



U.S. Burning Plasma Organization e-News
November 20, 2007 (Issue 15)

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Dear Burning Plasma Aficionados:

This newsletter provides a short update on U.S. Burning Plasma Organization activities. E-News is also available online at <http://burningplasma.org/enews.html>. Comments on articles in the newsletter may be sent to the editor (R. Nazikian rnazikian@pppl.gov) or assistant editor (Emily Hooks ehooks@mail.utexas.edu).

Thank you for your interest in Burning Plasma research in the U.S.!

Director's Corner by J. Van Dam

There were a number of USBPO-sponsored activities during the APS Division of Plasma Physics Annual Meeting (November 12-16, Orlando, FL):

- On Tuesday evening, a well-attended Town Meeting on the ITER Design Review was held, with very informative presentations by Günter Janeschitz (Design Review Coordinator) and Rich Hawryluk and Ron Stambaugh (members of Design Review Working Group 1). Their talks are posted on the USBPO web site at <http://burningplasma.org/reference.html>.
- The USBPO supported a mini-conference "The First Microns of the First Wall" (organized by the Edge Coordinating Committee).
- A list was prepared of burning plasma-related contributions at the meeting. The list included 8 invited talks (one given by a USBPO Topical Group leader), 10 oral contributed, 58 posters, 1 review talk (given by a USBPO Topical Group leader), 1 tutorial (given by yours truly), the First Microns mini-conference (22

talks), and the Town Meeting (3 talks). This list was posted on the USBPO web site for general information.

- The tutorial talk entitled “The Scientific Challenges of Burning Plasmas” is posted on the USBPO web site at <http://burningplasma.org/reference.html>.

Also during the APS-DPP Annual Meeting, the USBPO Council met in session to review recent activities of the Organization. One action item of broad interest is that the Council decided to create a new category of membership, called Associate Member, for scientists whose home institutions are outside the US and who wish to join the USBPO. We sincerely welcome and encourage all such scientists who are interested in knowing about and participating in the various activities of the USBPO—please join!

The week before the APS-DPP Meeting, the Science and Technology Advisory Committee (STAC) of the ITER Council held its second meeting (Nov. 5-7, Cadarache, France). The STAC was charged with reviewing the scope of the ITER facility, as described in the Project Specifications document and the Design Review Report, in conjunction with information about the cost and the schedule. The Project Specifications document, which has superseded the former Project Design Specifications document, lays out the objectives for the 2007 Baseline Design; the details are now provided at length in the new Project Requirements document. The Design Review Report describes the status of the approximately 140 Design Change Requests that had been submitted during the Design Review process, which has now officially ended, although work continues on 61 Design Change Requests that are classified as “under study.” At this meeting, the STAC determined to recommend to the ITER Council, which will meet November 27, that the Project Specifications be approved as a provisional 2007 baseline document so that it can be used by the ITER Organization in order to proceed with its urgent tasks. The STAC will provide a final review next year after the documentation for Overall Project Cost and Overall Project Schedule documents has been finalized. At its recent meeting the STAC also identified a small number of high-priority technical issues that need to be considered. Most of the work related to completing the project baseline should be able to be completed in time for the ITER Council meeting to be held in the summer of 2008.

Looking ahead, the USBPO is preparing to meet with the National Research Council committee that has been set up to review the 2006 Energy Policy Act Report, concerning US plans for participating in the research program of ITER. The official name of this committee is “Committee to Review U.S. ITER Science Participation Planning Process” (or CRISPPP for short). The task of this committee is to prepare a short report addressing the following three tasks:

1. Review the document "Planning for U.S. Fusion Community Participation in the ITER Program." Determine whether the plan provides a good initial outline for effective participation of U.S. plasma scientists in research at ITER.
2. Evaluate the following required elements of the plan: (1) an agenda for U.S. research at ITER, (2) methodologies to evaluate ITER's contribution to progress toward a power source, (3) description of the anticipated relationship between the U.S. ITER research program and the overall U.S. fusion program.
3. The committee will recommend next steps in the development of the plan,

including: (a) appropriate elements and/or goals for the plan; (b) procedures to facilitate further development of the plan; and (c) metrics for measuring progress in establishing robust U.S. participation in the ITER research program.

The CRISPPP committee will hold a meeting in Washington, D.C., on December 14. The names of the members of this committee are listed on its website:

(<http://www7.nationalacademies.org/bpa/CRISPPP.html>).

📣 Announcements

The USBPO Council voted to ratify Associate Membership status for scientists whose home institutions are outside the US and who wish to join the USBPO. Sign up today by visiting us at <http://burningplasma.org/home.html>, then click on the Topical Groups sign up link. Please use your institutional email address when registering.

Submit BPO-related announcements for next month's eNews to Raffi Nazikian at rnazikian@pppl.gov.

Feature Article

US BPO reports on “Choices for Plasma-Facing Components in ITER,” for the ITER Design Review

By D. Whyte

November 2007

The materials on plasma-facing components (PFCs) will represent the boundary condition for the burning plasmas of ITER. There are three choices of PFC materials in ITER: CFC (carbon-fiber composite) at the divertor strikepoints, tungsten (W) at other locations in the divertor, and beryllium (Be) at the first-wall outside the divertor. The choice and location of the materials, and the deployment strategy of PFCs, will play a critical role in the successful development of the ITER scientific mission. Ideally the optimal PFC mix would satisfy several criteria simultaneously: 1) Minimize core plasma contamination, impurity dilution and line radiation in order to ensure access to high Q operation, 2) Be sufficiently robust to the high energy density environment of ITER to not require frequent replacement, and 3) Minimize the operational delays than can be caused by ITER surpassing regulatory limits linked to PFCs, namely in-vessel tritium fuel inventory and dust accumulation. Unfortunately it is not generally possible to make accurate predictions on these issues given the complexity of the plasma-material interactions in ITER, which will experience several limitations for PFCs not encountered in present devices, such as ablation/melting from type-I ELMs.

During the summer of 2007, the USBPO was asked by Working Group 1 (Design Requirements and Physics Objectives) of the ITER Design Review to prepare white papers on a wide variety of issues related to the choice of PFCs. The activity involved a

large number of USBPO experts who provided timely input to both the Design Review and ITER STAC meetings in September 2007. The EU undertook a similar activity. The objective of the white papers was not necessarily to resolve the PFC issues, but to convey the latest and best information and extrapolation possible for the ITER Design Review.

We now briefly summarize the results of selected white papers (the lead coordinator of each issue acknowledged). All of the white papers will be available on the USBPO web page.

1. Need for shaping the first-wall configuration and requirements for additional limiters for protection of the first wall (P. Stangeby)

- Experimental findings over the past several years indicate that charged particle flux to the first-wall is significant due to both normal and off-normal events, in contradiction to the original design requirement that assumed only photon and neutral fluxes.
- The solution is to shape the front face of each first-wall blanket module or to install a protection limiter in order to prevent damage to exposed edge (e.g. at port entrances).

2. Heat loads on start-up limiters (P. Stangeby)

- The issue raised was whether the two outboard movable port limiters could accept heat loads during current startup and rampdown without excessive Be erosion or melting.
- The design requirement of 9 MW to a single port limiter would yield a peak heat-flux in excess of the 8 MW/m² acceptable local heat load. A further concern would be excessive heat flux if auxiliary heating is required during startup.

3. Impact of enhanced sputtering by RF-induced sheaths (S. Wukitch)

- Sheath rectification is the leading candidate for enhanced impurity sources from Ion Cyclotron heating (ICRH) planned as one of the heating sources for ITER.
- This is a particular concern for “turning-on” sputtering of high-Z PFC materials (tungsten in ITER) for which the core plasma has a low tolerance.

4. Heating and melting of Beryllium from heat loads during disruption mitigation (T. Petrie)

- The relatively low melting point of beryllium makes it vulnerable to surface melting even during the relatively uniform radiative flash from disruption mitigation.
- Given the present uncertainties in radiation pattern uniformity, it is likely that some sectors of the Be wall will experience surface (~100 microns) melting, although the operational consequences of the re-solidified films is uncertain in ITER.

5. Tritium codeposition, implantation and diffusion properties for Be, C, W (A. Haasz)

- For all three materials there are a number of large uncertainties involved in making estimates of tritium retention, and no material stood out as being free of concern.
- Codeposition of tritium in plasma-deposited films is expected to be the main retention mechanism for C and Be. On average the tritium retention rate will be about a factor of two less with Be than for C. The large range of possible film surface temperature in ITER leads to factors of about 50 uncertainty in the retention rate, with the result that the in-vessel limit of 350 g-T could be met between 100 to 10,000 discharges.

- For tungsten, new analysis showed that the impact of volumetric neutron damage could be critical to properly estimating T retention in the D-T phase of ITER. Preliminary estimates showed a shot limit within the uncertainty range of retention in Be and C.

6. Thermo-oxidation for recovering tritium from carbon-based deposits (J. Davis)

- Thermo-oxidation essentially “burns” through C deposits to recover retained tritium using the combination of oxygen and high surface temperature.
- Thermo-oxidation is marginal for ITER maximum temperatures of 240 C, but is satisfactory for T removal if water coolant is removed to allow divertor baking to 350 C.
- The capability to handle tritiated water exhaust resulting from thermo-oxidation is technologically available, but would need to be included in the ITER design.

7. Properties of mixed materials (R. Doerner)

- Predicting mixed-material (Be, W, C) is highly uncertain due to the complicated history of the PFC materials in the ITER environment.
- It appears that mixing of Be and C in the divertor will be beneficial from an erosion viewpoint.
- The mixing of Be with C or W may be detrimental due to the lowered effective melt temperature of the mixed-materials / alloys versus the original materials.

8. Damage to high-Z tungsten from transient heating and helium ions (B. Lipschultz)

- While melting is a primary concern, when surfaces reach high temperature, even without melting, surface cracks form which may reduce the capability of the surface to handle future heat loads.
- A macro-brush design that breaks the surface into smaller sections generally keeps melted layers from shifting too far from their original location.
- Should ITER attempt an all-W divertor, helium ion induced surface damage is likely to become more severe as the W strikepoint locations will likely operate around 1500 K.

Other issues:

- *Molecular hydrogen out-gassing from graphite walls with long pulse pumped divertor operation as a substitute for high baking temperature (R. Maingi)*
- *Dust production mechanisms and rates for tokamaks (P. Sharpe)*
- *Modification of thermo-mechanical properties of C, Be and W by neutron radiation (R. Nygren)*

The USBPO white papers were significant contributions to the ITER Design Review, which was declared completed in September 2007. Several important design changes have been made, although details of the changes are still being formulated by ITER. A particular example is the decision to change the geometry of the first-wall blanket modules to a more standard "poloidal limiter" configuration in order to protect against direct plasma flux (issue 1 above). This decision is symbiotic with the startup requirements (issue 2) in that the new first-wall limiters can also be used for startup with much greater tolerance to auxiliary heating in the current rampup phase. While the Design Review is complete, research activities continue to provide the best up-to-date information to ITER on PFC issues.

BPO-Related Meetings

Dec 4-5

Fusion Power Associates Annual Meeting
Fusion Energy: Preparing for the NIF and ITER Era
DoubleTree Hotel, Oak Ridge, TN

<http://fusionpower.org/>

Dec 10-14

13th International Conference on Fusion Reactor Materials
Nice, France

<http://www-fusion-magnetique.cea.fr/icfrm13/index.html>

Jan 7-10

ITPA SOL & Divertor Physics Meeting
Toledo, Spain

March 10-13

15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron
Resonance Heating

Yosemite National Park, California, USA

<http://fusion.gat.com/conferences/ec-15/Home.php>

May 26-30

18th International Conference on Plasma Surface Interactions
Toledo, Spain

<http://psi2008.ciemat.es/>

Please submit your 2008 events to Emily Hooks at ehooks@mail.utexas.edu.

For more Fusion Research-related events, visit the USBPO Upcoming Events page online at <http://burningplasma.org/events.html>.