

APEX

Part 1: Background Information

- Part 1 will cover APEX Scope, Phases, Process, “How we got here”, Documentation, and How to get more information.
- Future Briefings
 - Part 2: EVOLVE (High-Temperature W with Li evaporation)
C. Wong (GA)
 - Part 3: Liquid Walls in NSTX
B. Kaita (PPPL)
 - Part 4: Liquid Wall Concepts, Modelling, and Experiments
N. Morley (UCLA)
 - Part 5: Liquid Wall Engineering Issues
D. Sze (ANL), Nelson (ORNL), Nygren (SNL)

Environment in 1997

No. 2

- The prevailing mood in the technology community was dominated by “pessimism” and “frustration” (e.g. Chamber Technology in ISFNT-4 [April 1997, Tokyo]).
- The US developed a Restructuring Plan
Emphasis on: Science and Innovation
- US Chamber Technology Discussions led by Mike Saltmarsh
- DOE and the Community agreed on initiating ALPS and APEX
- (Independently and about the same time frame)
Letter from 23 Senior US Scientists to Dr. Anne Davies encouraging research on innovative high power density concepts (“we believe that it is timely for the technology side of OFES to consider a new focus to develop first wall/blanket schemes which can demonstrate high heat and neutron fluxes”)

APEX Objectives

Identify and explore NOVEL, possibly revolutionary, concepts for the Chamber Technology that might:

- 1. In the near-term: enable plasma experiments to more fully achieve their scientific research potential.**
- 2. In the long-term: substantially improve the attractiveness of fusion as an energy source.**
- 3. Lower the cost and time for R&D.**

APEX Phases

1. Preparation Phase (early 98)
2. “Idea” Exploration Phase (98-99)
3. “Concept Exploration” Phase (Nov 99 – present)

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, vol. 45, pp 145-167, May 1999.

Chamber Technology Goals Used in APEX to Calibrate Progress

No. 6

1. High Power Density Capability*

Peak Neutron Wall Load ~ 10 MW/m²

Peak Surface Heat Flux ~ 2 MW/m²

2. High Power Conversion Efficiency (> 40%)

3. High Availability (MTBF > 43 MTTR)

4. Simpler Technological and Material Constraints

* The APEX Steering Committee in May 2000 modified the goal as follows: “APEX will explore concepts with lower power density capabilities if they provide significant improvement in power conversion efficiency or other major features”

2. “Idea” Exploration Phase (98-99)

- 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 strong push to liquid wall research.

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

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.

3. “Concept Exploration” Phase (11/99-present)

- Focus is on “concept exploration” of the most promising ideas that emerged from the prior phase.
- Started Nov. 99 and is being conducted according to a Reference Plan Document (published on the web) that was developed by the community with VLT and DOE providing input and oversight functions.

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). [Ying \(UCLA\)](#); [Ulrickson \(SNL\)](#)

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. [Morley \(UCLA\)](#)

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. [Sze \(ANL\)](#), [Nelson \(ORNL\)](#), [Nygren \(SNL\)](#)

Task IV: Investigate key issues and develop a practical design for high-temperature refractory solid walls with primary focus on EVOLVE. [Wong \(GA\)](#)

Task A: Plasma-liquid surface interactions. [Rognlien \(LLNL\)](#), [Brooks \(ANL\)](#)

Task B: Liquid wall-bulk plasma interactions. [Kaita \(PPPL\)](#)

Task C: Materials. [Zinkle \(ORNL\)](#)

Task D: Safety and environment. [McCarthy \(INEEL\)](#)

3. “Concept Exploration” Phase (cont’d)

Organizational Structure

- A Steering Committee (SC) consisting of 12 members is responsible for conducting APEX.
- 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” via two electronic and two “physical” meetings per year.

APEX TEAM

Organizations

UCLA	ANL	PPPL
ORNL	LLNL	SNL
GA	UW	UCSD
INEL	LANL	U. Texas

Contributions from International Organizations

- FZK (Dr. S. Malang, Dr. L. Barleon)
- Japanese Universities
 - Profs. Kunugi, Satake, Uchimoto and others
 - Joint Workshops on APEX/HPD
- Russia
 - University of St. Petersburg (Prof. S. Smolentsev)
- Spain
 - Official proposal under review

APEX Steering Committee

Mohamed Abdou (UCLA)

Bob Kaita (PPPL)

Kathy McCarthy (INEEL)

Neil Morley (UCLA)

Brad Nelson (ORNL)

Tom Rognien (LLNL)

Mohamed Sawan (UW)

Dai-Kai Sze (ANL)

Mike Ulrickson (SNL)

Clement Wong (GA)

Alice Ying (UCLA)

Steve Zinkle (ORNL)

How to Get APEX Documentation or Other Information

1. [APEX Website](#) has considerable information: meeting presentations, papers, interim report, study participants, etc.

www.fusion.ucla.edu/APEX

2. APEX Interim Report (issued 11/99)
 - Volume I: APEX Overview, ~90 pages
 - Volume II: 17 Chapters, detailed, ~600 pages
 - Complete copy is displayed on the APEX Website.
 - Hard copies were distributed (1/2000)
3. If you wish to obtain a hard copy of the APEX Interim Report, or any other information on APEX, please send e-mail to the APEX Scientific Secretary, Dr. Mahmoud Youssef
<youssef@fusion.ucla.edu>