US HL-LHC Accelerator Upgrade Project

QXFA Coil Fabrication Electrical QA

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Revision History

Revision	Date	Section No.	Revision Description
v0	6/27/17	All	Initial Release
v1	4/10/18	3	Changed in 3.1 Trace Hipot from 3500 V to 5000 V; and in 3.14 and 3.16 QH to Coil Hipot from 3200 V to 4800 V
v2	5/16/18	All	- Added Ranges for acceptable RLQ, Voltage tap, and Quench heater measurements - Updated Impulse testing procedure - Updated Hipot location for testing - Merged Sec. 2 into Sec. 1
v3	5/31/18	2	Changed in 2.14 & 2.16 the QH to Coil Hipot from 4800 V to 3680 V
v4	5/31/18	2	Changed in 2.1 the Trace Hipot value from 5000 V to 3800 V
v5	6/11/19	2	Changed in 2.1 Trace Hipot after receiving from 3800 V to 3700 V (value used at CERN before delivery to AUP)
V6	9/13/19	2	Changed in 2.14 & 2.16 the Coil to Pole Hipot from 500 V to 100 V

Contents

1 Comments

- **Hipot tests**:
  - Power the component listed first, keep untested components floating.
  - Test each Quench Heater separately.
  - Connect the 11 pole segments together to perform Coil to Pole Hipot. Be sure that Inner and Outer pole segments are connected.
  - Set the maximum leakage current threshold to **1 µA** (10 µA when 1 µA does not work). The maximum leakage current must not be exceeded neither during Ramp up nor at Plateau.
- **Impulse tests**:
  - Impulse tests with direct polarity (High Outer Layer – Ground Inner Layer) at 1000 V, 1500 V, 2000 V and 2500 V
  - Impulse tests with reversed polarity (High Inner Layer – Ground Outer Layer) at 1000 V, 1500 V, 2000 V and 2500 V
- **Electrical Measurements:**
  - Coil inductance (LQ) measurements at 20 Hz (unless otherwise specified)
  - Coil resistance (R) and VT measurements at 1 A. After Impregnation, connect Multimeter Terminals at **7 inches from the Splice Blocks**.

2 Fabrication Process

Pre-Fabrication Tests

1. Trace Hipot after receiving: 3700 V

Coil Fabrication Tests:

2. Coil winding:
   ·Real-time monitoring of continuity between coil, parts and mandrel

3. After curing, coil on curing mandrel, OD up:
   ·Coil RLQ
   R: (520.00 -540.00 mV)
   Ls: (10.40 – 11.00 mH)
   Q: (2.20 – 2.50)
   ·Continuity check:
   coil-to-RE saddles,
   coil-to-LE saddles,
   saddle-to-saddle,
   coil-to-end spacers,
   coil to pole

4. Before reaction, fixture open, w/o mold blocks and SS shell, OD up:

·Coil RLQ
R: (520.00 -540.00 mV)
Ls: (6.10 – 6.80 mH)
Q: (1.40 – 1.60)
·Continuity checks:
coil-to-RE saddles,
coil-to-LE saddles,
saddle-to-saddle,
coil-to-end spacers,
coil to pole

5. Before reaction, After close and flip, fixture open, ID up:

·Coil RLQ
R: (520.00 - 540.00 mV)
Ls: (6.20 – 6.40 mH)
Q: (1.40 – 1.50)
·Continuity checks:
coil-to-RE saddles,
coil-to-LE saddles,
saddle-to-saddle,
coil-to-end spacers,
coil to pole

6. After reaction, fixture open, OD up:

·Coil RLQ
R: (590.00 -610.00 mV)
Ls: (6.10 – 6.40 mH)
Q: (1.20 – 1.30)
·Continuity checks
coil-to-RE saddles,
coil-to-LE saddles,
saddle-to-saddle,
coil-to-end spacers,
coil to pole

7. After splicing, OL trace installed, OD up:

·Coil RLQ
R: (590.00 -610.00 mV)
Ls: (6.00 – 6.40 mH)
Q: (1.10 – 1.30)
·OL Voltage tap
B1: 590.00 – 610.00 mV
B2: 590.00 – 610.00 mV
B3: 490.00 – 430.00 mV
B4: 260.00 – 280.00 mV
B5: 260.00 - 280.00 mV
B6: 260.00 - 280.00 mV
B7: 260.00 – 280.00 mV
B8: 260.00 – 280.00 mV

·OL Heater R
B01: 1.70 – 2.20 Ω
B02: 1.70 – 2.20 Ω
B03: 1.70 – 2.20 Ω
B04: 1.70 – 2.20 Ω

8. After fixture bolted closed, OD up:

·Coil RLQ
R: (590.00 -610.00 mV)
Ls: (6.50 – 6.90 mH)
Q: (1.20 – 1.40)
·Continuity checks
coil-to-OL Heaters

9. After flip, fixture open, ID up:

·Coil RLQ
R: (590.00 -610.00 mV)
Ls: (6.50 – 6.80 mH)
Q: (1.20 – 1.40)
·Continuity checks:
coil-to-RE saddles,
coil-to-LE saddles,
saddle-to-saddle,
coil-to-end spacers,
coil to pole

10. After IL trace installed, ID up:

·Coil RLQ
R: (590.00 - 610.00 mV)
Ls: (6.50 – 6.80 mH)
Q: (1.20 – 1.40)
·IL Voltage tap
A1: 0.00 – 1.00 mV
A2: 0.00 – 1.00 mV
A3: 190.00 – 210.00 mV
A4: 240.00 – 260.00 mV
A5: 240.00 - 260.00 mV
A6: 250.00 - 270.00 mV
A7: 250.00 – 270.00 mV
A8: 260.00 – 280.00 mV
·IL Heater R
A01: 3.40 – 3.70 Ω
A02: 3.40 – 3.70 Ω

11. After fixture bolted closed, ID up:

· Coil RLQ
R: (590.00 -610.00 mV)
Ls: (7.20 – 7.50 mH)
Q: (1.30 – 1.50)
·Continuity checks
coil-to-IL Heaters

12. After impregnation, fixture open, OD up:

·Coil RLQ
R: (590.00 -620.00 mV)
Ls: (6.60 – 6.90 mH)
Q: (1.30 – 1.50)
·Continuity checks:
coil-to-RE saddles,
coil-to-LE splice blocks,
coil-to-OL Heaters,
saddle-to-saddle,
OL Heaters-to-saddles,
coil to pole,
pole segm to pole segm
·OL Voltage tap
B1: 590.00 – 610.00 mV
B2: 590.00 – 610.00 mV
B3: 190.00 – 430.00 mV
B4: 260.00 – 280.00 mV
B5: 260.00 - 280.00 mV
B6: 260.00 - 280.00 mV
B7: 260.00 – 280.00 mV
B8: 260.00 – 280.00 mV
·OL Heater R
B01: 1.70 – 2.20 Ω
B02: 1.70 – 2.20 Ω
B03: 1.70 – 2.20 Ω
B04: 1.70 – 2.20 Ω

13. After flip, ID up:

·Coil RLQ
R: (590.00 -620.00 mV)
Ls: (6.10 – 6.50 mH)
Q: (1.20 – 1.50)
·Continuity checks:
coil-to-RE saddles,
coil-to-LE splice blocks,
coil-to-IL Heaters,
saddle-to-saddle,
IL Heaters-to-saddles,
coil to pole,
pole segm to pole segm
·IL Voltage tap
A1: 0.00 – 1.00 mV
A2: 0.00 – 1.00 mV
A3: 190.00 – 210.00 mV
A4: 240.00 – 260.00 mV
A5: 240.00 - 260.00 mV
A6: 250.00 - 270.00 mV
A7: 250.00 – 270.00 mV
A8: 260.00 – 280.00 mV

·IL Heater R
A01: 3.40 – 3.70 Ω
A02: 3.40 – 3.70 Ω

/* Steps 12 and 13 can be reverse depending on the process*/

14. Before shipping, coil on bench and on shipping Mandrel, OD up:

·Coil RLQ (20 Hz, 100 Hz, 1 kHz)

@ 20 Hz
R: (590.00 -610.00 mV)
Ls: (4.80 – 5.10 mH)
Q: (0.80 – 0.90)

@ 100 Hz
Ls: (3.20 – 3.50 mH)
Q: (1.50 – 1.70)

@ 1k Hz
Ls: (1.80 – 2.00 mH)
Q: (1.90 – 2.10)

·Continuity checks:
coil-to-structure,
heaters-to-structure,
coil-to-RE saddles,
coil-to-LE splice blocks,
coil-to-heaters,
saddle-to-saddle,
heaters-to-saddles,
coil to pole
pole segm to pole segm

·Voltage tap
A1: 0.00 – 1.00 mV
A2: 0.00 – 1.00 mV
A3: 190.00 – 210.00 mV
A4: 240.00 – 260.00 mV
A5: 240.00 - 260.00 mV
A6: 250.00 - 270.00 mV
A7: 250.00 – 270.00 mV
A8: 260.00 – 280.00 mV
B8: 260.00 – 280.00 mV
B7: 260.00 – 280.00 mV
B6: 260.00 – 280.00 mV
B5: 260.00 – 280.00 mV
B4: 260.00 - 280.00 mV
B3: 410.00 - 430.00 mV

B2: 590.00 – 610.00 mV
B1: 590.00 – 610.00 mV

·Heater R

A01: 3.40 – 3.70 Ω
A02: 3.40 – 3.70 Ω
B01: 1.70 – 2.20 Ω
B02: 1.70 – 2.20 Ω
B03: 1.70 – 2.20 Ω
B04: 1.70 – 2.20 Ω

·**Hipots:**

QH to Coil	3680 V
Coil to Pole	100 V
Coil to Endshoes (all)	1000 V
QH IL to Endshoes IL	2500 V
QH OL to Endshoes OL	2500 V
Endshoes IL to Endshoes OL	1000 V

·**Impulse tests** (Direct and Reverse)

15. After receiving, coil in the crate on shipping Mandrel, OD up:

·Coil RLQ (20 Hz, 100 Hz, 1 kHz)
·Continuity checks:
coil-to-structure,
heaters-to-structure,
coil-to-RE saddles,
coil-to-LE splice blocks,
coil-to-heaters,
saddle-to-sadle,
heaters-to-saddles,
coil to pole
pole segm to pole segm
·Voltage tap & Heater R.

16. After receiving, coil on Wooden Table

·**Hipots:**

QH to Coil	3680 V
Coil to Pole	100 V
Coil to Endshoes (all)	1000 V
QH IL to Endshoes IL	2500 V
QH OL to Endshoes OL	2500 V
Endshoes IL to Endshoes OL	1000 V

·**Impulse tests** (Direct and Reverse)