Introductory Remarks and Key Technical and Management Questions for the APEX May 2000 Meeting

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APEX Meeting, May 10 – 12, 2000
Argonne National Laboratory

Introductory Remarks

- Welcome to all participants. Thanks to ANL for hosting the meeting. Thanks to Dai-Kai Sze for his efforts in arranging the meeting.
- This is the only "physical" meeting this fiscal year.
- Since our last November 99 meeting:
  - Good work, good progress.
  - A number of questions have been raised.
- We look forward to a productive meeting:
  - Review results and progress.
  - Discuss technical issues.
  - Make technical and management decisions whenever they are needed.
  - Note: Plasma-LW surface interactions were covered on Tuesday.
- Agenda is very tight
  - Ask the session chairs to strive for a balance between technical presentations and discussions.
  - For session chairs: please try to adhere to the exact start and finish times for your session.
- Mid-Year Progress Report: The summary of each session (3-5 pg's) by the Task Leaders/Session Chairs.

Brief "Reminder" of APEX phases and how we got here.

APEX Objective

Identify and explore novel concepts for Chamber Technology that can substantially improve the attractiveness of fusion energy systems.

1. Preparation Phase (early 98)

- Agree on goals for Chamber Technology
- Assess issues and status of current (conventional) Chamber Technology concepts
- Agree on approach
- Agree on organizational structure for the team

Documentation:

- Presentations & Documents are preserved on the APEX website
- Assessment & approach published in Fusion Engineering &Design (appeared in May 99 issue)

Brief "Reminder" cont'd.

2. "Idea" Exploration Phase (98-99)
   (also called idea screening & formulation phase)

   - Encouraged, solicited, and screened ideas
   - Design "idea" formulation and analysis with existing tools
   - Ideas were broad (solid walls, particulate bed, spray cooling, liquid walls, etc.)

   External Events: Snowmass and its impact

- The physics community seemed to find important benefits in liquid metal walls (low recycling / improved confinement, increased elongations, increased Beta). These benefits were not on the list of technologists.
- The technology sessions concluded that liquid wall research should be pursued.
- The community was challenged to put liquid wall in NSTX (plasma physics device) in 5 years.
- Overall, Snowmass gave a very positive push to liquid wall research.

   Documentation:
   - All presentations, papers, communications are published on the APEX website.
   - Many papers published by individual scientists in journals and conference proceedings.
   - Comprehensive Interim Report issued November 99.

2. "Idea" Exploration Phase (cont'd)

Outcome:

A. Identified two classes of "ideas" as worth proceeding with to the "Concept Exploration" phase. These are:

   1) Liquid Walls (as a class that has many widely varying options yet to be explored and sorted out in the next phase: thin, thick, molten salt, LM's, restraining forces, etc.)

   2) Advanced Solid Wall with High-Temperature Refractory Alloy and evaporative Li cooling (EVOLVE)

B. Identified key issues for the two classes of ideas. Identified deficiencies in tools and knowledge that are necessary for meaningful concept exploration

C. During the period mid-August to mid-November 1999, the APEX team (in consultation with VLT and DOE) discussed and agreed on:

   a) a technical plan, and

   b) a new organizational and management structure for the "Concept Exploration Phase"

   The goals, plan, and resource allocation were discussed in the broadly attended November meeting at UCLA with VLT and DOE providing oversight functions. The plan was published on the web.

3. "Concept Exploration" Phase (Nov. 1999 presentation)

- This is the current phase.
- Started Nov. 99 and is being conducted according to the Reference Plan Document (agreed to in Nov. 1999 and published on the web) evolved from the "idea exploration" phase.
- The Technical Tasks and organizational structure are suitable for "concept exploration".

Technical Tasks:
The essence of the tasks can be paraphrased as:

Task I: Explore the possibility of putting LW's in plasma devices (e.g. NSTX) and understand the issues involved (find out if this is a sensible idea and what is involved).

Task II: Explore the scientific basis and issues for the many diverse options in the liquid wall class. Develop models and simple experiments in key areas to understand scientific issues. Identify which ideas are worth exploring.

Task III: Begin understanding the engineering issues necessary for concept exploration of LW's. Begin with 2-cm flibe and gradually address other ideas whose scientific basis become available from Task II.

Task IV: Investigate key issues and develop a practical design for high-temperature refractory solid walls with primary focus on EVOLVE.

Task A: Plasma-liquid surface interactions.

Task B: Liquid wall-bulk plasma interactions.

Task C: Materials

Task D: Safety and environment

3. "Concept Exploration" Phase (cont'd)

Organizational Structure

- Each Task has one or two leaders responsible for leading the effort.
- Performers in each Task "meet" monthly via conference calls. A summary of each call is issued and posted on the web.
- M. Sawan is coordinating among the Tasks.
- The team "meets" in 3 electronic meetings (March, July[?], September[?]) and one "physical" meeting.
- A Steering Committee (SC) consisting of 12 members is responsible for conducting APEX.

Status

- The structure of the technical tasks and organizational structure appear reasonable and effective.
  - The team should always think of ways to enhance effectiveness.

- Technical progress seems reasonable.
  - A set of technical questions has been generated for discussion by the team and SC

- We need to think about and discuss adjustments and changes (if any) in the scope of the technical tasks and organizational structure for the rest of the year and next year (FY 2001).

List of Questions for Discussion
APEX Meeting, May 10-12, 2000

A. General Questions

1. Is there any innovative "Chamber Technology" concept or idea not being considered in APEX now that should be included in the APEX work scope (this year or next year)?

2. Do we have enough information to make a judgement on flibe as one of the liquid wall candidates? What conditions must exist for flibe to be successful as a LW?

   Examples of Possibilities
   a) Negative evaluation of flibe potential: eliminate flibe as a candidate
   b) There are good reasons to continue flibe at the current level
   c) Put flibe design exploration on hold but continue the two areas related to major uncertainties: plasma edge modelling and free-surface heat transfer

   Examples of Favorable Conditions?
   - Low recycling divertor required
   - Edge plasma heating required
   - Hot x-ray spectrum required
   - Destruction of thermal boundary layer required
   - Etc.

3. Given the limited resources in APEX, should we continue research exploration of both thin and thick liquid wall ideas?

Examples of Possibilities

a) For the near-term, focus only on THIN Liquid (CLIFF-Type) concepts.
   Possible Reasons: This is what is needed for near term plasma devices. Experience from thin liquid (if successful) will be a major input to thick liquid research. Most of the benefits (except substantial neutron attenuation) are realized by thin liquids.
b) Continue both thin and thick liquid concepts (current situation).
c) Focus primarily on thin LW but keep some areas relevant to thick LW (e.g. waste management).
d) Focus on thin LW for tokamaks but keep thick liquid exploration for alternate confinement concepts plus limited areas (e.g. waste management).

4. Do we need to address the stabilizing shell requirement in APEX? For the thin flibe liquid, is there anything about the stabilizing shell that is different from what has already been addressed in design studies? (When we move to liquid metals, the stabilizing effects will need to be considered.)

5. We need to hear (briefly) on the status of two items in the scope of work but not on the agenda:
   A) Assessment of impact of LW on waste management (McCarthy/Sawan/Youssef)
   B) Exploration of Liquid Wall in alternate confinement concepts, FRC and RFP (Moir). Do we need to increase the effort in this area?

B. Task-Specific Questions

Task I

6. Should we consider other plasma devices besides NSTX?

7. What are the main findings on exploring LW experiments on NSTX?

8. Can lithium flows be handled safely in plasma physics devices? Will the physicists accept the risk?

9. Are there more issues to be addressed next year?

Task II

10. Is the scope of work in Task II (design exploration, scientific issue, modelling experiments, etc.) too much to cover with current resources? How to reduce the scope of work for next year?

Possibilities

a) The answer to Questions 2 and 3 are important. If the focus is only on thin liquid for now this reduces the scope. Also if flibe is put on hold, then the scope will be focused enough
b) Move the design exploration to another Task (e.g. to Task III). Keep the task focused only on scientific issues and necessary tools (modelling and experiments).
c) Others?

11. What is the impact of the decision on flibe (answer to Question 2) on FliHy experiment?

Task III

12. Are we adequately addressing the engineering issues related to CLIFF-flibe (e.g. nozzle design, configuration, penetration accommodation)?

13. Is the design being explored capable of pumping helium?

14. When do we start work on CLIFF-LM (i.e. 1-2 cm Li or SnLi)? (This summer or next year?) Also should we start by Li or SnLi?

15. What are the favored options for integrating the divertor? Will these options change for liquid metals?

Task IV

16. Is it time to switch the EVOLVE effort to another cooling design variation (e.g. capillary cooling in trays versus boiling)? Or do we still need to investigate the boiling Li base design further?

17. Should we consider other advanced solid wall concepts next year in addition to or instead of EVOLVE?

18. The reliability/maintainability/availability (RMA) for designs with solid walls has been addressed in the past to the extent that we know it is a critical issue (some think it is a fatal flaw), but do we know what to do about it? Is there anything that we can do in APEX to address the issue? Should we recommend to VLT and DOE to initiate a study by a group (outside APEX) from the community and non-fusion experts to address the issue? (RMA may also be an issue for liquid walls but there are not enough details yet for meaningful assessment. But RMA for liquid walls can also be addressed sequential to the solid wall RMA assessment?)