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HL-LHC DFH-DFM meeting #2

Date: 2018/11/14	***Project/Activity:*** WP6a

Attendees:

TE-MSC: Amalia Ballarino [AB], Iole Falorio [IF], Jerome Fleiter [JF] , Yann Leclercq [YL], Vittorio Parma [VP],

TE-CRG: Serge Claudet [SC], Antonio Perin [AP]

EN-MME: Robin Betemps [RB], Julien Pascal Dequaire [JPD], Diego Perini [DP]

Excused: Yifeng Yang [YY]

Agenda: *https://indico.cern.ch/event/771911/*

- Approval of minutes
- Splice geometry input [JF]
- DFHs: One unit vs two units [YL]

DISCUSSION

SPLICE GEOMETRY INPUT [JF]

- The different splices in the SC-Link must satisfy the following criteria:
  - Mechanical robustness [JF];
  - Low and reproducible electrical resistance [JF];
  - Sufficient heat transfer to fluid to avoid over heat (particular attention has to be put in the he gas environment) [JF];
  - Continuity of copper stabilization. This criteria applies at the splices but also along the all line including the plug [AB];
  - No degradation I_c [JF];
- An overview of the REBCO material specifications has been presented in slide 3;
- REBCO splices in the DFH:
  - The splice resistance is dominated by the internal resistance of the material (in the HTS side of the tape it is dominated the interface between the Ag and HTS, in the MgB_2 wires it is dominated by the Monel) and the expected value for the HTS side at 20 K is 20 nΩ cm^2. In terms of total resistance of splices reasonable values to be taken into account are:
    - 1.5-2 nΩ for 18 kA splice (~10 nΩ for each 3 kA splice);
    - 12 nΩ for 2 kA splice;
    - 6 nΩ for 7 kA splice.
  - The cryostat team will provide information about the power that the system is able to absorb keeping in mind that a margin of at least a factor 2 should be take into account in the design [YL];
  - The extremities of both the SC-Link and the HTS current leads length are going to be pre-spliced at the surface and the copper to copper splices will be performed in situ. [AB] ;
  - The two-stages splices allow intervention in situ in case of damage. In particular, enough length of the SC-Link will be provided in case of damage of the MgB_2 to copper splices while the current leads can be replaced in case of damage of the HTS to copper splices [JF];

- The cable geometry has not been finalised but at the moment 12 REBCO tapes are foreseen for each 3 kA cable [JF];
- The HTS cables will have to be provided with enough length to allow matching the copper to copper extremities in a specific point and compensate for eventual differences [AB];
- The proposed splice length is 300 mm (it could be slightly increased of additional 75 mm depending on the test results in Demo 1) to guarantee a sufficient heat transfer with the he gas;
- A first estimate of the splice dimension is:
  - 18 kA (per splice): 70 x 60 x 300 mm
  - 2 kA (per splice): 20 x 30 x 650 mm
  - 7 kA (per splice): 20 x 45 x 300 mm
- Enough space should be taken into account for the brazing tools [VP]. These tools are R&D under development, still needed iteration for providing a value [AB]. The cryostat team will give a first idea of the reserved space in order to receive feedback if considered or not reasonable/sufficient [YL];
- It is difficult to guarantee the homogeneous cooling of big components, the dimension involved should be compared with existing NbTi and Nb_3Sn technologies [SG]. The comparison should be done only between cables of the same geometry [AB]. The discussion on the cooling of the splices is scheduled for next week [YL];
- The input on the splices longitudinal displacement is still missing but the cables team is working on it with models in order to provide it [AB];

DFHs: ONE UNIT vs TWO UNITS [YL]

- Four possible configuration for the DFH design have been presented: #1 DFB type, #2 Common vacuum, #3 Double staged and #4 Two units [YL];
- The configuration #1 and #2 are the solutions with the minimum HTS cables length but they are not compatible with the installation of connection/disconnection boxes (CDB). [YL];
- If the presence of CDB boxes is a complication for the project it should further discussed with the power converter team. It should be clarified and agreed what is baseline in order to identify the real constrains while debugging the parts of the system that can be optimised [AP,SC]. There are on-going integration meeting to identify the boundary conditions [AB];
- The solution #3 requires a bigger diameter on the first cryostat and implies a difficult cables distribution and vacuum jacket, but it requires a shorter length of the MgB_2;
- The two-units DFH concept (#4 in the slide) simplify the integration sequence, allows to be closer to the PC units and limit the amount of HTS length required. An MgB_2 length of 15 m is foreseen between the two DFH units [YL]. This is the solution preferred from the integration point of view (it allows to located the HTS current leads close to the Power converter and disconnecting boxes) and it facilitates the splices organisation and the cables routing ;
- A either flexi or rigid solution for the MgB_2 SC-Link between the two boxes should be further studied [AB];
- The cryogenic system for the two-units should be further discussed. The second box should be the one which sees the gas at 17 K but the flow rate needed for the low current leads is smaller (1 g/s per lead). One possibility could be to send extra mass flow rate in the second box and then send it back to line D [SC]. The cryogenic team is invited to come with a proposition to YL to be integrated [AB];
- Concerning the one-unit solution, the cryogenic team observes that 15 m low current HTS cable will not be a viable solution because the low flow implies a too high temperature (~ 40 K) at the current lead level;
- The gas injected in line D should be ideally at ~20 K but up to 22 K is acceptable (25 K is already considered unacceptable) [SC];
- In solution #4 the small MgB_2 cryostat is not compatible for integration with a pre-opening of the splices going into the second unit. [SC] Further studies discussion are required [AB];

- The point fix of the system will be presented at next DFHs meeting [AB];

ACTIONS

Presentation on cooling of the splices in the DFH	YL	21-11-2018
Input on splices displacements	AB,JF	Started
Clarify if the presence of CDB is a driving constrains	JF, YL	ASAP
Studies on the pre-opening of the MgB_2 splices	AB, JF	Ongoing
Presentation on point fix of the system	AB	21-11-2018
Cryogenic proposition for two-units DFH box	SC	ASAP

Documents:

Prepared by: Iole Falorio ***Verified by*** Yann Leclercq	***Date:*** 2018-11-17

Distribution List: All attendees