Task Force on the 11 T dipole - Team QA QC of coils and collared coils/magnets

CURING

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Table of contents

1. Applicable documentation and evolutions 11T and QXFB
2. Components
3. Tooling 11T and QXFB
4. Differences in the 11T and QXFB production strategy
5. Non conformities during production 11T and QXFB
6. Adopted mitigations on tooling following NCR - 11T
7. Adopted mitigations on procedure following NCR - 11T
8. Adopted mitigations following NCR - QXFB
9. Conclusion
Applicable documentation and evolution – 11T

1. Procedures:

<table>
<thead>
<tr>
<th>Modifications due to:</th>
<th>Manufacturing Procedure:</th>
<th>Contrôle Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of the applicable documentation with GE before starting production,</td>
<td>LHC-MBH_C-FP-0004 rev 9.0</td>
<td>LHC-MBH_C-FP-0070 rev 5.0</td>
</tr>
<tr>
<td>Comments from operators.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Following the NCR 2004465: quantity of ceramic binder decreased.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Applicable documentation and evolution QXFB

Procedures:

<table>
<thead>
<tr>
<th>Curing Procedure</th>
<th>Control Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHC-MQXFBC-FP-0011 v4.0</td>
<td>LHC-MQXFBC-FP-0057 v3.0</td>
</tr>
</tbody>
</table>

Modifications due to:
- Review of the applicable documentation during the “deverminage” campaign,
- Comments from operators.
Components

Ceramic binder:
- Specification Ceramic binder CTD 1202 (example for batch 7353-074: LHC-MBH_C-RPT-0007).
Tooling – 11T

• Curing tool inner layer: all drawings approved: LHC-MBH_T-DF-0027
• Curing tool outer layer: all drawings approved: LHC-MBH_T-DF-0028
  Approved on December 2017, before series production
• Reception of the carcan and shells: conform (LHC-MBH_T-RPT-0018)
Tooling – QXFB

- Curing tool for inner and outer layers: all drawings approved: EDMS 1479822
  Approved on December 2015, before series production
- Carcan and half shells measured by the supplier (EDMS 208470), no metrology performed at CERN.)
# Differences in the 11T and MQXFB production

## 1. Pressure in the press:

<table>
<thead>
<tr>
<th></th>
<th>11T</th>
<th>MQXFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure in the straight part's jacks</td>
<td>80bar</td>
<td>40bar</td>
</tr>
<tr>
<td>Pressure in the heads' jacks</td>
<td>50bar</td>
<td>40bar</td>
</tr>
</tbody>
</table>

## 2. Quantity of ceramic binder

<table>
<thead>
<tr>
<th></th>
<th>11T</th>
<th>MQXFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qty of ceramic binder in each head IL</td>
<td>13.8g</td>
<td>13g</td>
</tr>
<tr>
<td>Qty of ceramic binder in straight part IL</td>
<td>28g/m</td>
<td>60g/m</td>
</tr>
<tr>
<td>Qty of ceramic binder in each head OL</td>
<td>21.3g</td>
<td>13g</td>
</tr>
<tr>
<td>Qty of ceramic binder in straight part OL</td>
<td>46g/m</td>
<td>60g/m</td>
</tr>
</tbody>
</table>

## 3. Areas without ceramic binder

<table>
<thead>
<tr>
<th></th>
<th>Inner Layer 11T</th>
<th>Outer Layer 11T</th>
<th>MQXFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 first turns</td>
<td>2 turns around each spacer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No area free of binder</td>
<td>4 first turns around poles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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2021.05.12

New Task Force on 11T Dipole
NCR related to the curing production step – 11T

3 non critical NC

- NCR 2381672: Heating cycle not registered on CR117 (MQXFB). Heating device upgraded for better reliability.

- NCR 2385866: Due to a switch not activated, the pressure in the jacks reached 103.4 bars (instead of 80 bars).

- NCR 2004465: On GE01, the insulation of the two first turns is missing on 12cm.
Adopted mitigations on tooling following NCR – 11T

NCR due to tooling (improvement of the tooling):

- NCR 2381672: Heating cycle not registered on CR117 (MQXFB). Heating device upgraded for better reliability.
  All the data are now registered in the CERN supported interface (Timber).

- NCR 2385866: Due to a switch not activated, the pressure in the jacks reached 103.4 bars (instead of 80 bars).
  - The coil GE29 and the tooling were inspected and showed no damage,
  - A lock must be installed on the switch to make sure it is ON. Action ongoing.
Adopted mitigations on procedure following NCR – 11T

Corrective actions following NCR 2004465: On GE01, the insulation of the two first turns is missing on 12cm.

It is decided to avoid ceramic binder application on the 2 first turns around the pole on the inner layer. And to decrease the quantity of ceramic binder on the inner layer.

<table>
<thead>
<tr>
<th>Masse totale pour la couche interne [g]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Produit A</td>
<td>139.5</td>
</tr>
<tr>
<td>Produit B + C</td>
<td>146.5 + 19.6 = 166.1</td>
</tr>
<tr>
<td>Total Couche Interne</td>
<td>305.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Masse totale pour la couche interne [g]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Produit A</td>
<td>90.26</td>
</tr>
<tr>
<td>Produit B + C</td>
<td>94.79 + 12.68 = 107.5</td>
</tr>
<tr>
<td>Total Couche Interne</td>
<td>197.7</td>
</tr>
</tbody>
</table>
NCR related to the curing production step – QXFB

10 non critical NC

- Ceramic binder (1 NC):

- Machine + Tooling (5 NC):
  - NCR 2326848 (CR112): Impregnation data not registered in Timber.
  - NCR 2344270 (CR116): Failure in heating cabinet during IL curing cycle.
  - NCR 2381672 (CR117): Regulation cycle not registered during inner layer curing.
  - NCR 2397489 (CR118): Regulation cycle not fully registered during outer layer curing.

- Manpower (3 NC):
  - NCR 2384251 (CR117) and NCR 2397499 (CR118): mandrel temperature out of range.
  - NCR 2466935 (CR124): Cable insulation damaged after IL curing.

- Component (1 NC):
  - NCR 2381667 (CR116): Coating of 2 spacers chipped after outer layer curing.
Adopted mitigations on QXFB following NCR

- **Machine:** Corrective actions following NCR 2326848, 2344270, 2381672, 2397489:
  - Machine upgrade (heating cabinet, press software, data acquisition)
  - Data storage in Timber database.

- **Curing tooling:** Corrective actions following NCR 2385008:
  - Missing chamfrain machined
  - Update of drawing.

- **Spacer coating chipped after outer layer curing:** Corrective actions following NCR 2381667 (coil CR116) and similar defects observed on coils CR121 and CR125: spacer coating chipped after outer layer curing:
  - QA inspection of the internal cavity of the coil after outer layer curing during the transfer to the reaction baseplate added to the control procedure (reaction).
  - Deformation slits on IC2 and OC3 spacers: currently under evaluation.
Conclusion

- The curing production step is the one with the less non-conformities (1.5% of total NCR).
- The shorter step of production, process mainly automatic.
- Most of delicate operations are treated in the winding procedure.
Thank you