WP6a: DFH Detailed Design Review

Follow-up from CDR

Paul Cruikshank for WP6a

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DFHX CDR

- DFHX Conceptual Design Review 15/11/2019, https://indico.cern.ch/event/862994/

- Reviewers: M. Modena (chair), B. Bozzini, K. Brodzinski, D. Perini, F.M. Rodriguez.

- CDR Report – Edms 2275273
  - Recommendations - #6
  - Findings and comments
    - Design - #12
    - Interfacing equipment design - #3
    - Cryogenic design - #1
    - Transport & installation - #3

⇨ Short replies to each point as upcoming presentations will address most in more detail

CDR Recommendation N.1

- Pursue on the finalization of the DFHX design a.s.a.p. More specific comments on important design aspects are provided in Section 3; please refer to them. Reference scenario should be a design with the most compact as possible "combined assembly" (DFHX with spooled DSHX), but keeping always valid and possible the alternatively approach with interconnection (i.e. installation) of the DFHX with the DSHX to be done in the UR.

- ⇨ OK. All points are adopted and will be presented during the DDR

CDR Recommendation N.2

- The study of DFH integration in the UR is urgent and essential to validate and confirm the new design. An aggressive plan of technical meetings and studies with WP15, Transport, WP6b, etc. has to be planned for that.

- ⇨ OK. Weekly meeting were held via the integration forum with presence of concerned teams including WP6a, WP6b, WP9, WP15, WP17, EN-HE. Solid progress has been achieved and the integration solution is nearing maturity (see dedicated presentation)

CDR Recommendation N.3

- It is essential to perform a detailed study including:
  - All critical dimensions of CE shaft & caverns as "guaranteed" by SMB after works executed. ⇨ to be planned and included in integration model
  - The final dimensions of the (very) rigid frame needed for the "combined assembly" transport (not yet studied). The design of this rigid frame shall proceed in parallel with the design of the "combined assembly" since it is the maximum global volume of the two that must be compatible with the transport volumes and procedures. - The detailed transport procedures and manipulations required. ⇨ advancing, but more extensive studies Q3,Q4 2020

- Two scenarios must be considered: the "combined assembly" one and the one assuming connections of DFHX and DSHX done in the UR. Duration time and assembly sequences should be developed for BOTH scenarios. A third scenario was envisaged and it deserves further investigation (see Section3 comments). ⇨ baseline surface assembly sequence developed for DFH. Spooling method needs further studies and trails. The third scenario hasn't been investigated further.

- Assess with WP15 the impact of the "combined assembly" transport & manipulation on the UR equipment layout, since some equipment must not to be in place, and this could affect the installation plan details. ⇨ studies made by integration team to identify which equipment cannot be in place at UL/UR junctions – sequencing is imposed but no showstoppers identified.

CDR Recommendation N.4

- It is strongly suggested to standardize the design pressure of all the elements of the cryogenic system (DFH, DSHX, DFHX) to 3.5 bara. From the additional discussions after the review, it is understood that the actual DSHX design pressure value (2.5 bara) comes from the development done with industry up to now. Changing it is not straightforward, and it might imply a new validation process. We understood that WP6A will ask to the Manufacturer to investigate this possibility when launching the DSHX series procurement, by asking a technical analysis on the implications (flexibility, thermal loads, etc.) of having a design pressure increased to 3.5 bara. ⇨ OK 3.5 bara adopted for SC link

- If feasibility is confirmed, adopt the release valves and burst disks setting as indicated above. ⇨ OK, dedicated presentation during DDR

- The position of the release valves and burst disk on the cryostats should be optimized considering the presence of personnel in the UR. ⇨ OK, agreed positions to be presentation during DDR

- The MCI must be carefully identified and evaluated for its impact on Safety of personnel and equipment (e.g. correct handling of forces developed on cryostat fixations). ⇨ OK, MCI are being analysed & documented thro' a WG – see DDR safety presentation. Handling of forces in engineering presentation.

CDR Recommendation N.5

- The procurement of the DFHX with the Uppsala University will be done on a “build to print” basis. If the challenging prototype procurement plan has to be maintained, it is suggested to start soon with the CERN Drawing Office (i.e. in parallel with detail design phase) a plan for the drawings checks and approval since this activity will be long (i.e. 80-100 drawings estimated, to be approved with the “3-signature” process). ⇨ OK, 2D detail drawings are on-going and planned for completion in few weeks.

- Dedicated discussions and plan for the DFH prototype installation and test at SM18 must be planned together with WP16. ⇨ Started, more focus will be possible after the DDR milestone

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Recommendation N.6

- It is expected that for the next Detailed Design Review, other important aspects as the design following PED directive and HSE approval, fulfilment of the HL- LHC Quality plan and procedure will be covered in the presentations.
- ⇨ OK, dedicated presentations

Findings & Comments: DFHX design

- A1. The detailed design of the DFH should include analysis and optimization of maintenance/repair scenarios that will be not evident in the UR limited area. ⇨ OK, dedicated presentation during DDR
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- A2. Clarify with Uppsala University all aspects linked with PED Directive requirements and eventual third party role in the design/manufacturing process. ⇨ Started, main assembly & p.test made at Cern, but UU must follow all material selection, NDT and doc needs for Cern qualification
- A3. Cryostat supports and bolted connections: the rigidity and design of the supports and bolted connections (6 seals in 4-m length) should be revised and optimized. To be analysed if so many bolted connections are preferable to welded ones. To be carefully analysed the vacuum axial forces generated at the end covers levels for any working and failure scenarios, support of DFHX on its frame and of the frame on the ground should be developed consequently. ⇨ OK, bolted connections retained and support frame designed accordingly. The design follows the LHC solution for access to electrical splices.
- A4. The compensation of the thermal contractions relative movements inside the cryostats should be carefully addressed. Consider what would be eventually required to avoid condensation at HTS CL extremities. ⇨ OK, see mech eng presentation. The proven CL design and chassis inclination avoid condensation issues – upgrade to include dry air housing is possible within the design.
- A5. Carefully optimize the thermal shield thermalization by the exhaust He gas line. ⇨ OK, actively cooled thermal shield not retained
- A6. IFS system: the number of instrumentation wires is impressive; the design and needed spaces for the splicing boxes and for the IFS system will be relevant and seem under-evaluated. It should be avoided that IFS and related cables are located laterally, close to passage areas, in order to avoid accidents. The position of the IFS must be optimized for an easy access and maintenance. ⇨ OK, IFS moved to vertical orientations. Splice volume requirement based on lab, Demo1 & 2 experience.

Findings & Comments: DFHX design

- A7. Even if not required by RP considerations, the equivalent of the DFBX "proximity equipment" could be beneficial (ex. installing some sort of patch panels; the connection from this patch panel to the feedthrough is tested at surface, and then long cables are routed to this patch panel). ⇨ OK, space reservation made for proximity equipment for CL heater p.supplies, plus IFS instrumentation patch panel now included in design.

- A8. Evaluate which mechanical element or procedure will need to be implemented in order to customize the DFHXs (Right vs. Left layout). ⇨ OK, design is made for universal left/right design including CL circuits and polarity. Only safety valve and cryo by-pass connections will change sides for installed configuration.

- A9. Evaluate and iterate with EN-CV about the final thermal budget to be dissipated in AIR vs. WATER. ⇨ OK, requested data transmitted to CV team via integration forum.

- A10. Provide an estimation of electromagnetic stray field around the equipment. ⇨ to be evaluated

- A11. Upon addition of the cold diodes to the baseline design, the central 7 kA rated line (from HTS current lead to intermediate connection between the two central cold diodes) will not be powered. This line could be used to mitigate some failure scenarios. It is recommended to analyse the different possibilities of use of such a line during failure scenarios. ⇨ OK, spare 7 kA cable will equipped with redundant CL.

- A12. Make sure that the mechanical supports of the different bus bars in the different modules are properly dimensioned to withstand the Lorentz forces during powering and fast discharges while coping with the differential contractions during cool down. This is in particular applicable after the point where the round geometry of the cables is lost due to shuffling. ⇨ OK, dedicated presentation during DDR

Findings & Comments: Interface equipment design

- B1. The possibility of using water-cooled busbars instead of water-cooled cables should be studied since the path between PC and Disconnector boxes is straight (the need for flexibility of cables is not clear). ⇨ OK, water-cooled busbar for 18kA & 14kA circuits, air cooled for 2 kA and 600 A.

- B2. For the heat exchangers on the 14kA and 18kA bus bars, the requirements in terms of thermal power extraction should clarified. ⇨ To be studies (but not WP6a scope)

- B3. The interfaces ("Who is responsible of What") among WP6a, WP6b and WP17.2 must be clarified.⇨ Good level of technical clarification in integration forum, but need interface document for technical and financial aspects

Findings & Comments: Transport & installation

- C1. Already mentioned in Section 2, the recommendation to equalize the design pressure of all the equipment of the system (DF box, SC Link and DFH box) to 3.5 bara. ⇨ OK, 3.5 bara design pressure adopted for cold power systems

Finding & Comments: Transport & installation

- D1. Beside the two proposed scenarios (the DFHX/DSHX "combined assembly", and the assembly of the two equipment done in the UR), a third one "without drum" seems to deserve an analysis and evaluation: It consists in lowering in the shaft the DFHX with the unspooled DSHX (which one of the two in front remains to be evaluated). This, of course, if it is not excluded "a priori" that the DSHX internal part cannot bear its own weight). In fact it seems that this layout is often the one adopted in installations with a similar type of configuration (installation of big electrical cables attached to a "supporting cable or structure"). ⇨ OK, dedicated presentation during DDR
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- D2. The exact boundary conditions for the DSHX manipulation are not clear (limit of applicable forces on it). WP6a has to clarify this aspect with EN-HE and involve them in future discussions and tests about these aspects (for future manipulations in Demo2, SM18 and LHC). ⇨ On-going, more extensive discussions and studies are planned during Q3/Q4 2020 (frame design, installation path from assembly to SM18 to UR)
- D3. Develop the installation sequence baseline for all the systems (e.g. priority in circuits interconnection). Develop also standard maintenance scenarios and exceptional maintenance or repair scenarios (to check also potential impacts on the design). ⇨ OK,
- DFHX surface assembly sequence is developed. Sequencing with all items in UR gallery need to be refined. Strong collaboration with WP6b and EN/EL for warm cabling configurations. Space reservation around installed DFH is retained to allow all repair and maintenance tasks – intervention types to be documented.
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Thanks for your attention