LMBHA001 - Electrical integrity Non-conformities at fabrication

QA.LMF 15/01/2020

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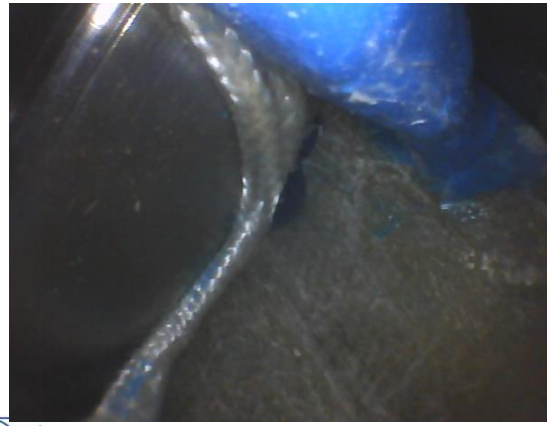
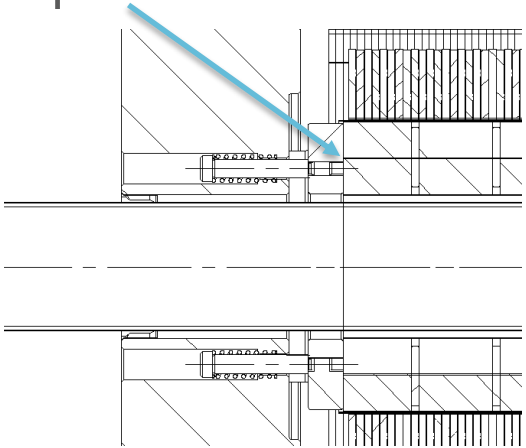
NC1 : Defect insulation Aperture2 to the ground

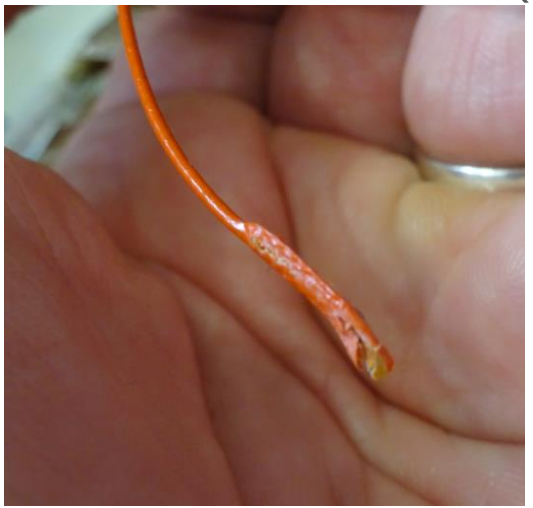
- Link: https://edms.cern.ch/document/2226886
- Defect detected @750V during HV tests.
- An endoscopy showed that 2 wires are damaged:
  - EE2161 is pinched between the plate and the coil's saddle





NC1 : Defect insulation Aperture2 to the ground

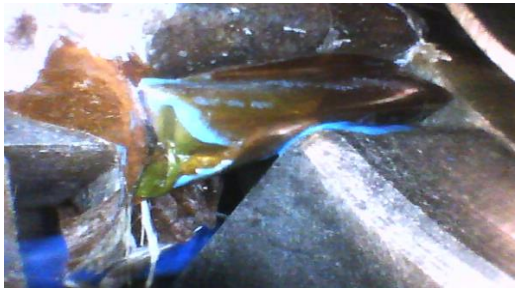
- EE2164 is pinched between the plate and the coil's saddle (wire cut)



NC1 : Defect insulation Aperture2 to the ground

- Disposition:
  - EE2164: the wire is not replaced
    - The extremity was insulated with a polyimide tube (Ø3) filled with Eccobond.

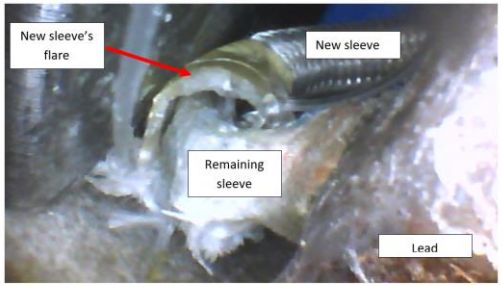
    - A 2nd polyimide tube (Ø5) is applied over the first.

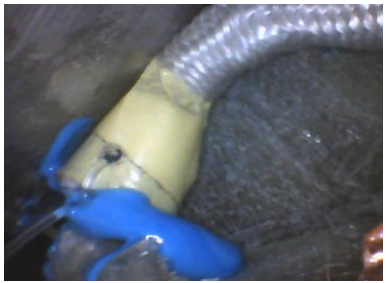


NC1 : Defect insulation Aperture2 to the ground

- EE2161:
  - The damaged glass fibre sleeve is removed and trimmed.

  - A new sleeve is slid on, then glued with Eccobond





- The repairs were validated with a HV test at 3.3kV during 2min.

NC2 : HV tests Voltage decrease to 3.2kV

- Link: https://edms.cern.ch/document/2263516
- Inserting the IFS wires in the capillary tube was difficult.

- Defect detected @2000V during HV test.
- After inspection, the insulation of 3 wires was damaged because of sharp edges of the pipe at the entry point of the capillary.

NC2 : HV tests Voltage decrease to 3.2kV

- Disposition:
  - The 3 wires were repaired (as described in the IFS repair procedure https://edms.cern.ch/document/1430439).
  - It was agreed by the WPE to resume the electrical tests at 3.2kV to avoid a risk of a short to ground in the IFS.

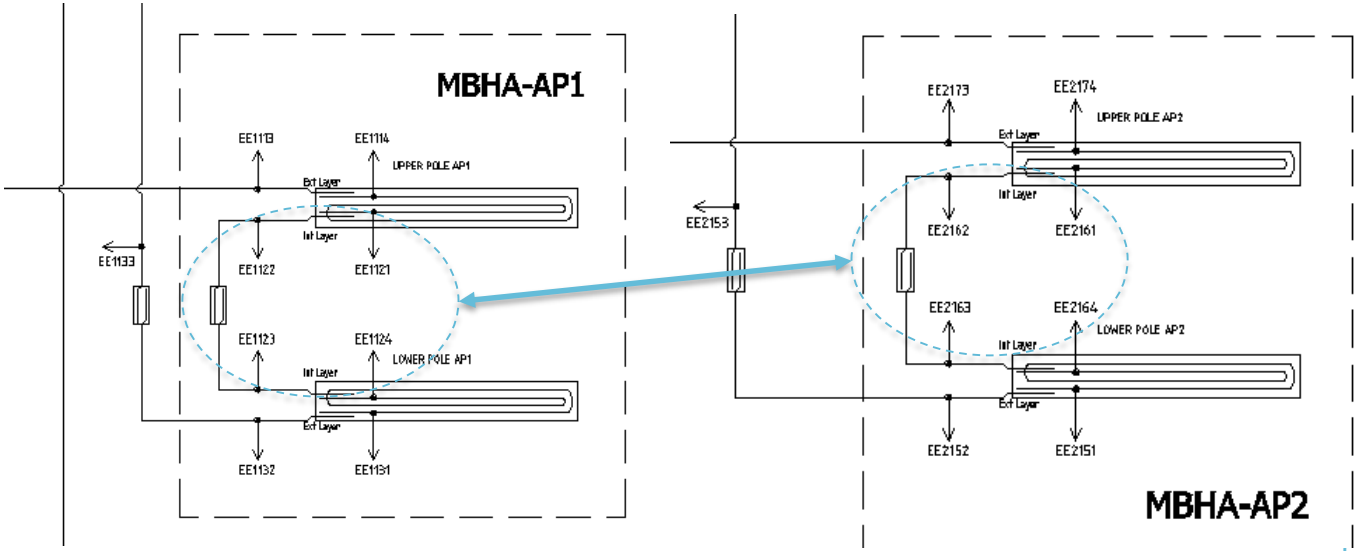
NC3 : Electrical defects during Cold Tests

- Link: https://edms.cern.ch/document/2281956

- During the electrical tests at cold temperature 2 defects were detected:
  - Defect 1: Insulation defect between ground and coils appears at roughly 2kV (analysis of the defect: link).

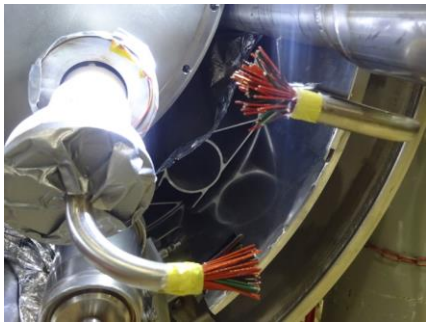
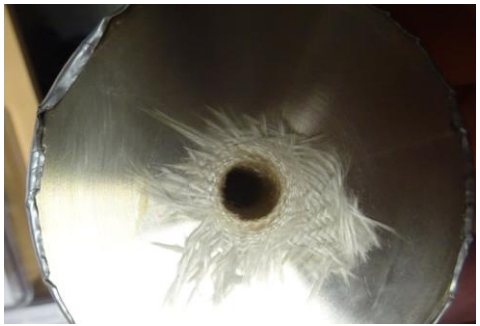
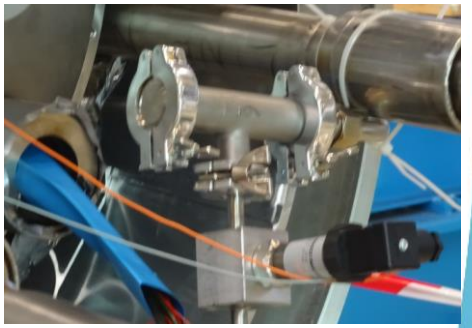
NC3 : Electrical defects during Cold Tests

- Defect 2: In quench 2 and 3 unusual spikes were seen on the voltage signals.
  - Further investigations (EDMS 2281449): It seems most likely that wire 1121, 1122, 1123 or 1124 is touching one wire 2161, 2162 or 2163 somewhere in the bundle of wires, possibly in the capillary (EDMS 2281449).



NC3 : Electrical defects during Cold Tests

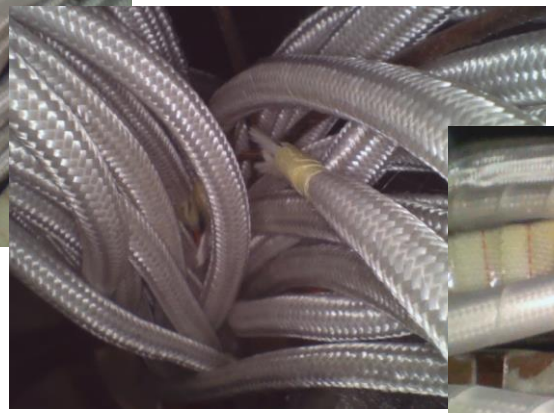
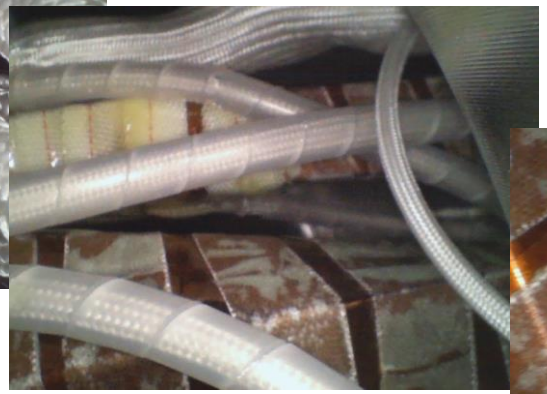
- Investigation:
  - The capillary tube is being dismantled:

  - Several electrical tests were performed meanwhile under different conditions (Voltage, injection of He…). Those tests didn't reveale any defects.
  - Several visual inspections were carried out:
    - Endoscopy in the flat cover,
    - Visual inspection of the wires near the cold head,
    - Visual inspection of the wires in the warm head (after cutting the cover flanges).

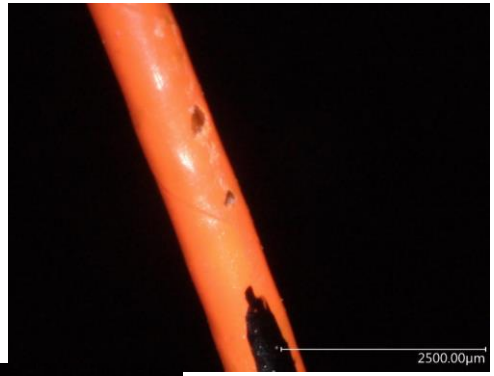
NC3 : Electrical defects during Cold Tests

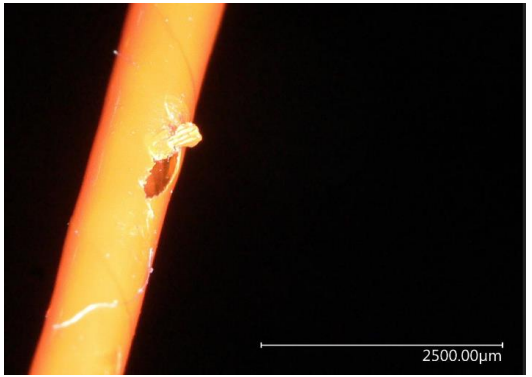
- Visual inspection:
  - Endoscopy didn’t show any damage (fibreglass, heat-shrink sleeves, plyospire, insulation…).

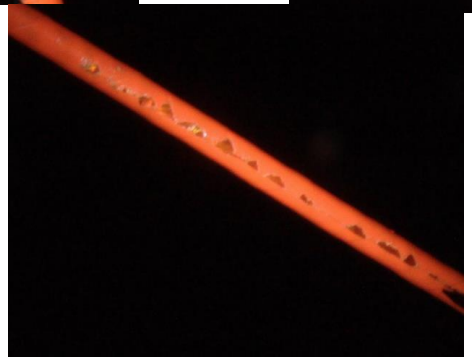




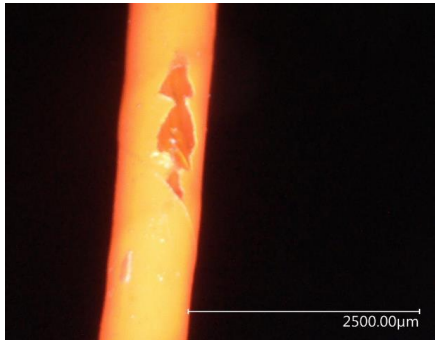

NC3 : Electrical defects during Cold Tests

- Visual inspection of the wires near the cold head
  - Different types of defect were found:
    - External sleeve scratched (18 defects)





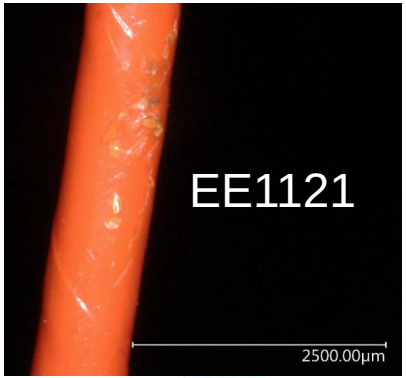


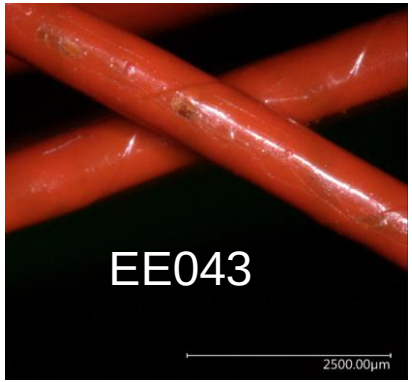


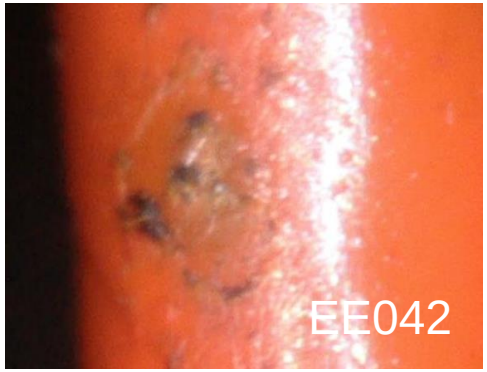
NC3 : Electrical defects during Cold Tests

- Conductor visible (1 defect, EE1123):

- Black stain (3 defects, EE1121, EE043 and EE042):

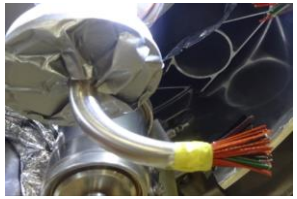




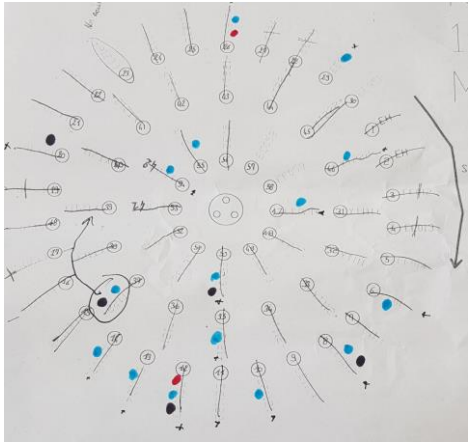


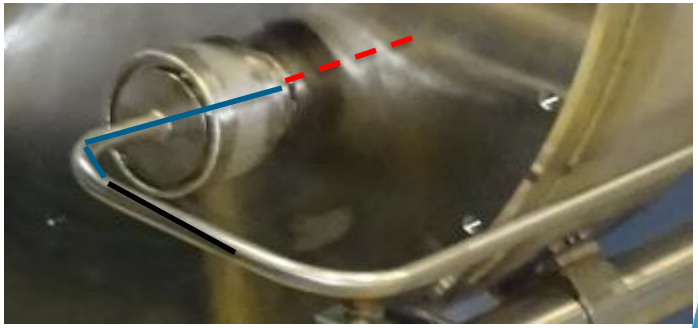
NC3 : Electrical defects during Cold Tests

- Positions of the defects:
  - This sketch shows the arrangement of the wires in the capillary.
  - Most of the defects seem to be positioned in and before the first turn of the capillary (in blue).
  - Defects showed by black spots are at the extremity of the wires (likely caused during the IFS cutting),



  - Defects showed by red spots are in under the flat cover.

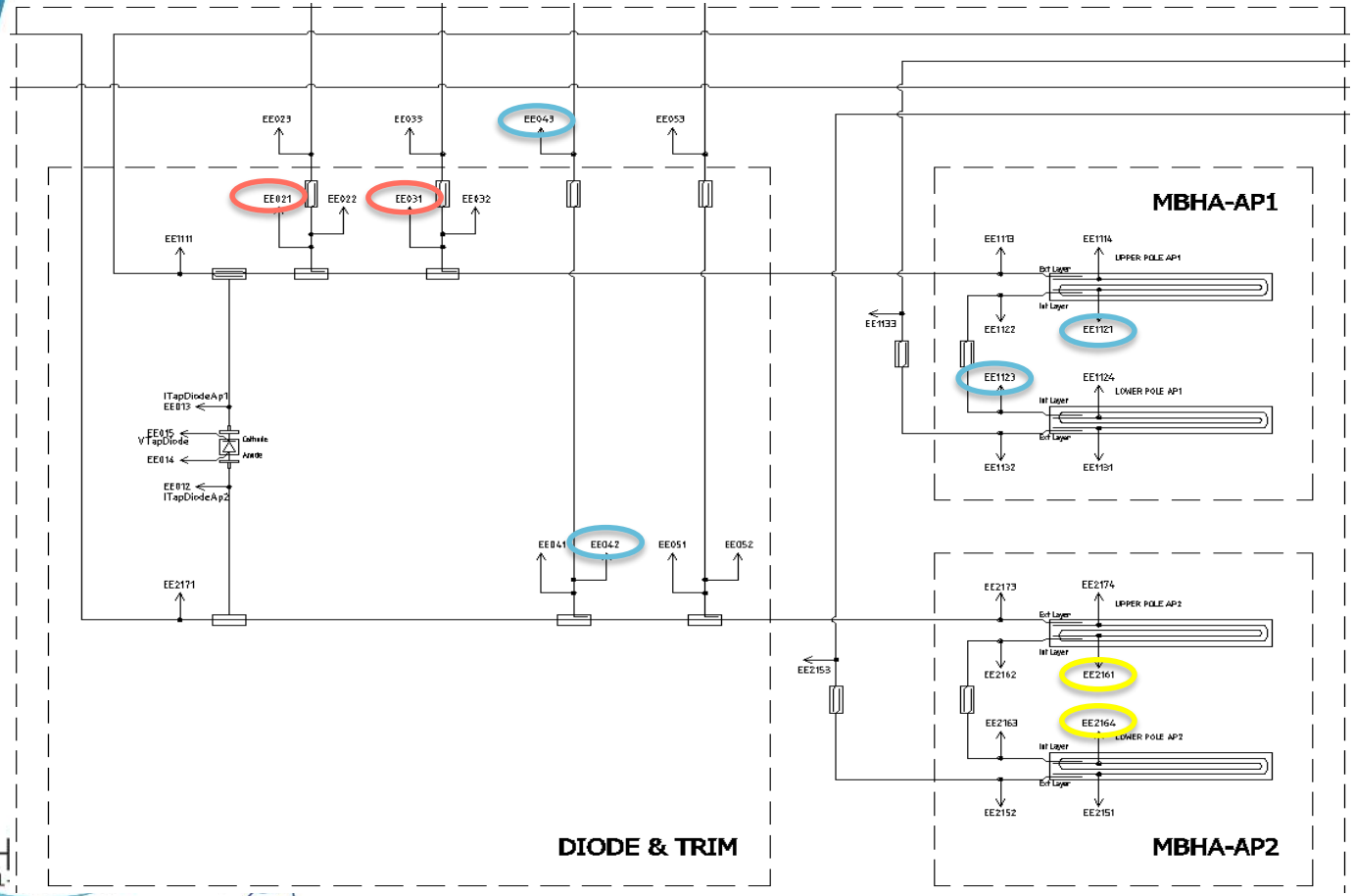




NC3 : Electrical defects during Cold Tests

- Visual inspection of the wires near the warm head:
  - Different types of defect are found:
    - External sleeve scratched (13 defects),
    - Conductor visible (1 defect, EE021),
    - Black stain (1 defect, EE031).
  - These defects are close to the warm end (possible direct contact?)

Positions of the defects (for all NCR)



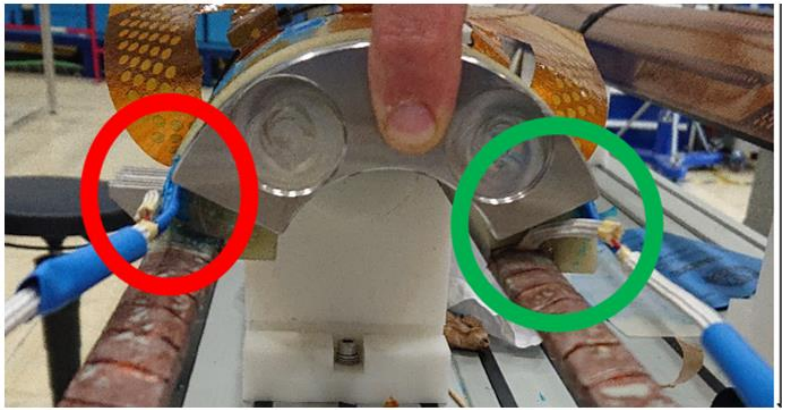
Defects near bullets (NC1)

Defects near cold head (first turn, NC3)

Defects near warm head (NC3)

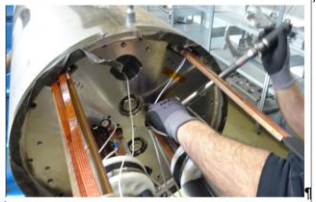
Corrective actions

- NCR1:
  - During coil manufacturing, the Vtaps are routed in line with the quench heater wires. A Hold point by CERN QA was added to check the positions of the wires.



Corrective actions

- NCR1:
  - During the bullet tightening, QA carries out checks with the endoscope throughout the process.

5.13	**En collaboration avec le service QA,** serrer au couple (30N.m) les écrous des bullets côté connexion en s'assurant en permanence à l'endoscope que les fils des prises de potentiel et des quench heaters ne sont pas coincés **Les bullets poussent directement sur les bobines qui sont très fragiles. Bien vérifier le couple de la clef dynamométrique et le fonctionnement de celle-ci avant.** **Le service QA prend des photos de chaque saddle après serrage.** **Signer l'étape K.1.3 de la fiche de suivi [3].**	 

An insulation test is performed immediately after tightening.

CONTACTER LE SERVICE ELECTRIQUE POUR CONTROLER L'ISOLATION DES BOBINES PAR RAPPORT A LA MASSE **Renseigner les valeurs mesurées dans l'étape K.1.4.1 de la fiche de suivi [3].**

Corrective actions

- NCR2:
  - Cleaning and an inspection are added before the wires are inserted (operations 6.17 and 6.18 https://edms.cern.ch/document/1990289/0.2).
  - As requested, any NCR calling for a lower HV test level should be raised as critical and should be agreed with all stakeholders (e.g., MCF, MEB, MP3).

Corrective actions

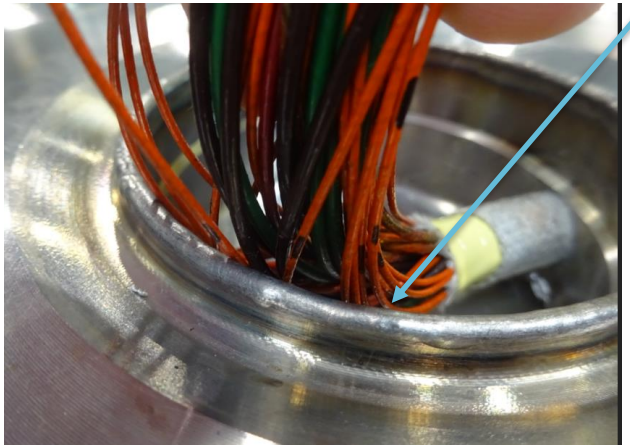
- NCR3:
  - In order to avoid possible damage during the cold mass manufacturing, the wires are spooled properly.
  - It is now check by QA (hold point) throughout the production.

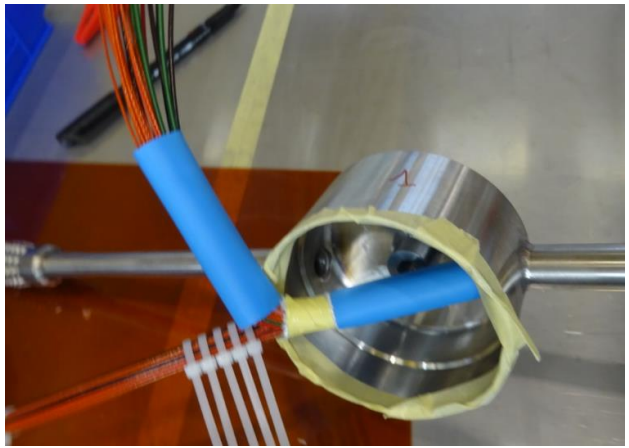
10	Vérifier que les fils d'instrumentation sont bien rangés en toron.	

  - A new tooling have been created. It will be used for the next cold masses (11T, MQXFB…).

Corrective actions

- NCR3:
  - All the defects, which have been observed, are on the wires touching the edge of the warm head.





  - Therefore, extra insulation could avoid scratches caused by friction at this location (picture taken on the new IFS).