSITION	REINSPECTION	
1	Series of electrical failures starting during final (Step 6) EQC hipot testing and continuing through follow-up investigation. Refer to attached slides for chronology of non-conforming findings.	☐ ACCEPT AS-IS ☐ REWORK ☒ REJECT MQXFA12 to be disassembled for further inspection and investigation. Coils 136 and 137 to be sent back to FNAL. Validated, undamaged non-coil structural components to be reused for MQXFA14 build.	☐ YES ☐ NO	
2		☐ ACCEPT AS-IS ☐ REWORK ☐ REJECT	☐ YES ☐ NO	

Use continuation sheet if necessary. Attach red-lines, photos as necessary

APPROVAL:	CONCURRENCE:	CONCURRANCE:	CONCURRANCE:
2/22/23	2/24/23		
Technical Lead Date	QA Rep. Date	Stakeholder/CAM Date	PM (High Risk NCRs Only))

Indicate all follow-on or related processes: NONE CAR (ECN) HOLD

Is it a 'Suspect/Counterfeit' Item? ☐ YES* ☒ NO

*Report to OCA (Office of Contractor Assurance) and follow PUB-3111 to dispose material

MQXFA12 Hipot Weakness Investigation

Dan Cheng
Josh Herrera, Bob Memmo, and more

Nov 16, 2022

US HL-LHC AUP

Recent MQXFA12 Chronology

- Magnet Preload Complete: 10/13/22
- Magnet EQC started 10/18/22
  - PH, SG connectors, and CVTs were already mounted to LE and RE skirts, etc.
    - Only missing connector block was FVTs from Splice box
  - **All tests passed successfully 10/24/22**
- Splice box assembly started 10/25/22
  - FVT connectors were then added to LE skirt; completed 10/27/22 (*This is the only configuration change from earlier successful EQC*)
- Magnetic measurements & fiducializations completed 11/6/22
- MQXFA12 Final EQC started 11/7/22

MQXFA12 EQC Chronology

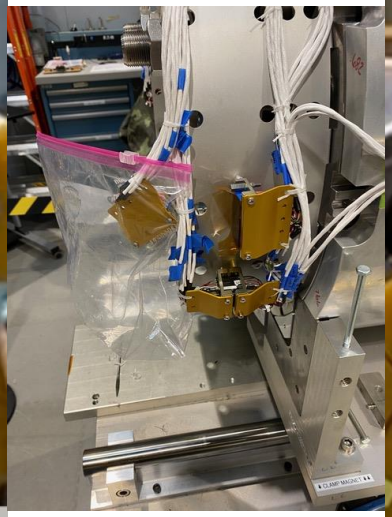
- Day 1 (Mon 11/7):
  - EQC hipot initially noticed higher than normal leakage current (coil to ground)
    - Hipot failed Coil to Structure, 300 V
      - Action: CLIQ lead moved and protected
    - Hipot failed Coil to Structure, 900 V
      - Action: Noticed FVT wires were wrong, Not Axon HH2619
  - Conclusion and Actions taken:
    - Replace FVT wires with proper Axon HH2619

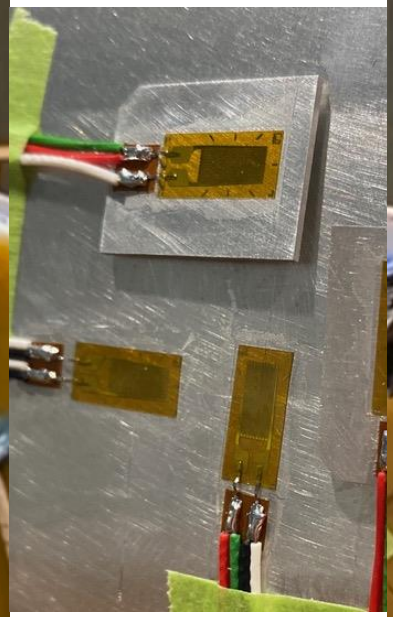
MQXFA12 EQC Chronology (2)

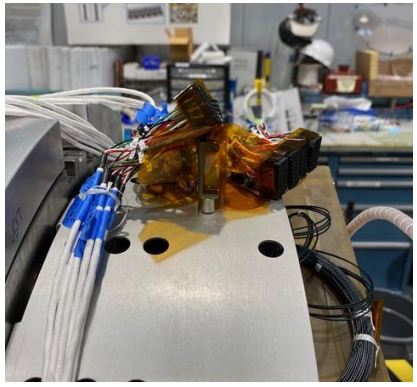
- Day 2 (Tue 11/8):
  - Hipot failed 3.65 kV
    - Video captured simultaneous flashes on pins on LE SG connectors 4-3, 4-6 (Shells/Coils, respectively)
    - Disconnected SG harness from RE end (Coils, Shell 7)
  - Hipot failed 3.67 kV
    - Video captured flash on a single SG pin on 4-3 (shell)
    - Noticed Shell gauge with ”low wire”, attempted to move away from shell; reconnected RE SG harness
    - *“Ground to ground” is a strange breakdown…*
  - Hipot failed at 3.51 kV
    - Video captured simultaneous flash on single pins of 4-3 and 4-6
    - Disassembled SG connector block on LE
      - Bundled 4-1 to 4-3 connectors (shells) and Coils & rods (4-4 to 4-7) separately and protected with Kapton to skirt
  - Hipot passed 3.68 kV
    - FVT connectors (with Axon wires) were not connected to LE skirt yet
  - Conclusion and Actions taken:
    - Protection of SG to skirts with Kapton is beneficial, Kapton layer added to LE top skirt

MQXFA12 EQC Chronology (2)

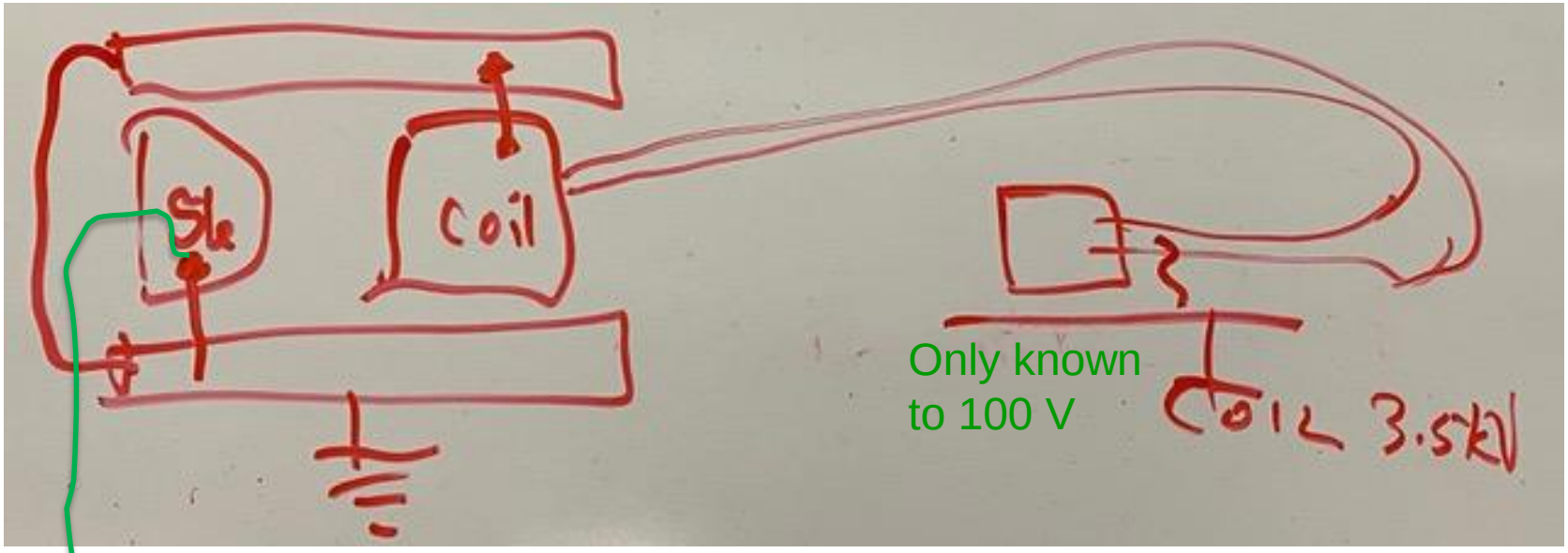
2:

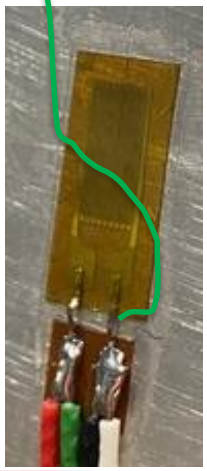






Initial theory of path



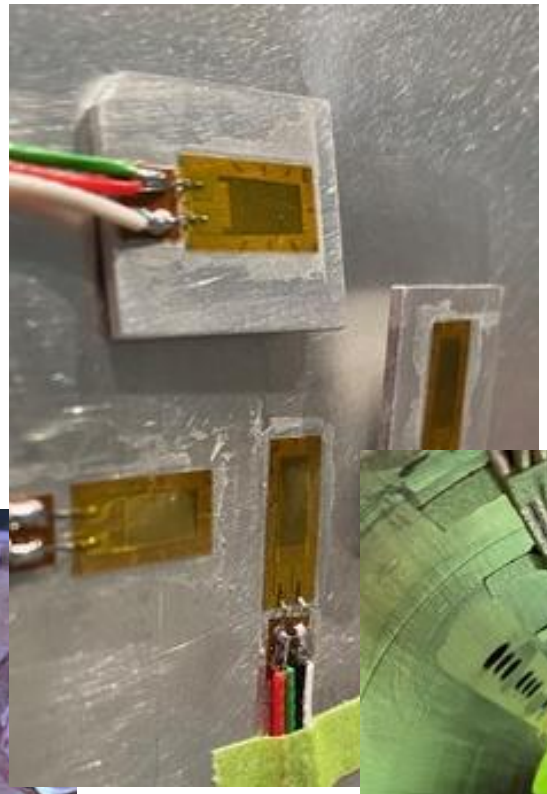


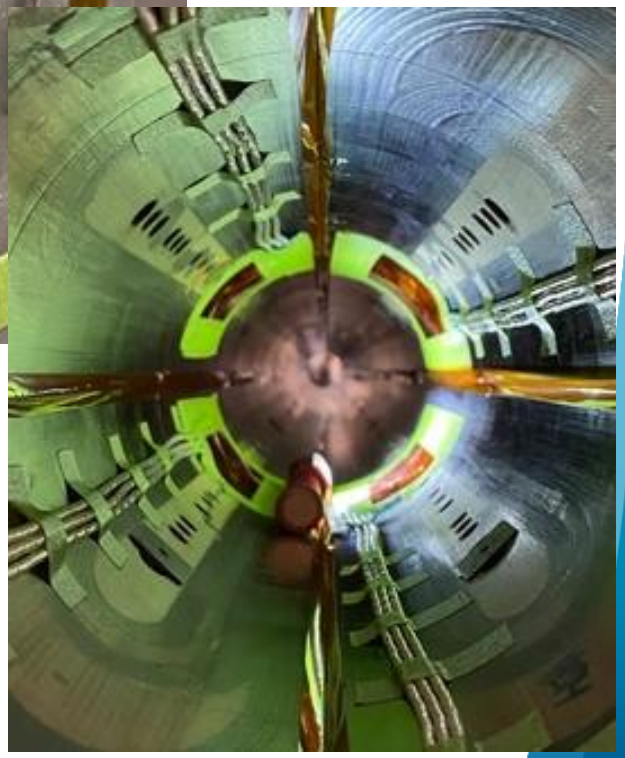
MQXFA12 EQC Chronology (3)

- Day 3 (Wed 11/9):
  - Hipot reached 3.68 kV, failed ~5 sec into hold
    - LE Video captured flashes on pins SG pins still (4-3 to 4-6)
    - RE video also captured flash reflection from Q2 inside bore
    - FVT connectors still not connected to LE skirt yet
  - Conclusion and Actions taken:
    - Remove SG connectors from coil from RE skirts
    - Re-soldered Shell 4RT gauge lead to add relief

MQXFA12 EQC Chronology (3)

- Day 3 (Wed 11/9):





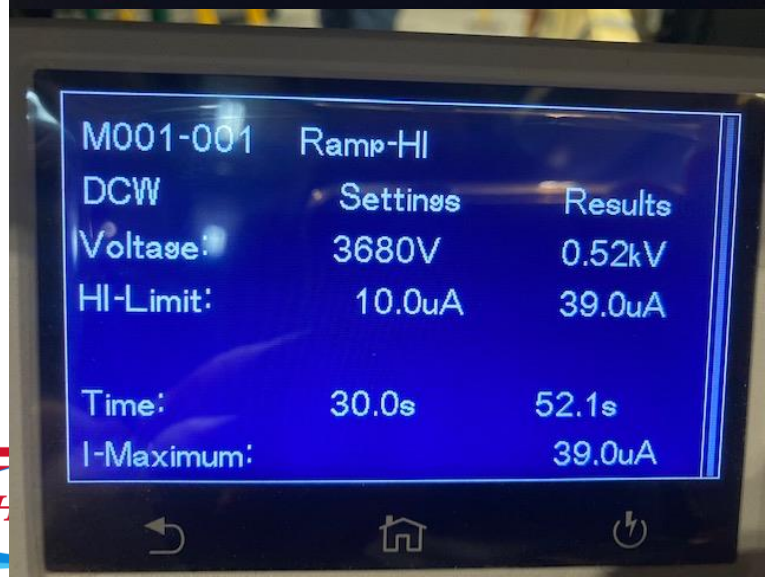
MQXFA12 EQC Chronology (4)

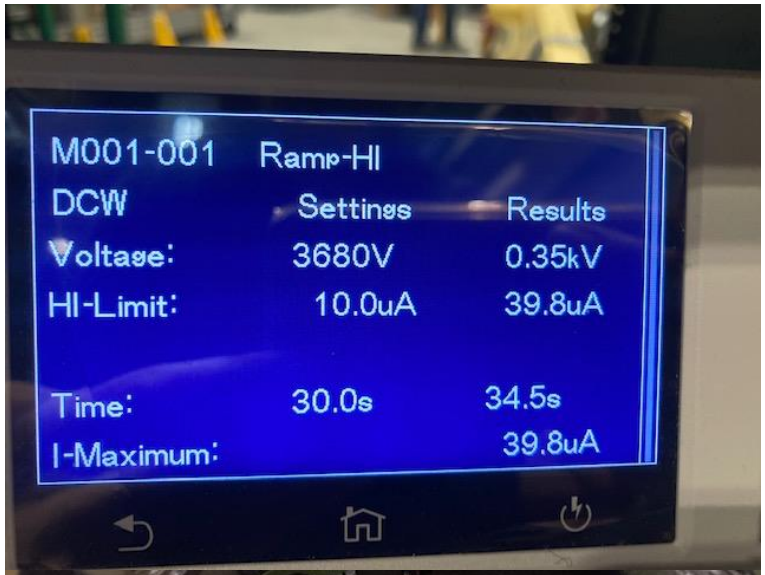
- Day 4 (Thursday 11/10):
  - Hipot coil to structure test failed at 3.45 kV
    - Did not see flash; heard "*near FVT, or through bore*"
    - Had disconnected RE SG connector block from skirts
  - Hipot test failed with high leak @350 V @39.8 µA
  - Hipot test failed with high leak @520 V 39.0 µA

- Diagnostics performed
  - Coil to Structure Open
  - Coil to Pole Diagnostics (11 segments, SG on Segment 10 from LE)
    - Q1: Open
    - Q2: 220 kΩ (Segment 10)
    - Q3: 40+ MΩ
    - Q4: 950+ kΩ (Segments 10, 9)
  - SG wires connected in groups (T, Z, per station)
    - All gauges open to coil

MQXFA12 EQC Chronology (4)

- Day 4 (Thursday 11/10):



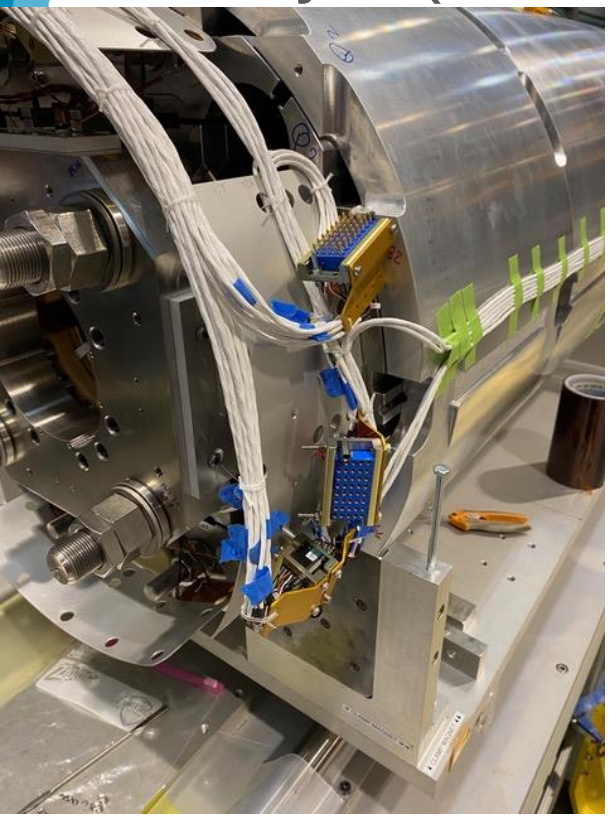


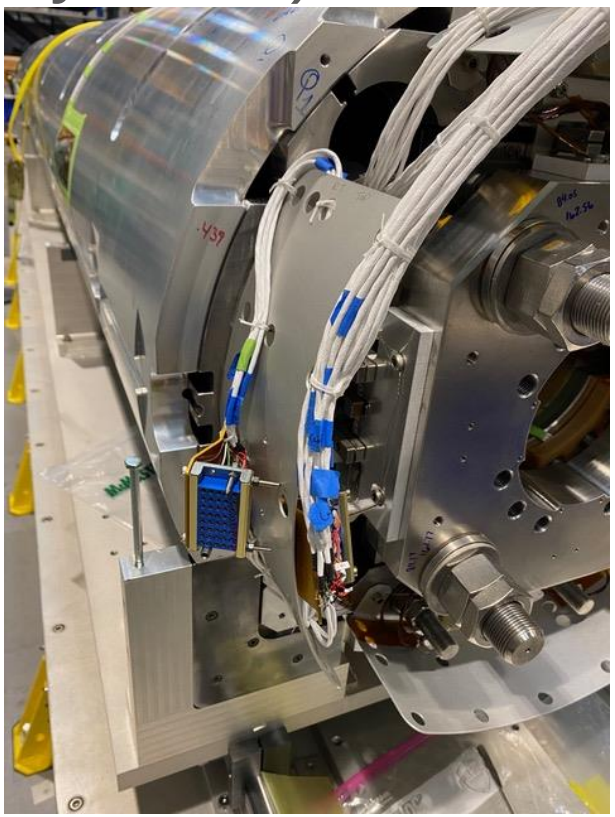
MQXFA12 EQC Chronology (5)

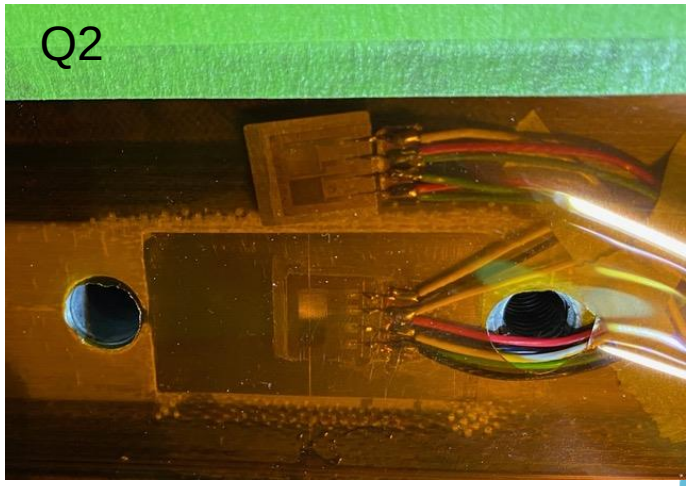
- Day 5 (Monday 11/14):
  - Coil SG connectors still not on RE skirts
  - Coil-Pole Diagnostics (11 segments, SG on Segment 10 from LE)
    - Q1: Open
    - Q2: 238 kΩ (Segment 10)
    - Q3: 35+ MΩ (Segments 11, 10)
    - Q4: 66 kΩ (Segment 10,9)
  - Pole-Structure continuity
    - All coil poles open to Structure
  - Coil-Structure continuity is open
    - Have not performed any operations since before the weekend

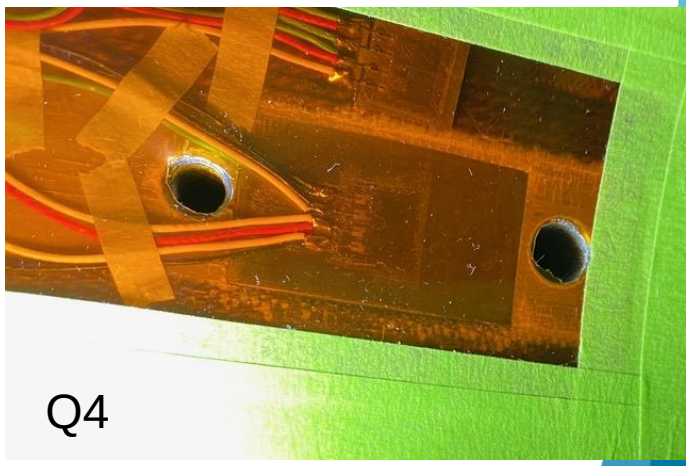
MQXFA12 EQC Chronology (5)

- Day 5 (Monday 11/14):





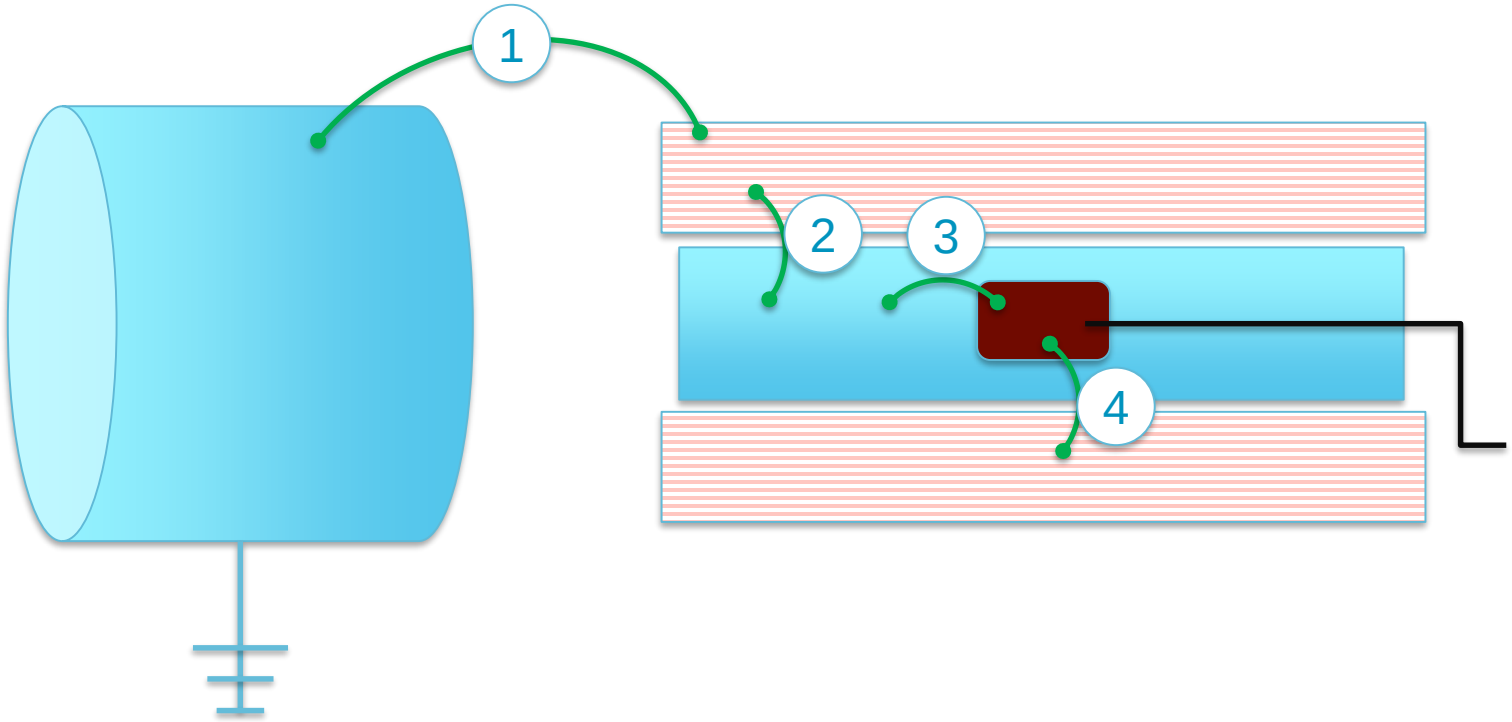




MQXFA12 EQC Chronology (6)

- Day 6 (Tuesday 11/15):
  - Coil-Pole Diagnostics (11 segments, SG on Segment 10 from LE)
    - Q1: Open
    - Q2: 238 kΩ (Segment 10)
    - Q3: 35-45 MΩ (Segments 11, 10)
    - Q4: 68 kΩ (Segment 10, 9)

Present Continuity Checks



Pair	Status	Notes
1. Coil to Structure	Open	
2. Coil to Pole	Q2, Q4 weak	Passed 100V acceptance initially
3. SG to Pole	Open	
4. SG to Coil	Open	

Notes

- Coils and SG all passed earlier (post-preload)
  - May still have had a weak condition that eventually broke down: coil-pole + coil SG-ground
  - Unknown: Coil-Pole integrity above 100 V
- Coil SG was installed by a new technician
  - Also reused some wiring from MQXFA06
- Shell 4RT gauge had a ”close” wire to shell
  - After repair initially passed

MQXFA12 Coils SG installation (several)