QXF Coil Fabrication & Tooling

Reaction / Impregnation

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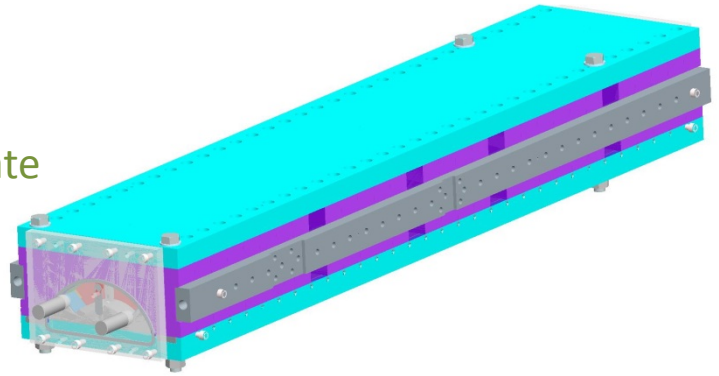
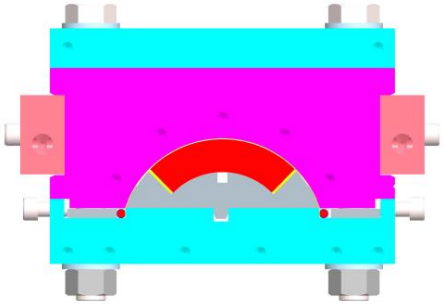
Outline

- Tooling design
- Coil fabrication
- Status
- Summary

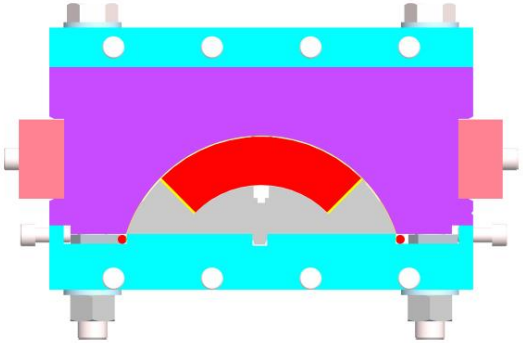
Coil Tooling Design

- QXF tooling design is based on tooling used successfully for LQ and HQ.
  - Reaction & Impregnation Tooling:
    - Stainless steel fixtures used to react and impregnate coils.
    - Full length base plate, top plate, side rails.
    - Mandrel and form block pieces are short blocks, approximately 50 mm long.
    - Thin stainless steel liner inside form blocks.
    - End plates seal the ends.

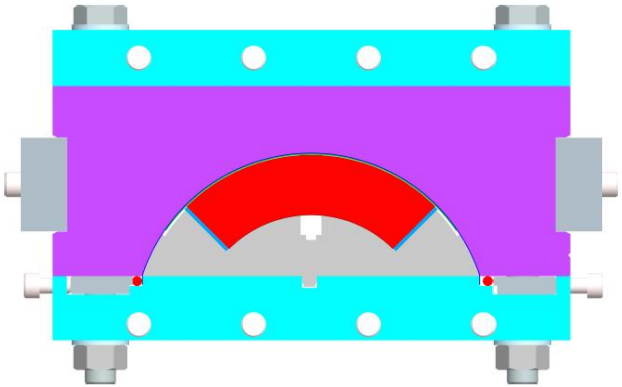




LQ (90 mm)
Coil Length 3.3 m



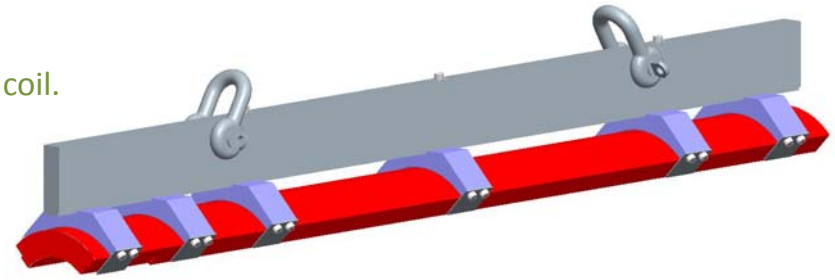
HQ (120 mm)
HQ 1.2 m, LHQ 3.3 m

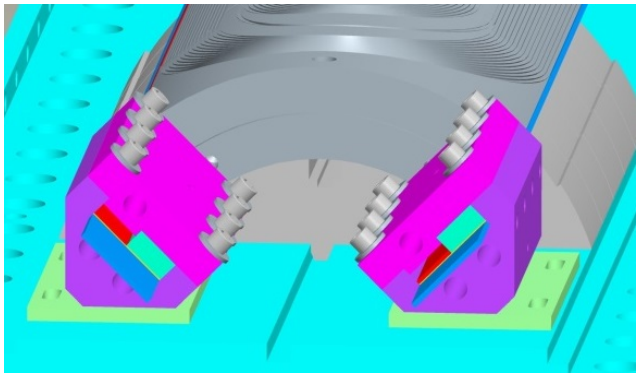


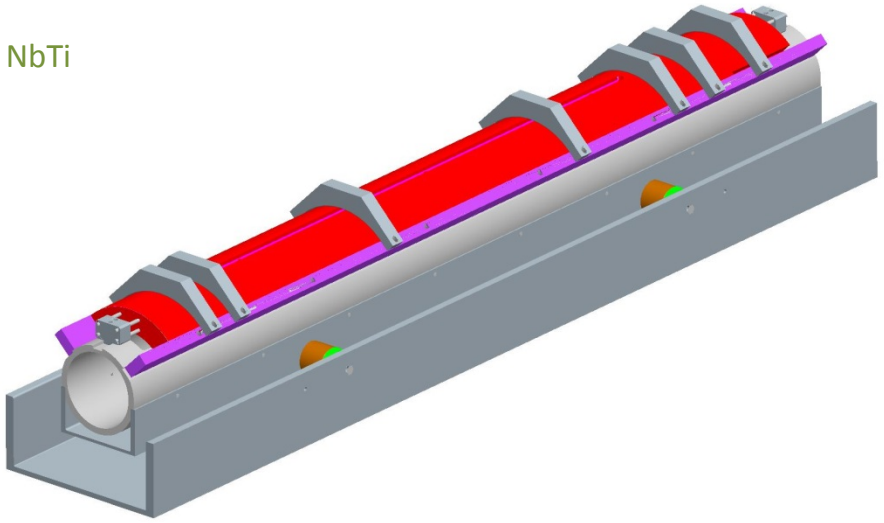
QXF (150 mm)
SQXF 1.5 m, LQXF 4.3 m

Coil Tooling Design

- QXF tooling design is based on tooling used successfully for LQ and HQ.
  - Coil Lifting Fixture:
    - Rigid support for handling cured coil or impregnated coil.
    - Reacted coil not handled until after impregnation.
  - Coil Shipping Fixture:
    - Coil support tube mounted on rubber shock mounts.
  - Coil lead solder fixture:
    - Make connection between Nb_3Sn conductor and NbTi extension leads.







Coil Fabrication

- Coil fabrication procedures are well established and documented from LQ and HQ.
  - Travelers used on the shop floor provide step by step instructions, place for technicians to sign-off as operations are completed. Engineering sign-off at key points, e.g. after electrical checks.
  - QXF travelers are based on most recent HQ travelers.
- Facilities / Infrastructure is in place at multiple labs.
  - Reaction ovens at 3 labs (accommodate 4m coils).
  - Vacuum impregnation facilities at 3 labs.

Superconducting Magnet Division

LARP - LHQ Coil Prep for Impregnation

MDC No. LARP-210 Rev: A
Page 4 of 23
Rev Date: 05/08/2013
Author: J. Schmalzle
Approved: 10/11/2013

OP	Description	Name/Life #	Date	DR
170	Coil electrical checks. Measure and record R, L and Q:	DC24716	27DEC13	

R (kOhms)	(apply 25 V DC / 1 Amp)	.559 kΩ .559 VDC

F (Hz)	20	50	100	200	500	1000
L (mH)	3.68	3.58	3.42	3.29	2.97	2.60
Q	.81	1.75	2.69	3.59	3.57	2.76

175 Perform continuity checks: — DC24716 | 27DEC13

Coil to LE outer layer saddle: OPEN
Coil to LE inner layer saddle: OPEN
Coil to NL outer layer saddle: OPEN
Coil to NL inner layer saddle: OPEN
Coil to Pole (check each segment): OPEN
Coil to End Spacers (2 LE, 1 NL): OPEN

180 Cognizant Electrical Engineer to sign-off results "OK to proceed".

Cog. Electrical Engineer:

190 Remove the LE saddle extension pieces and sst lead shims from the coil.
Note: Saddles are not to be removed. — TRL 21627 DC24716 | 27DEC13

195 Carefully fold back the two layers of glass cloth from between to coil layers.

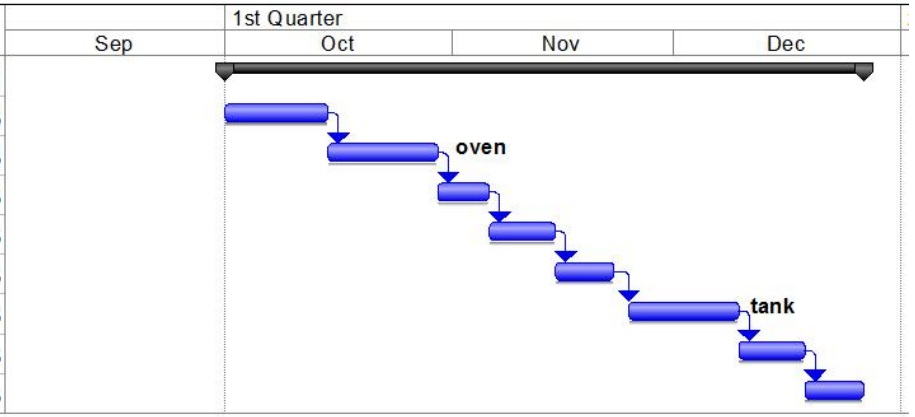
200 Remove the glass sleeve from coil leads. Carefully clean the lead with a SST brush. — 12/30/13

LHQ03

Coil Fabrication

- Typical Reaction Impregnation schedule:

ID	Task Name	Duration
1	**Coil Reaction Impregnation**	**58 days**
2	prep for reaction	10 days
3	reaction	11 days
4	coil leads / insulation	5 days
5	outer layer prep / trace install	6 days
6	inner layer prep / trace install	6 days
7	impregnation	9 days
8	coil removal / prep	7 days
9	final prep / QA	4 days

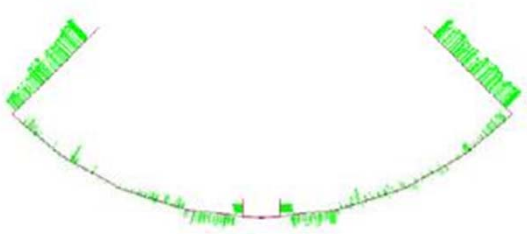


Procedure Outline:

- Reaction:
  - Base plate and mandrel blocks laid out on assembly table.
  - Cured coil placed into reaction mandrel blocks.
  - Outer layer covered with fiberglass cloth and mica paper.
  - Reaction liner, form blocks and top plate installed.
  - Fixture bolted closed, flipped over and opened.
  - Inner layer and midplanes covered with mica paper.
  - Reaction mandrel blocks and base plate installed.
  - Fixture bolted closed, end plates installed.
  - Fixture moved into oven for reaction.
  - Reaction includes steps at 210 C, 400 C and 640 C.
- Impregnation:
  - Fixture moved from oven to assembly table.
  - Reaction top plate, form blocks, liner, mica, fiberglass removed.
  - Lead extensions soldered to coil leads.
  - Outer instrumentation trace installed, covered with fiberglass.
  - Impregnation liner, form blocks and top plate installed.
  - Fixture bolted closed, flipped over.
  - Reaction mandrel blocks, base plate and mica paper removed.
  - Inner instrumentation trace installed, covered with fiberglass.
  - Impregnation mandrel blocks and base plate installed.
  - Fixture bolted closed. End plates and lead seals installed.
  - Fixture moved to vacuum tank for impregnation.
  - Pump down, bake out.
  - Impregnate with CTD101k.
  - Cure includes steps at 110 C and 125 C.

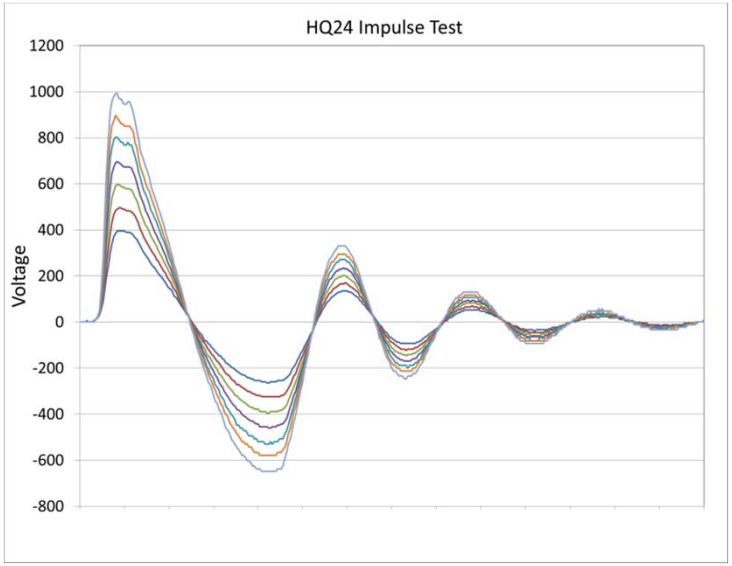
Coil QA

- Coil QA
  - Electrical:
    - Resistance / RLQ
      - Coil
      - Voltage Taps
      - Heaters
    - Hipot
      - Coil to Heaters
      - Coil to End Shoe
      - Heaters to End Shoes
      - End Shoe to End Shoe
    - Impulse
  - Mechanical:
    - Coil Length
    - Coil Azimuthal Size



Coil CMM Measurements

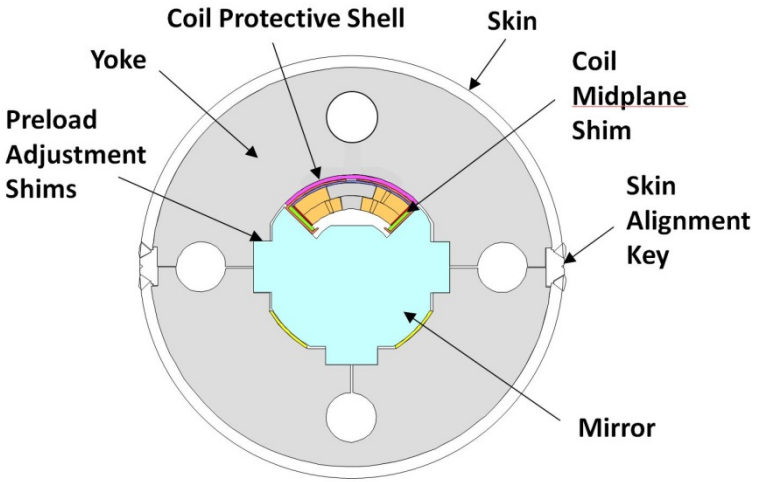
	Coil			Coil Hipot Checks			
		Heater PHA01		Actual / Target			
Heater PHA01	1000 / 1000		Heater PHA02				
Heater PHA02	1000 / 1000			Heater PHB01			
Heater PHB01	1000 / 1000				Heater PHB02		
Heater PHB02	1000 / 1000					LE IL Endshoe	
LE IL Endshoe	500 / 500	500 / 500	500 / 500				RE IL Endshoe
LE OL Endshoe	500 / 500			500 / 500	500 / 500	500 / 500	
RE IL Endshoe	500 / 500	500 / 500	500 / 500				
RE OL Endshoe	500 / 500			500 / 500	500 / 500		500 / 500

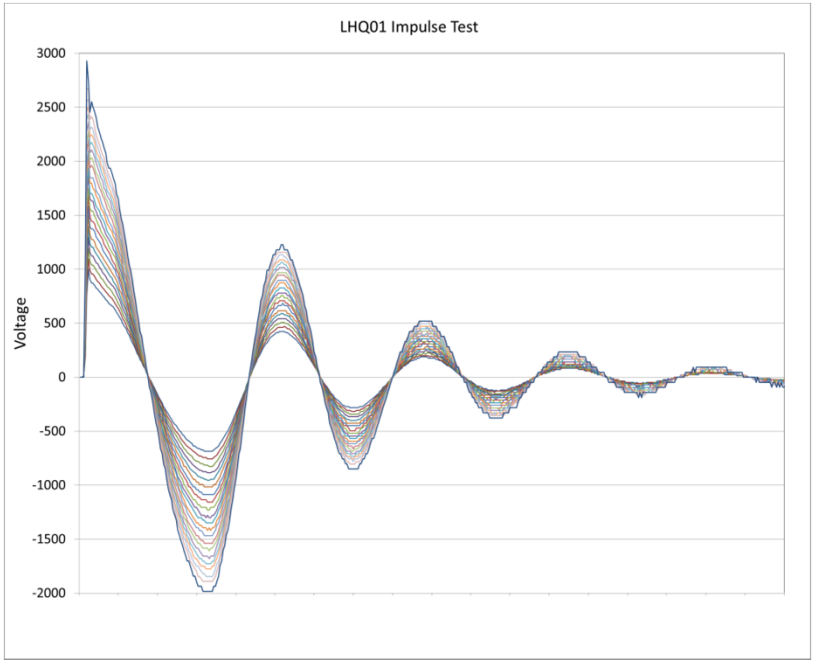


LHQ Coil Fabrication & Testing

- Electrical tests of the LHQ practice coil were run at higher levels than normal for HQ in order to demonstrate the ability to meet CERN's more stringent requirements.
  - Hipot coil to quench heaters – Passed at 5000 volts.
    - (Normal HQ test - 1000 volts)
  - Coil Impulse test – Passed at 3000 Volts.
    - (Normal HQ test - 1000 Volts)

- Upcoming mirror test of LHQ coil will demonstrate HQ features not present in the LQ magnets.
  - Cable with core, braided insulation, stainless steel end parts.





Status

- Coil fabrication procedures:
  - SQXF traveler preparation underway (based on HQ).
  - Coil QA is in place, being reviewed for compliance with CERN requirements.

- Tooling fabrication:
  - SQXF Reaction Impregnation fixtures – fabrication underway (FNAL).
    - First reaction set due early March.
    - First impregnation set due mid March.
    - Remaining sets by end of March.
  - SQXF Coil lifting fixtures - fabrication underway (BNL).
    - Some parts received, remaining due by end of February.
  - SQXF Coil shipping fixtures - fabrication underway (BNL).
    - Some parts received, remaining due early March.
  - Coil lead solder fixture - fabrication underway (BNL)
    - Due mid March.
  - LQXF Reaction Impregnation fixtures – design complete, drawings ready.
  - LQXF Coil lifting & shipping fixtures - design complete, drawings ready.

Summary

- QXF tooling designs based on tooling used successfully for LQ and HQ.
- Procedures well established and documented.
- Facilities / Infrastructure in existence at multiple labs.
- SQXF tooling fabrication well underway.