

APEX Status and Future Directions

Introductory Remarks

APEX Meeting, SNL, November 14 – 17, 2000

Objectives of the Meeting

- Report and Discuss Technical Progress
- Continue to Discuss and Finalize Plan for FY01 Efforts

Items to be Noted

- Town meeting held for APEX/ALPS Tuesday evening 11/14
- A Steering Committee conference call 11/7
- There will be a Steering Committee meeting Thursday evening
- APEX Team General Discussion Session starts Thursday afternoon
- Task Leaders were asked to provide “Performance Evaluations”
- We plan on a 2-yr report by the end of 2001

APEX Reference Document

FY 2000 Technical Plan

Tasks / Performers / Level of Effort

Introduction

This document serves as a reference document for the APEX Study for FY 2000. It defines scope, approach, milestones, tasks, subtasks, and task leaders as well as individual and institutional performers for FY 2000. The level of effort is also indicated and corresponds exactly to the DOE January Fin Plan made available by Sam Berk in early December.

The technical plan contained in this document evolved from a “process” that took approximately two months. Task leaders worked with core groups in a “bottom up” approach to identify key issues and priority technical tasks and level of effort. The process expanded to include all team members and was discussed during the November 8-11 meeting. Several iterations took place.

This final plan incorporates all comments and suggestions and follows DOE guidelines. Minor revisions were made by the APEX Steering Committee on December 6th and 7th.

Finally, it should be noted that the tasks defined here for FY 2000 were derived from a set of 5-year goals, developed by the APEX team, for Liquid and Solid Walls. These 5-year goals are:

Liquid Walls:

1. Fundamental understanding of free surface fluid flow phenomena and plasma-liquid interactions verified by theory and experiments.
2. Operate flowing liquid walls in a major experimental physics device (e.g. NSTX).
3. Begin construction of an integrated Thermofluid Research Facility to simulate flowing liquid walls for both IFE and MFE.
4. Understand and document advantages and implications of using liquid walls in fusion energy systems.

Solid Walls:

5. Understanding of novel concepts that can extend the capabilities and attractiveness of solid walls.

APEX
FY 2000 Technical Plan:
Tasks / Performers / Level of Effort

Task I: Explore options and issues for implementing a flowing liquid wall in a major experimental physics device. Characterize the technical issues and develop an R&D plan.

Task II: Explore high pay-off liquid wall options. Include: a) tokamaks and other confinement schemes, b) flibe and liquid metals (Li and Sn Li), c) concepts with physics advantages, and d) concepts with engineering advantages.

Task III: Investigate practical engineering issues associated with the design of a liquid wall in a high-power density fusion energy system (start with CLIFF-flibe because it is better understood and has more data available).

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

Task V: Other tasks.

Cross-Cutting Tasks

Task A: Plasma-Liquid Surface Interactions and Plasma Edge Modelling

Task B: Liquid Wall-Bulk Plasma Interactions

Task C: Materials

Task D: Safety and Environment

Key Points on FY01 Effort

- **Budget: *Reduction?***
 - Unfortunate because the needs for fundamental experiments and modelling are growing.
 - We have to work together with DOE to minimize impact.
- **5-YR Goals for Chamber Technology**
 - Still valid: no need for change.
 - But we must understand that the potential for realizing these goals in 5 years is also budget dependent.
- **APEX Tasks**
 - The Primary Structure (Tasks I – IV and A – D) will be retained.
 - Some changes in the focus of the Tasks.
 - Task II will focus on Experiments and Modelling for Liquid Walls. Design effort previously under Task II will be moved to Task III.
 - With the completion of design exploration of EVOLVE, Task IV will shift to a new solid wall concept and/or R&D.

Chamber Technology: 5-YR Goals

Liquid Walls:

1. Fundamental understanding of free surface fluid flow phenomena and plasma-liquid interactions verified by theory and experiments.
2. Operate flowing liquid walls in a major experimental physics device (e.g. NSTX).
3. Begin construction of an integrated Thermofluid Research Facility to simulate flowing liquid walls for both IFE and MFE.
4. Understand and document advantages and implications of using liquid walls in fusion energy systems.

Solid Walls:

5. Understanding of novel concepts that can extend the capabilities and attractiveness of solid walls.

APEX Tasks: FY 2001

Task I: Explore options and issues for implementing a flowing liquid wall in a major experimental physics device. Characterize the technical issues and develop an R&D plan. Begin R&D (in coordination with Task II).

Task II: Plan and perform fundamental experiments and develop analytical and computational models to predict the behavior and performance of liquid walls. Explore phenomena and fundamental principles of liquid wall concepts. Experiments and models are for both near-term applications (e.g. NSTX) and long-term attractive fusion energy systems.

Task III: Explore designs for liquid wall systems in high-power density attractive fusion energy systems. Investigate practical engineering issues associated with such designs. This task includes: 1) the first wall region, 2) the divertor region, 3) regions behind the first wall, and 4) interface and integration issues.

Task IV: Explore designs and investigate issues for novel design concepts with solid walls that have high potential for attaining one or all of the “challenging” attractiveness criteria: a) high power density, b) high operating temperature (high thermal efficiency), and c) acceptable reliability/maintainability.

Task V: Other tasks.

Cross-Cutting Tasks

Task A: Plasma-Liquid Surface Interactions and Plasma Edge Modelling

Task B: Liquid Wall-Bulk Plasma Interactions

Task C: Materials

Task D: Safety and Environment

APEX 2000-2001 Report

- We issued an Interim Report.
- We need to issue a second report documenting our APEX technical results from FY00 and FY01 (i.e. a 2-yr report).
- Partial reports documenting results from subtasks should be written as soon as the work is completed (should **not** wait until the end of the year). All these partial reports will be integrated into the full **Second APEX Report** at the end of the year.

Partial reports expected to be completed soon are:
a) Flibe design report from Task III, and b)
EVOLVE design report from Task IV. Others are encouraged.

- In writing the Second APEX Report, we need to be efficient and respectful of deadlines.
 - We will make the report outline consistent with the Task breakdown structure.
 - Task Leaders will have full responsibility.

Outline of Second APEX Report

Executive Summary (Abdou and Task Leaders)

0. Introduction and Summary (Abdou and Task Leaders)
1. Exploring Liquid Walls in NSTX (Ying, Ulrickson, et al.)
2. Modelling, Experiments, and Phenomena for Liquid Walls (Morley, et al.)
3. Designs and Engineering Issues for Liquid Walls (Sze, Nelson, Nygren, et al.)
4. Advanced Solid Wall Concepts (Wong, et al.)
5. Plasma – Liquid Surface Interactions (Rognlien, et al.)
6. Liquid Wall – Bulk Plasma Interactions (Kaita, et al.)
7. Materials (Zinkle, Ghoniem, et al.)
8. Safety and Environment (Petti, et al.)

Schedule for the Second APEX Report

Schedule

11/17/00	Finalize Report Outline (by Chapter)
3/15/01	Task Leaders provide M. Abdou with chapter breakdown (sections and subsections) and names of responsible authors)
7/31/01	Task Leaders provide brief status report (1-page) on plans for report writing and request for modifications in report outline
8/15/01	All draft sections completed and sent to Task Leaders
8/31/01	Task Leaders distribute chapters to Task authors
9/15/01	Task Leaders distribute their draft chapters to entire APEX Team (or send them to M. Abdou to post on the web)
10/15/01	Deadline for comments from the team and Editorial Committee to the Task Leaders
10/31/01	Task Leaders send final chapters to M. Abdou
11/28/01	Complete report is issued and distributed

Other Specific Issues (cont'd)

- 1) The use of liquid walls as “conducting shells” to provide higher plasma elongation and beta has tremendous pay-offs. The flowing liquid can be free surface or between two solid “guiding” shells.
 - We need to enhance the effort in this area.
 - Separate Task or Part of Task III?

- 2) What do we do about alternate confinement concepts?
 - We set up a working group last May.
 - Moir was asked to work with Wisconsin on RFP.
 - Need to agree on what to do.

- 3) There are important liquid wall activities related to but outside APEX (e.g. UW experiments on rotating conducting shells and liquid walls, PPPL work on Liquid Surfaces, SBIR, etc.)
 - We need to coordinate with these activities.
 - Maybe: devote one full day to this before next APEX meeting.

Other Specific Issues (Cont'd)

- 4) David Petti will replace Kathy McCarthy on the Steering Committee
- 5) Mohamed Sawan has been playing a role in coordination among Tasks in FY00. He has done a good job. His responsibilities in this area will be increased in FY01.
- 6) The Peer Review for Chamber Technology is likely to occur in the Spring.
 - We should schedule the next APEX meeting to be about one month before this review.