

ARIES-CS Power Core Engineering: Status and Next Steps

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ARIES Meeting

GA

February 24-25, 2005



Major Focus of Engineering Effort During Phase II

(from last meeting)

1. Divertor design and analysis
2. Detailed design and analysis of dual coolant concept with a self-cooled Pb-17Li zone and He-cooled RAFS structure:
 - Modular concept first (port-based maintenance)
 - Field-period based maintenance concept next
3. Coil cross-section (including insulation + structural support)
 - Do we need to do structural analysis?
4. Integration with credible details about design of different components, maintenance and ancillary equipment for both maintenance schemes.

(Note that much of the effort on the modular concept is compatible with either 3-field period or 2-field period configurations. For simplicity we should focus on one configuration and flag any potential issue if applied to the other configuration.)



Action Items for Phase II (from last meeting)

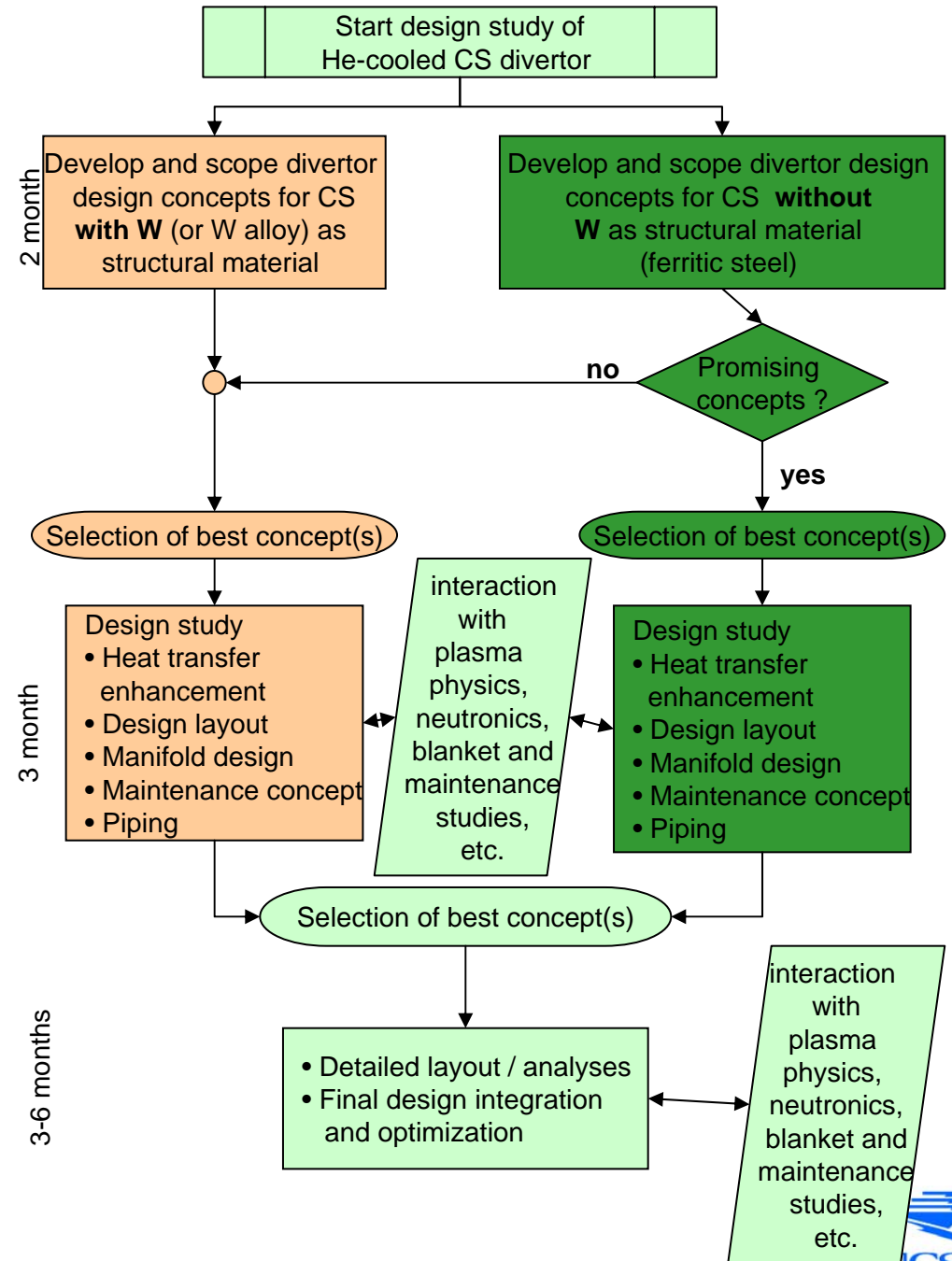
1. Run LOCA/LOFA case with low contact resistance between blanket and hot shield (UW)
2. Check effect of local radial conductance in blanket and between shield and vacuum vessel (UW)
3. Do we need to consider any other accident scenario? (INEL/UW) LOVA
4. Structural analysis of coil support to have a better definition of required thickness for cases with separate coil structure for each field period (MIT)
5. Details of module attachment and replacement (choice between “single” module maintenance or “series” module maintenance) (FNTC/UCSD)
6. Port maintenance including all pipes and lines (realistic 3-D layout including accommodation of all penetrations) (UCSD)
Details of module design and thermal-hydraulic analysis for dual coolant design (FNTC/UCSD)
7. Coolant lines coupling to the heat exchanger (choice of HX material, e.g. W-coated FS vs. refractory alloy such as niobium alloy) (FNTC/UCSD)
8. Tritium extraction system for Pb-17Li + tritium inventories (FNTC/UCSD/INEL)
9. How high can we push the Pb-17Li/FS interface temperature based on corrosion limits? (FNTC/UCSD)
10. External vacuum vessel design (thickness and configuration) (FNTC/UCSD)
11. Divertor design and analysis (T. Ihli/UCSD)

Divertor Study

- **Three possible design configurations identified**
 1. Pin design (current EU concept)
 2. Plate design (considered previously, e.g. FZK former design)
 3. T-tube (new concept being developed here and to be presented in more detail by T. Ihli)
- **Heat transfer enhancement techniques with He as coolant can be applied to the different configurations**
 - Possibility of using simple He flow reconsidered (S. Abdel-Khalik)
 - Heat transfer enhancement techniques include jet flow configuration and fins
 - Independent confirmation on CFD analysis to be provided by G.Tech.
- **Rely on progress on physics side to obtain better estimate of heat flux on divertor and divertor location (T.K. Mau, A. Grossman, H. McGuinness)**
 - For the initial analysis, a maximum heat flux of 10 MW/m^2 is assumed
- **Separate ARIES town meeting on divertor (for discussion)?**
 - Engineering/physics interaction
 - Short term v. long term
 - Unique issues related to stellarator as compared to tokamak



Plan for Divertor Design Study



Dual Coolant Module Design

- **Updated design and cooling configuration for dual-coolant blanket modular concept (S. Malang and X. Wang's presentation)**
- **Thermal-hydraulic analysis of blanket coupled to Brayton cycle**
- **Maintenance of DC concept requires pipe cutting behind module**
 - **In-bore or outside access for pipe cutting and rewelding**
 - **Communication with K. Ioki (ITER JCT) for input on remote handling equipment**
 - **Visit on March 7**



Corrosion Workshop Briefing

- **Organized by Russ Jones at UC Berkeley, February 17-18, 2005**
- **The scope of the meeting was to identify scientific and technical issues associated with corrosion of materials in fusion relevant environments and possible theoretical and experimental routes to resolving these issues.**
- **Mostly material experts attending (some not familiar with fusion).**
- **2006 presidential budget zeroing fusion material research weighed in on the meeting.**
- **Very useful for fusion technology in completing and prioritizing list of materials of interest, in understanding conservativeness in “old” prescribed material limits, in identifying issues and required R&D**
 - **FS/Pb-17Li compatibility temperature limit revisited (need fundamental property measurements as well as corrosion loop reproducing prototypical conditions: DT, velocity, channel size, etc..)**



W (and W alloy) should be included in fusion material list since they are most likely to be used for divertor design (oxygen control in He is a key issue)

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Ancillary Equipment

- **Tritium extraction and recovery method**
- **Heat exchanger design and material choice**
 - **Connection to blanket structural material**
 - **Compatibility with Pb-17Li at a temperature of up to $\sim 700^{\circ}\text{C}$**
- **Can benefit from effort on ITER test module, which can be updated and applied to our blanket configuration (B. Merrill)**



Coil Structural Analysis

- **Need structural analysis of coil support to have a better definition of required thickness for cases with separate coil structure for each field period (MIT)**
- **Steady-state case (no disruption). Need force definition based on coil current and stress analysis**
- **How best to do this?**



ISFNT-7, Tokyo, May 2005

- **We have an ARIES-CS paper:**

Major Integration Issues in Evolving the Configuration Design Space
for the ARIES-CS Compact Stellarator Power Plant

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and the ARIES Team

- **Late but I requested an extension**
- **I will put a draft together and circulate it for comments within the next couple of weeks**

